Risk Index Tool: Phase 1 draft implementation guidance

Estimating the risk of farm-level nitrogen loss

Ministry for the Environment
Manatū Mō Te Taiao

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Draft release

This guide is being published as a draft.

Changes that may be made to this guide between publication in April 2024 and the release of the Risk Index Tool will be limited to tool functionality and any omissions to assumptions and limitations that may be identified as we undertake stakeholder engagement.

The science underpinning the tool will not change. This is now set and is outlined in the technical documents also being released in their final form in April 2024.

We do not foresee any changes to the guidance for how the tool could be used to support regulatory purposes.

Background

In response to the 2018 review[1] of Overseer, a science advisory panel determined there was no confidence in the Overseer model's estimates of nitrogen lost from farms across the range of Aotearoa New Zealand's climate, topographies and land uses.[2] The government[3] response,[4] based on advice from an external advisory group, was to commit to investigating and putting in place at least one of four options.

This guide is specific to the option of creating a new tool – the contaminant discharge Risk Index Tool (RIT). The RIT will provide a practical way to identify areas of greater nitrogen-loss (N-loss) risk on land, to help meet freshwater outcomes.

Development of the RIT began in early 2022. We are delivering the RIT in phases. Phase 1 is a functional tool for farmers, growers and councils to understand total N-loss risks.

The RIT does not estimate N-loss, but rather indicates the risk of N-loss. Councils chose nitrogen as the priority contaminant for the tool, to help them achieve their near-term freshwater outcomes. This would allow them to understand and potentially use the tool in their planning frameworks, to give effect to the National Policy Statement for Freshwater Management 2020.

Using the RIT is not a legal requirement – it is one of the tools you can use when implementing policy.

We acknowledge that this first phase is not a 'one size fits all' solution, and that it would require further development to refine its use. Any future phases will address other contaminants (eg, phosphorus, sediment and pathogen) and functionality that we were not able to incorporate in phase 1.

Audience

The primary audience for this guide is regional councils and unitary authorities (councils). Others can use it to understand the RIT's potential role in a multi-evidence approach to decision-making in environmental regulation.

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1 *Overseer and regulatory oversight: Models, uncertainty and cleaning up our waterways*, December 2018. The review was an independent investigation of the nutrient management model that could inform the debate about its role in improving water quality and identify how to improve Overseer's suitability for use as a regulatory tool.

2 *Overseer whole-model review: Assessment of the model approach*, July 2021.

3 Labour-led government 2017–2023.

4 *Government response to the findings of the Overseer peer review report*, August 2021.

Purpose of this document

This guide will help councils understand how the RIT can be used to support freshwater regulatory decision-making. It provides guidance on implementing the RIT for phase 1 – estimating the risk of farm-level nitrogen loss.

It includes an overview of how the RIT can support consent processing and drafting freshwater farm plans,[5] and how the tool works, including assumptions and limitations for its use. There is also a glossary.

This guide is not a technical report or a user manual.

Associated documents

Other documents we are drafting for the RIT include:

- a user manual on inputting data and information
- technical overviews of the scientific logic behind the RIT including:
  - Appendix A: Animal nitrogen inputs via urine and faeces
  - Appendix B: Soil residue N inputs
  - Appendix C: Erosion losses associated with land use and management
  - Appendix D: Nitrogen concentrations for common fertilisers and manures
  - Appendix E: Mitigations and modifiers
  - Appendix F: Testing and revisions
  - Appendix G: Upgrades of the existing RIT
  - Appendix H: Peer review feedback and final report.

Other guidance on using models and tools in a regulatory context:

- *Developing, adapting and applying environmental models in a regulatory context in New Zealand.* Ministry for the Environment.

These documents will be on the Ministry's website: environment.govt.nz.

[5] For further information on freshwater farm plans, see https://environment.govt.nz/acts-and-regulations/freshwater-implementation-guidance/freshwater-farm-plans/.

Phase 1

Phase 1 focuses on N-loss risk. Councils said that N-loss was the most pressing contaminant, and one with enough scientific evidence for the RIT build. We are scoping future phases to include other tool functions, and other potential contaminants.

We convened three specialty groups for the RIT.[6]

Group	Role
Technical Working Group (TWG)[7]	To provide technical and scientific oversight, guidance, advice, and leadership in developing the tool.
Regional Council Reference Group[8] • Waikato Regional Council • Hawke’s Bay Regional Council • Greater Wellington Regional Council • Environment Canterbury • Southland Regional Council	To provide: • a regulatory perspective on the RIT • feedback on the TWG’s recommendations and decisions • input on developing this guidance.
Subject Matter Expert Group:[9] • two regional council staff • two Māori/collective landowner representatives • three farmers • one farm nutrient management advisor	To capture user-centric, functional requirements in RIT development.

6 We set up these groups to ensure development and delivery of a high-quality product based on a set of principles, including transparency, fitness for purpose, and robustness in the face of uncertainty.

7 TWG members: Professor Richard McDowell (Lincoln University), Dr Valerie Snow (AgResearch), Reina Tamepo (Scion; Advisor for Māori perspectives), Dr Bethanna Jackson (BEEA Limited). Observers: Dr Gerald Rys (Ministry for Primary Industries), Dr Kohji Muraoka (Ministry for the Environment).

8 Council Reference Group members: Mike Scarsbrook (Waikato Regional Council), Kate Proctor and Katrina Brunton (Hawke’s Bay Regional Council), Alastair Smaill (Greater Wellington Regional Council), Olivia Cook (Environment Canterbury), Jane Carroll (Southland Regional Council).

9 Subject Matter Expert Group members: Jon Palmer (Waikato Regional Council), Kate Proctor (Hawke’s Bay Regional Council), Charlotte Senior (farmer and farm consultant – AgriIntel, Canterbury), Chris Dennison (farmer, North Otago), Charles Taituha (collective landowner, Waikato), Chevon Horsford (collective landowner and farm consultant, Northland).

Use as a decision-support tool in a regulatory context

The Ministry for the Environment does not require councils to use the RIT. Councils may choose to use it to support their decisions, as part of a multi-evidence approach, in regulatory processes, and to assist in developing freshwater farm plans. Councils will need to create their own scenarios to determine what the risk scores mean in their catchment contexts.

In 2023 the Ministry published guidance about developing, adapting and applying models in a regulatory context.[10] That guidance presents a framework that can be used for:

- developing and adapting environmental models for use in Aotearoa New Zealand
- deciding how to apply model outputs
- informing decisions and a benchmark of good practice against which decisions can be assessed.

The Ministry advises that it is generally more appropriate to use environmental models to inform actions and decisions at the 'softer' end of the regulatory spectrum. This entails:

- identifying potential management issues
- educating and empowering people to make their own decisions
- identifying where to focus sampling activities
- specifying thresholds that trigger investigation or greater level of regulatory scrutiny.

At phase 1 the RIT is a new tool that simulates risk in highly complex systems, and it requires real-life testing. It therefore meets the criteria for use at the 'softer' end of the regulatory spectrum.

Potential uses of the RIT

As part of a multi-evidence approach, the RIT can inform users making decisions to manage N-loss risks from land use. This includes:

- preparing and certifying freshwater farm plans
- preparing consent applications along with conditions
- establishing a trend for the risk of farm-level N-loss
- preparing land and water regional plans.

The risk score should not be treated as a 'hard number' where there is a threshold that cannot be exceeded or must be reduced.

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[10] Ministry for the Environment. 2023. *Developing, adapting and applying environmental models in a regulatory context in New Zealand*. Wellington: Ministry for the Environment.

Preparing reports and sign-off

The RIT is designed for the farmer/landowner as the primary user. However, it is widely accepted that farm advisors or consultants are more likely to use it on their clients' behalf. Councils may also choose to restrict who can prepare and submit reports to them if the RIT is being used for regulatory purposes. Councils must set up their own mechanisms to do this.

Use for freshwater farm plans

Farmers or their advisors and certifiers may use the RIT to help identify on-farm risks and actions,[11] to help meet freshwater farm plan requirements. The tool is pre-populated with some inputs and modifiers, but these may not represent all the risks on a given farm. It may also not identify all sources of risk. In that case, a freshwater farm plan would need other actions and information.

Possible uses in freshwater farm plans	Strengths	Limitations
Identifying risk	• Helps identify on-farm risk areas. • Identifies N-loss risk. The aggregation of scores provides an overall risk status for blocks and farms. • A useful prompt for discussion between farmer and certifier to understand likely risk. • Useful for certifier that it identifies N-loss risks. • Provides useful information for catchment group management and reaching better freshwater outcomes.	• Soil and climate data gaps on te ture whenua[12] may disadvantage these landowners. • Phase 1 is limited to N-loss risk only (leaching and runoff). • Scale of background biophysical risk layers (broad or differing scales may mask farm-scale risks). • Does not extrapolate or advise on risk score drivers. This may be a barrier to compliance auditing (such use is not currently recommended). • Users cannot add modifiers that are not on the RIT list. • RIT farm management data inputs may not be as detailed as those for freshwater farm plan risk assessments. • Biophysical data are based on average data, potentially masking efficient and inefficient performers. • Users can't overwrite biophysical data (eg, correcting soil type or rainfall quantities). • Does not consider proximity of waterways or critical source areas.
Identifying actions (mitigations and modifiers)	• Provides useful risk status, modifiers, mitigation strategies, and effectiveness information for farmer and certifier.	• Mitigation and modifier options only for N-loss risks (phase 1). • Users can't enter modifiers that are not on the RIT list. • Freshwater farm plan may need more detail.

[11] For the purpose of the RIT and this guidance, mitigations and modifiers could be considered 'actions' for freshwater farm plans.

[12] Land owned by Māori and managed under the Te Ture Whenua Māori Act 1993.

Possible uses in freshwater farm plans	Strengths	Limitations
	• A means of assessing various mitigation options and their impact on risk status. • Useful for certifier to identify other modifiers and mitigations. • A useful prompt for discussion between farmer and certifier to understand actions that may be useful to manage risk.	• May be more useful for some land uses than others (eg, dairy versus pork) due to modifiers included. • Pre-populated RIT modifiers may not be sufficient to manage a risk. Other actions could be required as part of a freshwater farm plan.

Use for resource consenting

There was initial discussion about using the RIT to determine activity status (eg, permitted, discretionary, non-complying). This was deemed inadvisable for the reasons given in the 'Use as a decision-support tool in a regulatory context' section.

The RIT could help farmers and advisors prepare consent applications. It could identify areas of risk and whether the mitigations and modifiers are already doing enough to manage these. This could also help councils determine which, if any, mitigations and modifiers to require in the consent conditions, and whether to grant a consent.

Possible uses for processing consents	Strengths	Limitations
Determining consent conditions (This is not determining activity status)	• Provides a N-loss risk score which may help determine consent conditions.[13]	• Does not consider proximity of waterways or critical source areas.
Identifying mitigations and modifiers	• Provides broad direction for farmers and advisors preparing consent applications on modifier and mitigation options. • Provides broad direction for regional council consents officers on whether mitigations and modifier options are appropriate. • Technical experts have reviewed the RIT's mitigations and modifiers.	• Mitigation and modifier options only for N-loss risks (phase 1). • The phase 1 table may not include some mitigations and modifiers used by farmers and growers. • May be more useful for some land uses than others (eg, dairy versus pork) due to modifiers included. • The risk score should not be treated as a hard number for compliance purposes.

[13] To be used as a part of a multi-evidence approach.

Use for preparing regional plans

Councils could use RIT assessments to review 'hot spots' of risk in their catchments, and for receiving environments. Identifying sources of nitrogen and their N-loss risk level within catchments could help determine the controls for improving or achieving freshwater quality in catchments and sub-catchments.

Possible uses in regional plan changes	Strengths	Limitations
Developing policies and rules	• Broadly indicates the areas of high-risk contaminant loss. • Broadly indicates whether mitigation and modifier options improve the risk score.	• No clear links between risk score and catchment objectives. • Can't be used for allocation or accounting because it does not specify kg N/ha/year loss. • Phase 1 is only for nitrogen risk. Later phases may include other contaminants.

Compliance and enforcement

What may not be enforceable

Risk scores as a 'hard number' may not be enforceable. The RIT is a model and therefore contains errors and uncertainties. Risk scores could also change after future upgrades to the risk calculation service.[14] Therefore, councils should not write risk scores into consent conditions or freshwater farm plans.

What may be enforceable

Four matters may be enforceable, depending on the context:

1. Commitments to any mitigations and modifiers identified as actions in a freshwater farm plan, or in a consent application if referenced in the consent conditions.
2. Consent conditions requiring the RIT for reporting.
3. Modifiers not included in a risk report could be required by consent conditions.
4. Plan rules requiring use of the RIT.

[14] The RIT functionality that uses the biophysical characteristics, nitrogen inputs, nutrient transport factors, and mitigations and multipliers to calculate the estimated N-loss risk at the block and farm level.

How the RIT works

What is the RIT?

The Risk Index Tool (RIT) is an online decision-support tool. Adaptable across sectors, it provides an N-loss risk score based on farm activity and biophysical characteristics – soil, slope and climate (precipitation). RIT risk assessments can inform users, as part of a multi-evidence approach, on the risk of N-loss from agricultural land use. This will help to achieve improved outcomes for freshwater quality.

RIT users and consumers

A user is anyone who uses the RIT for information or decision-making. They can be defined as users or consumers and may be both.

Users: Input information into the RIT for a risk assessment. They will most likely be farmers/landowners, and nutrient or farm advisors.

Consumers: Receive or use **outputs** from the RIT. This will likely include farmers/landowners, nutrient or farm advisors, farm plan certifiers or auditors and council staff.

Principles

The RIT was developed under a set of guiding principles.[15] These include:

- The initial tool must be available for councils to use in a timely manner.
- There must be proper and effective engagement with iwi and hapū Māori – in particular for future phases.
- The tool must be fit for purpose and meet users' needs. It must be robust and defendable so councils can use it with confidence.
- The framework should allow for future functionality to meet users' needs for improving freshwater (eg, catchment modelling, and water and contaminant accounting).
- Monitoring and evaluation must enable fit-for-purpose, agile version updates.
- The tool should be robust in the face of inherent uncertainties, including climate change.
- It must complement the redeveloped Overseer, but also function on its own.
- The scoring system must consider environmental as well as management risks associated with contaminant discharges, rather than factors determined mainly by ease of implementation and use.

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15 These were based on the outcomes from the Science Advisory Panel, the Government Response Report, various workshops and feedback, and the recommendations of the Parliamentary Commissioner for the Environment to the Overseer review.

- Transparency is critical. Supporting material must clearly set out the assumptions, the evidence (and its quality), the method of scoring and weighting, and planned future phases (including indicative dates).
- The RIT should be readily and easily implementable by users.
- It should calculate risk at the block level.
- Strong communications and implementation guidance should support the release of the RIT.

Overview

The RIT provides an unbounded[16] overall **N-loss risk score** for a farm. This is done in three stages.

1. Estimating the baseline risk from the availability of nitrogen sources and the likelihood of N-loss through leaching and runoff transport pathways (see below).
2. Modifying the baseline risk through actions or practices (ie, mitigations and modifiers).
3. Aggregating block-level risk to the farm level. This provides the overall N-loss risk score.

Because management practices have a strong influence on N-losses, the RIT estimates the risk of loss at a block scale, where blocks represent areas of land having consistent land management practices (see 'Blocks' section below). The RIT requires users to map their farm into blocks and then enter their nitrogen source inputs, management practices, and mitigations for each block.

Blocks

Blocks represent areas of land with consistent management practices. The RIT is designed to estimate N-loss risks based on both farm block management and underlying biophysical information. The tool already accounts for variation in soil, slope and climate (precipitation) through underlying geospatial layers. When blocking, the main consideration is whether the land is under consistent management. For example, where this includes:

- irrigation
- effluent
- different grazing regimes (eg, wintering, non-wintering)
- different fertiliser management.

For consistent comparison between years, particularly if you're comparing mitigations or modifiers, we recommend keeping blocking consistent across the years reported where possible.

[16] Scores are a number between 0 and infinity (limited by practicality) and are termed 'unbounded'. Please see the section on 'Understanding risk scores'.

NOTE: Councils may also prescribe how they would like land to be blocked on farms in their region, to suit their purposes – for example, by biophysical features. In this case, be aware that:

- blocking decisions can affect the final RIT value reported
- inconsistent blocking may affect risk comparisons across the years reported
- it is not essential to create blocks for each crop rotation, but a user may wish to do so if they are targeting a rotation to a particular soil type
- choosing very coarse blocking is not technically incorrect but may inhibit the ability of the user to realise the benefits of actions to reduce risk.

Unproductive land

Users will not have to block these areas. The RIT will automatically consider unproductive land.

Transport pathways: leaching and runoff

The RIT estimates N-loss that is transported through two pathways:

- Leaching – Transport pathway that refers to a percolation of water that carries dissolved nutrients and contaminants through the soil profile towards and below the root zone (also known as vertical flow).
- Runoff – Transport pathway over the soil surface that travels by gravity towards a stream channel, often incorporating particulate form of nutrients and contaminants (also referred to as non-vertical, horizontal or overland flow).

These are assessed separately at a block level.

Transport processes that make N-loss likely are modelled to reflect daily variation – for example, in climate. However, for each reporting period, users enter management information monthly, and mitigation information for each block. This avoids onerous daily recording.

Mitigations and modifiers

Mitigations alter the baseline risk by changing nitrogen sources – for example, changing fertiliser inputs or stocking rate (which alters urine and dung nitrogen inputs).

Modifiers (such as wetlands) do not affect source inputs. They act on the baseline risk of N-loss through a modification factor. Modifiers are applied as a diminishing return, in the order of most to least effective. Any subsequent modifiers would act on the product of the previous modifier.

Users can select from over 50 pre-defined modifiers. Three criteria were applied to the modifiers included in the RIT:

1. Data was published and accessible. Grey literature[17] was included where the report was peer-reviewed and there was no conflict of interest, such as commercial gain.

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[17] Research or information produced outside of the traditional commercial publishing, for example reports, working papers, government documents, and conference papers.

2. Data was sourced from multiple and preferentially replicated studies.
3. The modifying actions were tested in a range of locations.

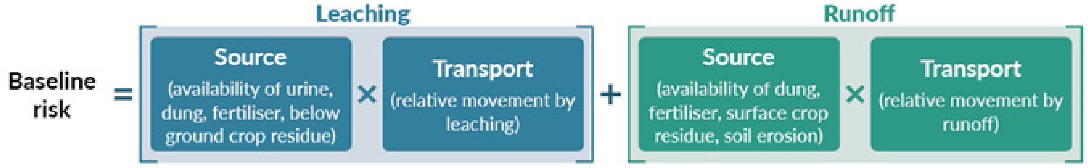
Phase 1 does not include relationships between individual modifiers; therefore, modifier effects are not 'stacked'.

Calculating risk

Baseline risk

The baseline risk is the initial risk of N-loss from land at a block-scale within a farm.[18] This is calculated as the sum of the products of nitrogen source(s) and nitrogen transport factors for leaching and runoff (figure 1), as they interact with biophysical characteristics (soil type, slope, climate (precipitation), and irrigation[19]).

Figure 1: Baseline risk calculation



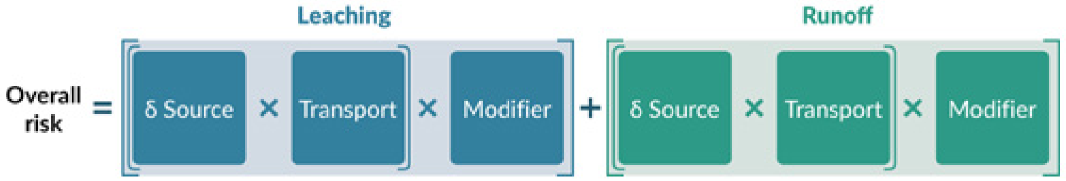
Overall risk

Overall risk is the risk of N-loss from land in management blocks within a farm, after N-loss mitigations and modifiers are applied.

Phase 1 of the RIT allows users to select from over 50 mitigations and modifiers.

The overall risk is calculated as the sum of the products of the altered baseline risk (being the product of the change (δ) in source and transport) and the modifiers (figure 2).

Figure 2: Overall block risk calculation



[18] Baseline risk is the first step in estimating the overall N-loss risk score. It is not a farm's base risk to use for comparisons.

[19] Users inform the RIT if the block is irrigated (a yes/no question), as irrigation adds precipitation and could increase nitrogen uptake.

Farm risk and block scores

The **farm risk score** is calculated as *the sum of risk scores from all blocks on the farm*.

The block risk score is calculated as *the area-weighted average risk of polygons within the blocks*.

Councils will be able to view farm data by block risk scores and overall farm risk score.

Understanding risk scores

Score is 'unbounded'

Scores are a number between 0 and infinity (technically, although limited by practicality) and are termed 'unbounded'.

The RIT does not categorise the risk outputs. Score categories of low, medium, or high were deemed unsuitable as the RIT does not consider catchment contexts. For example, a risk score could be considered high in an overallocated catchment, but low in another.

We also considered scores of fixed numerical categories to be unsuitable. For example, if scoring 1–5, all viticulture could score 1, while all dairying and vegetable production could score 4–5. This would be unhelpful for both farmers and councils. It also does not allow for fair comparisons between farms of the same enterprise type.

Interpreting scores

The RIT produces an index of N-loss risk from agricultural land use. It does **not** provide a kg of N-estimate of the quantity of nutrient loss. The RIT applies to all sectors.

The risk score should not be treated as a 'hard number', where there is a threshold that you cannot exceed or must reduce. Rather, lower RIT scores relate to lower N-losses and higher scores to higher N-losses. However, it can't be assumed that there is a direct relationship between the score and the N-loss, even if aggregated across several years. Also, higher scores may be more acceptable in a robust or under-allocated catchment than in a sensitive one.

The risk score does not give a full indication of the farm's impact on the receiving environment. Rather, this will be influenced by:

- the state of the catchment (eg, whether it is over-allocated for nitrogen)
- sensitivity of the receiving environment to nitrogen inputs
- cultural and social factors (eg, cultural significance of the receiving environment).

Councils will need to:

- determine what the RIT risk scores mean in the context of each catchment, as the RIT does not define or categorise the risk scores
- compare risk scores between farms in a catchment, to understand the farm's position on the risk distribution curve for that catchment
- work with tangata whenua and communities to decide on the acceptable risk in a specific situation – for example, setting limits within a freshwater management unit.

Assumptions and limitations

Assumptions during phase 1 development

When developing the tool, general assumptions were made for assessing the baseline N-loss risk.

- N-loss risks are only relevant for nitrate for leaching, and for nitrate and non-nitrate forms of nitrogen for runoff.
- If irrigation increases plant growth in the summer months, the RIT methodology ensures that irrigation lowers the leaching transport risk. Often, irrigation will result in higher runoff transport factors, due to the effect of rainfall arriving on already wet soils. Usually, irrigated conditions are accompanied by greater N inputs (eg, fertiliser, stocking rate). It is the combination of the transport factor and the inputs that determines baseline risk. The methodology assumes that the irrigation is well scheduled, and the system is efficient and well maintained (centre pivot with variable rate irrigation technology).
- Irrigation usually leads to the intensification of farming systems. The RIT captures the increase in intensification and in risk. It addresses the higher inputs (source) of nitrogen due to higher fertiliser use or higher stock numbers than non-irrigated land.
- Slope has been accounted for by estimating soil erosion losses. We obtained observations for sediment loss from different slopes from the literature. We used these to generate mean observed sediment losses for land use and slope classes (flat, rolling, easy and steep corresponding to <7, 7–15, 15–25, and >25 degrees, respectively).[20]
- Unproductive areas of a farm, or unproductive land, is assumed to have no managed inputs of N. The risk from these areas is calculated as that from erosion, only assuming the values taken from the literature for 'exotic forestry'.

Assumptions for leaching

- S-map's soil properties are suitable for the RIT. Some land areas have been mapped from the Fundamental Soil Layers to S-map layers.[21]
- The Agricultural Production Systems sIMulator (APSIM)[22] processes for water, carbon and nitrogen are adequate for the RIT.
- The nitrogen applied to a ryegrass/white clover pasture is a reasonable proxy of risk in a general sense, although testing against horticultural rotations (such as arable and vegetable production) is still required.
- Risk increases linearly with the amount of nitrogen applied to the soil.

[20] The RIT uses APSIM (Agricultural Production Systems sIMulator) output only from categorically flat land (ie, less than 7.5 degrees of slope). Testing empirical evidence for slope correction showed that none were satisfactory for New Zealand conditions. Further work is suggested.

[21] https://smap.landcareresearch.co.nz/.

[22] https://www.apsim.info/.

Assumptions for runoff

- Commonly used in modelling runoff, the curve number approach used to calculate runoff is reasonable for a simple risk index. We selected it as it was consistent with the input data available.
- Modifications for the availability of nitrogen sources as inputs for runoff risk can vary according to month and type of source.

Assumptions for mitigations and modifiers

- Full effectiveness and good implementation.
- Effects apply at a block scale.
- Modifiers may be working in parallel, but a series effect is assumed on the basis that the most effective modifier would reduce risk first.
- Relationships between individual modifiers are not included in the first phase of the RIT; therefore, modifier effects are not 'stacked'.

Limitations

Other contaminants

Phase 1 only estimates risk for diffuse N-loss. Users need to be mindful of the risks from other contaminants (eg, phosphorus and pathogens). Consider using other models or tools, as part of a multi-evidence approach to assess the risks of other contaminants.

Catchment allocation and accounting

Phase 1 cannot quantify the mass loss of nutrients (eg, as kg N/ha/year) and should not be used for catchment accounting or allocation that requires quantification of loss estimates.

Currently the tool does not allow users to extract risk scores for uploading into other systems.

Versions

The RIT is designed to evolve, so that it uses the best data and knowledge available at the time. Improvements will likely change risk scores. We will release new RIT versions as knowledge and technical information change. This may include updating biophysical information (soil, climate, transport factors), mitigations and modifiers, or include additional contaminants.

We will notify or publicise upcoming version changes.

Leaching and nitrogen movement

The RIT does not account for the movement of nitrogen from one block to another. For example, if a block ends at the bottom of a slope, the adjacent block at the bottom of the slope does not receive the nitrogen loss from the slope as an input.

Users can’t upload or overwrite data

The RIT does not have the functionality for users to upload or overwrite underpinning data, whether biophysical, or nitrogen source inputs, beyond changing the quantity of inputs, or modifiers.

Aggregating scores and discounting high-risk areas

The risk score aggregation method could obscure risks from small areas that are relatively high-risk but are only a fraction of the farm or block area. The risk calculation happens first at the polygon level (polygons represent areas of slope, soil, climate) and these are then aggregated to block scores. High risk polygons could be hidden once the averaging to block-level scores occurs.

Councils could mitigate this by providing more prescriptive guidance, including criteria for users to define blocks. This guidance should be well-informed by knowledge of the underlying data and functions of the RIT.

Sites and species of cultural or community significance

Phase 1 does not allow users to identify sites or species of significance on-farm or within catchments. The tool also does not recognise if a block is adjacent to a waterway. These are all considerations when writing freshwater farm plans and assessing inherent vulnerabilities.

Consumers will need to view other evidence (eg, maps) to determine block proximity to waterways, and assess if there are sites and species of significance when determining appropriate actions.

Critical source areas

Critical source areas are areas within a farm or catchment that contribute a disproportionately large quantity of contaminants to water (relative to their extent), leading to poor water quality. Phase 1 does not allow users to identify critical source areas on-farm or in catchments. These must be identified as part of assessing features related to inherent vulnerabilities in freshwater farm plans.

Mitigations and modifiers

The RIT has a pre-populated list of modifiers and does not account for modifiers not on the list. Users can’t add their own modifiers but can use other mitigations that reduce the N input to blocks. Users may wish to report this supplementary information through their freshwater farm plan or resource consent application assessment of environmental effects.

The RIT does not include modifiers that may increase risk.

Irrigation

Irrigation is a key concern for councils. This is because of the ability to intensify irrigated land, and the impact of poorly managed equipment and poorly scheduled irrigation on neighbouring water bodies, degrading freshwater. The impacts of intensification are captured through increases in N-source inputs (eg, stock numbers, fertilisers and crop residues).

The RIT assumes that the irrigation is well scheduled, and the system is an efficient, well-maintained centre pivot that takes account of different soil types within a block. Centre pivots can achieve much higher distribution uniformities than other systems commonly used in New Zealand. The RIT does not currently induce a modifier that would account for irrigation systems that perform to lower standards.

Poorly designed, poorly maintained and less efficient irrigation systems will increase the risk of N-loss from both leaching and runoff.

Production systems with rotations

In context of the RIT, rotations are for a single grower or growing enterprise rotation schedule.

The RIT requires one year of inputs to calculate a score. We acknowledge that some vegetable and arable systems typically have a 5–7-year rotation. However, we recommend users enter current rotation input values for the reporting year.

There could be implications for users trying to block land leased for short periods (less than one year). This may affect their overall farm score, but if blocked separately they can be considered at the ‘block score’ level.

Sensibility testing

The Technical Working Group (TWG) did sensibility testing to:

- look at the effect of different factors on APSIM transport outputs
- compare observations of N-loss against RIT risk estimates.

Sensibility testing looked at the effect of different factors on APSIM transport outputs using 156 farms, two of which were te ture whenua.[23] The risk scores were consistent with the measured N-losses, except for vegetable rotations.

Vegetables were included in the analysis. Initially the risk index values were consistently lower than expected, given the observed (measured) losses. As the risk relative to observed losses was consistently under-predicted, risk was boosted by a factor of five as an interim fix until vegetable-specific transport factors can be investigated.

[23] Land owned by Māori and managed under the Te Ture Whenua Māori Act 1993.

Data gaps

S-map and the fundamental soil layer

At the time Whitiwhiti Ora data was supplied to MfE,[24] S-map covered 10 million hectares of land, equating to about 50 per cent of all productive land. Around 45 per cent (0.56 million hectares) of te ture whenua (1.26 million hectares) is not covered by S-map.

For areas where S-map was not available, the Fundamental Soil Layer data was aligned to S-map proxies.

Virtual climate station network (VCSN)

Whitiwhiti Ora used VCSN data for RIT's climate input data. The VCSN uses 150 physical weather stations from NIWA and MetService networks to interpolate weather across New Zealand at a grid of approximately 5 km. Higher uncertainty about the data is likely for locations furthest from the physical stations, in regions where the climate changes rapidly with distance, or in coastal areas where fewer physical stations are available for interpolation (ie, there are no weather stations at sea).

The VCSN grid has some gaps on coastal areas where the centroid of the grid falls outside the coastline. In these cases, the nearest VCSN station was used. The proportion of production land area this affects has not been calculated but will be small. This data gap affects both general land and te ture whenua.

Chatham Islands

The Chatham Islands are not currently covered in the RIT because of a lack of usable soil and climate data.

Transport risk for runoff on slopes

Phase 1 uses APSIM outputs only from categorically 'flat' land, ie, slope less than 7.5 degrees. The RIT adjusts those flat outputs for steeper slopes. There are several methods to account for slope (without adjustment). These have been captured and will be considered for future phases.

In general, te ture whenua is on hill country with moderate to steep slopes, and so may be more affected by future developments in this aspect than general land.

Year-to-year variation in weather and management on transport risk

The transport risks are presented as long-term aggregations and do not vary from year to year. Therefore, extreme weather events are not considered. However, farm management varies, responding and adapting to weather variation. In a future phase we will investigate the interaction between the specific year management information entered by the user, and the long-term median aggregation of the transport risk.

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[24] 27 October 2022.

Nitrogen uptake data averaged over a year

The TWG outlined a method to account for nitrogen uptake by shallow-rooted crops. However, this was not used. Due to a lack of data, the group was unable to test whether the transport risk for nitrogen leaching under pasture was materially different from that under a range of crop rotations. We will consider this for future phases.

Total nitrogen uptake should be distributed according to an exponential or sigmoidal curve (depending on the crop and its growth pattern). However, for simplicity and the time constraints for this project, a normal distribution has been assumed.

As noted, shallow-rooted crops tend to receive lower risk scores than expected. This is because they only have access to shallow depths in the soil, and the modelling is based on pasture species. This has been identified as a gap, and more modelling work is underway using APSIM for these crop types. The data was unavailable for phase 1.

Inclusion of soil nitrogen mineralisation as a soil residue nitrogen source

It has been questioned why the RIT does not include soil organic matter mineralisation in the N input sources. This is entirely separate from mineralisation of crop or plant residues (including cultivated pastures), which are explicitly included. Soil organic matter mineralisation is not an input that is controllable by the land manager. The effects of seasonal mineralisation are already included in the leaching transport factors. Given this, soil organic matter mineralisation is treated as an underlying biophysical feature rather than an explicit input. This manner of inclusion does assume that the soil organic matter is in a general steady state – meaning that it can vary within the year but will return to its previous state.

Production forestry

The RIT does not consider the age of trees and associated nitrogen uptake.

Dairy, sheep and goats

There is no effluent nitrogen source for dairy, sheep and goats, as data was not available.

Dairy cows

There is no consideration of breed, number of milkings per day, seasonality, or animal health in the concentration of nitrogen in effluent, as data was not available.

Racehorses

Racehorses are grouped with all horses in terms of N in urine and dung, as no data was available to differentiate horse excreta.

Future phases planning

We have recorded these limitations for consideration in future development.

Tangata whenua and the RIT

Overview of Māori engagement

The Ministry for the Environment (MfE) and the Ministry for Primary Industries (MPI) set up two groups at the start of 2022 to collaborate on nutrient management. They provided the perspectives of:

- governors of Māori collective organisations (Governance Advisory Group)
- on-the-ground tool users and land managers (Operational Managers Advisory Group).

They were engaged through a series of online hui, two farm visits, and one in-person meeting in Wellington.

The Nutrient Management Tools team (NMT) also engaged with the Ministry's Freshwater Iwi Advisory Group. This was to ensure they had oversight of the project, and for the NMT team to fulfil obligations as Treaty partners.

Two more groups were established during the year and included Māori members to ensure representation: the Technical Working Group and the Subject Matter Expert Group.

An advisor for Māori perspectives has been a member of the Technical Working Group, which provided scientific oversight, subject-matter advice, expertise and guidance, and leadership in the development of the RIT. The Māori advisor also provided input into other workstreams across the NMT team and was a member of the Operational Managers Advisory Group.

Two Māori/collective landowner representatives were part of the six-person Subject Matter Expert Group, which gave technical advice to support the successful design and delivery of the RIT.

Mātauranga Māori

Mātauranga is the Māori knowledge system, which includes environmental knowledge, cultivation (mahinga kai), fishing (hī ika), and traditional cultural practice. It emphasises the connection of all life in the spiritual and material worlds. The knowledge system is based on acute observations over millennia. It draws on the observations of ancestors and allows contributions to knowledge in the present to be passed on to descendants in the future.

Māori are therefore experts in their local dynamic, natural environment, as they have the long-term knowledge of using ecosystems. The lessons from mātauranga Māori can assist in effective decision-making and provide a holistic approach to environmental management.

Mātauranga Māori is strongly connected to whakapapa and can be specifically located. Mātauranga can be associated with a particular area and held by a specific hapū or iwi. It is context-specific and should be used for a specific purpose. Use of mātauranga Māori for other than its intended purpose, is considered a lack of manaakitanga (showing respect and care) for the person who provided the knowledge.

Mātauranga Māori has not been built into the RIT

Although the Science Advisory Panel recommended that we incorporate mātauranga, we later learnt through the engagement at the start of the development, that it was culturally inappropriate to do so.

Mātauranga has therefore not been incorporated into the RIT because:

- it is strongly connected to whakapapa and is shaped locally at the level of iwi, hapū, whanau and production landowner or operator
- it is not possible to reflect specific mātauranga for every potential user of the RIT within the tool itself
- when shared, it is given for a specific context, and can only be used for that specific purpose.

Partnering to enable Māori landowners to influence the design, implementation and monitoring of nutrient management tools

We encourage councils to engage with tangata whenua to develop and maintain relationships that will enable iwi Māori to influence the design, implementation and monitoring of the nutrient management tools for achieving freshwater outcomes.

Preparing catchment context challenges and values (CCCVs) is a notable part of the Freshwater Farm Plan Regulations. Catchment context challenges and values could inform RIT scores at catchment or sub-catchment level.

Expert peer review

An independent technical peer review of the RIT's science model was completed in mid-2023.

The reviewers had the following expertise:

- editor-in-chief of scientific journals
- environmental and catchment science
- lake ecology
- lake water quality modelling
- land and water management
- limnology
- Māori agri-business
- nitrogen processes
- New Zealand regional councils
- soil science and pedology
- sustainable agriculture
- water-use efficiency / irrigation science.

The feedback was collated and provided to the TWG. From this work, we identified what could be improved now, what this guidance could cover, and what we could address in future phases.

The RIT and other nutrient management tools

Using the RIT and other tools

This guidance does not endorse any other tools or discuss their use for regulatory purposes.

However, we acknowledge that councils may use a range of tools to help with nutrient management and accounting requirements.

Councils are not required to use the RIT – it is optional. Those adopting the RIT may:

- use the RIT as their only tool
- use other tools when these are more suitable than the RIT
- use the RIT as an indicator for more analysis, which may include other tools to investigate the potential for N-loss.

Contact us

If you have any questions or feedback on this guide or the Risk Index Tool in general, please email: riskindextool@mfe.govt.nz.

Glossary

Term	Definition
Accuracy (model)	The closeness of a measured or computed value to its 'true' value. Due to the natural complexity, variability and dynamism of many environmental systems, this true value is likely to be a distribution rather than a discrete value.
Accounting[25]	The freshwater quality accounting system must (where practicable) record, aggregate and regularly update, for each freshwater management unit (FMU), information that is measured, modelled or estimated: (a) loads and concentrations of relevant contaminants; and (b) where a contaminant load has been set as part of a limit on resource use, or identified as necessary to achieve a target attribute state, the proportion of the contaminant load that has been allocated; and (c) sources of relevant contaminants; and (d) the amount of each contaminant attributable to each source.
APSIM	Agricultural Production Systems sIMulator. A process-based simulation model encompassing a soil-plant-atmosphere-management system. (www.apsim.info)
Biophysical characteristics	Features of the land or environment including soil, slope and climate.
Block	An area of land within a farm or orchard boundary subject to similar and consistent farm management practices.
Blocking	Geospatial identification of a block of land.
Critical source area	Area within a farm or catchment that contributes a disproportionately large quantity of contaminants to water (relative to their extent), leading to poor water quality.
Consistent management	Management actions that are carried out in the same way over time.
Curve number	The curve number estimates the proportion of fast lateral runoff (including overland flow) from storm rainfall depth. Numbers range from 0 (no fast runoff) to 100 (complete fast runoff). It aggregates effects of soil type, land use, and management and surface condition/permeability. Curve numbers can be adjusted as soil wetness changes. Advantages of the method are its simplicity and reliance on only one parameter, as well as its wide use historically.
Farm	As per section 217B of the Resource Management Act 1991, a farm is where all or part of the land use is— (a) arable land use; or (b) horticultural land use; or (c) pastoral land use; or (d) other agricultural land use prescribed in regulations made under section 217M(1)(b); or (e) any combination of the above. RIT farms can include one or more parcels of land (contiguous or not) managed as a single operation.

[25] As defined by clause 3.29 of the National Policy Statement for Freshwater Management 2020.

Term	Definition
Farmer	In this guide, the person with ultimate responsibility for operating a farm (to match the definition of 'farm operator' in section 217B of the Resource Management Act 1991).
Freshwater farm plan[26]	A legal instrument established under Part 9A of the Resource Management Act 1991 (sections 217A to 217M). The plans identify practical actions on farm that help improve local waterways.
Freshwater management unit (FMU)[27]	All or any part of a water body or bodies, and their related catchments, that a regional council determines under clause 3.8 of the NPS-FM 2020 is an appropriate unit for freshwater management and accounting purposes. **Part of an FMU** means any part of an FMU including, but not limited to, a specific site, river reach, water body, or part of a water body.
Inherent vulnerabilities[28]	Risks to freshwater and freshwater ecosystems from the biophysical features of the land, including from irrigation or drainage.
Leaching	Transport pathway that refers to a percolation of water that carries dissolved nutrients and contaminants through the soil profile towards and below the root zone. (Also known as vertical flow.)
Loss (contaminant)	The load (mass such as kg N) or yield (mass area time such as kg N/ha/year) of contaminant discharged to the receiving environment.
Model	A simplification of reality built to gain insights into select attributes of a physical, biological, economic or social system, or a formal representation of the behaviour of system's processes. Can be defined in mathematical, statistical terms, physical or conceptual terms.
Mitigations	Actions that change the inputs, usually lowering them and the risk of N-loss. For example, the stocking rate changes urine and dung values, fertiliser use, and timing. Mitigations do not always decrease inputs; they could increase them, therefore increasing risk.
Modifiers	Actions that do not change the inputs but can change the level of risk of N-loss. For example, a wetland is a modifier. Phase 1 of the RIT only includes modifiers that reduce risk.
N-loss	Loss of nitrogen
Nitrogen input	Amount of nitrogen applied to the soil from various sources including crop residues, animals (urine and faeces), soil residues, and fertiliser.
Overseer	Online software that is used for calculating nutrient losses and helps farmers and growers make management decisions on fertiliser application to improve their farm's environmental sustainability and productivity.
Regulatory context	The way effect is given to national or regional regulation (eg, the RMA, regional plans).
Risk calculation service	The RIT functionality that uses the biophysical characteristics, nitrogen inputs, nutrient transport factors, and mitigations and multipliers to calculate the estimated N-loss risk at the block and farm level.
Risk index	A measure of risk.

[26] For further context, see the Resource Management (Freshwater Farm Plans) Regulations 2023.

[27] As taken from the National Policy Statement for Freshwater Management 2020.

[28] As defined by the Resource Management (Freshwater Farm Plans) Regulations 2023.

Term	Definition
Risk score	The number generated by the RIT for risk. The score is termed unbounded as in theory the range is 0–infinity. The RIT does not define scores as low, medium, high. Either an individual block (block score) or an aggregation of blocks forms a farm risk score.
Runoff	Transport pathway over the soil surface that travels by gravity towards a stream channel, often incorporating particulate form of nutrients and contaminants. (Also referred to as non-vertical, horizontal, or overland flow.)
Sensibility testing	Comparative testing between modelled or calculated results. This includes sensitivity to inputs and relativity between land uses and their management, to determine if the estimates are sensible, or if there is a material difference between observations.
Sensitivity (model)	The degree to which model outputs are affected by changes in selected input parameters.
S-map	Digital soil map of Aotearoa New Zealand. It includes fundamental soil data – such as depth, texture, available water, macroporosity, P retention, pH, and soil carbon. (soils.landcareresearch.co.nz/tools/s-map-online/)
Te ture whenua	Land owned by Māori and managed under the Te Ture Whenua Māori Act 1993.
Uncertainty	Lack of knowledge about models, parameters, constants, data and beliefs. There are many sources of uncertainty, including the science underlying a model, model parameters and input data, observation error, and codes.
Variability	Observed differences attributable to true heterogeneity or diversity. Variability is the result of natural random processes and is usually not reducible by further measurement or study, although it can be better characterised.
Whitiwhiti Ora **(Land Use Opportunities: Whitiwhiti Ora)**	A workstream in the Our Land and Water National Science Challenge (https://landuseopportunities.nz/). It is led by Manaaki Whenua – Landcare Research, which has provided the baseline scoring maps using S-map, slope and APSIM.

Appendix A: RIT assessment against best practice

We report on the core components and prompts in our report *Developing, adapting and applying environmental models in a regulatory context in New Zealand*. The report column includes input from the Technical Working Group (TWG).

Core component	Prompt	RIT report
Conceptual basis	1. The choice of model is supported by the quantity and quality of available data.	1. Partially achieved: The TWG used national and international data to develop a risk index rather than a loss number based on these criteria. However, quality and availability of data for modifiers were often limited and did not cover all situations. Runoff curve data for overland flow was not fully addressed for all situations. Vegetable systems and nitrogen mineralisation data was limited. Data gaps may disproportionately affect te ture whenua.
	2. Appropriate scientific theories form the basis for models, including their relationship to te ao Māori (the Māori world view), and extent to which they draw on mātauranga (knowledge) and maramataka (Māori lunar calendar).	2. Not achieved: The development of the tool did not draw on a te ao Māori view, nor on maramataka. Mātauranga was not included either, as the Māori Governance Group determined the inclusion was inappropriate.
	3. The attributes, relationships and processes of the modelled system are relevant to the problem of interest, and the important drivers and processes represented by the model are relevant to the assessment being undertaken.	3. Achieved: Phase 1 only considers N-loss risk, as it was deemed the most urgent. The model considers leaching and runoff risks, and biophysical characteristics. We did not include other contaminants but will consider them for future phases.
Respect for Te Tiriti o Waitangi	1. Mana whenua participation.	1. Māori engagement to date has included: – the Māori Governance Advisory Group, established by MfE to collaborate with the RIT development – Māori Operational Managers Advisory Group – Māori perspective provided by a TWG member – two collective Māori landowners on the Subject Matter Expert Group – presentation to the Freshwater Iwi Advisory Group. They are a subsidiary of the National Iwi Chairs Forum and the Freshwater Iwi Leaders Group.
	2. The role of te ao Māori and degree of focus on inter-generational health of te taiao (the environment).	2. Partially achieved: Not within the RIT itself. The inter-generational health of te taiao will depend on the uptake and implementation of the RIT. Māori should be consulted when interpreting risk scores in their local catchments.

Core component	Prompt	RIT report
Range of perspectives	1. Incorporate the range of perspectives and information sources into models.	1. We consulted primary industry bodies on mitigations and modifiers used in the RIT. A TWG member provided Māori perspectives. Five regional councils provided representatives to form a refence group. The Subject Matter Expert Group for the RIT build included two council staff, two Māori farmers, a non-Māori farmer, and a farm advisor.
Scientific and technical rigour	1. Address the principles of sound science when developing the model. The modellers' assumptions and choices are underpinned by defensible and scientific or technical rationale.	1. Achieved: We used APSIM, a reputable, documented and open access model to calculate the transport risks. Data on nitrogen inputs are from published and peer-reviewed literature. In estimating the value to assign for modifiers, experts surveyed the literature and only used data that was fit for purpose. We did sensibility testing to look at the effect of different factors on APSIM transport output, and to determine if there was a material difference between observations of N-loss and RIT estimates of risk.
	2. The quality and comprehensiveness of data is appropriate, as are the choices about which data to feed into the model.	2. Achieved: see previous point. Data gaps and limitation are documented in technical documents and this guide.
	3. The quality assurance and evaluation (including planning, implementation, documentation, assessment, and reporting) are appropriate to ensure the model and its components are suitable for its intended use and meet required or reasonable performance standards.	3. In progress: At the time of writing, we were preparing all documentation and planning for delivery and implementation support. We are also discussing monitoring and evaluation of the RIT.
Trust and confidence	1. Degree of access to objectives, assumptions, sources of data and methods of data collection; mathematical frameworks, accuracy thresholds and quality assurance used.	1. Achieved: Data that the TWG used is referenced, peer reviewed and published in the technical documents, and is on MfE's website. References to these can be found in the technical reports. This was a deliberate decision, to allow for transparency. The technical reports outline the methodology for the risk scoring. The TWG is also drafting two journal articles, one on the RIT to minimise the risk of N-loss from land to water, the other on using APSIM to estimate nutrient (eg, nitrogen) transport factors.
	2. Extent to which we have identified limitations and uncertainties, including evidence gaps, complexities and contentious areas.	2. Achieved: We identified these, and openly discussed them in the technical reports and the regional council guidance.
	3. The process to ensure individuals and groups outside the project team (eg, decision-makers and mana whenua, kaitiaki, policy, regulatory and operational staff in public authorities,	3. Partially achieved: The Subject Matter Expert Group was convened to ensure that the functionality of the RIT was suitable for users and consumers. The Regional Council Reference Group was consulted bi-weekly

Core component	Prompt	RIT report
	and parties likely to be affected by decisions made on the basis of model outputs) can feed into the evaluation processes, influence the design of the model, and understand its outputs and their implications.	on the TWG's decisions and given an opportunity to meet with the TWG directly on two occasions, in May and October 2022. All groups likely would have wanted more opportunity to engage, but the project had limited time and resources. MfE and the TWG gave a technical presentation to the councils to help them understand how the RIT works. MfE was planning similar discussions with industry at the time of writing. More engagement is needed, particularly on implementation.
	4. The extent to which users can easily understand model predictions and supporting analyses, model evaluation or peer-review reports, and model implications.	4. Achieved: This guide explains in plain language how the RIT works, its limitations, and its role in a multi-evidence, decision-support framework. Although we aimed for ease of understanding when writing the technical documents, the intended audience has some technical knowledge of diffuse nutrients in an agricultural system.
Assumptions and limitations	1. Detail important assumptions used in developing or applying a computational model, and the resulting limitations that will affect the model's applicability.	1. Achieved: Recorded in the technical documents and included in this guide.
Computational infrastructure	1. The mathematical algorithms and approaches used in the model computations.	1. Achieved: Algorithms and approaches were underpinned by peer-reviewed, published research. They are recorded in the technical documents, which are peer-reviewed.
Data availability and quality	1. The availability and quality of monitoring and other data that can be used for developing model input parameters and assessing model results.	1. Partially achieved: In some instances, there was scarce data available to develop and test the RIT. This is documented in the peer-reviewed technical documents.
Model resolution capabilities	1. Assess the level of disaggregation of processes and results in the model, compared to the resolution needs from the problem statement or model application – the resolution includes the level of spatial, temporal or other types of disaggregation.	1. Achieved: The spatial disaggregation is at the minimum (ie, finest) scale allowable by the intersection of the weather grids with the soil and slope map polygons. The exception is that polygons occupying less than 0.1 hectare were incorporated into their neighbours. Achieved: The transport model works on a daily basis to reflect daily variation in weather. The 15th of the month is taken as a proxy for transport processes for the entire month. The temporal disaggregation of nitrogen input sources is monthly. Partially achieved: Transport risks are based on a pasture system. Testing is needed to understand how well this applies to other systems, such as forests and crops/vegetables.
Sensitivity and uncertainty analysis	1. Investigate the parameters or processes that drive model results, as well as the effects of lack of knowledge and other potential sources of error in the model.	1. Achieved: We did sensitivity testing to determine sensitivity of sources on risk scores. We also tested sensitivity of mitigations. However, sensitivity of modifiers was not required, as we used all available data in creating the modifiers. As a

Core component	Prompt	RIT report
		result, there was no data to compare potential interactions. Uncertainty work analysed losses as yields (kg N/ha/yr) against RIT scores for all relevant published data in New Zealand (n~150 observations). Recognising that observations and scores were not normally distributed, we compared estimated RIT scores against observed losses on ranked data. This showed good, consistent predictability (eg, R^2>0.7, NSE>0.7 and MAE<0.75).
	2. Identify and explain the implications for the potential scope of model application.	2. Achieved: We defined the scope of RIT use. The RIT is to be used as a part of a multi-evidence approach. Amendments to this use could be refined through monitoring and evaluation. This guide explains the tool's limitations.
Test cases	1. Develop basic model runs where an analytical solution is available, or an empirical solution is known with a high degree of confidence. This ensures that algorithms and computational processes are implemented correctly.	1. In progress: At the time of writing, farm scenario test cases were being developed to test and ensure the correct use of algorithms and implementation of computational processes (eg, the risk calculation service). The nature of risk models is that they are not suitable for comparison against analytical solutions. There has been comparison (see above) against data (empirical) using ranks.
Validation and corroboration	1. Compare model results with data collected or observed in the field, to assess the model's accuracy and improve its performance.	1. Achieved: Completed in the sensibility analysis (above). The technical documents were peer reviewed. It is unlikely that this project would ever cause change in the underlying transport model (APSIM). The model is heavily validated against a wide dataset, is designed with a run-everywhere philosophy (ie, there are few or no site-specific parameters), and has a strong requirement for the review of software engineering and science.
	2. Compare model results with other similar models.	2. Not achieved. Currently, no similar models are available to run a comparative analysis (ie, risk score models that consider the same biophysical and anthropogenic factors).
	3. Assess the level of certainty for its predictions under the full range of conditions the model operates within, at a range of spatial and temporal scales.	3. Achieved: Sensibility testing was part of RIT development.
	4. Assess how closely the model matches the real system of interest, or how accurately it represents observed relationships between key model parameters.	4. Achieved: See previous point.

Appendix B: Potential use scenarios

Scenario	Purpose	User (U) and consumer (C)	Strengths	Limitations
Freshwater farm planning	Identify risk	Farmers (U, C) Advisors (U, C) Certifiers and auditors (C)	• Helps to identify on-farm risk areas. • Identifies N-loss risk. The aggregation of scores provides an overall risk status for blocks and farms. • A useful prompt for discussion between farmer and certifier, to understand likely risk on farm. • Useful for certifier that risks have been identified for N-loss. • Provides useful information for catchment group management and progress towards better freshwater outcomes.	• Soil data gaps on te ture whenua disadvantage these landowners. • Phase 1 covers N-loss risk only (leaching and runoff). • Scale of background biophysical risk layers (ie, broad or differing scales may mask farm-scale risks). • The RIT does not extrapolate or advise on risk score drivers. This may be a barrier to its use for compliance auditing. • Users can't enter their own mitigations. • RIT farm management data inputs may not be as detailed as those required for freshwater farm plan risk assessments. • Biophysical data is based on average data, which could mask efficient and inefficient performers. • Users can't overwrite biophysical data. • Does not consider proximity of waterways or critical source areas.
	Identify mitigations and modifiers	Farmers (U, C) Advisors (U, C) Certifiers and auditors (C)	• Provides useful risk status, modifiers, mitigation strategies, and effectiveness information for farmer and certifier. • Provides a way to assess mitigation options and their impact on overall risk status. • Useful for certifier to identify other modifiers and mitigations that could be implemented. • A useful prompt for discussion between farmer and certifier, to understand actions that may help to manage risk.	• Mitigation and modifier options only for N-loss related risks (phase 1). • Users can't enter their own modifiers. • Greater level of detail may be required in freshwater farm plan. • May be more useful for some land uses than others (dairy versus pork) due to the mitigations or modifiers. • Pre-populated modifiers and mitigations may not be appropriate to manage a risk. Other actions could be required as part of a freshwater farm plan.

Scenario	Purpose	User (U) and consumer (C)	Strengths	Limitations
Consenting	Determine consent conditions (This does not determine activity status)	Farmers (U,C) Advisors (U,C) Regional councils (C)	• Provides an N-loss risk score which may help determine consent conditions.[29]	• Scores may change if practices or tool versions change, which could affect consent conditions. • Does not consider proximity of waterways or critical source areas.
	Identify mitigations and modifiers	Farmers (U, C) Advisors (U, C) Regional councils (C)	• Provides broad direction for farmers and advisors preparing consent applications on modifier and mitigation options. • Provides broad direction for regional council consents officers on whether the mitigation and modifier options are appropriate. • Technical experts have reviewed the RIT's mitigations and modifiers.	• Mitigation and modifier options only for N-loss risks (phase 1). • The table in phase 1 may not include some mitigations and modifiers used by farmers and growers. • More detail may be required at actual farm level. • May be more useful for some land uses than others (eg, dairy versus pork) due to the mitigations or modifiers. • The score should not be treated as a hard number for compliance.
Regional plan changes	Develop policy and rules	Regional councils (C)	• Broadly indicates the location of high-risk contaminant loss areas. • Broadly indicates improvements in risk score, through the mitigation and modifier options.	• There are no clear links between risk score and catchment objectives. • Can't be used for allocation or accounting because it does not specify kg N/ha/year loss. • Phase 1 only provides nitrogen risk. Other contaminants may be included in later phases.

[29] Councils must do their own RIT output analysis to determine how to interpret the score for activity status.