Contaminants Present in Organic Waste: Phase 3 Management Framework and Thresholds Report

Prepared for Ministry for the Environment

23 February 2024

Report for Ministry for the Environment

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1.0 Audience and the Purpose of the Report

1.1 Introduction

The Ministry for the Environment (MfE) commissioned Eunomia Research & Consulting, Whetū Consulting Group, and Massey University, to examine issues of contaminants in organic waste. The project aims to understand and address the challenges posed by contaminants in our organic waste material streams in order to mitigate risks to soil, human and animal health and expand end markets for processed organic waste. The project outputs will build on existing knowledge and standards and provide clear action recommendations for addressing the contaminants challenge.

The report is one of a series in the project's three phases:

Phase 1: Review of Regulations and Guidelines

- Establish framework
- Review of NZ standards regulations and guidelines
- Review of international practice
- Gap analysis and synthesis report

Phase 2: Engagement and End Markets

- Develop stakeholder engagement plan
- Tangata whenua engagement
- Industry engagement
- Analysis and reporting

Phase 3: Recommendations

- Thresholds (this report)
- Review by Tangata whenua and industry
- Final recommendations.

1.2 Report Purpose

This report presents two key outputs from the study – a high level conceptual framework for managing organic waste contamination, and a suggested approach for identifying priority contaminants and thresholds.

1.3 Definitions

For the purposes of this work, we use the following definitions:[1]

> **Contaminant** means:
>
> *any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat that is present in the environment or a specific substance under investigation at a level above what is expected or normal for that environment or substance.*
>
> **Pollutant** means:
>
> *A contaminant in the environment or a substance under investigation that causes, or is likely to cause, harm to resident biological communities (which can be microorganisms, plants, animals or people).*

The benefit of this definition of contaminant is that it allows consideration of contaminants through the system before they cause adverse effects. This is important as adverse effects are not necessarily known until the interaction with the receiving environment has occurred. Contaminants may cause issues in some receiving environments but not in others.

[1] Based on: Chapman, P. (2007) Determining when contamination is pollution – Weight of evidence determinations for sediments and effluents. *Environment International*, 33: 494-501. doi:10.1016/j.envint.2006.09.001

2.0 Framework for Managing Contamination

2.1 Material Management

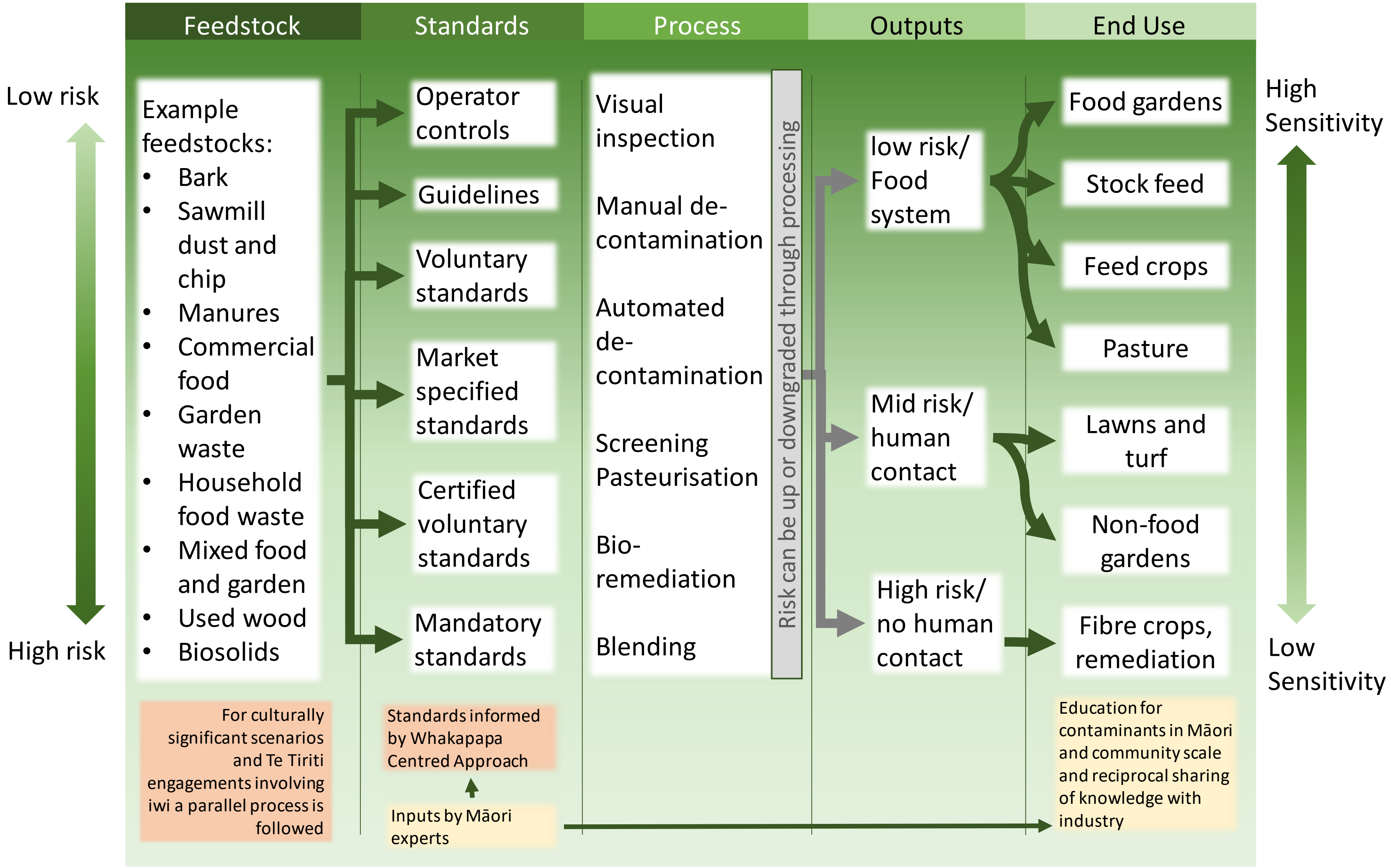
One of the key themes to emerge from the study has been that there are different levels of contamination risk depending on the feedstock, the level of process control, and what end uses the product made from organic waste is put to.

In broad terms different feedstocks present different levels of risk, which tends to provide an initial default pathway for use of those feedstocks – feedstocks with lower risk of contamination being preferred for higher sensitivity end uses and vice versa. However, this default pathway can be altered through a range of controls and management processes, that seek to prevent, remove and remediate the respective contaminants, so that the resulting products are suitable for application to higher sensitivity end uses. Overlaying this, there are various levels of standards, certification, and monitoring that can be applied to provide assurance of the quality of the product and its suitability for the intended end use.

Figure 1 is an attempt to capture these interactions and characterise the risk and the level of intervention and oversight that is going to be most appropriate. A further key principle embedded in the diagram is the idea that intervention and oversight should be focused where needed, as unnecessary oversight will primarily add cost and reduce recovery of organic waste with little or no added benefit in terms of reducing risk from contamination. Striking this balance will likely require ongoing adjustments.

Note: the specific items in each column (e.g. feedstocks in the feedstock column, or end uses in the end use column), are intended to be illustrative only.

Figure 1: High-Level Framework for Managing Contamination



The diagram is explained below:

Feedstock: The first column indicates feedstocks. The feedstocks listed are simply common examples and are not meant to be definitive. In the column, feedstocks are graded in terms of their level of contaminant risk – with lowest at the top and highest at the bottom. The lowest risk feedstocks are essentially those where the inputs are from identifiable controlled sources and feedstocks are of a single type with minimal opportunity for known contaminants to be introduced. These can, generally speaking, go towards any use including food production uses with only minimal controls required.

Further down the list are feedstocks that have lower levels of control, contain mixed material or material from mixed sources, and some risk of containing known contaminants. However, contaminant levels are not high and/or the types of contamination present low to moderate risks, and/or can be managed. These feedstocks do require appropriate controls to be in place (such as picking, screening, pasteurisation, etc.), and also require oversight to ensure that the products meet the appropriate standards for their intended use. If the level of control is sufficiently high these can go to higher value uses such as supporting food production.

At the lower part of the column are feedstocks that contain relatively high levels of contamination and or contaminants that present substantial risk. These tend to come from sources where the level of input control is low and/or where the nature of the contaminants are known to be problematic. These feedstocks will by default go to non-food system or non-contact uses but through processing could be upgraded to contact or even food system uses. However, for this to be achieved a high degree of control and oversight is required.

Figure 1 recognises that the level of control applied can result in an upgrade or downgrade of the end use to which the product from that feedstock is put.

Standards: The 'Standards' column characterises the level of oversight that can be applied to the production of a product. This ranges from operator controls through to mandatory standards. The level of oversight that is most appropriate is a combination of the feedstock and the end use to which the product is intended for. Broadly speaking the lower the risk, the feedstock presents, the lower the level of oversight that is required. On the other hand, the higher the risk to humans and the environment from the use of an end product, the more control that is required. For example, a product utilising a low-risk feedstock may only require operator controls or adherence to guidelines to be appropriate for use in the food system (i.e. low level of control). While a product from a moderate risk source may require certification to a recognised voluntary standard to be considered appropriate for use in the food system (in other words a much higher level of control).

Standards and certification are tools to provide a higher level of confidence to users that the product will not cause contamination issues for their purposes.

Process: The 'Process' column identifies the broad types of contaminant control that can be applied at the processing stage to potentially reduce contamination and hence upgrade the output. The contamination controls that are applied will depend on the input feedstock, the process, and the intended market for the product.

Outputs: The ‘Outputs’ column characterises the quality of the products from organic waste in terms of the level of contaminant risk (not their nutrient content). For the purpose of this framework these are linked to the contaminant thresholds presented in section 3.0, with products characterised as being used in the food system, or subject to human contact, or non-contact.

End Use: The ‘End Use’ column presents in broad terms the type of end uses that product might be applied to. These are roughly divided into products that would go into the food system, those that would go to human contact type use (sports fields, ornamental gardens etc.), and products that would be applied to non-human contact uses such as site remediation, forestry/fibre crops, landfill cover etc. The type of end uses outlined are broadly characterised in terms of their sensitivity to contamination with higher sensitivity applications at the top of the column and lower sensitivity applications at the bottom of the column. As with the feedstocks, these are meant to be illustrative only.

It is noted that for inputs into the food system there are already substantive controls and testing in place to monitor and maintain the quality of food supply. This framework does not modify existing controls in any way but aims to identify a clearer pathway to enabling feedstocks to be applied to their highest value use while safeguarding against contamination.

It is recognised that the end use markets set the expectations for what may or may not be acceptable levels or types of contamination. This can apply irrespective of standards and guidelines that may be in place. For example, cultural or public perceptions play a role in acceptance. Standards are therefore likely to set minimum requirements with market acceptance presenting criteria for producers over and above this.

Culturally significant scenarios and Te Tiriti engagements with Māori: Te Ao Māori views are increasingly crucial in projects involving Māori interests, particularly in culturally significant scenarios or in accordance with Te Tiriti partnership. Market-driven solutions are often unfeasible due to the limited presence of Māori operators and the narrow focus on organic waste reuse. Thus, the Whakapapa Centred Approach[2] is most effective in scenarios requiring collaboration with iwi or in culturally significant matters. Notably, this adds another social layer to the material-based focus of the high-level management framework presented in this report. In this layer, where contaminants are impacting on Māori interests and culturally significant sites to Māori, the additional components within the Whakapapa Centred Approach should be considered.

Most importantly, this should support decision-making around risk and risk identification detailed below, as the scale of risk for a) Output after Process and b) Environment/product could very likely shift when considering these Te Ao Māori views. For example, product made from biosolids may meet specific contaminant threshold levels but not be considered culturally acceptable in relation to particular land uses, such as food production.

[2] Whetu Consultancy (2023) Understanding Views of Te Ao Māori on contaminants in Organic Waste. Report prepared for Ministry for the Environment, December 2023

2.2 Monitoring and Testing

Monitoring and testing effectively overlays what might occur in the above framework. There are several key factors that should be considered when assessing the level of monitoring required. These are:

- **Feedstock risk:** the level of perceived risk associated with a given feedstock. This is likely to be related to the severity (a combination of toxicity and frequency) of possible contaminants
- **End use sensitivity:** the proximity of the output product to sensitive environments, such as use on human food, or in scenarios that may bioaccumulate in human food, or result in degradation of ecosystems
- **Mitigation:** the level of risk mitigation that occurs during the processing/decontamination of a feedstock.

Monitoring can occur at multiple points in the process including the following:

- **Testing of feedstocks.** Feedstocks may be tested by the supplier and/or the operator prior to acceptance for processing. This is typically in the form of surveillance monitoring and can include visual inspection and laboratory testing.
- **Testing during processing**. Process testing includes process monitoring such as temperature, moisture, pH etc.
- **Testing of products.** This is to ensure that product quality is met. It may include testing for a range of parameters such as nutrient values as well as contaminant levels. In may include visual testing, laboratory testing, and growth trials.
- **Testing of soil** or receiving environment to ensure thresholds are not exceeded.

If a process is sourcing a low-risk feedstock (e.g. a single, highly controlled origin with limited chance of low-level contamination), it may not conduct any testing at all, or may utilise minimal levels of monitoring.

If a process is designed to significantly reduce the risk of contamination in its feedstock to a much lower level in its output, a higher level of monitoring may be expected (e.g. in order to ensure this process is functioning appropriately).

Finally, outputs that are intended for use on highly sensitive scenarios, such as the growing of human food, may also expect stringent monitoring of any relevant standards and requirements.

It should be highlighted that these three factors are not independent of one another; for example, a high-risk feedstock that is destined for a high-sensitivity end use is likely to inherently undergo processing that significantly mitigates the risk of contamination.

Examples of the types monitoring that could be considered include:

Table 1: Monitoring Examples

Monitoring Level	Examples of monitoring
High levels of monitoring required	Mandatory testing for full range of probable contaminants

Monitoring Level	Examples of monitoring
Limited levels of monitoring acceptable	Voluntary testing for full range of probable contaminants; mandatory testing for limited range of contaminants
Minimal levels of monitoring acceptable	No testing; visual inspection; voluntary testing for target contaminants

This approach is not intended as detailed guidance for deciding how to monitor a process but may be used to help inform what controls may be missing and/or inappropriate and to design a control regime to effectively manage organic wastes in order to minimise risk and optimise their end use applications.

3.0 Suggested Approach for Identifying Priority Contaminants and Thresholds

Organic waste is a valuable source of soil nutrients and carbon and can be used as a feedstock in the production of products that will reuse the components of this waste. This is as an alternative to the disposal of this waste to landfill. However, contaminants have the potential to restrict the reuse of organic waste and therefore, managing contaminant level is important in the context of reuse strategies.

There is a range of organic waste materials that can be formulated into new products. The High-Level Framework for Managing Contamination (Figure 1) presents a summary of feedstocks for processing and the potential re-use options for organic waste that are considered in this report. For example, food scraps can be turned into compost which can be used as a soil replacement or applied to vegetable gardens as a soil amendment to support food production. As another example, biosolids from a municipal treatment plant can be applied to forestry blocks to support timber production. For each combination of input feedstock, process option and use, end-use defined exposure pathways will define the acceptable level of contaminants in products that have been formulated from organic waste.

For any feedstock, standards are applied, and processes are adopted to create an organic material for end use. Figure 1 has been developed to consider organic material as a general **output** from processing. The term contaminant in Figure 1 follows the definitions in Section 1.3 and is used to mean any substance that is present in a media of study at a level above what is expected or is considered normal[3]. This definition does not distinguish between a beneficial change or an adverse change. This report takes the definition of Chapman (2007) that "*Contamination is simply the presence of a substance where it should not be or at concentrations above background. Pollution is contamination that results in or can result in adverse biological effects to communities. All pollutants are contaminants, but not all contaminants are pollutants*''. The risk that contaminants present in feedstocks will cause harm (i.e. become pollutants) can be downgraded during processing. Technology used during processing can remove contaminants from the product. Where contaminants are present after processing, end use is controlled to mitigate the risk of harm.

Setting acceptable limits for contaminants in any media is a complex area of science. It is beyond the scope of the current work to comprehensively review the science behind limit setting and to challenge limits that have been set. Limits for contaminants in media vary depending on the receptor (e.g. freshwater, soil, ecological indicators) and vary between countries. Instead, the opportunity for the current work is to establish an overall framework by which contaminant thresholds can be used to manage the risk of exposure depending on end-use scenarios for organic waste products. This framework is described as the Contaminant Threshold Framework and is developed in this report. Specific attention has been paid to existing contaminant guidelines and regulations in New Zealand that consider the protection of both human health and ecological indicators.

[3]Eunomia (2023) Contaminants Present in Organic Waste: Framework. Report prepared for MFE.

3.1 Brief overview of regulation controlling the discharge of contaminated waste to New Zealand soils

Any application of waste to land is controlled by the Resource Management Act 1991 (RMA) and regulated by Regional Councils through rules that determine what can be applied, how this can be applied, and when it is applied. Organic waste encompasses a range of materials and products and the constituents of a material/product define the controls on use. Based on these constituents, and consideration of regional plan rules, use of material/product can be unrestricted (does not require a resource consent) or has a level of restriction and consent is required to permit use. Biosolids, as an example, are covered by rules and consent may be required from the relevant council. The consent sets out conditions managing both the discharge of waste and the management of the waste into the future. The consenting process (where needed) requires an assessment of environmental effects (AEE) of waste application to land. and in the context of the current work, sets out a risk minimisation plan for contaminants in the waste. Restrictions are defined based on the chemical, physical and biological properties of the waste being applied to land and are set based on threshold limits for individual waste products (e.g. biosolids) described in this work (see Phase 1 report Review of NZ standards regulations and guidelines for more detail on relevant standards, regulations and guidelines).

Case study: biosolids, nitrogen (N) limits and contaminant thresholds

Organic waste is a valuable source of nitrogen, and the N application associated with organic waste (e.g. biosolids) is regulated. In New Zealand there has been more specific focus on regulating the application of biosolids to soil than any other waste as soil applications is seen as a possible disposal mechanism for biosolids. Due to the inputs for this class of organic waste, contaminant levels can be high. Using the definitions in this report, contaminants in biosolids can include beneficial elements such as N as well as metals, chemical residues, plastics and pathogens. Under current guidelines, biosolids application to land is limited to applications of 200 kg/N per year, or a one-off application of up to 400 kg N/ha every two years[4]. The N loading of biosolids is usually the component of biosolids that sets both land application rates, and the threshold level for a range of other contaminants in biosolids. In other words, threshold levels for higher risk contaminants (such as metals) in biosolids are set based on the amount of biosolids that can be applied to land within the N limit. This is because when biosolids are applied to land, any contaminants within the applied material become distributed into the soil, and the initial concentration of contaminants in the applied material is diluted. Threshold levels for contaminants in biosolids have been set based on the diluted concentration that can be expected in soil, based on application up to the N limit. Guidelines are defined to ensure that relevant EcoSGV and NES-SC levels are not exceeded at this N-defined application limit. Therefore, there is an inherent connection between the concentration of contaminants in biosolids, the application rate of biosolids to land, and relevant site-specific environmental guidelines.

[4] https://envirolink.govt.nz/assets/Envirolink/742-TSDC53-Best-management-practices-for-applying-biosolids-to-forests.pdf

Prior to the consented application of waste to land, baseline soil monitoring is needed. As part of the consent, soil monitoring is required to ensure that application to land meets conditions into the future and does not exceed relevant Ecological Soil Guideline Values (EcoSGV) and the National Environment Standard for Assessing and Managing Contaminants in soil to Protect Human Health (NES-CS). Ongoing monitoring is needed to ensure compliance with the consent conditions that permit the application of organic waste to land.

3.2 Overview of Relevant New Zealand Guidelines

This section briefly discusses the relevant New Zealand guidelines that set or can be used to set limits for contaminants in organic wastes. In the development of the Contaminant Threshold Framework, considerable attention was focussed on guidance and threshold values presented in the key reports described in Table 2. These reports represent a subset of standards, regulations and guidelines selected from the earlier report "Contaminants Present in Organic Waste: New Zealand Review of Regulations and Guidelines" prepared by Eunomia as part of this organic contaminates project. Values presented in these reports describe contamination limits in soil, as well as in waste products, and these values constitute the criteria for their inclusion in the current work. The guidelines described in Table 2 have been used to define contaminant thresholds in the Contaminants Threshold Framework described in this report.

Threshold values developed in the current work do not supersede guidelines values that have been set for land. Soil threshold values define intervention points at which environmental management is triggered. The purpose of the current work is to provide guidance on the use of organic waste. This may be used as soil or applied to soil. Here is an important point of differentiation: the Contaminant Threshold Framework described in the current report considers both the use of organic waste products as a soil substitute, and the application of organic waste products to soil. The use of organic materials as a soil substitute or soil replacement is poorly considered in the reports described in Table 2.

Management of soil is defined by existing frameworks that extend beyond the guidelines reviewed in Table 2. For example, the National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS) is an important framework that guides land use based on soil contamination status and is used during consenting. However, the NES-CS have not been used in the derivation of values in the Contaminant Threshold Framework. Instead, there has been a focus on the intersection of guidelines for organic waste (contaminant thresholds) and soil guidelines.

The guidelines described in Table 2 have been developed with recognition of the importance of ecological receptors in soil and the associated ecosystems[5], as well as human health. Consideration of ecological impacts of trace metals was included as early as 2003 in the New Zealand Wastewater Association guidelines (NZWWA, 2003). For example, the guideline level of 1 mg/kg Cd was considered to protect the microbial population of the soil and limit significant leaching of soil Cd to groundwater.

[5] MWLR (2023) describe ecological receptors to include microbes, invertebrates, plants and higher animals.

Contaminant thresholds for organic waste need to be enacted to ensure that relevant soil thresholds (NES-CS, or EcoSGV) are not exceeded. Thresholds are used to direct use of organic waste to ensure that transfer of contaminants presents an acceptable risk.

Table 2: New Zealand guidelines relevant to organic waste reviewed in establishing the Contaminant Threshold Framework

Document	Coverage	Status in context of Contaminant Threshold Framework
Guidelines for the Safe Application of Biosolids to Land in New Zealand **New Zealand Wastewater Association** **NZWWA (2003)**	National guidelines to support consistent management of the application of biosolids to land Released in 2003 to supersede previous guidance Limits for contaminants set based on review of science at time; Volume 2 of the guidelines provides comprehensive review of how values were set Guideline values for biosolids are defined as what is acceptable in soil considering the dilution effect of soil on a controlled loading of biosolids Guidelines strongly driven by human health but also consider ecological impact of contaminants (animals, soil bacteria, plants, potential for leaching to groundwater) Guidelines classify grade of biosolids based on chemical (metal) (a, b) and biological (pathogen) (A, B) contaminants where a or A is a higher grade (lower level of contamination than b or B	Adopted as baseline for values used in Contaminant Threshold Framework Guidelines are developed to limit the level to which contaminants will build up in soil These are hard limits, not intervention values Guideline can be applied to any material that is used as a soil substitute
Guidelines for beneficial Use of Organic Materials on Productive Land (Draft) **Water NZ (2017)**	Significant update on NZWWA (2003) guidelines and designed to supersede 2003 guidelines Applies to products made from organic materials or mixtures of organic materials that have been processed to make them safe for further use Table 5-5 of the Water NZ (2017) guidelines sets product contaminant concentration limits which can be used for general organic material. Guidelines are based on Grade b maximum concentration in NZWWA (2003) guidelines	Guide does not provide a specification for use of organic material as a soil replacement – Guide defers to NES-CS (NES for Assessing and Managing Contaminants in Soil to Protect Human Health) or EcoSGVs Recommendations are presented for soil replacement: Rural – meet EcoSGV limits. Urban – Meet EcoSGV except for Zn where limits of 2003 biosolids guidelines are met Limit setting follows the science of the NZWWA (2003) report

Document	Coverage	Status in context of Contaminant Threshold Framework
	[i.e. there is a general increase in tolerance of metals in biosolids for unrestricted use]	Report is Draft. Water NZ guidelines have not been finalised and released
An implementation framework for ecological soil guidelines values **Envirolink Tools Grant: C09X2206** **Manaaki Whenua Landcare Research (MWLR) (2023)**	Focus on protection of ecological receptors in soils/ecosystems from effects of contaminants There are incidences of EcoSGV exceeding NES-CS limits (As, Cd, Pb)[6] – precedence for lower standard is built into MWLR (2023)	EcoSGVs are used to protect soil quality and for contaminated land management. EcoSGVs work with NES-CS and set intervention limits for environmental management EcoSGVs were not developed for application to non-soil media (e.g. organic wastes)
Draft PFAS National Environmental Management Plan: Version 3.0 **PFAS NEMP Version 3 (2023)**	Nationally agreed guidance on the management of PFAS (Per- and polyfluoroalkyl substances) contamination in the environment, including the spread of contamination Sets soil threshold levels of intervention based on a range of indicators (e.g. human health, ecology) Version 3.0 builds on previous release of NEMP	Overarching framework for managing PFAS contamination in the New Zealand environment Specifically covers biosolids, but no other organic waste products Contaminant Threshold Framework does not investigate the relationship between the margin of safety variable limit setting for PFAS in biosolids (Table 11) and contaminant limits in NZWWA (2003) and Water NZ (2017) guidelines PFAS NEMP V3 (2023) does not consider PFAS-containing materials as a soil substitute (soil replacement) Values reported in the Contaminant Threshold Framework should be considered in the context of the PFAS NEMP V3 (2023)
New Zealand Standard NZ4454. Composts, Soil Conditioners and Mulches **Standards New Zealand (2005)**	Covers organic products and mixtures of organic products that have been treated by pasteurisation or composting to a defined level (i.e. commercial) Methodology to test against standards is defined	Standard for physical contaminants applied across the Contaminant Threshold Framework

[6] Kim (2018) Review of work to determine background concentrations and develop ecological guideline values for soil contaminants in New Zealand. https://www.envirolink.govt.nz/news-and-events/ecological-soil-guidelines/

3.3 Classification System for Organic Waste Reuse

In setting a contaminant threshold framework for organic waste, the following four classification of organic waste reuse are used:

1. Soil substitute
2. Food grade
3. Contact grade
4. Non-contact grade

The intention of this reuse classification system is to establish a relatively simple and transparent matrix for contaminant thresholds regardless of the feedstock used to generate an organic waste product that can be reused.

The **soil substitute** classification is for the scenario where a product made from organic waste is used as a media for plant growth. An example is compost, which can be used as a soil replacement. In this scenario there is no dilution of contaminants within the organic product into a greater mass or volume of soil, and therefore the sensitivity to contaminants is high. The soil substitute or soil replacement classification has been poorly covered in existing regulations for organic waste products summarised in Table 2.

An example of **food grade** would be the use of organic waste such as compost or biosolids as a soil amendment on a vegetable garden or on agricultural land that is used for food production. Food production considers horticultural and agricultural land use, including meat production from pastoral farms. Given the potential for contaminant transfer from waste/soil to food to people, contaminant tolerance here is relatively low.

Contact grade defines the scenario where there is the opportunity for contact with organic waste products, although there is no food production. An example might be the application of compost to ornamental gardens where exposure is related to gardening and the potential dispersion of contaminants with dust. Another example is the use of organic waste on parkland or sportsgrounds where there is frequent land access. Contaminant tolerance is low for this scenario, however there is greater tolerance when compared with food production land.

Non-contact grade defines the scenario where organic waste products are applied to land that is used to support commercial fiber production (i.e. not food production such as forestry) or is applied as a soil amendment to commercial/industrial scale land rehabilitation projects (Waka Kotahi infrastructure projects, council landscaping works, contaminated land remediation). For land in this scenario there is restricted public land access; any access can be controlled through risk management planning. Where land access cannot be controlled, or there is an increased likelihood of public exposure to land, then the contact grade classification should be used. Tolerance for contamination in this scenario is at the highest level of the four.

3.4 Specific Contaminants Considered

The list of potential contaminants in organic waste is extensive: this report finds that there is no single comprehensive list of all contaminants. This is due to the constantly evolving nature of contaminant science: new contaminants are constantly being identified. The cultural context of contamination/pollution is also important here – the Whakapapa

Centered Approach can assist with classification and prioritization and support decision-making and increase knowledge around Te Ao Māori views of contaminants. Definition of a contaminant does not mean an environmental issue: new contaminants need to be considered in the context of exposure and risk to define a pollution status. Only when a contaminant is identified as a pollutant does management need to be enacted.

In defining contaminants and thresholds relevant to Māori, the Whakapapa Centred Approach is pivotal. It integrates Māori considerations to determine the pollution status of emerging contaminants and assesses risks from a Māori viewpoint. This approach is particularly vital when Māori representation is lacking or when there's limited capacity to address these crucial issues. It can aid the EPA or territorial authorities in setting limits and addressing Māori-relevant aspects. The implementation of these standards sits within the project, however the critical process of developing standards in an appropriate manner that reflects Māori perspectives is an external process to the project scope. Further, the approach should in no way replace or reduce the need for mana whenua engagement across the board. There is no one perspective of Māori view, and engagement is the primary way to understand these varying views.

The Contaminant Threshold Framework has been developed within the context of the High-Level Framework for Managing Contamination (Figure 1). Specific contaminants of concern have been identified through stakeholder engagement: contaminants in the Framework are limited to those identified in the stakeholder engagement sessions (see Stakeholder Engagement Report). Contaminants considered in the Framework are not a comprehensive list of all contaminants that may be present in organic wastes. There is potential to include additional contaminants or families of contaminants within the Framework in the future (an example is the extension of threshold values for clopyralid to the picolinic acid family of chemicals). The Contaminant Threshold Framework provides recommendations on existing thresholds that the project team assesses to be suitable to control contaminant exposure and risk in organic waste products. Where no suitable threshold exists, this is indicated.

Table 3 presents a summary of contaminants that can become pollutants in the context of the definitions of this report. This identification is based on the findings of the project team through the review of science completed for the work, and stakeholder engagement. Table 3 classifies contaminants as being either chemical, physical or biological. Chemical contaminants are identified through chemical analysis. Physical contaminants are identified through separation and screening. Biological contaminants are identified through a range of techniques that include, but are not limited to, extraction and spectroscopy, culturing and/or metagenomics.

It should be noted that the macronutrient composition of organic waste products must also be considered in any reuse strategy. For example, the nitrogen (N) loading through use of organic waste must comply with relevant regulations. However, consideration of N as a contaminant is outside the scope of the current work.

Table 3: Organic Waste Contaminants Considered in Threshold Framework

Chemical contaminants	Physical contaminants	Biological contaminants
PFAS	Glass	Viruses
Heavy metals	Stones	Bacteria
Microplastics[1]	Metal	Fungus
Clopyralid[2]	Household refuse	Parasites
Boron	Batteries	
	Plastics (macro size)	
	Oversize green waste	

Note 1. Microplastics (as opposed to macroplastics) are included as a chemical contaminant due to interactive effects with chemicals in the environment and the chemical techniques used for analysis.

Note 2. The chemical clopyralid is identified as a contaminant in Table 3. The threshold is relevant to any product containing this chemical.

3.5 Contaminant Threshold Framework

To develop the Contaminant Threshold Framework, existing guidelines (Table 2) have been assessed in the context of the contaminants presented in Table 3. The intention of this framework is to select threshold values most suited for specific contaminants across a range of products. This differs from the conventional approach of assessing each product separately. The decision to adopt thresholds across products is to integrate the management of contaminants across products and to provide increased clarity on how guidelines can reduce the risk associated with the use of organic wastes. It should be noted that this framework does not challenge the science behind setting contaminant standards. Instead, this report is seeking to provide new guidance on how contaminant thresholds can be used to facilitate the reuse of organic wastes. The framework takes the most appropriate guidelines across different products and integrates these into a single framework for all organic wastes.

The Contaminant Threshold Framework (Table 4) proposes the most suitable guideline levels for each contaminant and presents a colour coding of the extent to which contaminant thresholds are appropriately managing the reuse of contaminants as per Figure 1. Notes are provided to substantiate the individual contaminant thresholds that have been adopted. Green indicates that that the existing threshold approach is suitable. Orange indicates that a threshold framework is available but needs to be implemented. Red indicates that management is lacking, and that further work is needed to define contaminant thresholds based on exposure and risk. Variable land-use, other than that inferred in the four classifications of organic-waste reuse defined in Section 3.2, is not considered in the setting of proposed guideline levels in Table 4. The guidelines in Table 4 are designed to be applicable broadly across multiple land uses for the defined organic waste reuse classifications used in this work. Land use is considered in the science that has set specific guidelines values used in Table 4 (as described in Table 2) and is also considered in the context of permitted or consented activities.

The establishment of this Framework is a cumulative output of the current work. The Framework is intended to be a living document that will be changed and updated based on ongoing stakeholder engagement, technical review, ongoing interpretation of existing guidelines, and new science. The Framework is presented to facilitate the continuing advancement of guidelines that will achieve the aim of organic waste reuse.

With respect to the contaminants listed in Table 3, the Framework finds that for PFAS there are no appropriate existing New Zealand guidelines for organic waste. For metals, the Water NZ (2017) guidelines are considered to be most appropriate although the lowest level of tolerance set by NZWWA (2003) is used to set the threshold for organic waste as a soil substitute. For microplastics there are no suitable New Zealand guidelines. For boron and physical contaminants, the New Zealand Standard NZ4454 should be used. For clopyralid an effective zero limit is set, although this is quantified at the limit of analytical detection. For biological contaminants (viruses, bacteria and parasites) the guidelines set by NZWWA (2003) and adopted by WaterNZ (2017) should be used.

Table 4: Contaminant Threshold Framework for specific contaminants identified through stakeholder engagement as a function of the organic waste use classifications defined in this report.

	Organic waste use classification				Notes
Contaminant	**Soil replacement**	**Food grade**	**Contact grade**	**Non-contact grade**	
PFAS	PFAS NEMP Version 3 (2023) does not set a relevant guideline. Recommendation is to develop New Zealand specific threshold values. Experience from international research and soil limits developed by international regulators should be used as a starting point. Example starting point is the Denmark threshold where soil limit is set at 0.4 mg/kg for	Follow soil replacement guidelines	Increase the threshold limit of PFAS relative to food grade use	Increase the threshold limit of PFAS relative to contact grade use	Guidance on management of PFAS in the New Zealand environment is through PFAS NEMP V3 (2023). PFAS NEMP V3 (2023) defines soil limits for intervention but does not consider the opportunity to use PFAS-containing organic waste as a soil substitute. Further commentary on PFAS NEMP V3 (2023) is provided as Appendix 1. Framework recommends NZ adopt international standards for PFAS in organic waste and that values are investigated in context of PFAS NEMP V3 (2023). Work is required to select appropriate international standards. Framework is guided by Hall et al (2020) who present a review on PFAS in biosolids published by the Water e-Journal[7]. Initial recommendation is for NZ follow the Danish move towards a banning of PFAS treated food contact

[7] https://info.awa.asn.au/water-e-journal/pfas-in-biosolids-a-review-of-international-regulations

	Organic waste use classification				Notes
Contaminant	**Soil replacement**	**Food grade**	**Contact grade**	**Non-contact grade**	
	the sum of 12 PFAS				materials with a soil limit for PFAS set at 0.4 mg/kg as the sum of 12 PFAS: PFBS, PFHXS, PFOS, PFOSA, 6:2 FTS, PFBA, PFPeA, PFHxA. PFHpA, PFOA, PFNA, PFDA. The assumption in limit setting is that organic waste products may be used as a complete growth media for food plants. This soil limit is recommended as a conservative baseline for organic waste food use classification. Increasing tolerance to PFAS concentration can be set for contact and non-contact food grade use. Danish limit has been selected due to international leadership by this country in suite of actions to regulate PFAS in the environment.
Heavy metals	Use criteria for grade a chemical contaminant in biosolids according to NZWWA (2003) guidelines	Follow Water NZ (2017) guidelines which are based on criteria for grade b chemical contaminants in biosolids according	Follow Water NZ (2017) guidelines which are based on criteria for grade b chemical contaminants in biosolids according	Follow Water NZ (2017) guidelines which are based on criteria for grade b chemical contaminants in biosolids according	The term heavy metal is used in this report to collectively describe all trace element metals and metalloids (As, Se) that can be contaminants in organic waste. Some trace elements are essential to biological systems (e.g. Cu, Zn) while others have no know essentiality in biological systems (e.g.

	Organic waste use classification				Notes
Contaminant	Soil replacement	Food grade	Contact grade	Non-contact grade	
		to NZWWA (2003) guidelines	to NZWWA (2003) guidelines	to NZWWA (2003) guidelines	Hg and Cd), although biological systems have a level of tolerance to these contaminants. Water NZ (2017) (draft) guidelines are recognised as superseding NZWWA (2003) guidelines. Water NZ adopts the b classification of NZWWA guidelines where the limit for b classification is set by a threshold limit of metal concentration. Heavy metal limits (for all heavy metals) are set using the Water NZ guidelines with the exception of soil replacement classification which uses class a of NZWWA (2003). There is a lower level of acceptable metal concentration for grade a over grade b.
Microplastics	Physical standards are used for particles > 1mm There is a lack of standard for	Physical standards are used for particles > 1mm There is a lack of standard for	Physical standards are used for particles > 1mm There is a lack of standard for	Physical standards are used for particles > 1mm There is a lack of standard for	Guidance on limits for microplastics in soil have been taken from the USEPA (2021) report on plastic contaminant in foodwaste[8]. Microplastics are defined as plastic particles between 1µm and 5mm; physical parameters set

[8] https://www.epa.gov/system/files/documents/2021-08/emerging-issues-in-food-waste-management-plastic-contamination.pdf

	Organic waste use classification				Notes
Contaminant	**Soil replacement**	**Food grade**	**Contact grade**	**Non-contact grade**	
	microplastics <1mm Standard analysis method is needed to develop the science that will set thresholds for microplastics < 1mm	microplastics <1mm Standard analysis method is needed to develop the science that will set thresholds for microplastics < 1mm	microplastics <1mm Standard analysis method is needed to develop the science that will set thresholds for microplastics < 1mm	microplastics <1mm Standard analysis method is needed to develop the science that will set thresholds for microplastics < 1mm	threshold values for particles in this size range. However, lack of standardised testing for microplastics <1mm limit both analytical capabilities to find these plastics and the technology to meet physical thresholds. The USEPA concluded that there are no regulations in any country that regulate the acceptable concentration of microplastics <1mm in soil. This is supported by commentary by Porterfield et al., 2023 which concludes that here are no standardised methods for measuring microplastics in composts, digestates and food wastes[9]. The ability to regulate microplastics is constrained by a lack of agreed analytical testing methodology and reporting for microplastics. Work is required to establish a NZ testing system before threshold concentrations can be set that cover all size ranges of microplastics.

[9] Porterfield et al. (2023) Microplastics in composts, digestates, and food wastes: A review. *Journal of Environmental Quality* https://doi.org/10.1002/jeq2.20450

	Organic waste use classification				Notes
Contaminant	**Soil replacement**	**Food grade**	**Contact grade**	**Non-contact grade**	
Clopyralid	Limit of analytical detection	Limit of analytical detection	Limit of analytical detection	Limit of analytical detection	Review of global commentary and regulations suggests there is no tolerance for clopyralid and associated chemicals in organic waste for reuse. Setting a zero limit is complicated by the ability of analytical protocols and machines, that may vary between labs, to detect these chemicals in organic waste. As a compromise, this Framework sets a threshold as the limit of detection for approved analytical protocols. Approval needs to be established through further work. Limit of detection effectively places zero tolerance for clopyralid in organic wastes for reuse, and allows for differences in the analytical protocols used by different labs.
Boron	NZ4454 (<200 mg/kg to avoid contact plant toxicity)	NZ4454 (<200 mg/kg to avoid contact plant toxicity)	NZ4454 (<200 mg/kg to avoid contact plant toxicity)	NZ4454 (<200 mg/kg to avoid contact plant toxicity)	Boron (B) is an essential element for plant growth. Total B concentration is a poor indicator of potential ecotoxicity. B bioavailability varies as a function of form and environment, and extractable B is generally used for threshold setting. Limit setting for B is based on ecological

	Organic waste use classification				Notes
Contaminant	Soil replacement	Food grade	Contact grade	Non-contact grade	
					parameters not human toxicity. For example, The NES for Assessing and Managing Contaminants in Soil to Protect Human Health sets no limit (NL) for B in soil across land use. To prevent contact toxicity of inorganic B to plants, NZ4454 sets an upper limit for total B in composts. This existing threshold value is adopted for the Framework but could be reconsidered in the next review of NZ4454.
Glass **Stones** **Metal** **Household refuse** **Batteries** **Plastics (macro and micro size**	Use limits set by NZ4454	Use limits set by NZ4454	Use limits set by NZ4454	Use limits set by NZ4454	NZ4454 is used to set limits on physical contaminants. Screening to 5mm will remove bulky items such as batteries and general rubbish items that do not fall into the specific contaminants in Table 2. The guidelines in NZ4454 are extended to plastic fragments > 1mm due to lack of existing regulations for microplastics in the 1mm – 5mm size range. This is based on the need to develop standardised testing for microplastics < 1mm described in this Threshold.

	Organic waste use classification				Notes
Contaminant	**Soil replacement**	**Food grade**	**Contact grade**	**Non-contact grade**	
fraction > 1mm)					
Oversize green waste					
Viruses **Bacteria** **Fungus** **Parasites**	Criteria for Stabilisation Grade A biosolid Water NZ (2017)) guidelines	Criteria for Stabilisation Grade A biosolids Water NZ (2017) guidelines	Criteria for Stabilisation Grade A biosolids Water NZ (2017) guidelines	Criteria for Stabilisation Grade B biosolids Water NZ (2017) guidelines	Microbiology limits set by NZWWA (2003) for biosolids and adopted by Water NZ (2017) are used in this framework across all organic waste products for reuse. NZWWA guidelines are comprehensive in their management of pathogens in organic waste. NZWWA (2003) guidelines state that pathogens in sewage sludge include bacteria, viruses, parasites (helminths/protozoa) and fungi. Grade A biosolids are considered pathogen free. No guidelines exist for fungi.

Appendices

A.1.0 Rationale for Contamination Limits

Key question: 'Why has the Danish guideline level been adopted for PFAS in organic wastes?'

The Heads of Environmental Protection Agencies Australia and New Zealand (HEPA) PFAS National Environmental Management Plan (NEMP) [PFAS NEMP] has been reviewed in setting the Contaminant Threshold Framework. This is an evolving document and provides a strong framework for the management of PFAS in the environment. However, the conclusion of the current work is that there is no compelling guidance for criteria limits for general organic waste. Provisional criteria limits for biosolids are set in the PFAS NEMP Version 3 report, and these are set based on the application of biosolids to land.

The PFAS NEMP has a focus on contaminated land. This is appropriate. Any guidance on organic waste for re-use has a different focus. Associated criteria need to define where use of PFAS-containing organic materials is safe. Where PFAS-containing materials are unsafe for use, controls are then in place through the PFAS NEMP.

As a consequence of this mismatch between the intention of the PFAS NEMP and the intention of the Eunomia work, alternative guidance was sought. The Framework does not seek to define threshold levels from first principles. Instead, guidance has been sought from elsewhere that can propose threshold levels. The commentary of Hall et al. (2020)[10] is cited in the Threshold Framework. These authors make the following statements:

- Denmark is a leader in PFAS regulation. It has developed a suite of actions including a planned ban of PFAS treated food contact materials in 2020.
- Denmark, Germany, Norway, Sweden and The Netherlands are taking strong regulatory and practical action and are seeing PFAS concentrations drop across a range of monitored applications and in the environment. The approach is holistic and advocates source reduction, as well as end use limits

Based on these comments, the Danish soil PFAS limit has been selected as a starting point for the Framework. The intention here is to set a limit for acceptability of PFAS in organic waste that is used as a soil substitute. This threshold needs to be analysed in the context of the PFAS NEMP, but this is beyond the scope of the current work.

The current state of limits in Denmark has not been verified. Selection of Danish values is based solely on their apparent progress in this area of science.

This section presents notes generated through review of the NEMP during the development of the Framework. This section presents interpretation of various sections of the PFAS NEMP that underpin threshold setting.

[10] https://info.awa.asn.au/water-e-journal/pfas-in-biosolids-a-review-of-international-regulations

Analysis of PFAS National Environmental Management Plan: Version 3.0

The PFAS NEMP Version 3 (NEMP) is a comprehensive and robust document that will shape ongoing management of PFAS in New Zealand environment. The NEMP provides nationally agreed guidance on the management of PFAS contamination in the environment, including prevention of the spread of contamination. The NEMP calls for regulatory actions and decision that are risk-based and informed by scientific evidence (line 220).

NEMP guidelines are focussed on soil and define the point at which soil contamination is triggered. The potential for re-use of organic waste as part of the soil system is described, but focus is limited to biosolids. The potential use of organic waste as a soil substitute is specifically not considered. The relevance of cited soil guidelines is questioned where the decision-making is on the use of organic waste products as a potential soil substitute.

The NEMP calls for a feedstock management plan in the context of the reuse of organic waste. However, contamination limits underpinning this management plan are lacking. Only concentration in biosolids is considered.

Table 10 of the NEMP (referenced in TAG feedback) is important and highly relevant to the current work. However, this sets no guideline values and covers a range of feedstocks for re-usable organic waste products, other than biosolids. Further discussion within the NEMP on relevant limits across all types of organic waste would be helpful.

Section 8 PFAS environmental guideline values (line 734)

Ecosystems guidance can be more stringent than human health guidelines in setting environmental guideline values (line 741).

The identification of PFAS above relevant guidelines values acts as a trigger to undertake further investigations (such as site-specific risk assessment, as opposed to the assumption that harm will have occurred) (line 753).

The selection of guidelines values should have regard to the specific environmental values and characteristics of the site (line 765).

Section 8.1 (Consideration for using guideline values) has a focus on site specific issues. Guidelines have been derived from nationally recognised processes, or from relevant international criteria.

Table 4 - presents human health guidelines values for PFAS exposure developed by heath authorities (line 906).

Table 5 - human health investigation levels for soil:

Sum of PFOS and PFHxS 0.01 mg/kg PFOA 0.1 mg/kg (most strict criteria based on variable land use) (line 956). *These are investigation levels for soil and are a function of the types of PFAS in soil. Given the limited data on the chemical variability of PFAS in organic waste, soil criteria here seem inappropriate for application to organic wastes.*

NEMP covers ecological guideline values comprehensively.

The ecological guidelines values are not intended to be generic contaminated site remediation criteria (line 989).

Ecological guidelines values for soil could arguably be the most relevant to organic soil amendments, but (**opinion**) are too strict in the context of a soil substitute (Table 6 – line 1048). This would essentially mean zero PFAS in the organic waste product (the Framework has avoided zero PFAS as a threshold criteria).

Section 9 – PFAS contaminated site assessment (line 1398). This is different to the current task where use of organic waste is being regulated to avoid the site or land use becoming contaminated. Thresholds being proposed in the Framework are designed to avoid the situation where a site can be considered contaminated.

Section 10 – On-site stockpiling, storage and containment (line 1662) is not relevant to current task. The current work is trying to differentiate between waste and resource.

Section 11 – Transport of PFAS-contaminated material (line 2174) is not relevant to current task.

Section 12. Reuse of PFAS-contaminated materials including soils and water (line 2212).

Reuse of PFAS-contaminated materials is different to use/reuse of PFAS-containing materials. If material is contaminated through exceeding threshold criteria for specific use, then it cannot be used. Dilution of PFAS contamination is not an acceptable waste management strategy to create material suitable for reuse (line 2222).

In the NEMP the term reuse is intended to apply to situation involving the permanent or long-term placement of material for a beneficial purpose in compliance with environmental legislation (line 2226).

The decision tree is intended to be applied only to soil and should not be used to inform the use of other solid materials such as solid organic wastes, biosolids or other resource recovery materials (line 2241).

However, if the soils proposed for reuse have become PFAS contaminated due to the incorporation of these materials into the soils, the decision three is applicable to those soils (line 2243).

Note also, that the decision tree does not address reuse of PFAS contaminated soil in agriculture (line 2245).

The decision tree is focussed on beneficial soil reuse (line 2246).

Adding soil with low levels of PFAS to areas that have even lower or no levels of PFAS should be considered only in consultation with the relevant regulatory authority in exception circumstances where there is no feasible, practicable alternative (line 2262).

Table 10 provides a general guide to the level of assessment that may be required for considering suitability for reuse of different organic waste types (line 2413).

Any assessment of PFAS risks associated with a particular waste type should include a detailed consideration of where and how the waste material is sourced, and the findings of such an assessment may then be used to inform potential requirements for PFAS analysis and monitoring of the material (line 2420).

Footnote to Table 10 refers to Section 15 where use of resource recovery products containing biosolids must comply with concentration criteria and CLBAR requirements (PFAS in the wastewater treatment system - line 3028). However, Section 15 does not consider any organic waste-derived product other than biosolids.

Some jurisdictions restrict or prohibit the use of PFAS-containing materials in resource-recovery products and/or place concentration limits on the PFAS content of input materials, and the products. Practitioners should ensure that proposed reuse is compliant with jurisdiction-specific regulations (line 2424). This is very vague with respect to organic waste products.

The need for feedstock management plans is described in Line 2430 that control, monitor and record potentially PFAS-impacted waste inputs to form a product. Further details are only presented for biosolids as a feedstock (Section 15.4). There are no specific guidelines for PFAS limits in feedstock.

Table 10 (line 2453) uses language ranging from *PFAS analysis or management may not be necessary* to *use in resource recovery products is likely to be prohibited*.

Section 13 PFAS Remediation and Management – not considered

Section 14 PFAS disposal to landfill – not considered

Section 15 – PFAS in the wastewater treatment system. This section is cited in earlier sections.

Section 15.4 specifically considers PFAS criteria in biosolids (line 3130).

Table 11 present criteria for PFAS in biosolids (line 3228). These are draft guidelines, and appear provisional. There is no apparent application to other waste products.

Section 16 Data sharing – not considered

Section 17 PFAS notification – not considered

Section 18 PFAS sampling

Table 12. General guidance on sampling environmental media and materials and reference to relevant NEMP sections by media (line 3306)

Organic waste and resource recovery materials and landfills: this part of the table lists sections of the NEMP that must be followed. Cites Section 8 (8.8), Section 9 (9.2), Section 10 and Section 12 (12.4). Cites section 15.4 PFAS criteria in biosolids – however this is limited to biosolids from wastewater treatment plants.

Section 19 PFAS analysis – not considered

Section 20 Future Work – not considered

Section 21 Review – not considered