



# NSW Biosolids Guideline Review

Threshold derivation for contaminants in biosolids –  
PFAS, HHCB, triclosan, chlordane and PBDEs

Department of Planning and Environment



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# Executive summary

The NSW Environment Protection Authority (EPA) is currently undertaking a review of *Environmental Guidelines: Use and Disposal of Biosolids Products* (the NSW Biosolids Guidelines). As part of this review, the Environment and Heritage Group – Contaminants and Risk Team (C&R) of the NSW Department of Planning and Environment has prepared this report presenting risk-based thresholds for selected contaminants in biosolids (per- and poly-fluoroalkyl substances [PFAS], HHCB<sup>1</sup>, triclosan, polybrominated diphenyl ethers [PBDEs] and chlordane). In the current NSW Biosolids Guidelines, these contaminants are not regulated, with the exception of chlordane. The risks from these contaminants were previously assessed by C&R, to identify key exposure pathways. The recommendations from the previous assessments were that these contaminants require regulation in ‘unrestricted use’ and ‘restricted use’ biosolids and that thresholds should be derived to ensure they pose a low risk to the environment and human health.

In the current report, C&R used a ‘backwards’ risk assessment approach to derive thresholds for these contaminants based on the key exposure pathways (ecological or human health) identified in the risk assessments. In most cases, the thresholds apply to individual compounds. However, for PBDEs, which are a large group of individual compounds, the thresholds are presented as 2 groups: Br1–Br9 (sum of PBDEs with between 1 and 9 bromine atoms) and Br10 (fully brominated deca-BDE). This was done due to differences in toxicity and environmental fate between these two groups. In addition, for PFAS, which are also a large group of compounds, thresholds have been derived only for the sum of perfluorooctane sulfonate and perfluorohexane sulfonate (PFOS+PFHxS), and perfluorooctanoic acid (PFOA). This is due to nationally accepted guidance being available only for these PFAS compounds.

The thresholds were derived with a 5-, 2- and 1-fold margin of safety for consideration by the NSW EPA (Table 1). The selection of the most appropriate margin of safety for regulation will depend on a range of factors including the presence of other contaminants in the biosolids and the potential for exposure via multiple pathways.

In addition to the biosolids thresholds, C&R also derived maximum allowable soil contaminant concentrations (MASCCs) based on agricultural use of biosolids. These values can be used to calculate a contaminant limiting biosolids application rate (CLBAR), which is an approach consistent with the NSW Biosolids Guidelines for restricted use biosolids. C&R has also prepared a draft framework for applying the restricted use thresholds and MASCCs for land application of biosolids for consideration by the NSW EPA.

C&R notes the thresholds and MASCCs presented in this report are based on calculations only and do not consider laboratory reporting limits. C&R recommends NSW EPA consults with commercial laboratories to ensure there are reliable analytical methods for each of these contaminants in biosolids and soils, and to ensure the appropriate reporting limits are achievable.

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<sup>1</sup> 4,6,6,7,8,8-hexamethyl-1,3,4,6,7,8-hexahydrocyclopenta[g]isochromene

**Table 1 Risk-based contaminant thresholds for unrestricted use biosolids, restricted use biosolids and maximum allowable soil contaminant concentrations (MASCCs) at 3 margins of safety (all concentrations shown in µg/kg dw)**

| Contaminant(s)    | Margin of safety | Unrestricted use threshold* | Restricted use threshold | MASCC  |
|-------------------|------------------|-----------------------------|--------------------------|--------|
| PFOS+PFHxS        | 5                | 0.22                        | 6.2                      | 0.22   |
|                   | 2                | 0.55                        | 15                       | 0.55   |
|                   | 1                | 1.1                         | 31                       | 1.1    |
| PFOA <sup>#</sup> | 5                | 2                           | 54                       | 2      |
|                   | 2                | 5                           | 130                      | 5      |
|                   | 1                | 10                          | 270                      | 10     |
| HHCB              | 5                | 150                         | 4,000                    | 150    |
|                   | 2                | 375                         | 10,000                   | 375    |
|                   | 1                | 750                         | 20,000                   | 750    |
| Triclosan         | 5                | 13                          | 350                      | 13     |
|                   | 2                | 32                          | 870                      | 32     |
|                   | 1                | 65                          | 1,700                    | 65     |
| Br1–Br9           | 5                | 1.0                         | 28                       | 1.0    |
|                   | 2                | 2.6                         | 70                       | 2.6    |
|                   | 1                | 5.1                         | 140                      | 5.1    |
| Br10              | 5                | 5,600                       | 260,000                  | 9,600  |
|                   | 2                | 14,000                      | 650,000                  | 24,000 |
|                   | 1                | 28,000                      | 1,300,000                | 48,000 |
| Chlordane         | 5                | 0.78                        | 21                       | 0.78   |
|                   | 2                | 1.9                         | 52                       | 1.9    |
|                   | 1                | 3.9                         | 100                      | 3.9    |

\* the unrestricted use thresholds should be applied to the final biosolids product

<sup>#</sup> the PFOA thresholds and MASCCs were derived to protect ecological secondary consumers and are based on a soil screening criterion adjusted from the United Kingdom (UK EA 2017). Part of the future work program for the PFAS National Environmental Management Plan (NEMP) is looking to derive PFOA soil screening criteria for indirect exposure (secondary consumers). If this happens, the thresholds presented in Table 1 should be updated.

# 1. Background and scope

The NSW Environment Protection Authority (NSW EPA) is currently undertaking a review of *Environmental Guidelines: Use and Disposal of Biosolids Products* (the NSW Biosolids Guidelines). As part of this review, the NSW Department of Planning and Environment - Environment and Heritage Group – Contaminants and Risk team (C&R) has prepared 2 reports using human health and/or ecological risk assessments to identify key exposure pathways for PFAS<sup>2</sup>, HHCB<sup>3</sup>, triclosan, polybrominated diphenyl ethers (PBDEs) and chlordane in biosolids (the risk assessment reports). Details about these contaminants, their concentrations in NSW biosolids and the outcomes of the risk assessments can be found in:

- *Identification of key exposure pathways to assess risks from PFAS in biosolids* (prepared by C&R) (the PFAS Biosolids Risk Assessment) (February 2023)
- *Identification of key exposure pathways to assess risks from HHCB, triclosan, chlordane and PBDEs in biosolids* (prepared by C&R) (the Combined Biosolids Risk Assessment) (April 2023).

The type of risk assessment conducted (human health and/or ecological) was determined by the outcomes of the Contaminants Review (WCA 2016) and included:

- PFAS – human health and ecological risk assessment (HHERA)
- HHCB – ecological risk assessment (ERA)
- triclosan – ERA
- PBDEs – human health risk assessment (HHRA)
- chlordane – HHERA.

The aim of the risk assessments was to determine if these contaminants in biosolids require regulation in NSW, and to identify the key exposure pathways that should be considered in the derivation of contaminant thresholds for biosolids. The risk assessments were based on measured concentrations of these contaminants in NSW biosolids and considered 4 scenarios of biosolids use:

- Scenario 1 – ‘unrestricted use’ biosolids in residential gardens
- Scenario 2 – ‘unrestricted use’ biosolids for land rehabilitation
- Scenario 3 – ‘restricted use’ biosolids in agriculture:
  - for a low (10 t/ha) and high (50 t/ha) application rate
  - for single and repeat (7-times) applications
- Scenario 4 (additional scenario) – ‘unrestricted use’ biosolids in agriculture.

Scenarios 1, 2 and 4 assumed the concentrations in unrestricted use biosolids were equal to the concentrations in a biosolids-amended soil (i.e. no dilution). Scenario 3 assumed that biosolids are land applied and incorporated into soil, as required by the NSW Biosolids Guidelines for restricted use biosolids applications in agriculture. The concentrations in a biosolids-amended soil for Scenario 3 were calculated based on assumptions agreed to through consultation with NSW Government agencies in May 2019. For each scenario, a range of relevant exposure pathways were assessed (human health and/or ecological depending on the type of risk assessment) (refer to the risk

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<sup>2</sup> Per- and poly-fluoroalkyl substances

<sup>3</sup> Trade name Galaxolide (4,6,6,7,8,8-hexamethyl-1,3,4,6,7,8-hexahydrocyclopenta[g]isochromene)

assessment reports for a list of exposure pathways that were assessed for each scenario and contaminant).

For PFAS, human health risks were assessed for the sum of perfluorooctane sulfonate and perfluorohexane sulfonate (PFOS+PFHxS), and perfluorooctanoic acid (PFOA). Whereas ecological risks were assessed for PFOS and PFOA. Although other PFAS were identified in the biosolids samples, these could not be quantitatively assessed due to a lack of screening criteria and/or toxicity reference values endorsed for use in Australia. For PBDEs, the risk assessment was based on data separated into 2 groups: Br1–Br9 (sum of PBDEs with between 1 and 9 bromine atoms) and Br10 (fully brominated deca-BDE). This was done due to differences in toxicity and environmental fate between these 2 groups.

The risk assessments concluded that all contaminants assessed required thresholds for regulation in both unrestricted and restricted use biosolids. C&R recommended the key exposure pathways identified from the risk assessments should be used to derive thresholds. The following sections of this report present thresholds based on key exposure pathways for unrestricted and restricted use biosolids. Following this, C&R has also derived maximum allowable soil contaminant concentrations (MASCCs) for agricultural uses of biosolids and a potential framework for applying these values.

## 1.1 Limitations

This report does not outline all of the assumptions and limitations discussed in the risk assessment reports. The information in this report should be considered in conjunction with the risk assessment reports prepared by C&R.

## 2. Threshold derivation

The risk assessment reports recommended thresholds are derived for PFAS (PFOS+PFHxS and PFOA), HHCB, triclosan, PBDEs (Br1–Br9 and Br10) and chlordane in unrestricted use and restricted use biosolids based on key exposure pathways. The key exposure pathways are the most sensitive (i.e. highest risk) human health or ecological pathways identified through the detailed risk assessments (Table 2). Focusing threshold derivation on the most sensitive exposure pathway should protect exposure via all other potential pathways.

**Table 2 Key exposure pathways used for threshold derivation for unrestricted and restricted use biosolids**

| Contaminant | Unrestricted use biosolids                          | Restricted use biosolids                            |
|-------------|---|---|
| PFOS+PFHxS  | Human consumption of milk from grazing dairy cows   | Human consumption of milk from grazing dairy cows   |
| PFOA        | Ecological toxicity to secondary consumers          | Ecological toxicity to secondary consumers          |
| HHCB        | Ecological direct toxicity to terrestrial organisms | Ecological direct toxicity to terrestrial organisms |
| Triclosan   | Ecological direct toxicity to terrestrial organisms | Ecological direct toxicity to terrestrial organisms |
| Br1–Br9     | Human consumption of beef from grazing cattle       | Human consumption of beef from grazing cattle       |
| Br10        | Human consumption of chicken eggs                   | Human consumption of beef from grazing cattle       |
| Chlordane   | Ecological toxicity to secondary consumers          | Ecological toxicity to secondary consumers          |

C&R has derived the thresholds presented in this report using ‘backwards’ risk calculations. This involves starting with an acceptable or tolerable exposure for the key exposure pathway and working backwards to determine an acceptable biosolids concentration. For contaminants where an ecological pathway was identified as the key exposure pathway, soil screening criteria have been used as the acceptable or tolerable exposure for the backwards risk calculations (Table 3). Where human health pathways were identified as the key exposure pathway, nationally accepted tolerable daily intakes (TDIs) (minus background exposure) have been used (Table 4).

C&R has derived thresholds at three margins of safety (i.e. 1, 2 and 5)<sup>4</sup> for consideration by the NSW EPA. All values have been rounded down to 2 significant figures. The thresholds have been derived for the NSW EPA to consider alongside other influencing

<sup>4</sup> A margin of safety of 1 means the estimated exposure is equal to the acceptable exposure (corresponds to a risk quotient [RQ] of 1). This does not account for exposure via other pathways. A margin of safety of 2 means the estimated exposure is 50% of the acceptable exposure (corresponds to an RQ of 0.5), and a margin of safety of 5 means the estimated exposure is 20% of the acceptable exposure (corresponds to an RQ of 0.2).

factors and for consultation with stakeholders. The selection of the most suitable margin of safety for regulation may also consider:

- Biosolids will likely contain a wide range of contaminants, regulated and unregulated. The toxicity of some of these may be additive which means that the risks and effects are cumulative.
- The thresholds were each derived based on a single exposure pathway, but exposure may occur via multiple pathways.
- The potential implementation of a tiered approach where thresholds can be reduced over time to encourage biosolids producers to manage and reduce contaminant inputs.

**Table 3 Ecological screening criteria used as the acceptable exposure concentration in the threshold derivation (µg/kg)**

| Contaminant | Acceptable exposure | Source/comment   |
|-------------|---------------------|--|
| PFOA        | 10                  | Based on UK EA (2017) soil screening criterion for secondary consumers (i.e. 0.02 mg/kg) and adjusted to 1.7% soil organic matter (see PFAS Biosolids Risk Assessment, Appendix B).  |
| HHCB        | 750                 | Based on soil screening criterion for direct terrestrial toxicity from the European Chemicals Agency (ECHA) (i.e. 1.5 mg/kg) <sup>1</sup> and adjusted to 1.7% soil organic matter (see Combined Biosolids Risk Assessment, Appendix A). |
| Triclosan   | 65                  | Based on UK EA (2020) soil screening criterion for direct terrestrial toxicity (i.e. 0.13 mg/kg) and adjusted to 1.7% soil organic matter (see Combined Biosolids Risk Assessment, Appendix A).  |
| Chlordane   | 3.9                 | C&R derived soil screening criterion for secondary consumers adjusted to 1% soil organic carbon (equivalent to 1.7% soil organic matter) (see Combined Biosolids Risk Assessment, Appendix A).   |

<sup>1</sup> ECHA webpage: <https://echa.europa.eu/registration-dossier/-/registered-dossier/14504>

C&R notes these calculations do not consider laboratory limit of reporting (LOR). C&R recommends commercial laboratories are consulted to ensure there are reliable analytical methods for each of these contaminants in biosolids and soils, and to ensure the required detection limits are achievable.

**Table 4** Human health tolerable daily intakes (TDI) and background exposure used to calculate the acceptable exposure for threshold derivation (all shown as µg/kg/day)

| Contaminant | TDI  | Background | Acceptable exposure <sup>1</sup> | Source/comment   |
|-------------|------|------------|----------------------------------|--|
| PFOS+PFHxS  | 0.02 | 0.001      | 0.019                            | TDI from FSANZ (2017) and background from ToxConsult 2016) |
| PFOA        | 0.16 | 0.001      | 0.159                            | TDI from FSANZ (2017) and background from ToxConsult 2016) |
| Br1–Br9     | 0.1  | 0.08       | 0.02                             | TDI and background from US EPA (2008a,b)                   |
| Br10        | 7.0  | 5.6        | 1.4                              | TDI and background from US EPA (2008c)                     |

<sup>1</sup> acceptable exposure = TDI – background

## 2.1 Derivation of thresholds for unrestricted use biosolids

The thresholds for unrestricted use biosolids have been derived at 3 margins of safety for each contaminant (Table 5). C&R notes these thresholds apply to the final unrestricted use biosolids product. For example, if the biosolids are combined with another material to produce unrestricted use biosolids (e.g. garden waste), these thresholds apply to the final product to be land applied. This will ensure additional contamination is not introduced through other wastes. The derivation of these thresholds assumes an unrestricted use biosolids can be land applied as a topsoil (i.e. with no restriction on application rate). Therefore, they assume no dilution of the biosolids into the soil.

Table 5 also shows the percentage of biosolids data (either from the NSW EPA sampling campaign or the chlordane-specific data from water utilities) that exceed the derived thresholds. These percentages are based on the estimated concentrations in unrestricted use biosolids from the biosolids risk assessment reports.

**Table 5**      **Unrestricted use biosolids thresholds based on key exposure pathways at 3 margins of safety (1, 2 and 5) and percentage of biosolids samples that exceed the thresholds<sup>1</sup>**

| Contaminant       | Key receptor | Key pathway                                | Margin of safety | Threshold <sup>3</sup><br>(µg/kg dw) |
|-------------------|--------------|--|------------------|--------------------------------------|
| PFOS+PFHxS        | Human health | Consumption of milk from grazing dairy cow | 5                | 0.22<br>(100%)                       |
|                   |              |  | 2                | 0.55<br>(100%)                       |
|                   |              |  | 1                | 1.1<br>(98%)                         |
| PFOA <sup>2</sup> | Ecology      | Terrestrial secondary consumer             | 5                | 2<br>(53%)                           |
|                   |              |  | 2                | 5<br>(7.5%)                          |
|                   |              |  | 1                | 10<br>(0%)                           |
| HHCB              | Ecology      | Direct terrestrial toxicity                | 5                | 150<br>(98%)                         |
|                   |              |  | 2                | 375<br>(93%)                         |
|                   |              |  | 1                | 750<br>(83%)                         |
| Triclosan         | Ecology      | Direct terrestrial toxicity                | 5                | 13<br>(93%)                          |
|                   |              |  | 2                | 32<br>(80%)                          |
|                   |              |  | 1                | 65<br>(65%)                          |
| Br1–Br9           | Human health | Consumption of beef from grazing cattle    | 5                | 1.0<br>(100%)                        |
|                   |              |  | 2                | 2.6<br>(100%)                        |
|                   |              |  | 1                | 5.1<br>(100%)                        |
| Br10              | Human health | Consumption of chicken eggs                | 5                | 5,600<br>(5%)                        |
|                   |              |  | 2                | 14,000<br>(5%)                       |
|                   |              |  | 1                | 28,000<br>(5%)                       |

| Contaminant | Key receptor | Key pathway                     | Margin of safety | Threshold <sup>3</sup><br>(µg/kg dw) |
|-------------|--------------|---------------------------------|------------------|--------------------------------------|
| Chlordane   | Ecology      | Terrestrial secondary consumers | 5                | 0.78<br>(98%)*                       |
|             |              |                                 | 2                | 1.9<br>(55%)*                        |
|             |              |                                 | 1                | 3.9<br>(36%)*                        |

<sup>1</sup> the percentages are based on the estimated concentrations in unrestricted use biosolids presented in the risk assessment reports

<sup>2</sup> the PFOA unrestricted use biosolids thresholds were derived to protect ecological secondary consumers and are based on a soil screening criterion adjusted from the United Kingdom (UK EA 2017). Part of the future work program for the PFAS National Environmental Management Plan (NEMP) is looking to derive PFOA soil screening criteria for indirect exposure (secondary consumers). If this happens, the thresholds presented in Table 5 should be updated.

<sup>3</sup> Thresholds should apply to the final unrestricted use biosolids product

\* percentage of chlordane data exceeding the threshold may be an overestimate due to the range of LORs. Where concentrations were < LOR the LOR was used as the concentration when calculating percentages. C&R notes some of the LORs were less than the thresholds in Table 5.

## 2.2 Derivation of thresholds for restricted use biosolids

The thresholds for restricted use biosolids were based on agricultural use of biosolids, where there are restrictions on application rates (based on nutrients or contaminants). Therefore, some assumptions were required about how biosolids may be land applied in agriculture. This includes assumptions about the land-application rate, incorporation depth, and soil bulk density to allow conversion from a biosolids concentration to a soil concentration (or vice versa in the case of a backwards risk assessment) (Table 6). The land-application assumptions are designed to be conservative but realistic. All assumptions were finalised through discussions with other NSW Government agencies in May 2019.

Using these land-application assumptions, C&R derived biosolids thresholds at the 3 margins of safety (Table 7) based on key exposure pathways (Table 2). Table 7 also shows the percentage of biosolids data (either from the NSW EPA sampling campaign or the chlordane-specific data from water utilities) that exceed the derived thresholds.

These thresholds assume there is no contamination from these compounds in the in-situ soil at the land application site. C&R recommends that before biosolids application, in-situ soil is sampled and analysed for these compounds to determine the background concentrations that need to be considered in determining a biosolids application rate that will be protective. In Section 3 of this report, C&R presents a potential framework for applying these thresholds with consideration of the in-situ soil concentrations.

**Table 6 Land application assumptions used to derive thresholds for restricted use biosolids in agriculture**

| Parameter             | Value | Units             | Rationale   |
|-----------------------|-------|-------------------|---|
| Land-application rate | 50    | dry t/ha          | Maximum application rate based on information from the NSW water utilities is about 35 dry t/ha. 50 t/ha gives an additional buffer and allows for variation in the application process.                                      |
| Incorporation depth   | 10    | cm                | The current NSW Biosolids Guidelines use 7.5 cm but a deeper incorporation depth is likely based on the equipment used.   |
| Soil bulk density     | 1.3   | g/cm <sup>3</sup> | Standard consideration and roughly consistent with the current NSW Biosolids Guidelines that assume 1.333 g/cm <sup>3</sup> . With an incorporation depth of 10 cm, this assumes the biosolids are mixed with 1300 t soil/ha. |

**Table 7 Restricted use biosolids thresholds based on key exposure pathways at 3 margins of safety (1, 2 and 5) and the percentage of biosolids samples that exceed the thresholds<sup>1</sup>**

| Contaminant       | Key receptor | Key pathway                                | Margin of safety | Threshold (µg/kg dw) |
|-------------------|--------------|--|------------------|----------------------|
| PFOS+PFHxS        | Human health | Consumption of milk from grazing dairy cow | 5                | 6.2 (90%)            |
|                   |              |  | 2                | 15 (73%)             |
|                   |              |  | 1                | 31 (40%)             |
| PFOA <sup>2</sup> | Ecology      | Terrestrial secondary consumer             | 5                | 54 (0%)              |
|                   |              |  | 2                | 130 (0%)             |
|                   |              |  | 1                | 270 (0%)             |
| HHCB              | Ecology      | Direct terrestrial toxicity                | 5                | 4,000 (75%)          |
|                   |              |  | 2                | 10,000 (63%)         |
|                   |              |  | 1                | 20,000 (50%)         |
| Triclosan         | Ecology      | Direct terrestrial toxicity                | 5                | 350 (65%)            |
|                   |              |  | 2                | 870 (53%)            |
|                   |              |  | 1                | 1,700 (40%)          |

| Contaminant | Key receptor | Key pathway                             | Margin of safety | Threshold (µg/kg dw) |
|-------------|--------------|---|------------------|----------------------|
| Br1–Br9     | Human health | Consumption of beef from grazing cattle | 5                | 28 (93%)             |
|             |              |   | 2                | 70 (68%)             |
|             |              |   | 1                | 140 (10%)            |
| Br10        | Human health | Consumption of beef from grazing cattle | 5                | 260,000 (0%)         |
|             |              |   | 2                | 650,000 (0%)         |
|             |              |   | 1                | 1,300,000 (0%)       |
| Chlordane   | Ecology      | Terrestrial secondary consumers         | 5                | 21 (26%)             |
|             |              |   | 2                | 52 (12%)             |
|             |              |   | 1                | 100 (5.2%)           |

<sup>1</sup> the percentages are based on the biosolids data presented in the risk assessment reports

<sup>2</sup> the PFOA restricted use biosolids thresholds were derived to protect ecological secondary consumers and are based on a soil screening criterion adjusted from the United Kingdom (UK EA 2017). Part of the future work program for the PFAS National Environmental Management Plan (NEMP) is looking to derive PFOA soil screening criteria for indirect exposure (secondary consumers). If this happens, the thresholds presented in Table 7 should be updated.

## 2.3 Derivation of maximum allowable soil contaminant concentrations

The MASCCs are used in the NSW Biosolids Guidelines to allow biosolids land appliers to calculate a contaminant limiting biosolids application rate (CLBAR) for restricted use biosolids. C&R has used a similar backwards risk calculation as the one used for the biosolids threshold derivation to calculate MASCCs for PFOS+PFHxS, PFOA, HHCB, triclosan, Br1–Br9, Br10 and chlordane (Table 8). These were calculated to protect agricultural land uses and therefore used the same key pathways as used for the restricted use thresholds.

**Table 8 Maximum allowable soil contaminant concentrations (MASCCs) based on key exposure pathways at 3 margins of safety (1, 2 and 5)**

| Contaminant       | Key receptor | Key pathway                                | Margin of safety | MASCC (µg/kg dw) |
|-------------------|--------------|--|------------------|------------------|
| PFOS+PFHxS        | Human health | Consumption of milk from grazing dairy cow | 5                | 0.22             |
|                   |              |  | 2                | 0.55             |
|                   |              |  | 1                | 1.1              |
| PFOA <sup>1</sup> | Ecology      | Terrestrial secondary consumers            | 5                | 2                |
|                   |              |  | 2                | 5                |
|                   |              |  | 1                | 10               |
| HHCB              | Ecology      | Direct terrestrial toxicity                | 5                | 150              |
|                   |              |  | 2                | 375              |
|                   |              |  | 1                | 750              |
| Triclosan         | Ecology      | Direct terrestrial toxicity                | 5                | 13               |
|                   |              |  | 2                | 32               |
|                   |              |  | 1                | 65               |
| Br1–Br9           | Human health | Consumption of beef from grazing cattle    | 5                | 1.0              |
|                   |              |  | 2                | 2.6              |
|                   |              |  | 1                | 5.1              |
| Br10              | Human health | Consumption of beef from grazing cattle    | 5                | 9,600            |
|                   |              |  | 2                | 24,000           |
|                   |              |  | 1                | 48,000           |
| Chlordane         | Ecology      | Terrestrial secondary consumers            | 5                | 0.78             |
|                   |              |  | 2                | 1.9              |
|                   |              |  | 1                | 3.9              |

<sup>1</sup> the PFOA restricted use biosolids thresholds were derived to protect ecological secondary consumers and are based on a soil screening criterion adjusted from the United Kingdom (UK EA 2017). Part of the future work program for the PFAS National Environmental Management Plan (NEMP) is looking to derive PFOA soil screening criteria for indirect exposure (secondary consumers). If this happens, the thresholds presented in Table 8 should be updated.

### 3. Potential framework for screening restricted use biosolids for land application

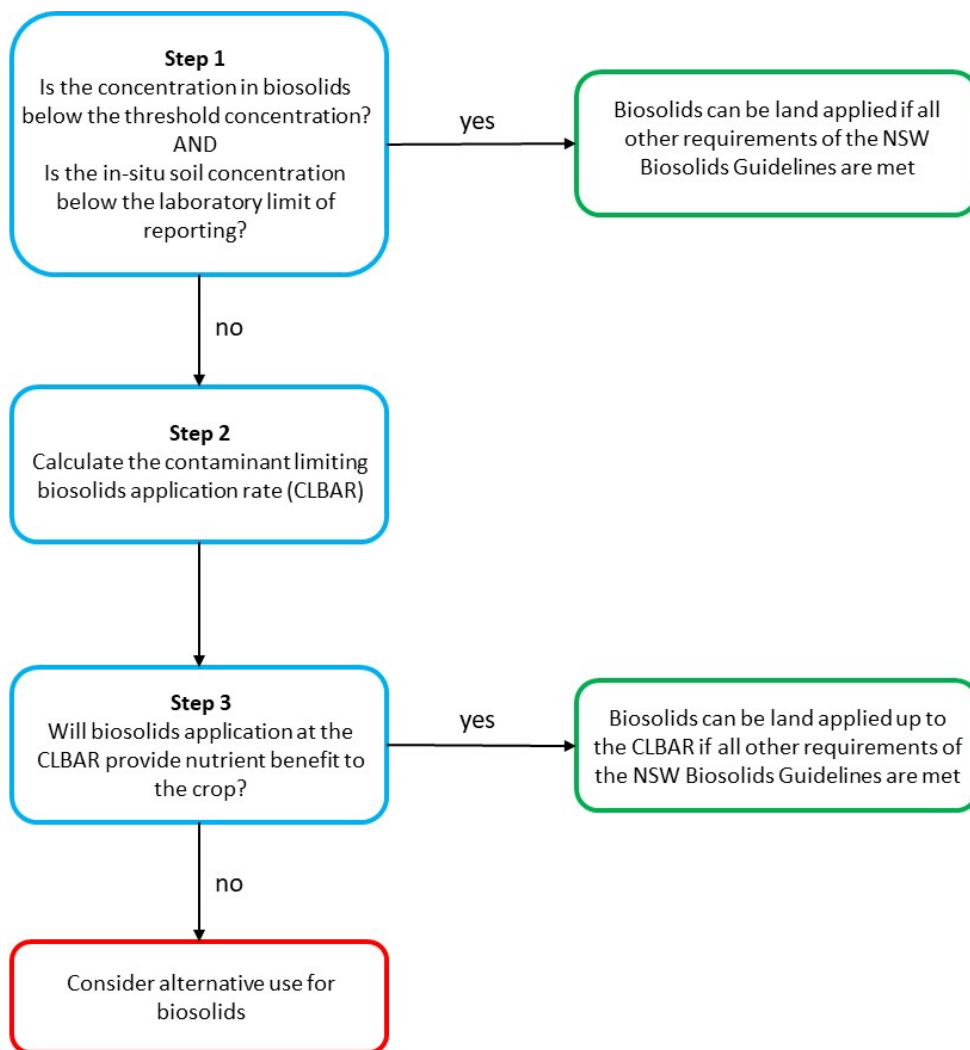
Using the restricted use biosolids thresholds and MASCCs presented in Section 2, C&R has developed a framework for applying these values for consideration by the NSW EPA. This draft framework provides a potential approach for water utilities/land appliers to screen biosolids for land application and determine the maximum application rates based on contaminant concentrations. This is a multi-tiered approach where each step determines the need to progress to the next step.

#### 3.1 Data and information required to screen biosolids for land application

The following data and information are required to apply the draft framework:

- concentrations of contaminants in biosolids to be land applied (this should be based on the sampling requirements outlined in the NSW Biosolids Guidelines)
- concentrations of contaminants in the in-situ soil at the proposed land application site (for example summarised as the 95UCL or the maximum if there are limited data)
- information about the proposed land application and soil properties, including the depth of incorporation and soil bulk density (conservative default values can be used if these are not available).

The following flowchart (Figure 1) can then be used to screen the biosolids for land application. Each of the components in the flow chart are discussed below. Some worked examples of applying this framework are provided in Appendix A.



**Figure 1: Draft potential biosolids assessment framework for land application**

### 3.1.1 Step 1 – screening biosolids and in-situ soil concentrations

In Step 1, the concentrations of each contaminant are screened against the restricted use biosolids threshold concentrations presented in this document, and the in-situ soil concentrations are used to determine if steps 2 and 3 are needed before the biosolids can be land applied. If the biosolids concentrations are below the thresholds **and** the in-situ soil concentrations are below the laboratory limit of reporting (LOR)<sup>5</sup>, then the biosolids can be land applied as long as all other requirements of the NSW Biosolids Guidelines are met. If both of these considerations are not met, the assessment should move to steps 2 and 3.

<sup>5</sup> The analysis used should have the lowest LOR achievable for biosolids and soil at the time of assessment.

### 3.1.2 Step 2 – calculation of the contaminant limiting biosolids application rate

The CLBAR considers the concentration of a contaminant in the biosolids and in the soil at the proposed land application site, together with the soil mass that the biosolids will be incorporated into. The CLBAR can be calculated using Equation 1.

$$CLBAR = \frac{MASCC - MISCC}{C_{bio}} \times SM \quad \text{Equation 1}$$

where:

CLBAR = contaminant limiting biosolids application rate (dry t/ha)

MASCC = maximum allowable soil contaminant concentration (µg/kg dw)

MISCC = measured in-situ soil contaminant concentration (µg/kg dw)

$C_{bio}$  = biosolids concentration of contaminant (µg/kg dw)

SM = incorporated soil mass per hectare (dry t/ha) (Equation 2)

$$SM = 10,000 \text{ m}^2/\text{ha} \times ID \times BD \quad \text{Equation 2}$$

where:

ID = incorporation depth (m) (if unknown, a default value of 0.1 m can be used)

BD = bulk density (t/m<sup>3</sup>) (if unknown, a default value of 1.3 t/m<sup>3</sup> can be used<sup>6</sup>).

### 3.1.3 Step 3 – determine if re-use will be beneficial

In NSW, the re-use of waste needs to be beneficial to comply with the resource recovery framework. For Step 3, the nutrient requirements of the crops to be planted following biosolids application should be considered to determine if land application at the CLBAR will provide agronomic benefit. This should be determined through consultation with a qualified agronomist. If the application rate will provide benefit, the biosolids can be land applied up to the CLBAR of the most limiting contaminant, if all other requirements of the NSW Biosolids Guidelines are met. If the biosolids are to be land applied below the CLBAR, it must still provide benefit. If the land application rate at the CLBAR of the most limiting contaminant will not provide benefit for the crops, an alternative use of the biosolids must be considered.

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<sup>6</sup> Soil bulk density is often reported as g/cm<sup>3</sup>. Unit conversion is 1 g/cm<sup>3</sup> = 1 t/m<sup>3</sup>.

## 4. References

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# Appendix A: Worked examples for applying the draft framework

## Worked example 1

As an example, the following data and information are available for land application of restricted use biosolids containing PFOS+PFHxS and PFOA:

- biosolids thresholds (example assumes 2-fold margin of safety [MOS] is used):
  - PFOS+PFHxS = 15 µg/kg dw (using a 2-fold margin of safety)
  - PFOA = 130 µg/kg dw (using a 2-fold margin of safety)
- biosolids concentrations:
  - PFOS+PFHxS concentration = 65 µg/kg dw
  - PFOA concentration = 20 µg/kg dw
- in-situ soil concentrations:
  - PFOS+PFHxS < LOR
  - PFOA < LOR
- incorporation depth – 0.15 m
- soil bulk density is unknown so default of 1.3 t/m<sup>3</sup> will be used.

### Step 1

The concentration of PFOS+PFHxS of 65 µg/kg dw is above the biosolids threshold concentration of 15 µg/kg dw (e.g. if the biosolids threshold based on MOS = 2 is used). Based on this, steps 2 and 3 need to be completed (as per Figure 1). No further consideration is required based on the PFOA concentrations.

### Step 2

Calculate the incorporated soil mass per ha (SM):

$$\begin{aligned}\text{SM} &= 10,000 \text{ m}^2/\text{ha} \times \text{ID m} \times \text{BD t/m}^3 \\ &= 10,000 \times 0.15 \times 1.3 \\ &= 1,950 \text{ t/ha}\end{aligned}$$

Calculate the CLBAR<sup>7</sup>:

$$\begin{aligned}\text{CLBAR} &= [(\text{MASCC } \mu\text{g/kg} - \text{MISCC } \mu\text{g/kg}) / \text{C}_{\text{bio}} \mu\text{g/kg}] \times \text{SM t/ha} \\ &= [(0.55 - 0) / 65] \times 1,950 \\ &= 16.5 \text{ t/ha}\end{aligned}$$

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<sup>7</sup> Worked examples provided here assume a zero concentration when the measured concentration is below the LOR. This is not consistent with the guidance in the current NSW Biosolids Guidelines which recommends using ½ the LOR when measured concentrations are < LOR. C&R notes that using ½ the LOR when concentrations are < LOR for PFOS and/or PFHxS may be problematic due to the relatively low MASCC. Current LORs for PFOS and PFHxS in soils and biosolids should be confirmed with commercial laboratories. **C&R recommends the most suitable approach here is discussed in more detail with the NSW EPA and other NSW Government agencies to determine the best approach in this instance.**

### Step 3

An assessment of the beneficial re-use of the biosolids is completed and it is determined that based on the nitrogen concentration in the biosolids, an application rate of 16.5 t/ha will provide a benefit to the crop.

### Outcome

An application of 16.5 t/ha does not exceed other limiting requirements for the biosolids (e.g. the nitrogen limiting biosolids application rate, NLBAR) and concentrations of all other contaminants comply with the NSW Biosolids Guidelines. Considering this, the biosolids are land applied at 16.5 dry t/ha.

## Worked example 2

As an example, the following data and information are provided for land application of restricted use biosolids containing triclosan and HHCB:

- biosolids thresholds (example assumes 2-fold margin of safety is used):
  - triclosan = 870 µg/kg dw (using a 2-fold margin of safety)
  - HHCB = 10,000 µg/kg dw (using a 2-fold margin of safety)
- biosolids concentrations:
  - triclosan concentration = 850 µg/kg dw
  - HHCB concentration = 950 µg/kg dw
- in-situ soil concentrations:
  - triclosan = 28 µg/kg dw
  - HHCB < LOR
- incorporation depth – 0.1 m
- soil bulk density is unknown so default of 1.3 t/m<sup>3</sup> will be used.

### Step 1

Although the concentrations of both triclosan and HHCB are below the corresponding thresholds (870 and 10,000 µg/kg, respectively), the concentration of triclosan is above the LOR in the in-situ soil at the land application site. Based on this, steps 2 and 3 need to be completed (as per Figure 1). No further consideration is required based on the HHCB concentrations.

### Step 2

Calculate the incorporated soil mass per ha (SM):

$$\begin{aligned}\text{SM} &= 10,000 \text{ m}^2/\text{ha} \times \text{ID m} \times \text{BD t/m}^3 \\ &= 10,000 \times 0.1 \times 1.3 \\ &= 1,300 \text{ t/ha}\end{aligned}$$

Calculate the CLBAR:

$$\begin{aligned}\text{CLBAR} &= [(\text{MASCC } \mu\text{g/kg} - \text{MISCC } \mu\text{g/kg}) / \text{C}_{\text{bio}} \mu\text{g/kg}] \times \text{SM t/ha} \\ &= [(32-28)/850] \times 1,300 \\ &= 6.1 \text{ t/ha}\end{aligned}$$

**Step 3**

An assessment of the beneficial re-use of the biosolids is completed and it is determined that based on the nitrogen concentration in the biosolids, an application rate of 6.1 t/ha will not provide a benefit to the crop.

**Outcome**

An alternative use for the biosolids is considered.