Technical Advice on Wastewater Performance Standards: Discharge to Land

Advice on Proposed Standards

Taumata Arowai

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This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

Executive Summary

Throughout 2024, the Water Services Authority - Taumata Arowai (Taumata Arowai) worked to prepare for the introduction of national performance Standards for wastewater as part of a suite of significant reforms to New Zealand's water services sector under the Government's *Local Water Done Well* policy package. A Technical Review Group (TRG) was established with members drawn from central, regional and local Government as well as industry technical experts. An initial series of Performance Standard Options Assessments (including one for discharges of treated wastewater to land) were commissioned and then reviewed by the TRG, to inform a discussion document regarding proposed national Standards for wastewater performance. The intention is to release this discussion document as part of public consultation collateral, for the general public to review and submit on in early 2025.

The initial technical reports were prepared by Tonkin + Taylor Limited (T+T) and Ernst & Young Strategy and Transactions Limited (EY). During discussion and review regarding these reports by the TRG, it became apparent that more detail was required to inform decision-making in several areas, and to give confidence that the proposed options for national Standards had been derived upon a robust technical and evidence-led basis.

In December 2025, GHD, Beca and Stantec were engaged to respond to specific technical queries arising from the early work done by T+T and EY regarding discharges of treated wastewater to land. As such, this report provides technical advice to:

- Support the development of national wastewater Standards for discharges of treated wastewater to land;
- propose a set of numerical Standards (supported by evidence) to assist Taumata Arowai in the preparation of the discussion document which will be used to formally consult with a range of stakeholders in March 2025; and
- to supplement and align with a separate report proposing national Standards for wastewater discharges to water.

This report was prepared during December 2024 and January 2025. It documents the methodology, rationale, assumptions, exclusions adopted and consideration of potential implications for implementation and a review and update of the approaches and treatment limits proposed by T+T. It summarises the revised recommendation for a national Standard for wastewater discharges to land and it also outlines other additional technical matters, which were not within the original scope of works of this assignment but require further consideration in relation to the discharge to land Standards. The report content was developed through a series of workshops held with technical experts from Beca, GHD, and Stantec as well as representatives from Taumata Arowai (in an observational role). Some of this content has been directly integrated into the report to ensure that the process of arriving at a set of proposed limits is transparent.

This scope of work is limited to responding to the specific technical queries and excludes consideration of Māori perspectives because Taumata Arowai has a separate process in place for this.

Overview of land discharges

The report focusses on the discharge of treated wastewater to land in public (municipal) wastewater systems. These discharges primarily occur through a mechanism involving irrigation over a substantial area of land, such as spraying onto a surface from a height (i.e. centre pivot irrigator) or slowly feeding into soils via a dripline (i.e. surface or sub-surface drip irrigation).

It was assumed that discharges would be subject to some form of secondary wastewater treatment prior to discharge (at minimum). Secondary wastewater treatment is defined[1] as "aerobic biological processing and settling or filtering of effluent received from a primary treatment unit" (see Glossary). Any treated wastewater discharge to land will contain contaminants such as total nitrogen (TN), total phosphorus (TP), and pathogens indicated by the level of *Escherichia coli* (*E. coli*) present. The report proposes limits for these three parameters, as was requested by Taumata Arowai. The limits are in the form of maximum annual loading rates per hectare of land (as kilograms per hectare per year; kg/Ha/yr) and concentrations in the treated wastewater discharge (*E.coli*, cfu/100mL), This

[1] As per definition in the Australian and New Zealand Standard 1547:2012 On-site domestic wastewater management

type of limit was chosen because it is already common in existing consents for discharges to land across New Zealand, and as such will be familiar to most wastewater asset owners and operators.

The report contains an overview of the existing consents to discharge treated waste to land held in New Zealand; however, it is limited to analyses of only those consents where the discharge is **solely to land, or where a discharge to land can then reach a groundwater and/or surface water body**.

A number of sites across the country hold consents for more than one discharge mechanism; that is, they 'mix and match' discharging to different receiving environments such as groundwater, surface water, open coast, and land depending on the volume of wastewater needing to be discharged and the physical conditions of the site and the climate of the region (for example, some sites experience longer wet periods during the year than others, and so cannot discharge to land via irrigation as often as a site with drier conditions). The Standards for discharge of treated wastewater to land are intended to cover both discharges **solely to land** (as above) and these Mix and Match schemes, however the required adjustments to numerical limits and any associated methodology for the Mix and Match schemes are yet to be developed.

Preliminary analyses of consenting data held by Taumata Arowai indicates that, as of January 2025, there are at least 89 resource consents for discharges of treated wastewater to land in New Zealand, where land is the primary discharge mechanism and there is no additional discharge to a surface water body.

The analyses were also limited to those sites where **irrigation** is used to discharge the treated wastewater, as opposed to rapid infiltration. Beneficial re-use of treated wastewater (for example, to irrigate crops for human consumption) was also excluded from the scope of the analyses.

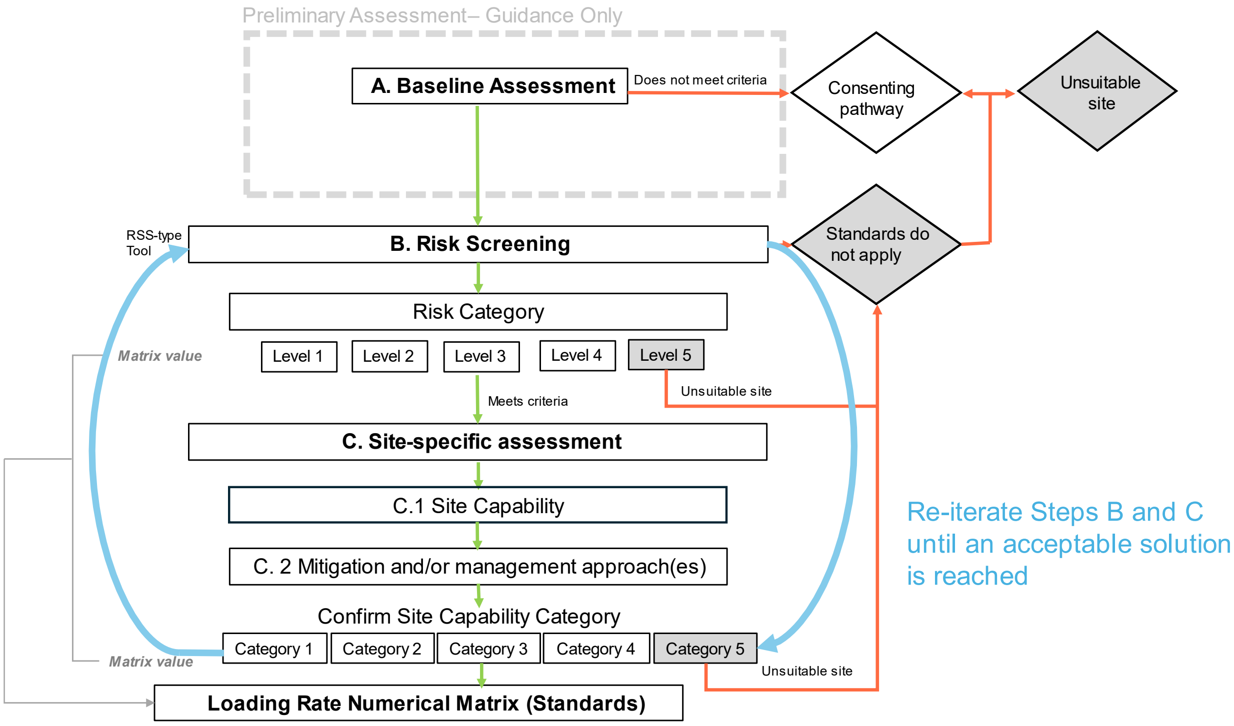
A Risk-Based Approach

While the report prepared by T+T and EY proposed that a table of numerical limits be applied directly to all sites where discharges of treated wastewater to land may occur, on closer consideration it is proposed that a tailored, risk-based approach is more appropriate. This proposal was made for several reasons, including:

- There is a wide range of variables relating to both the nature of the discharge, the discharge mechanism, and the receiving environment that needs to be considered when deciding which limits should apply.
- The interaction between these variables creates significant complexity for decision-making.
- A risk-based approach allows for conservatism / a precautionary approach, in line with best environmental management and engineering practice principles.
- Similar approaches have been applied internationally, as well as within different sectors in New Zealand (i.e. for contaminated sites and landfill management).
- The risk-based approach provides for consideration of both level of risk (for effects) and the capability of a site to assimilate and treat discharges.
- Risk can be reduced through changes in design and operation, and the implementation of various mitigation and management approaches. This provides essential flexibility for asset owners and operators.

The proposed risk-based approach would be used to determine which limits (from a range of established loading rates for TN, TP and *E. coli*) should be applied to discharges to a site, based on detailed baseline and site-specific characteristics. The overall approach is shown in the figure below. It features three major steps in selecting the most appropriate set of limits:

1. Baseline Assessment
2. Risk Screening, to define the 'Risk Category'
3. Site-Specific Assessment, to define the 'Site Capability Category'
4. Applying both the Risk Category and the Site Capability Category in a matrix to select one of three classes of loading rates (limits) that would apply to discharges to land on the site in question.



The Risk Category and Site Capability Category are used in combination to select a Class of loading rates, as shown in the tables below. These are the proposed numerical limits that would be applied to discharges of treated wastewater to land (and the point of discharge). They account for the total load of each contaminant to the land, including from the discharge and any additional sources.

		Site Capability			
		Category 1	Category 2	Category 3	Category 4
Risk	Category 1	Class 1 loading rates apply	Class 1 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply
	Category 2	Class 1 loading rates apply	Class 2 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply
	Category 3	Class 2 loading rates apply	Class 2 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply
	Category 4	Class 2 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply	**Standards can't be applied**

Notes:

Application rates and concentrations of Total N, P and E. coli will be determined based on the Matrix Class.

*The loading rates (TN and TP) within each Class account for the **total** load of a contaminant to a site, including from the discharge itself and additional sources such as the land on which it is applied and how it is managed (e.g. pasture / cut and carry; seasonal fertiliser application). The concentration limit for E. coli applies for the concentration within the treated wastewater discharge.*

Application rates and concentrations of Total N, P and E. coli will be determined based on the Matrix Class.

Where Standards do not apply, follow the usual consenting pathway under the Resource Management Act 1991.

Class	Total Nitrogen* (kg / ha / yr)	Total Phosphorus* (kg / ha / yr)	*E. coli* (Public Health) (cfu/100mL in treated wastewater)
1	500	75	No limit*^
2	250	50	< 2,000^
3	150	20	< 1000^

Notes:

- *Considering the Risk Categories (1-5) and Site Capability Categories (1-5) have not been formally confirmed, the values provided are provisional and intended to initiate and facilitate discussion.*
- *The values assume the Risk Categories and Site Capability Categories follow a normal distribution for a potential receiving site, i.e. a Class 1 site meets numerous robust numerical assessments in terms of both risk and capability.*
- *^The rationale for the values is presented in s3.3.4.1. The E. coli concentrations are for sites that apply restrictions on public access. For unrestricted public access sites, typically the E. coli concentration should be <1 cfu/100mL*
- **The 'No limit' for E. coli (Class 1) assumes the pathway / receptor connection can be adequately removed. Should this be possible for Class 2 scenarios, the 'no limit' could also be considered for this Class.*
- *The loading rates (TN and TP) within each Class account for the total load from a site, including from the discharge itself and the land on which it is applied and how it is managed (e.g. pasture / cut and carry; seasonal fertiliser application).*

Other matters for future consideration

Several matters were identified during workshop discussions that the authors agreed were important, and should be addressed in the near future, but were outside the scope of the work commissioned at the time of writing this report. These matters include:

- Consideration of Standards for sites utilising rapid infiltration systems as a discharge mechanism, and how best these should be developed.
- Developing a list (and accompanying detailed guidance) of topics that should be captured in Management and Operations Plans for wastewater schemes involving discharges of treated wastewater to land.
- Performing detailed checks (using the proposed Risk-Based Approach) of existing consented discharges to land to determine whether the proposed nutrient and pathogen loading rates are appropriate and practical.
- Developing a customised Risk Screening approach/tool to facilitate the Risk Screening component of the approach (as the examples presented in this report are demonstrative only and have been taken from existing guidance for the management of contaminated land in New Zealand developed by the Ministry for the Environment).

Contents

Table index

Figure index

Appendices

1. Introduction

The Water Services Authority – Taumata Arowai (herein referred to as Taumata Arowai), under its statutory authority conferred by the Water Services Act 2021, is developing national wastewater treatment Standards that will apply to new or renewed resource consents for publicly operated wastewater treatment plants (WWTPs). Consistent with the proposed legislation amendments announced by the Minister of Local Government in August 2024, principally revisions of the Water Services Act 2021, the Resource Management Act 1991, and the Local Government (Water Services) Bill, the proposed changes seek to implement "a single Standard rather than a minimum (or maximum), which would be implemented in resource consents".

The Government's rationale for these amendments is the need to:

- Provide directive provisions that ensure regional councils implement a single Standard approach in resource consents and cannot set additional or higher requirements than the Standard in consenting conditions (apart from on an 'exceptions' basis).
- Allow Taumata Arowai to set infrastructure and operating requirements that, if implemented by a wastewater operator, will meet the treatment requirements in the Standard.
- Allow an easier resource consenting path or 'pre-consented option' for lower-risk small-scale modular wastewater treatment plants that meet the wastewater environmental performance Standard."

The proposed new approach intends to[2]:

- Reduce the regulatory burden by ensuring environmental regulation in water services legislation is proportionate to risk and benefit.
- Deliver much greater standardisation of treatment systems and related infrastructure.
- Enable material cost efficiencies in the design, build and operation of wastewater systems.
- Provide councils with greater certainty of costs.

In line with this policy directive, Taumata Arowai engaged Ernst & Young Strategy and Transactions Limited (EY) and Tonkin & Taylor Ltd (T+T) in early 2024 to undertake a Performance Standards Options Assessment for wastewater discharges to land. The initial environmental performance Standards recommended through this assessment for wastewater discharge to land are summarised in Table 1-1.

Table 1-1 Proposed wastewater discharge to land Standards for all WWTPs, as proposed by T+T (2024)

Parameter	Proposed Standard
BOD_5 (mg/L)	<25 (or a COD limit of <125)
TSS (mg/L)	<20
TN (mg/L)	Set at-place
TP (mg/L)	Set at-place
E. coli (cfu/100 mL)	Set at-place
Enterococci (cfu/100 mL)	Set at-place

Feedback received from the Technical Review Group convened by Taumata Arowai to review and provide advice on the draft Standards highlighted the need for further technical advice and assurance that the proposed discharge to land Standard is a coherent and practical approach to consenting of WWTPs.

To undertake this assessment and progress work on the discharge to land Standard, Taumata Arowai engaged GHD, Stantec and Beca to provide technical advice on the following specific matters:

Part 1: Develop an approach for Standardising discharges to land using low-rate infiltration

1. Refine the overall approach to a proposed Standard (building on work previously completed by T+T)

[2] **Department of Internal Affairs (2024) Factsheet: Standards to help reduce water infrastructure costs**

2. Identify exclusions to the approach, i.e. situations/contexts where the Standards would not be applicable, and a site-based approach would be required
3. Define numerical limits (for wastewater quality and quantity in discharges to land) and a matrix for applying Standards.
   a. The limits shall be defined for Total Nitrogen (TN) and Total Phosphorus (TP) (as mass loads), and for pathogens for the following end-uses:
      - Recreation spaces (high levels of relatively unrestricted human contact);
      - Cut and carry agriculture
      - Areas with highly restricted human contact (used primarily or solely for discharge of effluent to land)
      - Vegetated areas
      - Production forestry.
   b. Provide advice on whether sub-categories should also be developed which specify soil types (and if so, those soil types should be specified with detailed descriptions).
   c. Advise on any recommended stand-down timeframes for the land uses outlined above (i.e. timeframe within which human or stock contact should be prevented or minimised)
4. Consider rapid infiltration methods for land discharge and provide advice with regards to how these should be covered within national Standards.

Part 2: Proposed outline programmes for monitoring the effects of discharges of treated wastewater to land, **including:**

1. Outline monitoring programme for groundwater
2. Outline monitoring programme for soils

The scope therefore excludes consideration of Māori perspectives which are intentionally not addressed in this document since Taumata Arowai has a separate process in place for this.

To address the specific matters above the following process was followed:

– For each specific matter a technical team and challenge team of subject matter experts was put together.
– The technical team worked together to provide a preliminary response to the specific matter.
– The preliminary response was then presented to the challenge team, and other project team members, in a workshop setting. In this setting the challenge team 'challenged' the preliminary outputs, and associated rationale and assumptions, and provided recommendations and advice regarding the outputs. Other team members were also welcomed to provide input where appropriate. Taumata Arowai representatives also attended as observers and provided initial feedback to inform the discussions.
– The technical teams then refined the outputs in response to the specific matters. An iterative process of presenting the refined outputs to the technical team and having it reviewed by the technical lead from each consultant was then completed until each specific matter was sufficiently addressed. Challenge team members were consulted during this process when necessary.
– A draft version of this document, capturing the draft responses, associated rationale and assumptions, for each specific matter was then presented to Taumata Arowai.
– Following feedback from Taumata Arowai, the content of this document was then refined by the technical team, reviewed by the technical leads again and finalised.

Acknowledgment is given to the various unnamed team members who contributed to this process and ultimately the delivery of the content presented in this document.

1.1 Purpose of this report

The purpose of this report is to provide technical advice to support the development of national wastewater Standards for discharges to land, to propose a set of numerical Standards and relevant additional material to assist Taumata Arowai in the preparation of a discussion document which will be used to formally consult with a range of stakeholders in March 2025. This report has been developed in parallel and, where possible, in general alignment with a separate report proposing national Standards for wastewater discharges to water.

This report documents the methodology, rationale, assumptions adopted and consideration of potential implications for implementation and a review and update of the approaches and treatment limits proposed by T+T (presented in Table 1-1 above). It summarises a revised recommendation for a national Standard for wastewater discharges to land and it also outlines other additional matters, which were not within the original scope of works of this assignment but require further consideration in relation to the discharge to land Standards.

This report should be read in conjunction with the presentation content included in Section 2 'Proposed Standards' of this report.

1.2 Limitations

This report: has been prepared by GHD and subconsultants, Beca, Stantec and John Cocks Limited, for Taumata Arowai and may only be used and relied on by Taumata Arowai for the purpose agreed between GHD and Taumata Arowai as set out in section 1.1 of this report.

GHD and its' subconsultants otherwise disclaims responsibility to any person other than Taumata Arowai arising in connection with this report. GHD and its' subconsultants also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD and its' subconsultants in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD and its' subconsultants have no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD and its' subconsultants as described in this report (refer section(s) 1.3 of this report) and specific subsections of this report. GHD and its' subconsultants disclaim liability arising from any of the assumptions being incorrect.

GHD and its' subconsultants have not been involved in the preparation of the Taumata Arowai Discussion Document (which will be used for consultation) and has had no direct contribution to the Taumata Arowai Discussion Document other than in the development of this report for the purpose as stated in Section 1.1. GHD and its' subconsultants exclude and disclaim all liability for all claims, expenses, losses, damages and costs, including indirect, incidental or consequential loss, arising directly or indirectly in connection with the Taumata Arowai Discussion Document.

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1.3 Assumptions

This report has been prepared based on the following general assumptions:

– The information contained in a national database of wastewater consents, developed by Taumata Arowai, reflects the number, location, type and discharge point of publicly operated wastewater treatment plants in New Zealand. This database has been updated with the best available information, by Taumata Arowai, as part of this work to inform the recommendations provided within this report. However, it requires verification and validation as some information is known to be inaccurate. Information, values and analysis contained in this report which has leveraged the database is therefore subject to change following verification and validation of the database.

– This report does not fully assess situations where a WWTP discharges to both land and water (e.g., when a contingency outfall to a river is consented alongside land application). However, it is intended that the Standards will also apply to these 'Mix and Match' discharges. The associated numerical limits and methodology for this are yet to be developed. The interactions and risks of Mix and Match schemes should be evaluated before applying the Standard(s) to them.

– This report considers situations where discharges to land may reach a secondary receiving environment (groundwater and/or surface water) as this is a common occurrence in New Zealand. In addition to the Government's objectives set out in the introduction of this report, we have assumed that the intent of discharge Standards is also to protect against a variety of potential effects in the receiving environment; to adequately protect public health and to enable the maintenance or improvement of receiving environment condition.

- A precautionary approach has been taken to the development of the risk-based approach and ultimately any numerical Standards arising from it.
- This report does not consider the existing and potential future legislative frameworks and implications of these proposed Standards on new and existing consenting processes for WWTPs. This is anticipated to be addressed in more detail in the Regulatory Impact Statement being prepared for the Local Government (Water Services) Bill (Dec 2024).
- The proposed Standard will not directly address potential effects beyond those parameters presented in the numerical limits. However, compliance with the proposed Standard will reduce the risks of other related effects as a result of co-regulation of the relevant contaminants (including TSS and BOD5) along with those for which Standards have been defined.
- Starting with a 50% risk-based approach and 50% site-specific assessment (i.e. equal weighting) is a prudent and conservative approach. However, the final weightings should be flexible and subject to validation and adjustment by the asset owner.
- It is assumed that the proposed Standard will apply to WWTPs of all sizes.
- The discharge to land Standards (the Standards) are intended to be applied in situations where the land is used as part of the treatment process, and to be consistent with the approach for other established Standards applicable to land application systems referenced herein, and already implemented in New Zealand.The loading rates proposed as Standards account for the **total** load to a site, including from the discharge itself and the land on which it is applied and how it is managed (e.g. pasture / cut and carry; seasonal fertiliser application).
- By incorporating nutrient uptake by plants (N and P) into the load balance, the allowable discharge limits (kg/ha/yr) could be increased. This would create further incentive for WWTPs to invest in land-based treatment systems that actively remove nutrients through biomass production. Additionally, this approach could promote the maintenance of receiving ecosystems, as WWTPs would have a vested interest in optimising nutrient cycling rather than just meeting discharge loading limits.
- Under current RMA requirements, consent renewals are considered “de novo” which means that the application for a renewal is considered as if it is a new consent application, and it has been assumed that this practice will continue. The assessments undertaken in this report have assumed that any consents issued for treated wastewater discharges will include treatment requirements or other conditions set out in the wastewater standards..
- The Standard is intended to compliment the discharge to water Standard to enable the relative benefits of both discharge routes to be considered by wastewater treatment plant operators. The provision of the Standard is intended to enable discharge to land as a viable, pragmatic and attractive option that manages the risk of adverse effects on receptors.

More detailed assumptions related to specific tasks outlined in the agreed scope are provided in the relevant sections of this report.

1.4 Precautionary Approach

A precautionary approach has been applied to this technical work and the development of the numerical Standards proposed in this document, addressing both environmental and public health aspects. The precautionary approach applied recognises that, instead of treatment limits being set on a plant-specific basis as is currently the case, under the proposed Standards treatment limits for some parameters will be set for multiple plants that have the same/similar level of risk (of effects on the receiving environment and sensitive receptors) and Site Capability.

While this approach does allow for some local variations to be accounted for, the precautionary approach is applied “overall” and is not intended to achieve the most precautionary outcome for every factor and situation. A small number of exceptions to the Standard are also anticipated and will be identified in Taumata Arowai’s Discussion Document.

Key parameters that reflect most of the potential for adverse effects in the receiving environment in relation to wastewater discharges were selected for inclusion in the numerical limits. The limits have been proposed with reference to relevant guidelines and limits commonly used in New Zealand and where necessary have drawn on international references where a more local option is not available.

The Standards have been designed to enable a deterministic approach to be taken at the asset owner’s discretion (with the prior approval of the relevant regulatory authority). This approach minimises the need for exclusions to the Standard and enables treatment limits and management of effects to be tailored to some specific site or plant-specific factors, notwithstanding the overall approach of Standardisation.

Further specific detail on these elements are presented throughout Section 2 of this report.

1.5 Overview of Wastewater Discharges to Land in Aotearoa New Zealand

Preliminary analysis of consenting data held by Taumata Arowai indicates that, as of January 2025, there are at least 89 resource consents for discharges of treated wastewater to land in New Zealand, where land is the primary discharge mechanism and there is no additional discharge to a surface water body. This is important to note, as many WWTPs in New Zealand have consents to discharge via more than one mechanism (for example, at least 17 further WWTPs are identified in the consents database as having consent for both discharges to land and to surface water). These are typically ‘mix-and-match’ schemes involving discharges to land during dry periods, and discharge to a river or stream during wetter periods or in emergencies). This analysis focused only on consents involving slow-rate application of treated wastewater to land.

It is assumed that in these cases the Standards for discharges of treated wastewater to water would apply when discharges to water occur, and likewise the Standards for discharges to land would apply when a discharge to land occurs. In some cases, discharges to land at different times of year (or under different conditions, such as higher rainfall) have been consented separately, so that there may be more than one ‘main’ discharge to land consent at a single location.

Over a quarter (24) of the consents were issued by Environment Canterbury, followed by Waikato Regional Council (issued 16 consents), and Horizons and Otago Regional Councils (both issuing 9 consents). Figure 1-1 provides an overview of the geographic distribution of land discharge consents, by consenting authority. The consents are also categorised according to the size of the WWTP they are associated with.

Almost half (43) of the consents are for discharges from ‘Small’ sized WWTPs, with the remaining consents for discharges from ‘Medium’ (29) and ‘Large’ (10) WWTPs. Seven (7) of the WWTPs have unknown or undefined size. For reference, the size classes for WWTPs have been defined as follows:

- ‘Small’ – servicing less than 1,000 population equivalents
- ‘Medium’ – servicing 1,000 to 20,000 population equivalents
- ‘Large’ – servicing over 20,000 population equivalents

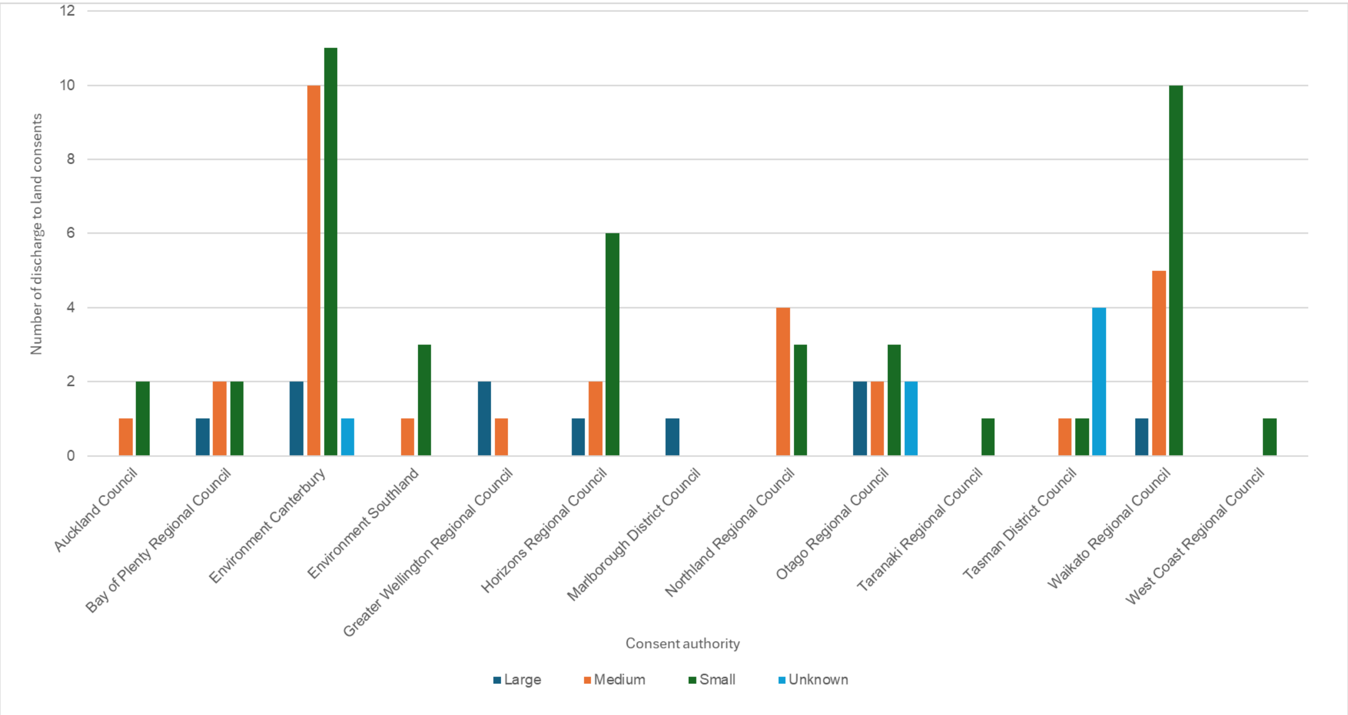


Figure 1-1 Number of existing consents to discharge treated wastewater to land, issued by consenting authorities (as of January 2025)

In addition to the above, it is recognised that when treated wastewater is discharged to land, it will eventually filter through soils, into groundwater and to any connected surface water bodies (including rivers, and at the coast). These connections between receiving environments are inherent due to Earth's water cycle (as shown in Section 2.3 below).

Given the generally slow movement of groundwater, it may take a considerable time for these connections to be made, and for any effect on each receiving environment as a result of the discharge to become evident. For example, the effect may be in the form of diffusion of the discharge, creating a 'plume' within the aquifer and then the sections of a river that connect with the affected groundwater aquifer. The scale of this plume will vary with the distance between the land surface and the groundwater surface (water table), the characteristics of soils and groundwater aquifers (for example, whether an aquifer is confined or unconfined), and the distance between the discharge location and any surface water bodies that are fed by groundwater.

2. Proposed Standards

The following content (in Section 2) presents the overall approach for national performance Standards for wastewater discharges to land, along with the proposed numerical limits derived by the process.

This content was developed through a series of technical workshops held in November and December 2024, supported by background research and desktop analyses. The methodology and rationale used to develop the approach are detailed in Section 3 of this report. The content is presented here in its original format (i.e., PowerPoint).

2.1 Agreed Scope

The following table is an excerpt from the proposal submitted to Taumata Arowai on 29 November, 2024 (and subsequently approved).

• **Building on the T+T/EY work and the Technical Review Group. This was the Task Breakdown for this stage of the work:**
• <u>**Working Session #1**</u> • <u>**Part 1 – # 1, #2 and #3 Low-rate infiltration approach**</u> 1. Refine overall approach 2. Exclusions i.e..: slope, soils, ponding, flood zone, snow, saturated zones, aquifers, buffer zones, upstream drinking water bore 3. Numerical limits context and matrix • **Advice is required on the treated wastewater quality (TN, TP (mass load) and pathogen numeric limits) that should apply to above ground and subsoil application of effluent to land with the following uses:** • Recreation spaces (high levels of relatively unrestricted human contact); • Cut and carry agriculture. • Areas with highly restricted human contact (used primarily or solely for discharge of effluent to land); • Vegetated areas (excluding production forestry); • Production forestry. • Advice is also required on whether sub-categories should also be developed which specify soil types (and if so, those soil types should be specified with detailed descriptions). • Advice on any stand-down timeframes for the classes of land outlined above (i.e. timeframe within which human or stock contact should be prevented or minimised)

- **<u>Working Session #2</u>**
- **<u>Part 1 , # 2 – Low rate infiltration approach continued</u>**
- Develop numerical limits for low-rate systems with assumptions, rationale and any required guidance
- Draft key definitions
- **<u>Part 1 , # 4 Begin Work on Rapid Infiltration</u>**
- Hydrogeological considerations and review exclusions

- **<u>Working Session #3 – Rapid Infiltration</u>**

1. Advice on TN, TP (mass load) and pathogen numeric limits that should apply to rapid rate infiltration application of effluent to land and whether this category also requires sub-categories based on the following:

- Soil categories
- Immediate receiving environment (surface water or groundwater)
- 2. Discussion of proposed monitoring

- **<u>Part 2: Monitoring as Parallel Workstream – Links back to Working Session #3</u>**
- Monitoring Programme Outline for Groundwater
- Monitoring Programme Outline for Soils

2.2 Basis of the discharge to land Standards

Taumata Arowai intends to create a National Environment Standard to Standardise the discharge of treated wastewater to land; currently addressed by S15(1) of the Resource Management Act 1991:

No person may discharge any—

(a) contaminant or water into water; or

(b) contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water; or

(c) contaminant from any industrial or trade premises into air; or

(d) contaminant from any industrial or trade premises onto or into land—unless the discharge is expressly allowed by a national environmental Standard or other regulations, a rule in a regional plan as well as a rule in a proposed regional plan for the same region (if there is one), or a resource consent."

2.3 Conceptual diagram for discharges of treated wastewater to land

The diagrams below illustrate the natural water and nutrient cycles and the connections between them. These natural processes are inherent in every landscape, and as such form the primary basis of any assessment of a site and its capability to assimilate discharges of treated wastewater.

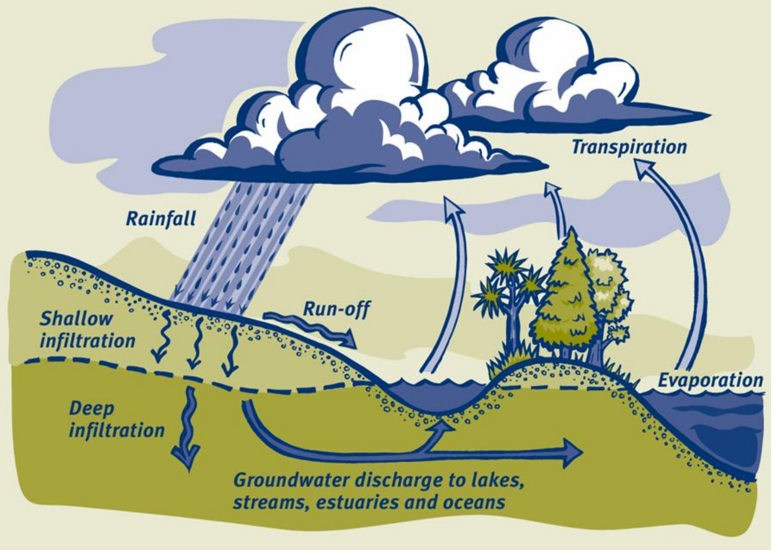


Figure 2-1 The Water Cycle (MfE 2003)[3]

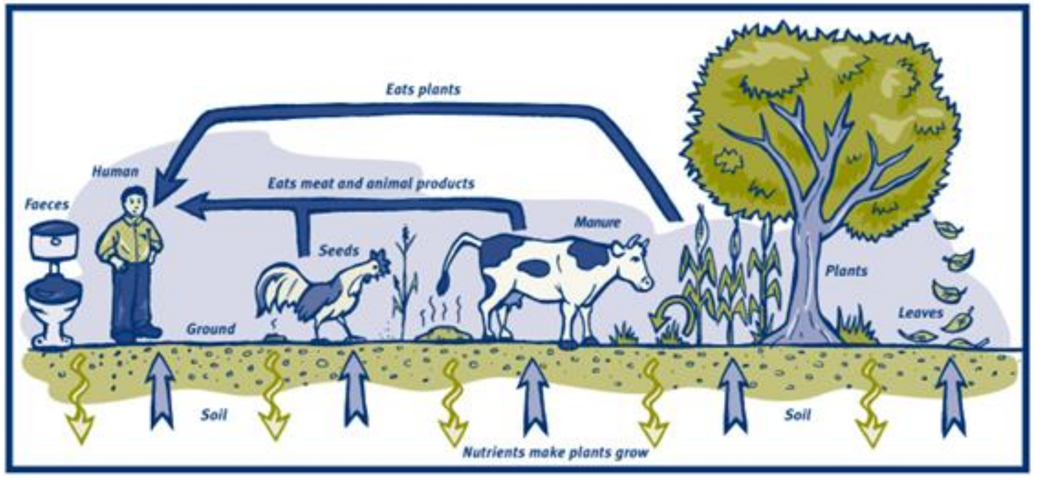


Figure 2-2 A simplified nutrient cycle (MfE 2003)

[3] MfE 2003 *Sustainable Wastewater Management: A handbook for smaller communities*, Ministry for the Environment, Wellington.

2.4 Purpose of the discharge to land Standards

The purpose is clear. Create Standards and monitoring and reporting requirements that enable WWTPs to discharge treated effluent to land whilst managing the risk of adverse effects to the receiving environment and other receptors.

Standardisation and Simplification of Consenting for Wastewater Discharges

- Reduce the regulatory burden by ensuring environmental regulation in water services legislation is proportionate to risk and benefit.
- Deliver greater Standardisation of treatment systems and related infrastructure.
- Enable cost efficiencies in the design, build and operation of wastewater systems.
- Provide councils with greater certainty of costs through Standardisation and longer-term consent durations.
- Provide a more consistent approach to national monitoring and performance.
- Provide direction to regulators (regional councils) to ensure they implement a single Standard approach in resource consents and cannot set any more or less restrictive requirements than the Standard in consenting conditions (apart from on an ‘exceptions’ basis).

2.5 Rationale

Wastewater is inevitable. Land discharge is complex.

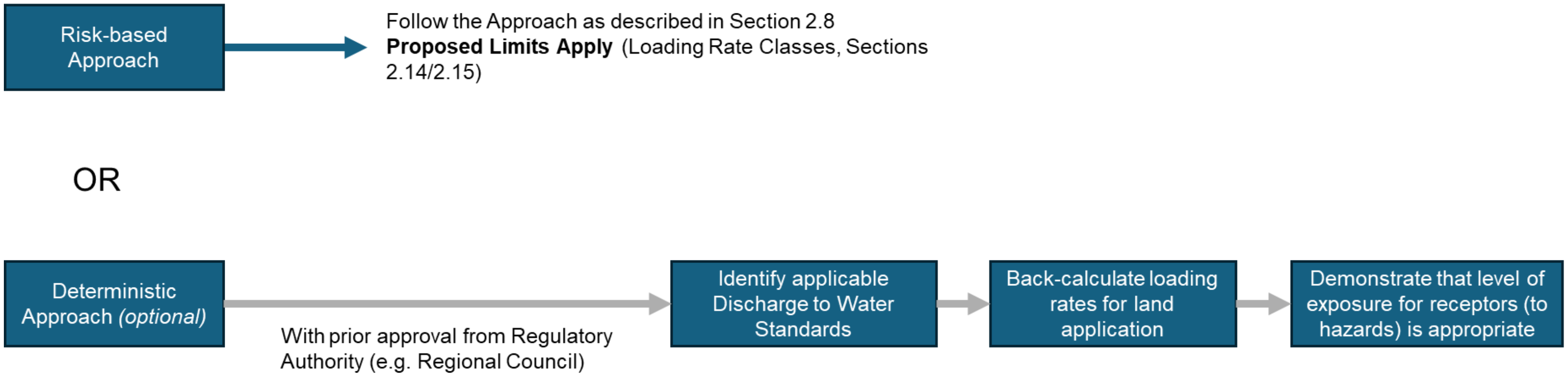
A site assessment/selection process will be undertaken by the asset owner. This proposed approach is intended to enable the asset owner to assess the suitability of a proposed site and identify the Standards that apply based on a risk-based approach.

The task has been to produce a framework to allow for numerical Standards of Total Nitrogen (TN), Total Phosphorus (TP) and *Escherichia coli* (*E. coli*) to be applied for discharges of treated wastewater to land.

It was assumed that discharges would be subject to some form of secondary wastewater treatment prior to discharge (at minimum).

- This proposal is currently focused on low rate infiltration. Rapid infiltration systems will be addressed subsequently.
- Overall, a precautionary approach has been taken to the development of this approach and ultimately any numerical Standards arising from it,
- To allow Standardisation, whilst recognising the complex environmental, social and operational variability for discharging treated wastewater to land - a risk-based approach has been proposed.
- **An alternative, deterministic approach could be feasible if applicants / asset owners are prepared to undertake significantly more work to 'back calculate' from discharge to water Standards**, in order to establish a higher loading rate than the otherwise applicable Standards might allow (see Section 2.6 below).
- The risk-based approach is intended to consider a range of relevant and material variables to determine a risk category which along with the site capability category will determine the numerical Standards to apply.
- The focus has been to allow for mitigation and management of risks whilst enabling land discharge to be an attractive and viable alternative to discharge to water, especially for smaller wastewater treatment plants
- Standards will cover TN, TP and E. coli, however, other parameters such as salts, suspended solids and cBOD5 will need to be considered during land discharge system design to avoid operational risks such as blockages, changes to soil structure and surface ponding/run-off.

2.6 Options


Risk-based Approach
Follow the Approach as described in Section 2.8
Proposed Limits Apply (Loading Rate Classes, Sections 2.14/2.15)
OR
Deterministic Approach (optional)
With prior approval from Regulatory Authority (e.g. Regional Council)
Identify applicable Discharge to Water Standards
Back-calculate loading rates for land application
Demonstrate that level of exposure for receptors (to hazards) is appropriate

2.7 Alignment with other Standards and guidance

Jurisdiction	Relevant Standards / approach
Australia	– National guidelines (Australian Guidelines for Sewerage Systems, Effluent Management (1997). – **Requires detailed site study**, including soil type, structure, vegetation, runoff, receptors, impact and soil, groundwater and surface water sampling. – Australian and New Zealand Governments, and Australian state and territory Governments, 2023 Primary industries – livestock drinking water guidelines (draft) – State of Queensland Technical Guidelines for Disposal of Effluent using Irrigation (2020) - Utilizes risk screening and modelling software (MEDLI) to simulate the operation of land disposal over a decadal period, estimating the fate of applied effluent, including nutrients, salts and pathogens
European Union	– European Parliament Resolution P9TA(2024)0222. – **No specific article relating to treated WW discharge to land** – with the exception of water reuse (not to be discharge to food crops), includes *E. coli*, BOD_5, TSS
UK	– The Urban Wastewater Treatment (England/Wales and Scotland) Regulations 1994 – **No specific discharge to land guidance**

US	– USEPA process manual for Land Treatment of Municipal Wastewater Effluents (2006)[4]
	    – Does not set specific regulatory limits
	    – Provides guidance on typical pollutant removal rates, suggested loading cycles, area requirements
	    – Provides effluent quality Standards for Faecal coliforms, BOD_5, TSS, ammoniacal-N, total N and P
	    – **Total N and P loading rate not defined and are to be determined on site specific depended on crop uptake / removal**

NZ	– Effluent irrigation guidelines (Dairy NZ, 2015)[5] – AS/NZS 1547 Onsite domestic wastewater management and TP 58 Auckland Council[6] – GWRC – Discharge of Treated Municipal Wastewater to Land – Lowe Environmental[7] – Land Treatment Collective (LTC) – Resources https://nzltc.wordpress.com/publications-resources/ – Regional Biosolids Strategy – Lower North Island[8] Biosolids Guidelines : Water New Zealand**,** 2003 and 2024 review

[4]USEPA 2006 *Process Design Manual: Land Treatment of Municipal Wastewater Effluents*, Land Remediation and Pollution Control Division, National Risk Management Research laboratory, Office of Research and Development, United States Environmental Protection Agency, Cincinnati, 193pp.
[5] Dairy NZ 2015 *Farm Dairy Effluent Design Standards and Code of Practice*, Version 3, September 2015, developed for Dairy NZ by Powers, J. & Borrie, N. (Aqualinc Research Ltd.), 70pp.
[6] Auckland Regional Council 2004 Technical Publication No 58 (TP 58) On-site Wastewater Systems: Design and Management Manual 3rd Edition 2004, Auckland Regional Council.
[7] Lowe Environmental Impact (LEI) 2020 Regional Biosolids Strategy – Lower North Island, available online at https://www.lei.co.nz/sludges-and-biosolids

[8] Lowe Environmental Impact (LEI) 2020 Regional Biosolids Strategy – Lower North Island, available online at https://www.lei.co.nz/sludges-and-biosolids

2.8 Overall framework assumptions

Note: the following assumptions were identified during the initial stages of the development of the framework, and provide context for the subsequent framework presented in this report.

- **General:**

Land application methods that are acceptable are able to be designed, constructed and managed to reduce environmental effects, such as turning off during unacceptable climatic events (rainfall and wind), have good distribution uniformity, create less aerosols and wind drift, can be automated, can be linked to soil moisture, and can apply low application rates and depths.

- **Soil** (Treatment Units/Performance)

– The Hydraulic loading rate shall not exceed 5 mm/hr, or 1
– /application event. This application rate is considered to be within the capacity of many soil types.
– The application shall not result in significant ponding or surface runoff.
– We recognise that additional contaminants may not be treated through soils (i.e. persistent organic pollutants / emerging organic contaminants, microplastics) . The currently proposed Standard does not directly address these contaminants.
– Our current assumption is that loading land application systems at the rates proposed above will ensure other contaminants in the wastewater will not be of sufficient quantity to be of concern and soil imbalances will not occur, i.e. BOD, TSS, sodium, and heavy metals. There may be some situations where specific trade waste inputs or existing soil characteristics need to be considered
– Land for rotation and contingency areas, including resting and/or retirement of areas, will be addressed through Management and Operations Plans.

- **Receiving Environment**

– WWTP processes will be in place sufficient to enable the loading rates specified to be met.
– Land application should not preclude compliance with rules relating to designated public drinking water source zones (surface water, groundwater). Potential effects on small domestic supplies could be managed with mitigation, i.e. provision of alternate supply.
– Receiving environment limits or Standards may also be applicable for schemes that do not involve application of 100% of discharge to land (i.e. mix-and-match, or with wet weather alternative discharge to surface water)
– Receiving environment limits for surface water where groundwater discharges to surface water. This effect may vary seasonally, i.e. groundwater baseflow may provide the majority of flow in summer in some streams.
– Degree of connection between surface water and groundwater, and seasonal changes with regards to this, is a key consideration.

2.9 The approach

The proposed approach is that multiple potential sites options could be assessed by a baseline assessment. Selected site(s) would then move forward for risk screening and some of these then also progressing for site specific assessments. By the end of the process a site would either have been ruled out as unsuitable for the application of the Standard or have been assigned both the Risk Category and Site Capability Category from which it can be aligned with one of the categories in the Loading Rate Matrix.

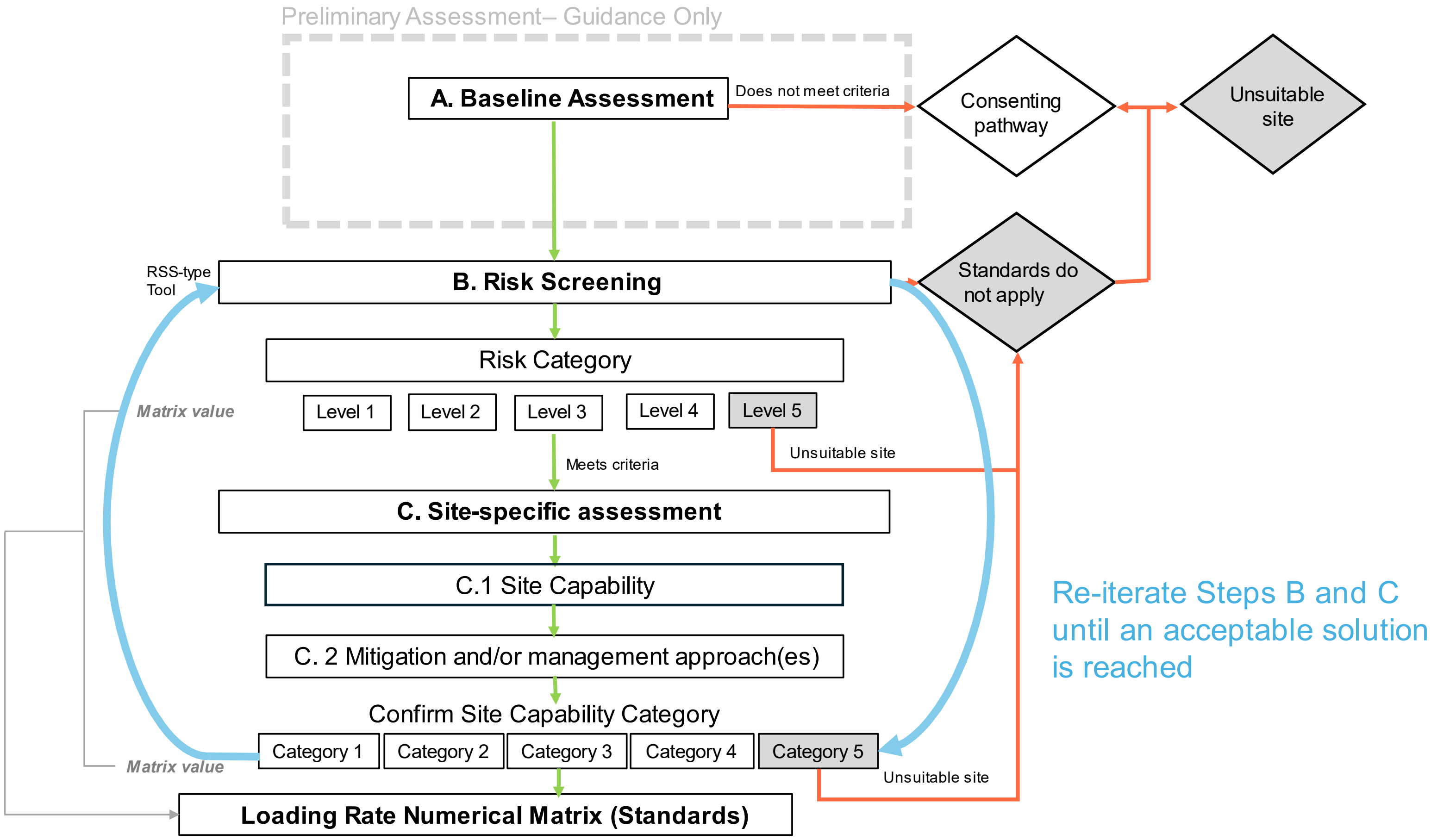


Figure 2-3 Overview of the proposed Risk-Based Approach

2.10 Proposed Standards – Loading Rate Matrix

		Site Capability			
		Category 1	**Category 2**	**Category 3**	**Category 4**
Risk	**Category 1**	Class 1 loading rates apply	Class 1 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply
	Category 2	Class 1 loading rates apply	Class 2 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply
	Category 3	Class 2 loading rates apply	Class 2 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply
	Category 4	Class 2 loading rates apply	Class 2 loading rates apply	Class 3 loading rates apply	**Standards don't apply**

Notes:

- *Application rates and concentrations of Total N, P and E. coli will be determined based on the Matrix Class.*
- *The loading rates (TN and TP) within each Class account for the total load of a contaminant to a site, including from the discharge itself and additional sources such as the land on which it is applied and how it is managed (e.g. pasture / cut and carry; seasonal fertiliser application). The concentration limit for E. coli applies for the concentration within the treated wastewater discharge.*
- *Application rates and concentrations of Total N, P and E. coli will be determined based on the Matrix Class.*
- *Where Standards do not apply, follow the usual consenting pathway under the Resource Management Act 1991.*

2.11 A: Baseline Assessment

Requirements will be detailed in guidance accompanying Standards.

To be completed as a desktop feasibility assessment on a prospective land parcel, including but not limited to:

- Climatic conditions including rainfall, evapotranspiration and average seasonality deficit.
- Site physical attributes – i.e. slope, topography, sufficient area available (ha required, subject to volume to be discharged and concentration)
- Existing groundwater data (depth, quality, flow direction, seasonal variation, sensitivity)
- Available soil data – types, drainage capacity (from regional and national maps, i.e. S-map)
- Underlying geology
- Required buffer distances
- Site contamination history
- Current and proposed land use within potential application area
- Identify potential receptors, proximity and sensitivity (including environmental, human / social, cultural, built environment)
- Natural hazards, such as flood-prone land and instability.

2.12 B: Risk Screening to allocate Risk Category

To qualify risks to receptors, including:

- Risk Screening approach
- Identify pathways and receptors for TP/TN and *E. coli.* As detailed in the following pages.
- **Risk of adverse effects on receptors** (including assessment of sensitivity):
- **Environmental risk**
    - Groundwater depth i.e. (> 10 m bgl = Category 1 or 2)
    - Site boundary > 100 m from surface water = Category 1 (dependent on connection to groundwater and flow direction)
- Receptors within 100 m, i.e.:
    - None = Category 1
    - Agricultural = Category 2
    - Horticultural = Category 3
    - Residential = Category 4
    - Natural inland wetland = Category 5 (Standard cannot be applied)
- **Public health risk (where people can have direct contact with a site)**
- Primary contact recreation within immediate receiving water (surface water) = Category 4
- People can walk past an application area with sub-surface drip irrigation = Category 2
- Drinking water protection zone (Source Protection Zone 2) = Category 5 (Standard cannot be applied)
- Domestic private bores = Category 4/5 depending on mitigation options considered
- **Social risk and amenity values**
- **Cultural considerations**

2.13 B: Risk Screening

The Risk Screening step will involve application of a qualitative risk assessment tool, whereby the sources, pathways and receptors will be assessed for nitrogen and phosphorus and *E. coli*.

A site could have multiple pathways for contaminants to reach a receptor as a result of the discharge.

We have identified some initial examples of pathways as a demonstration [see Appendix A to this report].

The guidance accompanying the Standards will include a list of pathways for asset owners to choose from (disregarding those that are not relevant to their site). This will enable greater consistency in the scope and quality of risk assessments.

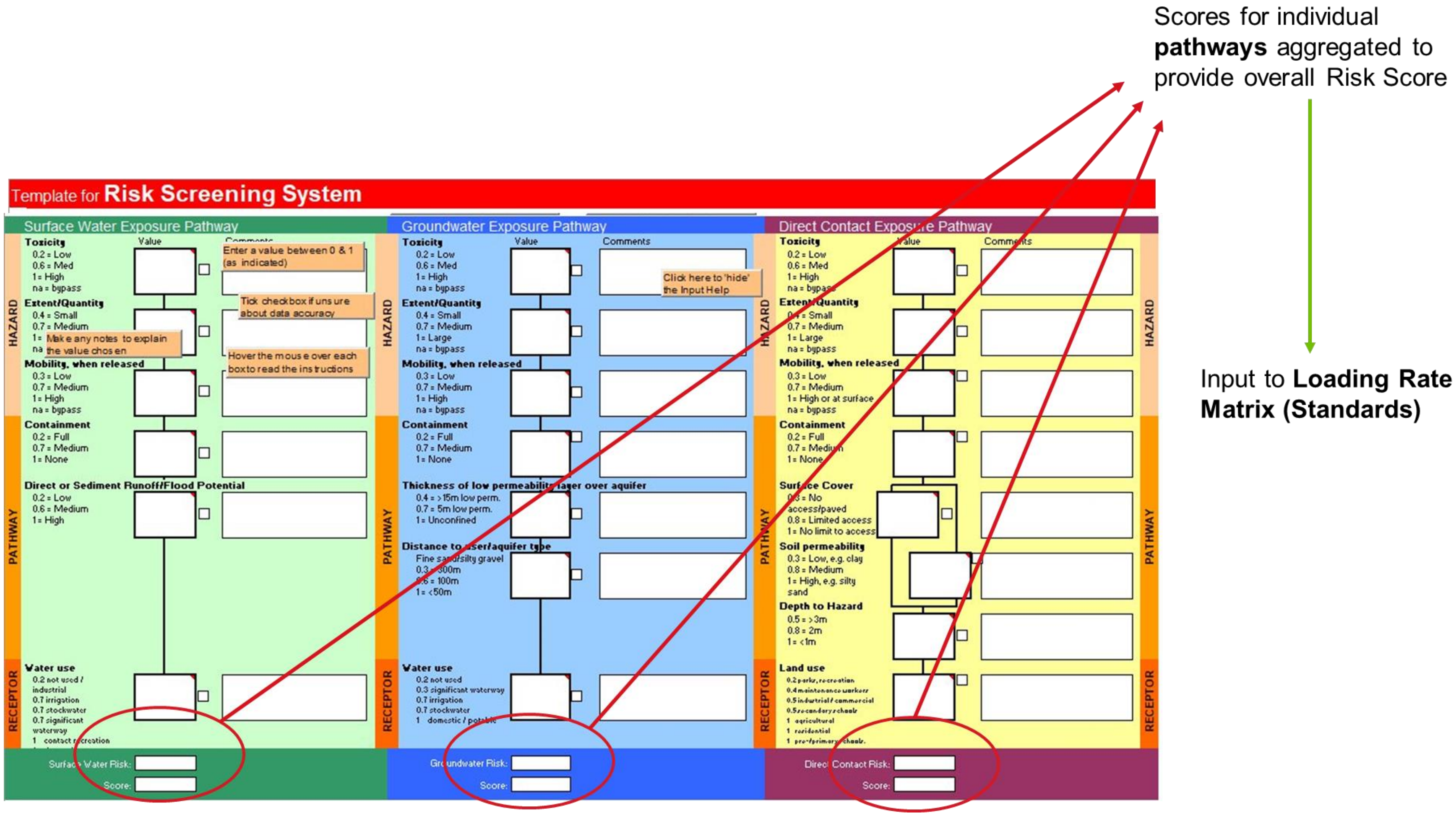
The resultant 'score' will translate to a risk category (1 through 5). Category 1 = Lowest risk, Category 5 = highest risk (refer to Section 2.13 below, and the overall approach diagram in Section 2.9).

Similar examples include:

- Risk Screening System. Contaminated Land Management Guidelines No.3 (MfE, 2004)
- Risk Index Tool (RIT) for on-farm nutrient management, under development (MfE)

Develop a Risk Screening Tool

The spreadsheet that forms part of Contaminated Land Management Guidelines No. 3 (MfE 2004) is illustrated below. A tool similar to this will be developed, with a separate spreadsheet for each of the three nominated hazards – *E. coli*, TN and TP.



The hazard will be identified in terms of concentration and loading rate, each pathway will be defined into terms of a soil type, travel dimension and hazard concentration reduction, and each water use will be defined in terms of the sensitivity of the receptor.

2.14 C: Site-Specific Assessment

2.14.1 C.1 Site Capability

A site-specific investigation is essential to evaluate the irrigation suitability of the site and to establish a pre-irrigation record of soil and groundwater parameters, prior to construction and commissioning of a scheme. This type of investigation is typically required to inform successful design and operation of a site, even without Standards.

The objective of this stage of the proposed process is to consolidate key interacting factors into a single classification system (Categories 1 to 5) and should therefore be conducted by a suitably qualified and experienced practitioner. The results of the Site-Specific Assessment should be compared against the information and assumptions of the Baseline Assessment to confirm the Risk Category is appropriate for the site.

This investigation will consider vegetation cover and application methods to ensure flexibility in the land application design and selection of appropriate methods based on factors not specifically assessed in this document (i.e. costs). It is expected that systems are designed to apply treated wastewater uniformly and at a rate that does not breach the criteria outlined below in section 3.2

The table below presents a preliminary categorisation of factors requiring consideration. It is recommended that the selected category also accounts for interactions between these factors. For example, rapid-draining soils (Category 4) may be suitable for sites with deep groundwater (>10 m, Category 1). In such cases, the site may be classified between Category 4 and Category 1, based on the professional judgment of a suitably qualified and experienced practitioner.

Factor	Category 1	Category 2	Category 3	Category 4	Category 5
Drainage	Well drained	Well drained	Moderately well drained to imperfectly drained	Excessively drained	Very poorly drained
Soil Type and Suitability[1]	Fine sand, loamy sand Sandy loam, loam, silt loam	Fine sand, loamy sand Sandy loam, loam, silt loam	Fine grained – clay loam, silty clay loam	Course granular soil	High Risk soils i.e.. heavy clays, peat, soils classified as Category 5 and 6 in AS/NZS1547:2012
Climate & soil moisture regime[2]	Enables Irrigation without soil saturation	Enables irrigation without soil saturation	Potential for soil saturation	Soil saturation for period likely	Soil saturated for periods
Land use / land availability[3]	Suitable for cropping & nutrient removal or sufficient land available for low nutrient loading	Suitable for cropping / nutrient removal or sufficient land available for low nutrient removal,	Permanent ground cover	Permanent ground cover	Permanent ground cover

Factor	Category 1	Category 2	Category 3	Category 4	Category 5
Topography	Low relief < 10 degree slopes	Low relief < 10-degree slopes	Slopes up to 17 degree	Slopes up to 17 degrees.	Slopes > 17 degrees
Depth to Groundwater[4]	>10 m	>10 m	Between 5 and 10 m below ground level.	Between 2 and 5 m below ground level	Shallow / at ground level < 2 m below ground level
Natural hazards (e.g. flooding, land instability)[5]	Negligible risk	Low risk	Medium risk	High risk	Very High risk

[1] Soil suitability should consider the capacity to assimilate wastewater, including physical characteristics such as water holding capacity and texture as wells as chemical and biological considerations, including potential cumulative effects such as soil pH, phosphorus (total, Olsen P and anion storage capacity) nitrogen (total N, TKN, ammonium-N, Nitrite-N, Nitrate-N) and exchangeable cations. Typically only the first 2-3 m bgl are characterised (as opposed to the entire soil column) when assessing a site.

[2] Typically, a site should not be irrigated immediately following or during a rainfall event or if the soil is at field capacity and wastewater operational storage is required.

[3] Sufficient land should be available to accommodate land application of wastewater, separation distances to property boundaries and surface waters, a reserved area (if required by designer), and sensitive cultural and ecological site

[4] A conservative approach is proposed for depth to groundwater to mitigate pathogen transport (Pang 2009)[9] and potential for groundwater mounding, site specific assessment of this risk could allow a lower category to be achieved.

[5] Regional and District Plans will be checked during the Baseline Assessments i.e. sites with an unacceptable risk will have already been excluded (e.g. flood-prone land). However, these plans and maps can be confirmed during natural hazard categorisation assessment.

[9] Pang 2009

2.14.2 C.2 Mitigation and management approach(es)

Additional mitigation measures and/or management approaches can be applied to further reduce risk (e.g. : reduce from Category 4 to Category 3)

Examples of mitigation / management:

- Buffer zones and planting
- Monitoring of discharge volumes and quality
- Irrigation scheduling
- Management of spray drift / odour
- Vegetation and stock management and monitoring
- Public access requirements
- Irrigation system maintenance
- Contingency plans

– Storage capacity

- Receiving environment monitoring
- Operations & Maintenance Plan reviews
- Alternate potable well supply

–

– *Note: This list was developed from existing resources and knowledge (i.e.. Land Treatment Collective Part 2 Guidance)*

Apply any relevant mitigation and derive final Site Capability Category

2.15 Proposed Numerical Limits – Part 1

Identify the **Class** of Loading Rates (Limits) that will apply to the site

		Site Capability Category			
		1	2	3	4
Risk Category	1	Class 1	Class 1	Class 2	Class 3
	2	Class 1	Class 2	Class 2	Class 3
	3	Class 2	Class 2	Class 2	Class 3
	4	Class 2	Class 2	Class 3	**Standards don't apply (Category 5)**

Example: Risk Category 2 + Site Capability Category 3 → Class 2 Limits apply to the site (Note: Loading rate is the **total** loading of a contaminant to the site, including the discharge and additional sources)

2.16 Proposed Numerical Limits – Part 2

The limits specified in the table below would be applicable to the site, including the discharge of treated wastewater immediately prior to land application, and any additional sources from the same site.

Considering the Risk Categories (1-5) and Site Capability Categories (1-5) have not been formally confirmed, the values provided are provisional and intended to initiate and facilitate discussion.

Class	Total Nitrogen* (kg / ha / yr)	Total Phosphorus* (kg / ha / yr)	*E. coli* (Public Health) (cfu/100mL, concentration in treated wastewater discharge)
1	500	75	No limit*^
2	250	50	< 2,000^
3	150	20	< 1000^

Notes:

- *The values assume the Risk Categories and Site Capability Categories follow a normal distribution for a potential receiving site, i.e. a Class 1 site meets numerous robust numerical assessments in terms of both risk and capability.*
- *^The rationale for the values is presented in s3.3.4.1. The E. coli concentrations are for sites that have restrictions on public access. For unrestricted public access sites, typically the E. coli concentration should be <1 cfu/100mL*
- **The 'No limit' for E. coli (Class 1) assumes the pathway / receptor connection can be adequately removed. Should this be possible for Class 2 scenarios, the 'no limit' could also be considered for this Class.*
- *The loading rates (TN and TP) and concentration (E. coli) within each Class account for the total load from a site, including from the discharge itself and the land on which it is applied and how it is managed (e.g. pasture / cut and carry; seasonal fertiliser application).*
- *Considering the Risk Categories (1-5) and Site Capability Categories (1-5) have not been formally confirmed, the values provided are provisional and intended to initiate and facilitate discussion.*

2.17 Proposed Groundwater Monitoring Requirements – Outline

Below is an outline of proposed monitoring requirements for **all loading rate classes (1, 2 and 3)**. Noting that additional monitoring, including additional monitoring wells may be required depending on site layout (in relation to groundwater flow) and location of sensitive receptors.

Location of bore	Up gradient	Down gradient	Up gradient of sensitive receptors
Number of monitoring bores[1,2,3]	Minimum 1 well	Minimum 2 wells	Site specific
Groundwater level monitoring frequency	monthly	monthly	-
Water quality (frequency)	3 monthly	3 monthly	3 monthly
Water quality parameters[4]	pH Electrical conductivity Total ammoniacal nitrogen Total nitrogen Nitrate nitrogen Dissolved reactive phosphorus *E. coli* Chloride		

Notes:

[1] Typically, a minimum of 3 bores is required to establish groundwater flow direction. Additional bores may be required to provide downgradient coverage if land disposal area is large or irregular shaped. Additional parameters may also be required at first, to establish the connections between the aquifers that the bores are targeting. i.e. making sure that the upgradient bore is in the same groundwater system as the downgradient bore, and not in a perched aquifer. These should be identified as part of the Site-Specific Assessment, when confirming that the Risk Category for the site is appropriate.

[2] Monitoring bores must be screened to intercept shallow water table aquifer, additional deeper bores may be required to intercept other aquifer layers depending on geological setting and location of sensitive receptors

[3] Groundwater monitoring bores constructed in accordance with NZS4411:2001 – Environmental Standard for drilling of soil and rock

[4] Groundwater sampling undertaken in accordance with the procedures outlined in National Environmental Monitoring Standards. Water Quality Part 1: Sampling, Measuring, Processing and Archiving of Discrete Groundwater Quality Data. March 2019. https://www.nems.org.nz/documents/water-quality-part-1-groundwater

2.18 Proposed Soil Monitoring Requirements – Outline

The proposed baseline and operational soil monitoring requirements are outlined below.

Soil monitoring	Requirements
Frequency	Pre-wastewater application (as part of Baseline and Site-Specific Assessments) Every 5 years thereafter
Number of samples	Soil samples are to be collected at per hectare rate, determined by a Suitably Qualified Experienced Practitioner considering the treatment level, plant size and soil capability.
Parameters	Cation exchange capacity (CEC) Exchangeable Cations: • Sodium (me/100g and base saturation %) • Potassium (me/100g and base saturation %) • Calcium (me/100g and base saturation %) • Magnesium (me/100g and base saturation %) Sodium adsorption ratio (SAR) Soil pH Total phosphorus Olsen phosphorus (Olsen P) Other contaminants*

Notes:

– *The list of soil monitoring requirements is not exhaustive, and it is expected that the sampling frequency and parameters to be measured on each site would be finalised in the site's Management and Operation Plan. Additionally, analysis could include organic matter, trace elements and/or ongoing hydraulic conductivity assessments.*

– *The results of the soil monitoring will be compared and reported alongside the groundwater monitoring results. These comparisons will help identify any potential issues and recommend remedial actions, if necessary, during the term of the consent or life cycle of the land application system.*

* *Consideration of additional contaminants such as heavy metals and organics has been excluded by the scope, however, could be left to the discretion of the Suitably Qualified Experienced Practitioner*

3. Supporting information

3.1 Risk-based approach

3.1.1 Agreed scope

1. **Low-rate Infiltration Approach**

A-1	**Refine overall approach**
A-2	**Exclusions e.g. : slope, soils, ponding, flood zone, snow, saturated zones, aquifers, buffer zones, upstream of stock/drinking water bore**
A-3	Numerical limits – context and matrix

The approach to developing and implementing national performance Standards for wastewater discharges to land has been significantly revised following the review by the Technical Review Group, which provided both written and verbal feedback, led to the subsequent technical analyses outlined in this report. This proposed approach and the associated numerical limits differ from the outputs published by T+T (2024) and are supported by reasoning based on the authors' collective experience in designing, consenting, and implementing discharges to land both in New Zealand and internationally.

3.1.2 Literature review

The risk-based approach and the proposed definitions (e.g. for risk and site capability categories) were developed following a review of a range of existing resources, including the proposed limits presented by T+T, as well as national legislation, policies, guidelines, and reports. Section 2.7 lists the resources reviewed.

In general, any definitions relevant to the proposed Standards were drawn from existing published and peer-reviewed material. The purpose of using terms from existing nationally recognised documents was to provide regulators, practitioners and WWTP operators with definitions that were already used and understood. However, these definitions were amended where they benefited from further clarity. A Glossary of definitions is provided at the end of this report.

Selected international approaches and published Standards were also reviewed in addition to resources from the local New Zealand context. The review scope was limited due to project time and budget constraints but covered a breadth and depth of resources as far as reasonably practicable. Efforts were made to build upon the review already undertaken by T+T where appropriate.

3.1.3 Rationale for Risk-Based Approach

A risk-based approach has been proposed and is appropriate for categorising potential discharges to land sites and assigning loading rates for contaminants of concern, for the following reasons:

- There are numerous variables driving the level of risk associated with discharges of treated wastewater to land. The interaction between these variables creates significant complexity for determining the potential for adverse environmental, health, social outcomes and decision-making.
- A risk-based approach enables a conservative or precautionary approach, aligning with best practices in environmental management and engineering.
- Similar approaches have been applied internationally, as well as within different sectors in New Zealand (i.e.. for contaminated sites and landfill management).
- The risk-based approach provides for consideration of both level of risk (for effects) and the capability of a site to assimilate and treat discharges.
- The framework allows for the mitigation of risk through design and operational changes, along with the implementation of various management strategies, offering flexibility for asset owners.

– A risk-based approach allows for the consideration of multiple exposure pathways by which contaminants could affect receptors in the receiving environment. This includes the various steps and risk reduction mechanisms along each pathway.

3.1.3.1 Exclusions from national performance Standard

Following the approach illustrated in Figure 2-3 above (Section 2.9), exclusions apply to sites that would not be able to comply with the Standards due to certain risks and situations on those sites. These exclusions are listed in Table 3-1 and were considered necessary for the following reasons:

– Selected sites will have land characteristics that may hinder land treatment or be negatively affected by irrigation, as well as circumstances that pose unacceptable risks to public health or the environment.
– Specific land use practices (e.g. irrigation of food crops) need to be excluded because these practices are already (or will be) addressed by other Standards.

The exclusions still allow for flexibility in land use and rely on site-specific assessments to establish their applicability.

Table 3-1 Summary of exclusions

Exclusion	Justification	Cross Reference to Other Guidance
At surface or above surface irrigation on slopes >10 degrees Subsurface drip irrigation on slopes > 17 degrees	Prevent the risks of runoff, erosion, and reduced infiltration efficiency, minimising potential operational and environmental challenges.	New Zealand Land Treatment Collective 2000. New Zealand Guidelines for Utilisation of Sewage Effluent on Land. Part 2: Issues for Design and Management. AS/NZS 1547: 2012 On-site domestic wastewater management
Geologically unstable sites	Prevent risks of infrastructure failure, groundwater contamination, surface runoff, and environmental degradation.	AS/NZS 1547: 2012 On-site domestic wastewater management
Impermeable or semipermeable layers of rock, clay, or hardpan.	Prevent risks of surface runoff, groundwater mounding, and the failure of natural filtration processes.	USEPA 2006, Process Design Manual Land Treatment of Municipal Wastewater Effluents
Areas which are wāhi tapu, tūpuna, and other sites on Rarangi korero / NZ heritage list	Protect cultural heritage, traditional land use practices, and respect the values of local communities.	Heritage New Zealand Pouhere Taonga
Irrigation of human food crops	Protect public health, preserve soil health, prevent contamination of crops, and ensure the sustainability of agricultural practices.	Taumata Arowai Meeting10 *Wastewater Environmental Performance Standards: Discharge to Land Part II.* discussion document should consider beneficial reuse of water, be explicit that it is out of scope, and note that beneficial reuse will be part of the Water Services Authority's future work programme.
Irrigation of areas for recreation or livestock grazing where the purpose is water reuse i.e. irrigation is only undertaken where soil moisture deficit is less	Protect public health and stock health, preserve soil health.	Any discussion document(s) should consider beneficial reuse of water, be explicit that it is out of scope, and note that beneficial reuse will be part of the Water Services Authority's future work programme

Exclusion	Justification	Cross Reference to Other Guidance
than optimal for recreational purposes. *Excluded unless access by people and/or livestock is prevented.*		
Intake/Wellhead Protection Zone (Zone 1) and Intermediate Zone/Microbial Source Protection Zone (Zone 2) *Excluded unless alternative supply is provided.*	Protect public health, preserve the quality of water supplies, and ensure the sustainability of water resources.	MfE 2018 Technical Guidelines for Drinking Water Source Protection Zones
Unsuitable soils	Inappropriate soils for land application of treated wastewater typically include heavy clay and peat soils, which have poor drainage and risk waterlogging, and coarse sandy soils, where there is a risk of leaching and groundwater contamination.	AS/NZS 1547: 2012 On-site domestic wastewater management USEPA 2006, Process Design Manual Land Treatment of Municipal Wastewater Effluents

3.1.3.2 Identifying and shortlisting potential land application sites

A commonly used approach for selecting a site for wastewater land application includes the following steps:

1. Defining focal area(s) for investigation (e.g. potentially suitable site(s) for land application of treated wastewater, and surrounding catchment).
2. Use a Baseline Assessment (refer to Section 2.11) to analyse the area in terms of go / no go factors (social, cultural, environmental / technical), which involves desktop information gathering. This step includes estimating an indicative area of land needed taking account of design discharge rates, and indicative design loading rates (i.e. those from AS/NZS 1547).
3. Identifying and shortlisting sites within the investigation area.
4. Determining potential availability of shortlisted sites
5. Comparing shortlisted sites to determine one or more preferred sites i.e. using multi criteria analysis (MCA).

It is intended that guidance will be provided regarding the scope and methodology for the Baseline Assessment, but it will not be a Standard. However, the information generated can be used to inform the Risk Screening (which is included in the Standard).

The MCA may require additional information, necessitating further desktop studies and site investigations. It could include an initial Risk Screening (Section 2.12) to rank sites based on preliminary Risk Categories.

3.1.3.3 Risk Screening Methodology

A risk-based approach is proposed for determining the applicable Standard, similar to the Risk Screening System (RSS; adapted from MfE 2004)[10]. The system uses a risk equation made up of a hazard, an exposure pathway and a receptor. Quoting from the RSS document (MfE 2004):

The hazard and pathway components of the risk equation are in turn defined by a variety of parameters that are considered to be the most important in determining the degree to which the hazard exists or a pathway to a receptor is completed. The equation is:

risk = hazard x pathway x receptor

where:

[10] MfE 2004 *Contaminated Land Management Guidelines No. 3 – Risk Screening System*, 17 February 2004, Ministry for the Environment, Wellington.

hazard = toxicity x quantity x mobility

pathway = containment x pathway barrier 1 x pathway barrier 2 x ...

receptor = a single value between 0 and 1 defining the sensitivity or vulnerability of the receptor, whether people or an ecological environment.

Using a methodology similar to this for these discharge to land Standards, components of the risk assessment would include:

- **Hazards** (anything that has the potential to cause harm, damage, or adverse effects); in this case, *E. coli* TP, TN, which pose a public health risk, a stock health risk, or an environmental risk.
- **Pathways** (the routes by which receptors are exposed to a hazard) and associated qualifying criteria – site specific, to be identified in the Baseline Assessment and Site-Specific Assessment.
- **Receptors** (those potentially affected by the hazards) and associated qualifying criteria – site-specific, to be identified in the Baseline Assessment and Site-Specific Assessment.

The RSS identifies three pathways and has an assessment template for each. The pathways are: Surface Water Exposure Pathway, Groundwater Exposure Pathway, and Direct Exposure Pathway. Either these same pathways, or similar adaptations, would be relevant for discharges to land.

Generally, risk assessment methods start with an established hazard or contaminant source (e.g. the RASCL approach developed for WasteMINZ (2002)[11]; the Microbial Risk Assessment tool developed by ESR (2023)[12]; or the approach developed for contaminated sites (Landcare Research 2003)[13]

The proposed risk-based approach for the Standards establishes contaminant source characteristics (i.e. the discharge to land Standards) as a result of:

- Characterising a site in terms of factors that affect the concentration, form, and mobility of a hazard (*E. coli*, TN or TP); and
- Managing the land application of discharge in ways that affect exposure pathways (e.g. surface application vs subsurface creates or avoids the surface water runoff or aerosol exposure pathways) and the concentration, form, or mobility of a hazard (i.e.. the dosing frequency and quantity) emerging from the soil treatment zone.

[11] WasteMINZ 2002 *Risk assessment for small closed landfills* (RASCL), report prepared by Golder Associates (NZ) Ltd for Waste Management Institute New Zealand Incorporated (WasteMINZ) , December 2002.
[12]ESR 2023 Microbial Risk Assessment (MRA) of Land Use on Drinking Water Supplies, Institute of Environmental Science and Research (ESR), June 2023, available online at **https://www.esr.cri.nz/news-publications/microbial-risk-assessment-of-land-use-on-drinking-water-supplies**
[13] Landcare Research 2003 'Risk Assessment for Contaminated Sites in New Zealand', web-based tool available at **https://contamsites.landcareresearch.co.nz/index.htm**

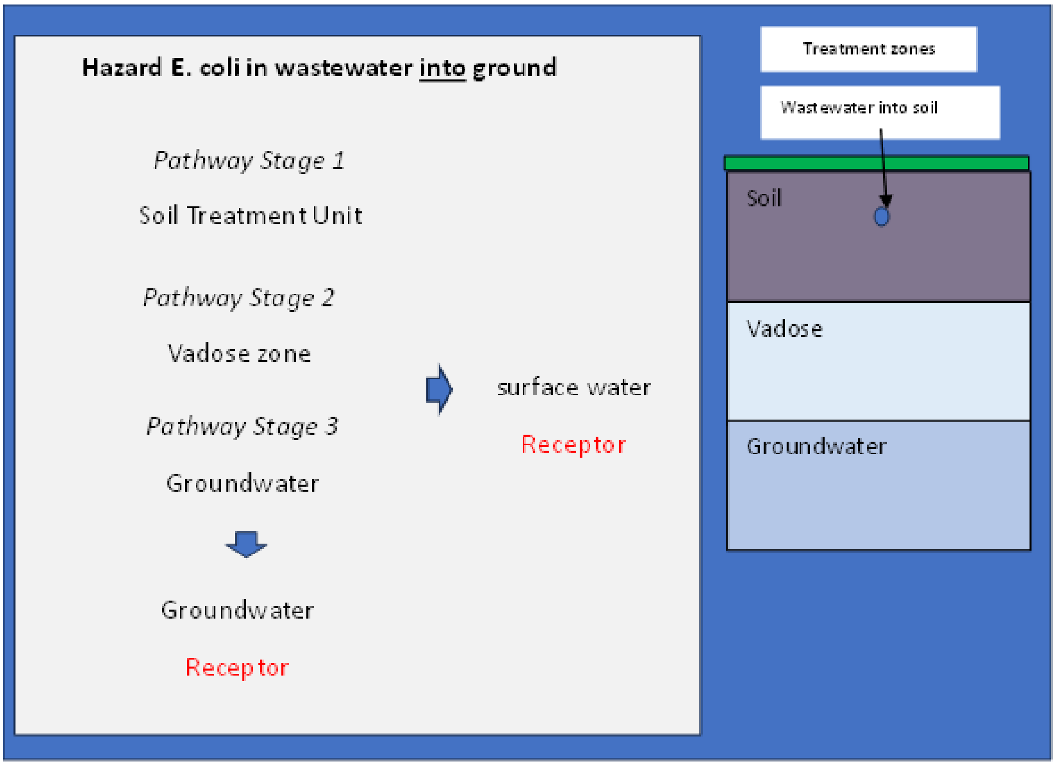


Figure 3-1 Risk-approach concept illustrating hazard-pathway-receptor flow path and treatment zones along the pathway

In terms of the equation **Risk = hazard x pathway x receptor**, the hazard is a function of the wastewater quality when discharged to land and could be determined by assigning values for the pathways and receptors and an acceptable risk value. Risk values could be determined by calibrating the RSS model using case studies.

The proposed initial Risk Screening would be carried out using a *Standard design* (wastewater quality, design land application method and design loading rate (i.e.. a nominated secondary treatment quality, spray irrigation, and design loading rates as in AS/NZS 1547)) and desk top information gathered in the Baseline Assessment..

3.1.4 Assumptions and potential implications

The general assumptions underlying the proposed Standards are described in Section 1.3. Specific assumptions related to **a risk-based approach** are as follows:

- A site screening process has been carried out during the process of identifying and shortlisting potential land application sites.
- The discharge to land load or concentration in treated wastewater related to a hazard (*E. coli*, TN or TP) accounts for the **total** load to a site including from the treated wastewater discharge itself, and any source of the hazard from the land on which the treated wastewater is applied and how it is managed (e.g. pasture / cut and carry; seasonal fertiliser application).
- Investigations during the Risk Screening and Site-Specific Assessment steps will quantify the treatment capability of each pathway in terms prescribed by the Standard or, if unknown, a worst-case scenario will be adopted.
- Starting with a 50% risk-based approach and 50% site-specific assessment is a prudent and conservative approach. However, the final weightings should be flexible and subject to validation and adjustment by the asset owner.
- Long term capacity of the land to maintain its hydraulic assimilative capacity (i.e. dispersive soil and sodicity) or its hazard treatment capacity (i.e. phosphorus adsorption capacity) will be considered and provision made for site remediation or alternative location.
- Continuity throughout the design construction process, operational management and monitoring, and environmental monitoring to ensure design requirements are met and maintained throughout the life of the asset.
- Buffer zones for separation from surface water, property boundaries, and buildings are established as part of pathway analysis or separation distances are prescribed in the Standards.
- A water balance assessment determines the hydraulic loading requirements based on the site's climate, ensuring that the treatment performance of the pathway zones and wastewater storage capacity is met. An operational management plan ensures the hydraulic loading regime is maintained according to the design.
- The operational management plan specifies the standdown period(s) before allowing access by individuals (other than WWTP operators) or livestock.
- Treated wastewater storage will be provided so that a discharge to land will only occur where oxidising conditions generally prevail in soils so that ammoniacal Nitrogen (Amm-N) is oxidised along a pathway to groundwater or, via the subsurface, to surface water such that the effects are no more than minor.
- Where discharges of treated wastewater to land (including those discharges that may enter groundwater or surface water following discharge to land) occur in proximity to human drinking water abstraction points, a Site-Specific Assessment will be required to assess the risk of discharged contaminants (including pathogens and other contaminants that may affect drinking water quality) adversely affecting the drinking water supply. This assessment could take place in either the Baseline Assessment or Site-Specific Assessment phase. It would need to consider the following:
- ‘In proximity’ is suggested as discharges to land occurring within 2,500 m upgradient/ 100 m downgradient of the groundwater drinking water abstraction point (with reference to the publication ‘Delineating Source Water Risk Management Areas, Ministry for the Environment, 2023). Consultation with the water supplier or regulator will be required to determine the approach for the risk assessment and specific contaminants of concern, including estimated groundwater flow / travel time to the bore, as well as flow direction (and any seasonal variations with respect to this), capture zones, etc.
- The definition of ‘drinking water supply’ in the Water Services Act 2021 is that the need to provide a risk assessment would apply to any drinking water take that serves more than one household group (or community supply). However, for the purpose of the proposed Standards for discharges of treated wastewater to land, all groundwater bores (or surface water takes) currently used for drinking water should be assessed.

- It is noted that ESR have done significant work regarding the assessment and management of microbial risk in relation to drinking water sources recently[14], and the findings of that work should be taken into consideration to inform any risk assessments.

Assumptions and potential implications that are applicable to the **Standards as provided or modified** are as follows:

Treatment limits

- An assessment of the effects of discharges to land that can reach a river, or stream can be performed by comparison to the Discharge to Water Standards. However, when doing this, it should be considered that upstream concentrations of contaminants were not considered (i.e. assumed to be zero). Whilst this may be accurate for some parameters, it would not be true for TN, TP and *E. coli*, and is not precautionary. However, using this approach is often the only way of determining any potential effects.
- Persistent organic pollutants / emerging organic contaminants including microplastics have been excluded from the treatment limits and further advice on these will be provided in due course by Taumata Arowai.

Exclusions (where Standards do not apply)

- Mitigating circumstances relating to an exclusion could enable the application of the Standards. For example, a flood plain area would not be excluded if a land application area were still available for use during a flood event and if post-flood soil saturation allowed.
- For those exclusions based on land use for food crops, recreation or livestock grazing, proposed Standards for the reuse of water after wastewater treatment will need to be established.
- A discharge to land application that cannot comply with Discharge to Land Standards (i.e. Standards do not apply, as one or more exclusionary factors are present) could still be consented via the conventional route (e.g. application under the Resource Management Act 1991).

Assessment of coherence, effectiveness and implications of Standards

A core purpose of discharge to land Standards is to protect against a variety of potential effects in the receiving environment (soils and groundwater). The parameters selected are those which can be utilised to avoid, remedy or mitigate the majority of the effects that could result from a treated wastewater discharge to land. These include:

- **Total Nitrogen (TN) and Total Phosphorus (TP):** have the potential to cause nutrient effects in the receiving environment including:
    - Increased periphyton cover in hard bottom streams (for example, where there is a pathway for contaminants to reach a connected surface water body)
- Overgrowth of plants, algae and bacteria in the water body (i.e. eutrophication).
- Toxicity impacts on humans (from nitrates) if used as drinking water.
    - Groundwater used as a potable supply
- ***Escherichia coli (E. coli):*** indicates the presence of pathogen contamination and the associated potential public health risks from exposure to pathogens. These could include contact with the discharge on the land (e.g. during recreational activities), drinking water taken from wells within the plume in the groundwater or through consumption of materials that have been in contact with the discharge, such as vegetable crops.

Some potential effects are not directly covered by the discharge to land **Standards**, including:

- Volume of discharge relates to the scale of the discharge compared to the receiving land, particularly with respect to cumulative effects of multiple discharges to the same land area (i.e. from other sources).

[14] Including: Close, M., Sarris, T., Kenny, A., Humphries, B., Devane, M., Tschritter, C., Hemmings, B., Moore, C. & Scott, L. 2023 Microbial Risk Assessment tool for discharges near drinking water wells: Documentation Report, May 2023, prepared for Regional and District Council in New Zealand via Envirolink Tools funding, Institute of Environmental Science and Research Limited (ESR). AND
Close, M., Humphries, B., Tschritter, C., Sarris, T. & Moore, C. 2020 *Model scenarios for a microbial risk assessment tool*, November 2020, prepared with support from Envirolink Large Advice Grant HZLC162 for Horizons Regional Council, Environment Canterbury and Hawke's Bay Regional Council, Institute of Environmental Science and Research Limited (ESR).

- Cumulative effects of nutrient load within a wider catchment which impacts the down-gradient receptors (e.g. groundwater aquifer and surface water bodies connected to groundwater).
- The proposed method for dealing with parameters not specifically included in the Standards will be developed by Taumata Arowai, such as:
- Toxicity of metals and other contaminants, such as pesticides, drugs, antibacterial agents, Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) etc. Presence of artificial materials such as microplastics, with largely unknown effects.
  - Bioaccumulation of contaminants in organisms in the receiving environment, particularly mercury, PCBs.
  - Bioaccumulation can also pose a human health risk through the consumption of affected organisms. This risk is in addition to the pathogen risk, which is explicitly addressed in the discharge Standards based on faecal indicator organisms.
- Other effects i.e. odour, and location of discharge to land infrastructure and bypasses, coastal occupation.

Implications of the Standards include:

- When reconsenting WWTPs that have an existing discharge to water, discharge to land may be a more attractive option.
- Many small sites will have no or very limited power supply.
- Higher energy and operator inputs (compared to what would be required for a discharge to water, for example).
- Additional GHG emissions.
  - May be cheaper to move away in some cases to aggregate with other WWTPs on a subregional basis
  - Not problematic from an operational perspective
- Septicity and odour can become a problematic issue (particularly if there are long pipelines from the WWTP to the land application site) but can be managed.
- More decentralised treatment is a possibility if new consents are significantly easier to obtain.

If individual asset owners can easily get consent for small size WWTP/ land application systems on an individual development basis, this has a serious implication for District Councils who may be forced to 'Vest', own and manage these small, under-resourced plants..

3.2 Site-Specific Assessment

A Site-Specific Assessment should be undertaken to confirm the assumptions and supplement information obtained from the desktop baseline assessment. The goals of the Site-Specific Assessment are:

- Confirm suitable loading rates (site capability).
- Confirm Risk Category (environmental receptors).
- Provide information for design and operational regime.

Table 3-2 below outlines the site investigation and monitoring activities that may be undertaken during this stage.

Table 3-2 Proposed Site-Specific Assessment activities

Monitoring target	Investigations/Activities
Groundwater	– Groundwater flow direction – Groundwater level – Groundwater quality – Seasonal variation (levels, flow direction and quality)

Monitoring target	Investigations/Activities
Soil	– Investigation of soil type, profile and texture (typically involving collection of surface samples, and/or core samples using hand auger, drill or test pits) – Hydraulic conductivity and determining the presence/absence of low permeability layers – Soil chemistry analyses – Consider existing site condition and historical use (e.g. prior contamination) including levels of contaminants included in the Standards, as well as any others that are deemed relevant.
Receptors	– Water level and quality in downgradient wells used for potable water supply – Water quality monitoring, ecological surveys and/or flow monitoring in connected surface water and/or springs – Water quality monitoring, ecological surveys / monitoring in receiving coastal waters

Qualifying site-specific criteria used to determine the Site Capability Category requires consideration of multiple interacting factors at both a site and regional scale. As with other National Environmental Standards[15,16,17], it is recommended that the Site Capability Category (Categories 1 to 5) is undertaken by a practitioner suitably qualified and experienced in site assessments, soil science, and hydrogeology

While this report does not define a 'suitably qualified' and experienced practitioner', the term typically requires relevant tertiary qualifications and at least 2 years' experience in the field or at least 5 years' relevant experience. It is expected that the site assessment requirements will be outlined in the guidance document accompanying the Standards.

3.2.1 Rationale

A Site-Specific Assessment is essential to evaluate the irrigation suitability of the site and to establish a baseline record of soil and groundwater parameters, prior to construction. It also provides essential direction to design and development of a proposed operational regime, as is required when developing any land application scheme. The objective is to consolidate key interacting factors into a single classification system (Categories 1 to 5), conducted by a suitably qualified and experienced practitioner.

The investigation will consider soil types, vegetation cover and application methods to ensure flexibility in the land application design to allow selection of appropriate methods, based on factors not specifically assessed in this document (i.e. labour, infrastructure and costs). It is expected that systems are designed to apply treated wastewater uniformly and at a rate that does not breach the criteria outlined in section 3.1.

The Site-Specific Assessment should be used to confirm that the Risk Screening inputs (determined during the Baseline Assessment, outlined in Section 2.11) are appropriate for the site. This may require monitoring of groundwater levels and flow direction (on a seasonal basis) and review of sensitive receptors downgradient of the site.

Reviewing the Site Capability Category involves the steps of:

1. Proving the hydraulic assimilative capacity of the preferred site(s).
2. Confirming the receptor(s) and the assumptions of the baseline assessment.
3. A repeat of the Risk Screening exercise, to confirm appropriate Risk Category.

These steps are detailed further below.

Step 1: Proving the hydraulic assimilative capacity of the preferred site(s).

The hydraulic assimilative capacity is the design quantity of water that the soil at a site can absorb and transport away. Characteristics used to assess hydraulic assimilative capacity are:

- Soil texture and permeability
- Limiting horizons (i.e.. rock, low permeability soil, hard pans, high groundwater level)

[15] Resource Management (National Environmental Standards for Commercial Forestry) Regulations 2017
[16] Resource Management (National Environmental Standards for Freshwater) Regulations 2020
[17] Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011

– Topography
– Surface water catchment area and water drainage features and facilities
– Climate.

USEPA 2006[18] states that:

> *"To account for required intermittent applications (reaeration), the variability of the actual soil permeability within a site, and the potential reduction with time, a small percentage of the vertical permeability is used as the design percolation rate. This small percentage ranges from 4 to 10 percent of the saturated vertical permeability as shown in Figure 3-5. The value used for clear water permeability should be for the most restrictive layer in the soil profile."*

A water balance assessment is required to determine wastewater storage requirements during wet weather events so as to minimise wastewater discharge during saturated soil conditions and ponding of wastewater at a site.

Step 2: Confirm the receptor(s)

The discharged wastewater will move through the soil profile into groundwater and moving laterally within the groundwater environment and /or discharge to connected surface water or springs. The desktop information and assumptions identified during the baseline assessment must be validated with site-specific data to review the appropriateness of the Risk Category. This assessment may involve:

– Monitoring of groundwater quality and levels up and down gradient of the site
– Confirmation of groundwater flow direction
– Identification of receptors (surface water, springs and groundwater users)

The monitoring requirements outlined in Section 3.4 may be adopted as a guide, however additional monitoring wells may be required to confirm groundwater flow direction.

Step 3: Repeat the Risk Screening exercise

Another iteration of Risk Screening is carried out with the *Standard design* (as defined in Section 3.1.3.3 above) and field information gathered to increase the confidence of values assigned to the initial Risk Screening variables. An assessment is carried out for each of the three hazards – *E. coli*, TN and TP.

The assessment determines whether:

– The *Standard design* gives an acceptably low risk to the receptor (s) or back calculation demonstrates the receptor to the hazards is within nominated loading rates; or
– The *Standard design* land application method and loading rate should be adjusted and tested for achieving an acceptably low risk to the receptor (s) or, by back calculation, demonstrating the receptor exposure is within nominated concentrations.

Means of adjusting the *Standard design* include those shown in Section 2.14.2 as well as:

– decrease the application dose rate or frequency, which will decrease the hazard.
– change the land use i.e.. Crop type and harvesting frequency.
– change the application method i.e.. subsurface irrigation would avoid the surface water and direct contact (i.e.. aerosols) pathways.

An outcome will be that either the *Standard design* without or with modifications are acceptable or they are not. If they are not, the hazard (s) that remains (i.e. *E. coli*, TN or TP) will be identified.

Meeting the *Standard design* with design modifications could create further challenges requiring additional solutions (i.e.. wet weather storage requirements become excessive), however treating wastewater to higher than the *Standard design* or a *Standard design* modified with a low application rate could also prove to be more cost effective. I.e.. A reduction in land application area results in land cost savings greater than the cost of treating to a higher Standard.

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[18] USEPA 2006 Section 3.5.1 in *Process Design Manual Land Treatment of Municipal Wastewater Effluents*, United States Environmental Protection Agency

If, after the first iteration of a Site-Specific Assessment, the resultant hazard exceeds the Standard for the receptor, or benefits would result from treating wastewater prior to discharge to a higher than Standard requirement, the Site-Specific Assessment will be repeated. The process will be reiterated until the hazard to the receptor (s) meets the applicable Standard or the Standard cannot be applied. If the latter is the case, and there are benefits in doing so, the usual consenting pathway can be followed. It is also possible that in following this process it becomes clear that the site is unsuitable for land application.

3.2.1.1 Selecting the applicable Discharge to Land Standard by a deterministic approach

The Risk Screening step of the risk-based approach for setting the discharge to land Standards requires solving the equation:

risk = hazard x pathway x receptor

The risk to a receptor is a product of the hazard (i.e. concentration of *E. coli* discharge to land), reduction in concentration along the pathway to a receptor and the type of receptor (i.e. sensitivity of the receptor to the hazard).

Compliance with the Standard based on nominated risk values requires establishing these risk values.

Alternatively, as indicated in Section 2.6, site-specific loading rates for a discharge to land can be derived using a deterministic approach if the applicant is prepared to undertake additional work in excess of that that would be required if following the risk-based approach. This would involve back-calculation using either the Discharge to Water Standards (where the receptor is one of the receiving water categories in those Standards) or the Drinking Water Protection Zone Guidelines (MfE[19] where the receptor is Zone 2.

3.3 Proposed Loading Rate and Concentration Limits

3.3.1 Agreed Scope

1 Low-rate Infiltration Approach

- 1.1 Refine overall approach
- 1.2 Exclusions e.g.: slope, soils, ponding, flood zone, snow, saturated zones, shallow aquifers, buffer zones, upstream of stick/drinking water bore
- 1.3 **Numerical limits – context and matrix**

3.3.2 Method

The method for developing the proposed discharge to land Standards has followed the general approach above. The Standards proposed exclusively rely on the information collected throughout the approach, specifically the Baseline Assessment, Risk Screening and the Site-Specific Assessment.

The numerical limits presented in Section 2.16 above were derived from various referenced materials and are proposed as provisional values to facilitate stakeholder consultation.

3.3.3 Rationale

The proposed numerical limits have been developed as a mean annual total loading rate of Total Nitrogen (TN) and Total Phosphorus (TP), expressed as kilograms per hectare per year (kg ha yr^{-1}), and median annual concentrations of *Escherichia coli* (*E. coli*) in the treated wastewater to be applied to land, expressed in cfu/100mL, including any additional loading from other sources (e.g. synthetic fertilisers).

[19] *MfE 2018 Technical Guidelines for Drinking Water Source Protection Zones*

Developing limits, based on TN, TP and *E. coli* requires that the three analytes serve as controls for the entire design of the land application system, similar to the approach outlined in the US EPA (2006) guidelines, whereby a single factor or parameter acts as a Limiting Design Parameter (LDP) (Crites et al., 2000[20]) assuming that the land application system will then function successfully for all other less-limiting parameters of concern. TN and TP, therefore, control not only nitrogen and phosphorus, but also the volumes of treated effluent added to soil (mm) and the potential accumulation of unmeasured constituents such as sodium (Na) (Menneer et al., 2001[21]), trace elements (Karvelas et al., 2003[22]), emerging contaminant (i.e. pharmaceuticals, pesticides, hormones, flames retardants (García et al., 2020[23]) and microplastics (Ruffell et al., 2021[24]). This is the co-regulation approach discussed in the proposed Discharge to Water Standards which Taumata Arowai are currently considering.

The E. coli limit, as a concentration, is proposed to act as the controlling measure with respect to all pathogens which can cause widespread illness (McBride & Ball, 2004). The values proposed additionally set the requirement for the treatment level required prior to land application (i.e. achieving 2,000 cfu/100mL will likely require some level of secondary treatment).

Additionally, the values are proposed with the expectation that further detailed guidance from Taumata Arowai is developed detailing anticipated sampling frequencies and compliance periods to enable these Standards to be applied and monitored consistently throughout the country. The details of which can be summarised in the proposed outline monitoring plans described in Section 3.4 below.

3.3.4 Literature review

Total Nitrogen

Irrigation of treated municipal wastewater to land can significantly increase the nitrogen (N) concentration in the soil, however, the accumulation and retention of N from treated wastewater as soil N can often at times equate for < 10 % of the added N from treated municipal wastewater (Meister et. al, 2022 [25]). Soil nitrogen cycling is complex with variation occurring due to biological, chemical and physical properties, as well as plant interactions in the rhizosphere (Houlbrooke [26]et al., 2004). The effluent quality and application rates also have an effect, and the proportion of losses will vary between, plant uptake, nitrate (NO_3^-) leaching and gas emissions of N_2 or N_2O following denitrification.

For this Standard, leaching is the primary concern and has previously been reported up to 22% of applied wastewater N after 4 years of irrigation (Sparling et al. 2006 [27]). The loading rates proposed therefore attempt to reflect this risk with respect to the receiving aquifer, as qualified during the risk-assessment.

It is expected that the fate of the applied N is monitored in accordance with operational monitoring guidelines, and if defined thresholds are exceeded, contingency and remedial measures are applied.

Total Phosphorus

[20] Crites, R.W., Reed, S.C. and Bastian, R.K., 2000. *Land treatment of municipal and industrial wastewater*. New York, NY: McGraw-Hill Book Co.
[21] Menneer, J.C., McLay, C.D.A. and Lee, R., 2001. Effects of sodium-contaminated wastewater on soil permeability of two New Zealand soils. *Australian Journal of Soil Research*, 39, pp.877-891. Available at: **https://doi.org/10.1071/SR99082** [Accessed 16 January 2025].
[22] Karvelas, M., Katsoyiannis, A. and Samara, C., 2003. Occurrence and fate of heavy metals in the wastewater treatment process. *Chemosphere*, 53(10), pp.1201-1210. Available at: https://doi.org/10.1016/S0045-6535(03)00591-5 [Accessed 16 January 2025].
[23] García, J., García-Galán, M.J., Day, J.W., Boopathy, R., White, J.R., Wallace, S. and Hunter, R.G., 2020. A review of emerging organic contaminants (EOCs), antibiotic resistant bacteria (ARB), and antibiotic resistance genes (ARGs) in the environment: Increasing removal with wetlands and reducing environmental impacts. *Bioresource Technology*, 307, p.123228. Available at: **https://doi.org/10.1016/j.biortech.2020.123228** [Accessed 16 January 2025].
[24] Ruffell, H., Pantos, O., Northcott, G. and Gaw, S., 2021. Wastewater treatment plant effluents in New Zealand are a significant source of microplastics to the environment. *New Zealand Journal of Marine and Freshwater Research*, pp.1-17. Available at: **https://doi.org/10.1080/00288330.2021.1988647** [Accessed 16 January 2025].
[25] Meister, A., Li, F., Gutierrez-Gines, M.J., Dickinson, N., Gaw, S., Bourke, M. and Robinson, B., 2022. Interactions of treated municipal wastewater with native ecosystems. *Submitted to Ecological Engineering*.
[26] Houlbrooke, D.J., Horne, D.J., Hedley, M.J., Hanly, J.A. and Snow, V.O., 2004. A review of literature on the land treatment of farm-dairy effluent in New Zealand and its impact on water quality. *New Zealand Journal of Agricultural Research*, 47(4), pp.499-511. Available at: **https://doi.org/10.1080/00288233.2004.9513617** [Accessed 16 January 2025].
[27] Sparling, G.P., Barton, L., Duncan, L., McGill, A., Speir, T.W., Schipper, L.A., Arnold, G. and Van Schaik, A., 2006. Nutrient leaching and changes in soil characteristics of four contrasting soils irrigated with secondary-treated municipal wastewater for four years. *Australian Journal of Soil Research*, 44, pp.104-116. Available at: **https://doi.org/10.1071/SR05084** [Accessed 16 January 2025].

Phosphorus (P) from treated wastewater is relatively immobile in soils; however, P can enter streams through surface runoff and erosion (Pionke et al., 2000) [28] and leaching (Meister et. al, 2022) [29].

Gutierrez-Gines et al. (2020) [30] reported that treated wastewater irrigation onto a local silt loam at a loading rates of 75 kg P ha^{-1} yr^{-1} would not exceed concentrations of P that are common in New Zealand productive soils for at least 50 years. However, leaching losses of P from well drained sands have shown that losses during four years of treated municipal wastewater irrigation were 8 % of the applied P (Sparling et al, 2006).

As with applied N, it is expected that the fate of the applied P is monitored in accordance with operational monitoring guidelines, and contingency and remedial measures are applied, should P leaching exceed the defined limits.

E. coli

Due to the direct risk to human health from pathogens in wastewater, the management and Standard has been assessed separately to that of N and P. *E. coli* is a faecal indicator organism, and is used as a proxy to indicate the presence of pathogens from faecal matter. *E. coli* is known to reduce in soil, but the residence time is dependent on numerous factors including, but not limited to soil type (Prosser et al[31].,2016), pH and plant type (Gutierrez-Gines et al., 2021). Where the pathway and exposure are removed (i.e. surface / subsurface irrigation and limited or controlled site access), the requirement to reduce *E. coli* in the effluent can potentially be omitted, however, where access is not controlled (i.e. open public recreational areas) median values of <1 cfu/100mL will be required (ESR, 2024)[32]

3.3.4.1 Comparison against existing consents

A preliminary review of the national consents database (December 2024) was undertaken to indicate the potential for the proposed Standard to require that WWTPs change their treatment level. Further to a general update of the database, which is being undertaken, this included the following specific actions:

- The consent limits within each of the main discharge consents were reviewed and included into the database. This included the parameters which are included in the proposed Standards and a few additional related parameters.
- At this stage, it is not appropriate to directly compare existing consented load limits with the proposed Standards, as a detailed assessment of each site would need to be undertaken to determine which would be the most appropriate Risk and Site Capability Categories (and therefore which class of loading rates would apply). It is proposed that further verification should be undertaken following submission of this report.

The consents database shows that the basis of nutrient and pathogen loading limits stipulated in existing discharge to land consents is highly variable: i.e. a percentile-based limit (i.e. a stipulated percentile of all samples cannot exceed the concentration limit), a daily, weekly or annual load, or an area-based load (i.e. X kg per hectare of land irrigated per year). Of the 89 consents analysed, over 46% (40 consents) did not have load-based limits for TP, TN or *E. coli.* The distributions of these consents without limits is illustrated below in Figure 3-2, with the number of consents within each WWTP size category shown.

[28] Pionke, H.B., Gburek, W.J. and Sharpley, A.N., 2000. Critical source area controls on water quality in an agricultural watershed located in the Chesapeake Basin. *Ecological Engineering*, 14, pp.325-335. Available at: https://doi.org/10.1016/S0925-8574(99)00059-2 [Accessed 16 January 2025].
[29] Meister, A., Li, F., Gutierrez-Gines, M.J., Dickinson, N., Gaw, S., Bourke, M. and Robinson, B., 2022. Interactions of treated municipal wastewater with native ecosystems. *Submitted to Ecological Engineering*.
[30] Gutierrez-Gines, M.J., Mishra, M., McIntyre, C., Chau, H.W., Esperschuetz, J., McLenaghen, R., Bourke, M.P. and Robinson, B.H., 2020. Risks and benefits of pasture irrigation using treated municipal effluent: a lysimeter case study, Canterbury, New Zealand. *Environmental Science and Pollution Research*, 27(11), pp.11830-11841. Available at: **https://doi.org/10.1007/s11356-020-07759-8** [Accessed 16 January 2025].
[31] Prosser, J. A., Woods, R. R., Horswell, J., & Robinson, B. H. (2016). The potential in-situ antimicrobial ability of Myrtaceae plant species on pathogens in soil. Soil Biology and Biochemistry, 96, 1-3. https://doi.org/10.1016/j.soilbio.2015.12.007
[32] Leonard.M (2024). Risks to human health from pathogens in recycled wastewater. ESR FW23030

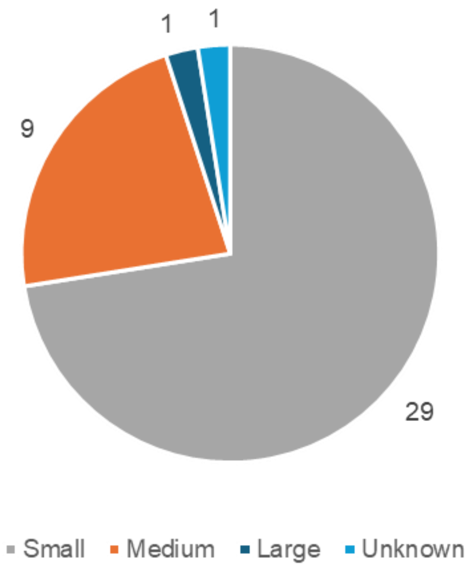


Figure 3-2 Number of land discharge consents (by WWTP size) without load-based limits for TP, TN or E. coli

The consents that involved 100% discharge to land had limits for a range of parameters (aside from TP, TN and *E. coli*), but for the majority the limits were concentration-based, rather than load-based. Other parameters with limits set in these consents included:

- $cBOD_5$ – typically an average concentration over 12 months, or a rolling mean; also maximum concentration. One consent had an annual average load of kg cBOD/day.
- TSS – any consents with a limit for TSS had concentration limits only (no load-based limits set). Typically on the basis of annual 90th or 95th percentile.
- Dissolved Reactive Phosphorus (DRP) – Only three consents (of those with 100% discharge to land) had limits for DRP, and all three were on a percentile-basis (e.g. X no of samples from 12, per year). These consents did not having load limits for TP.
- Ammoniacal nitrogen – No load limits set. Eight consents had concentration-based limits. Of these, four also had TN load limits set.
- Total Oxidised Nitrogen – One consent had a concentration limit set for nitrate-nitrogen. The same consent did not have a load limit set for TN.
- Total Kjeldahl Nitrogen – One consent set a rolling mean and an annual 90th percentile concentration limit for TKN.

A preliminary review of this information indicates that:

- There are a large number of WWTPs which currently do not have consent limits for the parameters and statistics which are included in the proposed Standards.
- Consents may include limits that relate to other related parameters, such as the other forms of nitrogen or phosphorus, or faecal coliforms instead of E. coli, but based on the consents currently included in the database this is not common.
- Some sites, particularly those with medium to large sized WWTPs, hold more than one consent to allow for variations in loading during summer and winter.
- There is a lack of consistency in the current consenting regime with regard to the monitoring parameters set out in resource consents, Thus, the provision of a consistent set of parameters to be monitored in wastewater treatment plant discharges and the statistical basis for them will enable greater insight across the sector into treatment plant performance.

Table 3-3 outlines selected examples of existing consented discharges to land using low-rate irrigation, and provides commentary, where information was available, on how risks and site capability have been considered.

Table 3-3 Examples of existing consented discharges of treated wastewater to land

Scheme	Max daily flow (m^3)	Size and Treatment Process	Discharge system	Current consent parameters	Risks and mitigation measures applied	Land capability	Additional Comments
Blenheim	50,000	Large (Pond system)	Hybrid - K-line and sub-surface drip on pasture with cut and carry or discharge to water (Wairau Estuary)	TN 200 kg N/ha/yr (50 kg N/ha/month)	Adjacent to estuary, wind controls and buffers in direction of dwellings.	Silty loam over sand, shallow groundwater in winter (irrigation only when >0.3m to groundwater)	Average daily consented flow of 28,500 m^3. Approximately 100 Ha of K line and 20 Ha of sub-surface drip lines.
Cardrona		Small (SBR)	Low pressure distribution system (underground) to pasture with cut and carry	TN 30 g/m^3 TP 8 g/m^3 E coli 1000 cfu/100 ml – all annual averages	On terrace above river, temperature adjustment on inputs from ski-field	Good drainage	-
Himatangi Beach	1,085	Small (Pond system)	K-line to pasture cut and carry	150 kg N/ha/yr, phosphorus loading no greater than 60 kg N/ha/yr and *E. coli* levels to be no greater than 260 *E. coli*/100 mL.	Groundwater unlikely to be impacted due to low discharge rate, large buffers to boundary and buffers to stream and drains	Sandy soils	-
Kinloch	1,500	Medium (MBR)	Sub-surface drip to golf course and land around WWTP	TN 1,314 kg N/year TP 900 kg P/year	No contact with wastewater due to sub-surface distribution Approx 1km from Lake Taupo Protection for Lake Taupo (nutrients) – installed seven groundwater monitoring bores around golf course.	Volcanic soils, good drainage (free draining pumice base)	-

Scheme	Max daily flow (m^3)	Size and Treatment Process	Discharge system	Current consent parameters	Risks and mitigation measures applied	Land capability	Additional Comments
Maketu	835	Small (SBR)	Sub-surface drip to pasture cut and carry	TN 15 mg/L, *E Coli* 260 cfu/100ml	Adjacent campground bore replaced with potable Council water supply. Nearby estuary	-	Replaced on-site systems which were impacting public health and environment
Mangawhai	5,500	Medium (CASS reactors)	Spray irrigation to pasture, cut and carry	TN 30 g/m^3 TP 15 g/m^3 *E coli* 10 cfu/100 ml (all annual average)	Groundwater approx. 1.6 m below ground level. Outside the boundary of the Tara Groundwater Management Area. The Tara Aquifer is the principal aquifer in the region, which is high yielding and the groundwater is of good quality	Clays, silts and sandy loams, limited drainage	Dam used for storage and irrigation on a deficit regime
Taupo	24,000	Large (Primary treatment and trickling filters)	Fixed Spray and Centre Pivot to pasture	550-640 kg N/ha/yr	Part system to Lake Taupo catchment, both sites have storage Cut and carry	Volcanic soils with good P adsorption and infiltration. High depth to groundwater	-
Te Anau	4,500	Medium (Oxidation pond with membrane filtration, constructed wetland, UV disinfection)	Sub-surface drip irrigation to pasture	394-468 kg N/ha/yr	40 ha offset area which includes a peat bog. Cut and carry (long term) Undulating topography: very long driplines required due to large irrigation area (120 Ha) and distance from WWTP to irrigation area (20 km). SDI system required algae-free treated wastewater to avoid blocking driplines and nozzles (which necessitated membrane filtration).	Site underlaid by gravels, gravelly sand and Morainic deposits and 'Monowai' loams. High capacity for retention of phosphate. Upper horizons are well drained, but deeper subsoil layer and compacted gravels inhibit rapid drainage. Situated within an unconfined aquifer (Te Anau Groundwater Management Zone) with water table at a depth of between 7 to 13.5 metres below ground level.	Consent includes discharge to land (that could enter surface water) but has been included as the complexity and nature of management provide an interesting example. This is currently the largest sub-surface drip irrigation scheme in NZ.

Scheme	Max daily flow (m^3)	Size and Treatment Process	Discharge system	Current consent parameters	Risks and mitigation measures applied	Land capability	Additional Comments
Whangamata	10,000	Medium (SBR)	Fixed spray into forest (harvested)	Total Nitrogen loading less than 150 kg N/ha/yr. *E. coli* and Faecal Coliforms <126 MPN/100ml (median)	Some steep land, limited irrigation during high rainfall events, nearby streams. Discharge is to Tairua Forest.	Clay soils	-
Waikouaiti	288.6 (Average Dry Weather Flow; ADWF)	Medium (Pond system)	Pine plantation on a sandy foreshore	TN 60 g/m^3 90th percentile TP 15 g/m^3 90th percentile	Directly adjacent to beach	Sandy soils	-

Table 3-4 below includes an estimate of annual volumes of wastewater produced based on the size of the population serviced by WWTPs. A flow of 300 L per person, per day has been allocated from each WWTP, however this will vary based on infiltration and commercial and industrial inputs.

Table 3-4 Wastewater treatment plant size, approximate wastewater production based on population

WWTP Size	Population	Approximate WW volume (m^3/year) *
Very Small	< 250	< 27,375
Small	250 - 1000	27,375 – 109,500
Medium	1001 - 20,000	109,610 – 2,190,000
Large	> 20,000	> 2,190,000

Determining how much land is required for low rate discharge of wastewater to land requires consideration of both hydraulic loading (restricted by soil type and requirement to avoid runoff) and nutrient loading (restricted by the wastewater standards). In some situations, reducing TN and TP concentrations in the treated wastewater can reduce the amount of land required and hence cost. Table 3-5 estimates the theoretical land area required in hectares (ha) for discharging to land in each Class, by WWTP size (or population serviced). This table is for illustrative purposes only and must not be used to size land treatment systems. Additionally, the indicative areas do not include buffer areas, contingency land or other non-irrigated land. When the designer is determining the size of a land application area, hydraulic loading may be the controlling factor rather than nutrients.

The concentrations in Table 3-5 are based on the high dilution and low dilution ratios for rivers from the proposed Discharge to Water Standards, which have been used for indicative purposes only (it is not intended that the discharge to water Standards would be applied to slow-rate discharges to land).

Table 3-5 Estimated land application area required based on the proposed TN and TP Standards for Class 1, 2 and 3.

		Total Nitrogen (mg/L) (annual median)		Total Phosphorus (mg/L) (annual median)	
		35	**5**	**10**	**1**
Discharge to Land Standards	**WWTP Size**	**Estimated land area required (ha)**			
Class 1	V. Small	< 2	<0.4	< 4	< 0.4
	Small	2 - 8	0.4 -1	4 - 15	0.4 - 1
	Medium	8 - 153	1 - 22	15 - 292	1 - 29
	Large	> 153	> 22	> 292	> 29
Class 2	V. Small	< 4	< 0.5	< 6	< 0.6
	Small	4 - 15	0.5 - 2.2	6 - 22	0.6 - 2
	Medium	15 - 307	2.2 - 44	22 - 438	2- 44
	Large	> 307	> 44	> 438	> 44
Class 3	V. Small	< 7	< 1	< 14	< 2
	Small	7 - 26	1 - 4	14 - 55	2 - 5
	Medium	26 - 511	4 - 73	55 - 1095	5 - 110
	Large	> 511	> 73	> 1095	> 110

While the table does not include setback distances and contingency requirements, it indicates that discharge to land at the proposed loading rates classes (Class 1, 2 and 3) may be an attractive option for very small, small and potentially medium sized WWTPs, when comparing to proposed discharge to water Standards for concentrations of TN and TP discharging to rivers and streams, lakes and wetlands, estuaries and low energy coastal environments, provided that the risks to human health associated with *E. coli* could be mitigated.

The discharge rates (mm) will likely be the limiting factor for WWTPs employing advanced or tertiary treatment tertiary, however, it is unlikely these schemes would opt for discharging to land and the daily application rates will vary based on dependent on climate and wastewater peak flows.

At a very high-level the table may also enable asset owners to balance the relative costs of upgrading a WWTP against the cost of establishing a land application site.

3.4 Proposed management and monitoring requirements

3.4.1 Agreed scope

2. Monitoring as Parallel Workstream

- 2.1 **Monitoring Programme Outline for Groundwater**
- 2.2 Monitoring Programme Outline for Soils

3.4.2 Method

It is proposed that all sites with a discharge to land would develop a Management and Operation Plan. It is expected that the Management and Operation Plan(s) would include:

– Site restrictions
– Site inspection requirements (general site operation)
– Management requirements and recommendations,
– Maintenance and contingency requirements and environmental monitoring (including consideration of asset life, rotation/retirement of irrigation areas as relevant).
– Environmental monitoring and reporting requirements

Guidance should be developed to accompany the Standards, to stipulate the preferred (consistent) content and layout of Management and Operation Plans.

3.4.3 Rationale

Prior to implementation of the discharge to land scheme is it assumed that:

– Baseline environmental conditions will be characterised, this may include the installation of groundwater monitoring wells up and down gradient of land discharge field.
– Identification of sensitive environmental receptors has been undertaken.
– The site has been categorised to receive Loading rate class 1, 2 or 3.

On that basis the Standards will not be applicable to high-risk sites, and the monitoring requirements described below are consistent with the approach for low-medium risk receiving environments (i.e. groundwater).

3.4.4 Assumptions and potential implications

The general assumptions underlying the proposed Standards are described in Section 1.3. Specific assumptions relating to the **proposed monitoring requirements** (**Sections 2.17 and 2.18**) were as follows:

– Groundwater and soil monitoring to be undertaken by a suitably qualified person in accordance with best practice.

- Further guidance supporting the Standard may be developed and provided to the sector regarding anticipated sampling frequencies and compliance periods to enable these Standards to be applied and monitored consistently throughout the country.
- The environmental monitoring and reporting requirements would be developed following a review of:
  - Resource consent conditions for existing WWTP discharges to land
  - Approach outlined in other New Zealand technical guidelines i.e. Technical Guidelines for Disposal to Land (WasteMINZ, September 2023) and New Zealand Guidelines for Utilisations of Sewage on Land (New Zealand Land Treatment Collective, 2000).
  - Guidance and approach outlined in international Standards (see Section 2.7)
- The requirements would be undertaken to confirm that the discharge to land:
  - Is not having a detrimental effect on the receiving environment (groundwater and connected surface water)
  - Is operated in accordance with best practice with regards to loading rates and soil capacity
- Should monitoring identify detrimental effects on soil or water, a review of the specific land discharge operation is to be undertaken, this review may include consideration of loading rates, area of application, groundwater flow direction and location of sensitive receptors. Recommendations from the review may require changes to the discharge to land system including, for example, the establishment of contingencies (e.g. offset areas, additional buffer storage capacity) that would have to be in place and triggered if effects are observed.
- The list of soil monitoring requirements is provided in Section 2.18, and it is expected that the sampling frequency and parameters to be measured on each specific site would be confirmed in the site's Management and Operation Plan.
- The results of the soil monitoring will be compared and reported alongside the groundwater monitoring results. These comparisons will help identify any potential issues and recommend remedial actions, if necessary, during the term of the consent or life cycle of the land application system.

4. Matters requiring further consideration

4.1.1 High level narrative on rapid infiltration

A number of WWTPs in New Zealand utilise high-rate application systems such as Rapid Infiltration Basins (RIBs) to discharge treated wastewater. Discharging treated wastewater to land by rapid infiltration is a simple and relatively low-cost method that involves discharging suitably treated wastewater to a series of bunded basins over high permeability soils such as sand or gravels. Systems such as RIBs are utilized as a compact means of land application typically requiring a relatively high level of wastewater treatment beforehand. The wastewater is dosed to the basin where some evaporation will occur, with the balance passing through the base where biological processes may provide some additional treatment.

The basins are typically filled and drawn down on a rotational basis to allow aerobic conditions to be maintained. RIBs can be operated year-round and designed to cope with extreme (i.e.. snow and ice) conditions. Aerobic conditions in the basin and underlying unsaturated material are suitable for further oxidization of ammonia (nitrification) to nitrate. However, once in groundwater, any further attenuation of nitrate is generally limited to dilution and dispersion processes, unless the aquifer substrate contains carbon, which would enable further nitrogen reduction.

Further attenuation of microorganisms such as *E. coli* can also occur within the bed of the basin and underlying strata through the processes of filtration and adsorption if there is sufficient finer material present. Therefore, appropriate vertical and horizontal separation distances to both groundwater and adjacent connected surface waters are an important design consideration for RIBs. However, these systems are not suitable for lower permeability soils, or where existing groundwater levels are high unless underdrainage is provided for recovery of treated wastewater, i.e. for reuse.

While an important means of wastewater discharge under appropriate conditions, RIBs have been specifically excluded from the current deliverable as there are some fundamental differences in design and operation compared with slow rate irrigation systems. For example, the relatively quicker rate high velocity at which contaminants can reach receptors presents a higher risk profile than for slow rate systems. As a result, it is anticipated that the design and application of limits on nutrient and pathogen loads for rapid infiltration systems will require detailed, site-specific assessments, leading to specific hydraulic loading rates and levels of treatment of the discharge.

The consents database (described in Sections 1.4 and 3.3.3.2 above) notes at least 30 resource consents where treated wastewater is discharged to land (including where the discharge may enter surface water) via high rate/rapid infiltration. Of these, 11 consents involve discharges to land only. These are detailed in Table 4-1 below.

There are other discharge mechanisms recorded in the consents database which may involve partial discharge via rapid infiltration (i.e.. “sand filters”), but it is not specified or the description of the mechanism is ambiguous (i.e.. “infiltration”). It is anticipated that these particular cases would be identified and investigated in more detail as part of further/future work to refine the national performance Standards for discharges of treated wastewater to land.

Table 4-1 Summary of existing consents where main mechanism for discharging treated wastewater to land is via rapid infiltration

Location	WWTP size	Discharge mechanism	Treatment process	Consent requirements in terms of TP, TN and *E. coli*
Arthurs Pass (Sunshine Terrace), Selwyn	Small	Sand beds - infiltration	Septic Tanks	No TP, TN or *E. coli* load limits
Foxton Beach, Horowhenua	Medium	Rapid infiltration	Oxidation pond	No TP, TN or *E. coli* load limits
Ellesmere – Leeston, Selwyn	Medium	Rapid infiltration basins; spray irrigation	Multi-stage Maturation Ponds	– No TP or *E. coli* load limits – TN total load of 200 kg/Ha/yr

Location	WWTP size	Discharge mechanism	Treatment process	Consent requirements in terms of TP, TN and *E. coli*
Waipu, Whangārei	Medium	Rapid infiltration basins; rapid infiltration wells	Rapid infiltration basins; rapid infiltration wells	No TP, TN or *E. coli* load limits
Tinui, Masterton	Small	Infiltration wetland	Septic tanks	No TP, TN or *E. coli* load limits
Lumsden, Southland	Small	Rapid infiltration basins	Oxidation pond	– No TP or TN load limit – *E. coli* average load of 10,000 cfu/100mL in 6 out of every 12 samples (quarterly monitoring) Percentile load limit of 100,000 cfu/100mL in every 2 out of 12 samples
Methven, Ashburton	Medium	Rapid infiltration basins	Oxidation ponds with Aerators	No TP, TN or *E.coli* load limits
Otematata, Waitaki	Small	Infiltration trenches	Screen, clarifier, trickling filter, secondary clarifier, pond, subsurface infiltration trenches, sludge digester & drying beds, UV	– No TP or TN load limits – *E. coli* median load of 260 cfu/100mL (quarterly sampling)
Riverton Townside, Southland	Small	Rapid infiltration trenches	Oxidation pond	No TP, TN or *E.coli* load limits
Wanaka, Queenstown Lakes	Medium	Rapid infiltration trenches	Activated sludge; Sequencing Batch Reactor (SBR)	– No TP load limit – TN 80th percentile load limit of 12 g/m^3 (monthly monitoring) – *E. coli* 80th percentile load limit of 1,000 cfu/100mL (monthly monitoring in first 5 years of consent term, then semi-annually thereafter)
Naseby, Central Otago	Small	Infiltration trenches	Oxidation ponds; wetlands	– No TN load limit – TP average load limit of 8 g/m^3 (rolling mean, quarterly sampling) TP maximum load limit of 15 g/m^3

4.1.2 Topics to be captured in management and operations plans

Most current consents for discharges of treated wastewater to land include conditions that require the development of Management and/or Operations and Maintenance Plans. These plans typically provide detailed guidance on routine activities on the site outline methods for ensuring compliance with consented limits such as treated wastewater quality and annual contaminant loads across the land application area.

While such plans tend to follow Standard structure, some common topics might may include:

- System overview and description
- Operational objectives and performance Standards
- Compliance Standards/consent conditions
- Operations and Maintenance Procedures
  - Asset management strategies/approaches
  - Routine operations
  - Preventative / corrective maintenance

- Monitoring, control systems and reporting
- Risk Management, Emergency Response and Contingency Planning
- Environmental Management and Best Practice
- Health and Safety Considerations
- Audit and Review Processes

It is expected that these matters will be addressed within the Management and Operations Plans and Monitoring Plans outlined in Section 3.4, which will provide Standard specifications for the content and implementation of the plans.

4.1.3 Other matters

It is recommended that the following items and topics are given further consideration by Taumata Arowai and their advisors:

- Develop a Risk Screening approach/tool during the consultation process. Consider collaborating with MfE to gain insight into the practical application of the currently available MfE tool and lessons learned to date, which will aid in further developing a similar tool for this new purpose.
- Undertake detailed checks of a variety of existing consented land application schemes against the proposed Standards, including a detailed work-through of the risk-based approach and identification of an appropriate loading rate class. This would allow for a robust sense-check of the approach and help to support conversations with stakeholders during the public consultation process.
- Develop detailed guidance to accompany Standards prior to enactment, including guidance on the Baseline Assessment that discusses site variables in depth.
- The Standards should consider bioremediation that would help to avoid accumulation of contaminants. If land needed retirement, finding new land would be challenging.
- With respect to emerging contaminants, there should be alignment with approach taken for the proposed biosolids Standard.

5. Abbreviations and acronyms

Term	Definition
ADWF	Average Dry Weather Flow
Amm-N	Ammoniacal Nitrogen
ANZG	Australia and New Zealand Guidelines
AS/NZS	Australian Standard / New Zealand Standard
bgl	below ground level
$cBOD_5$	5-day carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CEC	Cation Exchange Capacity
cfu	colony forming unit
E. coli	*Escherichia coli*
EY	Ernst & Young Strategy and Transactions Limited
FC	Faecal coliform
FIB	Faecal Indicator Bacteria
GHG	Greenhouse Gas
GWRC	Greater Wellington Regional Council
Kg ha yr	kilograms per hectare per year
LDP	Limiting Design Parameter
MAC	Microbiological Assessment Category
MBR	Membrane Bioreactor
MCA	Multi-Criteria Analysis
MfE	Ministry for the Environment
MPN	Maximum Probably Number
PCBs	Polychlorinated Biphenyls
PE	Population Equivalent
PFAS	Per- and Polyfluoroalkyl Substances
RASCL	Risk Assessment for Small Closed Landfills
RIB	Rapid Infiltration Basin
RIT	Risk Index Tool
RMA	Resource Management Act 1991
RSS	Risk Screening System
SBR	Sequencing Batch Reactor
SDI	Sub-surface Drip Irrigation
STU	Soil Treatment Unit
TN	Total Nitrogen
TBC	To Be Confirmed
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus

Term	Definition
TRG	Technical Review Group
TSS	Total Suspended Solids
T+T	Tonkin and Taylor Ltd
UK	United Kingdom
UVT	Ultraviolet Transmissivity
USEPA	United States Environmental Protection Authority
WasteMINZ	Waste Management Institute New Zealand Incorporated
WW	Wastewater
WWTP	Wastewater Treatment Plant

6. Glossary

Agricultural land: Cropping and pastoral land.

Agronomic rate: The agronomic rate for wastewater application is designed to provide the amount of nutrients needed by a crop or vegetation to attain a defined yield, while minimising the amount of nitrogen that will pass below the root zone of the crop or vegetation to the groundwater.

Application Method: The specific technique or approach used to apply a substance, treatment, or technology to a wastewater system. This includes the methods, equipment, and procedures employed to achieve the desired treatment or effect, ensuring efficiency, effectiveness, and compliance with relevant Standards. Application methodologies may vary depending on the treatment type, such as chemical addition, filtration, or biological processes, and are designed to optimize the removal or reduction of pollutants *(Source: **United States Environmental Protection Agency (EPA)**.)*

Aquifer: A body of permeable rock or sediments (eg sand and gravel) which can contain or transmit groundwater *(Source: **1838-HZLC143-Groundwater-Ecosystems-Functions-values-impacts-and-management.pdf**)*

Baseline Assessment: An initial evaluation or desktop exercise conducted to identify and assess potential sites suitable for the application of treated wastewater. This assessment typically involves reviewing high level existing environmental, geological, and land use information to determine the suitability of land parcel for wastewater discharge, without the need for immediate site-specific assessment that would require fieldwork i.e. a first qualitative base for a proposed/potential site.

Category: A level of between one to five applied to represent either the degree of Risk or the Site Capability of a site being considered for land application of treated wastewater.

Concentration: The measurement of the number of particles present in a given volume, often in a mixture or solution

Class: A group of numerical limits, part of the Standards

Contaminant: Any substance (including heavy metals, organic compounds and micro-organisms) that, either by itself or in combination with other substances, when discharged onto or into land or water, changes or is likely to change the physical, chemical or biological condition of that land or water. [RMA Definition].

Exposure Pathway: The route by which a receptor is exposed to a hazard.

Evapotranspiration: The sum of **evaporation** and plant **transpiration** from the earth's land surface to the atmosphere (Source: **Water status: Water in Australia: Water Dictionary: Water Information: Bureau of Meteorology**)

Grazed pasture: Area of land where plants (such as grass) are grown for the feeding especially of grazing animals.

Hazards: anything that has the potential to cause harm, damage, or adverse effects), such as E. coli, TP, and TN, which pose public health, stock health, or environmental risks.

High-Rate Application (rate): the discharge of wastewater to shallow basins constructed in permeable deposits of highly porous soils, 6 to 90 m / year. (Adapted from Wastewater Technology Fact Sheet - Rapid Infiltration Land Treatment, USEPA 2003).

Deficit irrigation system: Controlled application of treated wastewater to a site whereby the application rates do not exceed the soils moisture holding capacity or the evapotranspiration needs of the system. Deficit irrigation can limit the risk of over saturation and runoff, however, often requires storage and management during wet weather conditions.

Down gradient: refers to the direction in which groundwater flows, dictated by the hydraulic gradient of aquifer. Down gradient is the groundwater on the "downstream" side relative to a specific area or point of reference (i.e. land discharge area)

Groundwater: Water found underground in the cracks and spaces in soil, sand and rock

Horticultural land: Land used for process food crops, leaf crops, root crops.

Land application system: The system used to apply effluent from a wastewater treatment unit into or onto the soil for further in-soil treatment and absorption or evaporation (as per AS/NZS 1547:2012).
Land contact: term used to describe wastewater systems where the treated wastewater contacts some land before being discharged to surface or marine waters.

Loading Rate Numerical Matrix: A tool used to determine the appropriate class of Standards for wastewater discharge, combining Risk Category and Site Capability Categories.

Long rotation forestry: A forestry management practice where trees are grown for an extended period, typically several decades, before being harvested.

Low-rate application (rate): The controlled application of treated wastewater to a vegetated soil surface, where wastewater receives treatment as it flows through the plan root / soil matrix.

Mass Loading: The quantity of a particular substance or pollutant that is introduced into a wastewater system over a specified period, typically expressed in units of mass per time (i.e.., kilograms per day or pounds per day). Source: **United States Environmental Protection Agency (EPA)**. "Wastewater Treatment Plant Operation and Maintenance Manual."

Non-deficit irrigation system: Non-deficit irrigation refers to irrigation where rates that exceed the soil moisture holding capacity and evapotranspiration rates of the site, resulting in oversaturation but allowing for set irrigation rates.

Pastoral land: Grazed land, including land used for dairy, beef, sheep and deer production.

Pathogens: Disease-causing micro-organisms such as certain bacteria, viruses and parasites.

Pathways: refer to the routes through which contaminants from the discharged wastewater move or are transported to receptors. Examples include surface runoff, infiltration into the soil, or leaching into groundwater, that enable the exposure of receptors to the pollutants.

Population equivalent: The ratio of the total quantity of waste produced to that defined as being produced from one person in a dwelling (as per AS/NZS 1547:2012).

Primary treatment: The separation of suspended material from wastewater in septic tanks, primary settling chambers, or other structures, before effluent discharge to either a secondary treatment process, or to a land application system (as per AS/NZS 1547:2012).

Protozoa: Small, single-celled animals including amoebae, ciliates and flagellates.

Receptors: A component of the natural that is affected by the construction and/or the operation of a proposed development, in this instance, disposal of wastewater to land. This includes those potentially affected by the hazards and associated qualifying criteria, which are site-specific and need to be identified.

Risk: An expression of the likelihood of identified hazards causing harm in exposed populations or receiving environments, and the severity of the consequence (risk = likelihood x consequence); as per AS/NZS 1547:2012.

Risk Screening: the process of evaluating potential risks associated with discharging (treated) wastewater to land. The screening process is intended to determine the likelihood and severity/consequences of various risks including contamination of soil/land parcels and or groundwater, impacts on public health. The goal of risk screening approach is to prioritise areas or scenarios that require site specific assessment, helping asset managers to inform decision-making and ensure that appropriate management and operation measures are implemented.

Risk Category: A 1-4/5 scale classification system used to determine the level of risk associated with discharging wastewater to land, based on a risk screening that evaluates factors such as contaminant concentrations including E. coli, Total Nitrogen and Total Phosphorus, as well receptor sensitivity.

Secondary treatment: Aerobic biological processing and settling or filtering of effluent received from a primary treatment unit (as per AS/NZS 1547:2012).

Sensitive sites: Sites at which wastewater should not be applied due to the ecological, social or cultural values associated with them.

Soil type(s): Refers to the classification of soil (treatment unit) based on their physical characteristics, including texture, composition, and structure. These characteristics influence how the soil treatment unit behaves with regard to wastewater or land application in terms of water retention, drainage, fertility, and its ability to support plant growth.

Site-Specific Assessment: a detailed evaluation process conducted at a particular location to assess the potential risks and impacts of discharging (treated) wastewater to land. The assessment considers local parameters such as topography, geology, soil type, hydrology, climate, land use, and receptor sensitivity.

Site Capability: the suitability of a specific land parcel location to receive discharge of (treated) wastewater based on its physical, environmental, and ecological characteristics. Site capability takes into account factors like soil properties, topography, hydrology, hydrogeology, climate, and land use, and is used to assess whether the site can safely and effectively handle wastewater application without causing harm to the environment, public health, or surrounding receptors.

The Standard(s): The entire approach to regulation of discharges of treated wastewater to land, to be established under the Local Government (Water Services) Act. Includes the risk-based approach and proposed numerical limits described in this report.

Stock: Referring to farmed animals present on land; typically dry stock (sheep, beef, deer) on land where treated wastewater is discharged.

Total Nitrogen: The total amount of nitrogen in wastewater (including organic and inorganic nitrogen)

Total Phosphorus: The total amount of phosphorus in wastewater (including organic and inorganic phosphorus)

Up gradient: refers to the direction from which groundwater flows, dictated by the hydraulic gradient of aquifer. Up gradient is the groundwater on the “upstream” side relative to a specific area or point of reference (i.e. land discharge area)

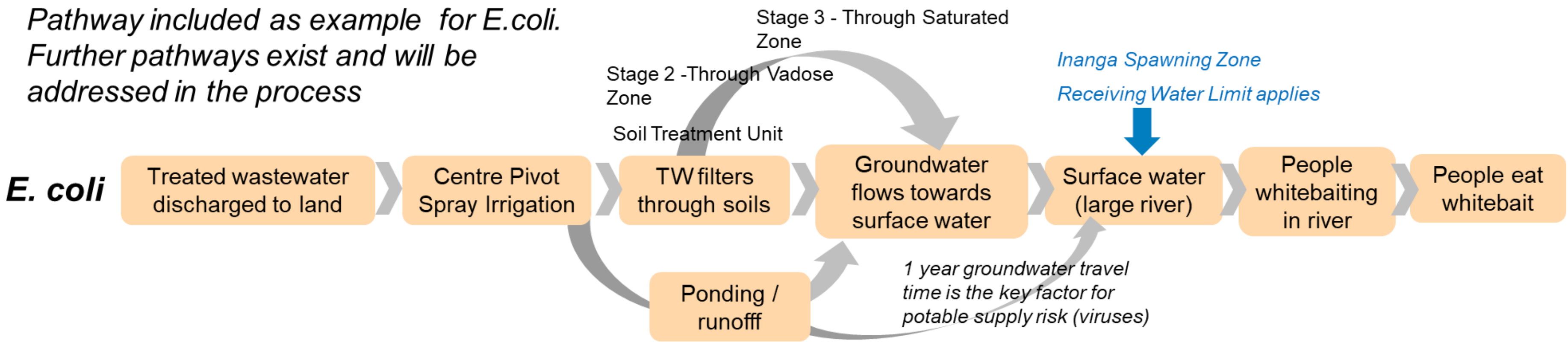
Urban land: Domestic gardens, lawns, public parks and gardens, golf courses, sports fields, turf farming, land rehabilitation.

Wāhi tapu: sacred place, sacred site - a place subject to long-term ritual restrictions on access or use, i.e.. a burial ground, a battle site or a place where tapu objects were placed. (Te Aka Māori Dictionary)

Appendices

Appendix A

Example Contaminant Pathways



Case 1.1 E.coli

Receptor(receiving water) standard must be met
Iterate assessment design / management variables to determine discharge to land standard

Source
Wastewater into ground

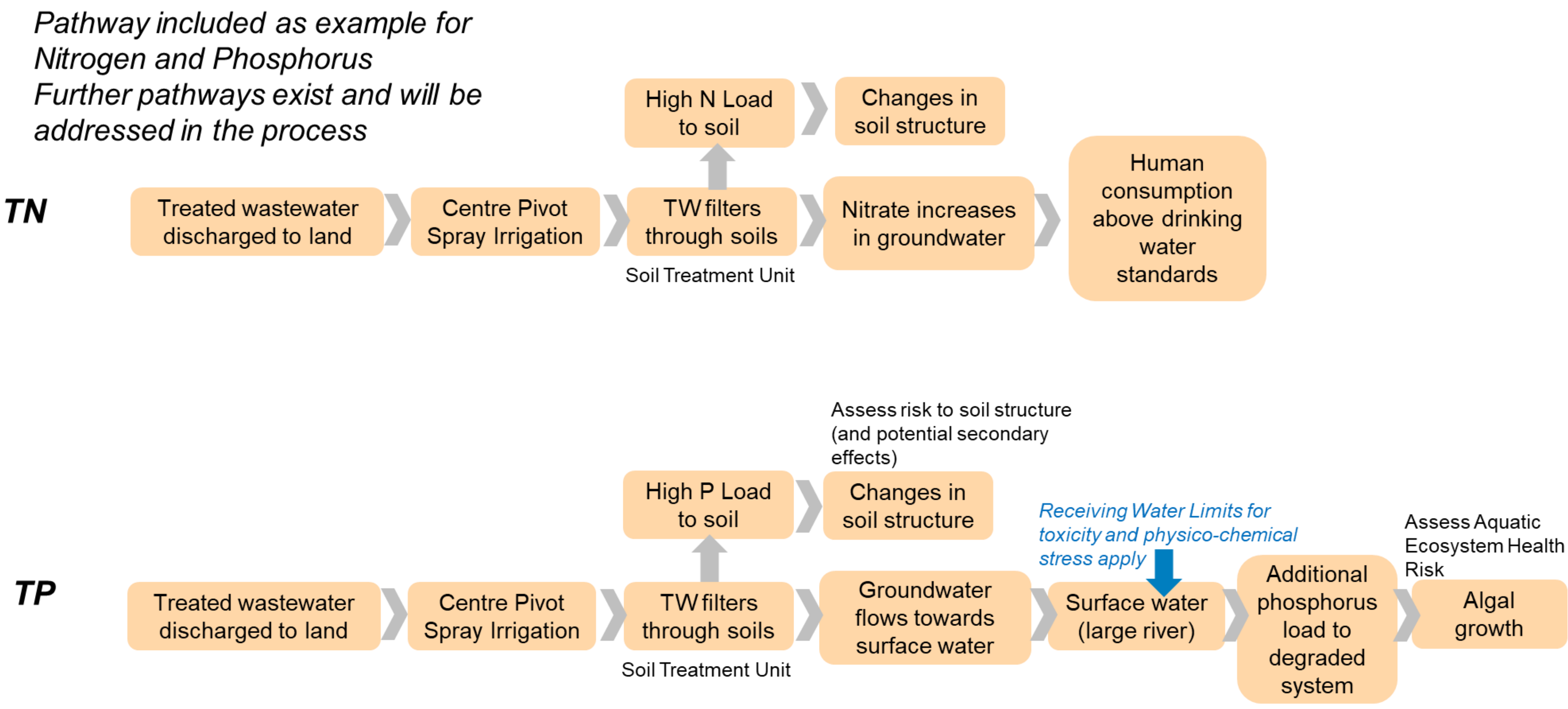
Pathway Stage 1
Soil Treatment Unit (soil zone)
↓
Pathway Stage 2
Vadose zone
↓
Pathway Stage 3
Groundwater → surface water
Receptor
↓
Groundwater
Receptor

Subsurface application
Drip irrigation

Pathway Stage 1 Soil Zone
Design variables affecting treatment
Water balance (storage requirements)
Organic loading rate
Nutrient (N, P) loading rates
Irrigation rate (mm/dose)
Irrigation frequency (doses/d)
Cropping for nutrient removal
Selection of crop
Fertiliser for crop management
Site variables
Climate
Soil characteristics / variability over site
Soil moisture characteristics
Groundwater characteristics

Other potential pathways for *E. coli*:

- Aerosol (from surface application); inhalation; dermal contact
- Sub-surface irrigation (reduces risk of direct exposure to humans/animals)


Pathway included as example for Nitrogen and Phosphorus
Further pathways exist and will be addressed in the process
TN
Treated wastewater discharged to land
Centre Pivot Spray Irrigation
TW filters through soils
Soil Treatment Unit
High N Load to soil
Changes in soil structure
Nitrate increases in groundwater
Human consumption above drinking water standards
TP
Treated wastewater discharged to land
Centre Pivot Spray Irrigation
TW filters through soils
Soil Treatment Unit
High P Load to soil
Assess risk to soil structure (and potential secondary effects)
Changes in soil structure
Groundwater flows towards surface water
Receiving Water Limits for toxicity and physico-chemical stress apply
Surface water (large river)
Additional phosphorus load to degraded system
Assess Aquatic Ecosystem Health Risk
Algal growth