



Manaaki Whenua  
Landcare Research

# Updating the Ecological Soil Guideline Values (Eco-SGVs)

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# Updating the Ecological Soil Guideline Values (Eco-SGVs)

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# Summary

## Project and client

- Manaaki Whenua – Landcare Research was asked to provide an update of the *Guidance on Background Concentrations and Ecological Soil Guideline Values* for Gisborne District Council in light of a review of relevant documents and international developments (as Envirolink Advice Grant 1935-GSDC156).

## Objectives

- To review the methodology used for deriving New Zealand ecological soil guideline values (Eco-SGVs) in light of recent international developments in the derivation of threshold values (OECD guidance, and a threshold calculator for metals in soil).
- To review the Eco-SGV for boron with regard to its application/relationship to water-soluble boron.
- To update the technical guidance supporting these Eco-SGVs where review indicated areas that were unclear, and where this could be readily undertaken.

## Methods

- The OECD guidance and the supporting documents for the threshold calculator were reviewed to assess the methods used and the values generated in comparison to the previously derived Eco-SGVs.
- Changes to the Eco-SGVs are summarised in this report, and annotated versions of the Eco-SGV technical document and user guide have been provided.

## Results and conclusions

- The methodology used to develop the New Zealand Eco-SGVs was generally consistent with that used for the international guidance, except that geomeans of microbial data were not used for copper and zinc Eco-SGVs, for which toxicity data were able to be adjusted for soil properties (normalised). Using the geomean of the microbial data generally increases the added concentration limits (ACLs).
- The revised ACLs were compared with values derived through the threshold calculator, which revealed some differences despite a similar approach and the use of similar studies. This difference was attributable to the use of effect concentration data developed from dose-response curves, and differences in the studies used.
- An empirical relationship between hot-water-soluble boron, a commonly used method of analysis, and spiked boron, used in toxicity tests, was identified and used to derive an ACL for boron expressed as hot-water-soluble boron.
- Further amendments were made to the supporting documents to improve clarity. These changes are summarised in this report.

## **Recommendations**

- Further consultation and discussion with central government, regional councils, industry groups (e.g. contaminated land practitioners, the waste industry, the organic waste sector) and other stakeholders on the currently proposed application for background soil concentrations and Eco-SGVs is required. This includes ensuring the intended approach is consistent with current New Zealand policy.
- Ultimately, national policy needs to be developed for the protection of soil quality and contaminated land management that includes the protection of terrestrial biota.



# 1 Introduction

Ecological soil guideline values (Eco-SGVs) developed to protect terrestrial biota (soil microbes, invertebrates, plants, wildlife and livestock) provide a useful way to readily assess the potential environmental impact from environmental contaminants. The absence of national Eco-SGVs in New Zealand has resulted in inconsistency and a lack of clarity for the protection of ecological receptors in soil, and a lack of focus on ensuring this protection in territorial and regional/unitary council functions.

Envirolink Tools Grant C09X1402 funded the development of New Zealand guidance on both natural background concentrations and Eco-SGVs for common soil contaminants to assist in protecting environmental receptors (including microbes, invertebrates, plants, and higher animals) in soils and their associated ecosystems. This resulted in the publication of the following three documents:

- *Development of Soil Guideline Values for the Protection of Ecological Receptors (Eco-SGVs): Technical Document* (June 2016)
- *Background Soil Concentrations of Selected Trace Elements and Organic Contaminants in New Zealand* (November 2015)
- *User Guide: Background Soil Concentrations and Soil Guideline Values for the Protection of Ecological Receptors (Eco-SGVs) – Consultation draft* (June 2016).

As part of the next steps identified in the *User Guide*, a peer review of the three guideline documents was undertaken by Dr Nick Kim of Massey University<sup>1</sup> in 2017/18 (Kim 2018). Also, since completion of the guidelines, the Organisation for Economic Co-operation and Development (OECD) has released guidance on incorporating bioavailability into soil guideline development (OECD 2017), and a soil threshold calculator has also been released.<sup>2</sup> Both of these developments build on research undertaken over the last decade for the risk assessment of metals triggered under the EU Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) process.

To be able to engage with the Ministry for the Environment in discussions on the high-priority need for central government leadership in the finalisation and national implementation of the *Guidance on Background Concentrations and Ecological Soil Guideline Values*, the Resource Manager's Group (RMG) recommended that an update of the guidelines be undertaken in light of the review and international developments. This report provides that update.

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<sup>1</sup> Envirolink Medium Advice Grant 1847-MLDC139

<sup>2</sup> <https://www.arche-consulting.be/tools/threshold-calculator-for-metals-in-soil/>.

## 2 Background

A brief description of the method used to derive the Eco-SGVs is presented below to provide a context for the report. Full details can be found in Cavanagh & Munir 2016.

### 1 Collation and screening of the data

Data collated and evaluated for the development of the Australian Ecological Investigation Levels (NEPC 2013) as well as under the REACH programme (EC 2007, 2008; ECI 2008; LDAI 2008) was compiled as a first step. Additional data were sourced from Cavanagh & O'Halloran 2006, and Cavanagh 2006, and by literature review to identify any more recent studies (in particular those from 2009 onwards).

### 2 Standardisation of the toxicity data

The LOEC/EC30<sup>3</sup> is the preferred toxicological endpoint for deriving Eco-SGVs in New Zealand, and is consistent with the approach used to derive ecological investigation levels in Australia (NEPC 2013). To maximise the data available to derive Eco-SGVs, toxicity data were converted to LOEC/EC30, using conversion factors where required.

### 3 Incorporation of an ageing/leaching factor for aged contaminants

Ageing and leaching processes tend to decrease the toxicity of contaminants added to soil. To more adequately reflect field effects, Eco-SGVs for most contaminants are developed for aged/leached contamination only. Copper and zinc are the exceptions, as these contaminants may be present in wastes such as stormwater discharged to land, and in a form that is similar to freshly spiked soils used for toxicity testing.

### 4 Normalisation of the toxicity data to New Zealand reference soils

Normalisation relationships attempt to minimise the effect of soil characteristics on the toxicity data so that the resulting toxicity data will more closely reflect the inherent sensitivity of the test species to the contaminant. Three reference soils were defined for New Zealand – typical soil, sensitive soil and tolerant soil – with the general soil properties provided in Table 1. Many normalisation relationships use pH determined in CaCl<sub>2</sub>, and effective cation-exchange capacity (eCEC, which is CEC at the pH of the soil), so the soil properties were adjusted to these values (Table 2) using relationships identified from the literature (see Cavanagh & Munir 2016 for details).

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<sup>3</sup> EC30 = effective concentration at which effects are observed in 30% of the test population/there is a 30% decrease in the endpoint being assessed.

**Table 1. Soil characteristics for New Zealand reference soils to be used to normalise toxicity data. Properties were determined from the National Soils Database**

Soil property	Sensitive soil (Recent soil)	Typical soil (Brown soil)	Tolerant soil (Allophanic soil)
pH (H <sub>2</sub> O)	5.0 <sup>1</sup>	5.4 (170)	5.5 (55)
Clay (%)	17 (83)	21 (216)	23 (49)
CEC (cmol/kg)	13 (154)	20 (366)	30 (103)
Org. carbon (%)	3.1 (159)	4.6 (363)	9.4 (101)

Notes: values in parenthesis are the number of samples used to determine characteristics; CEC = cation exchange capacity. <sup>1</sup>The actual mean pH for recent soils was 5.7 (greater than both the typical soil, and tolerant soil), but as soils with lower pH often have greater toxicity a pH of 5 was used here.

**Table 2. Soil characteristics for New Zealand reference soils adjusted for use in normalisation equations**

Soil property	Sensitive soil (Recent soil)	Typical soil (Brown soil)	Tolerant soil (Allophanic soil)
pH (CaCl <sub>2</sub> )	4.5	4.8	4.9
Clay (%)	17	21	23
CEC (cmol/kg)	15	19.5	30.1
Org. carbon (%)	3.1	4.6	9.4

Note: CEC = cation exchange capacity

- 5 Calculation of an added contaminant limit (ACL) by either the species sensitivity distribution (SSD) or assessment factor (AF) approach, depending on the toxicity data.

If sufficient data are available, the preferred methodology is the use of a species sensitivity distribution (SSD), because this is a risk-based approach. Where insufficient data are available, the assessment factor approach should be used, although this also has minimum data requirements. Where normalised plant and invertebrate toxicity data are used, SSD methods employ a single numerical value (geomean) to describe each species for the most sensitive endpoint, where different endpoints have been used.

Where toxicity data cannot be normalised, all screened data were retained to more adequately represent the variation in toxicity associated with variation in soil properties. Geomeans were not calculated for microbial processes, as different soils effectively represent different microbial communities, which may therefore respond differently.

The BurrliOZ programme<sup>4</sup> was used to derive added contaminant limits (ACLs) in this report. This software preferentially uses the Burr Type III method to determine the

<sup>4</sup> <https://research.csiro.au/software/burrlioz/>

SSD and was used to derive the Australian and New Zealand Water Quality Guidelines (WQG) (ANZECC & ARMCANZ 2000, Warne et al 2018).

## 6 Accounting for secondary poisoning

The approach adopted here to address secondary poisoning and transfer through the food chain is to increase the level of protection (i.e. the percentage of species and/or soil processes to be protected) by 5% (i.e. to 85% from 80%). Due to mathematical constraints, if the level of protection is 95%, the increased level of protection is 99%. This is a pragmatic approach but is not necessarily scientifically rigorous, and it may result in values that are under- or over-protective. However, the approach recognises the paucity of New Zealand data available for a food-web approach, which is often used internationally. This approach is also consistent with that used in NEPC 2013, which in turn is consistent with the approach used in the Australian and New Zealand water quality guidelines (ANZECC & ARMCANZ 2000, Warne et al 2018).

## 7 Determination of the background concentration (BC) of the contaminant in the soil

Background concentrations were determined in Cavanagh et al. 2015, with information for specific locations available from Land Resource Information Systems (LRIS).<sup>5</sup>

## 8 Calculation of the Eco-SGV by summing the ACL and BC values: $\text{Eco-SGV} = \text{BC} + \text{ACL}$

The approach of 'adding' the background concentration to the derived toxicity limit is known as the 'added-risk' approach. This approach assumes that the availability of the background concentrations of a contaminant is zero, or sufficiently close to zero that it makes no practical difference, and that it is the added anthropogenic amounts that are of primary importance for toxicity considerations (e.g. Crommentuijn et al. 2000). This approach is used internationally and ensures that derived values don't fall below naturally occurring concentrations.

The toxicity data predominantly used are those that have sub-lethal endpoints, and they can be considered chronic (long-term) studies.

- For plants this includes biomass (above and below ground), seedling emergence, root and shoot elongation, yield, and seed production.
- For invertebrates, measured endpoints are typically growth and reproduction (number of juveniles or cocoons).
- Microbial tests use chemical endpoints related to soil functions or processes that are closely linked to biogeochemical processes linked to soil fertility. Some examples include potential nitrification rate, soil respiration, nitrogen mineralisation and enzymes such as phosphatase. Preference is given to non-enzymatic data, but these are the only data available to assess the effect of contaminants on the phosphorous and sulphur cycles.

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<sup>5</sup> <https://lris.scinfo.org.nz/>

Some mortality data was used where there was limited toxicity data available (e.g. for arsenic), and the mortality data were for species for which no other data were available and were in the range of sub-lethal effects of other species. Most often the NOEC<sup>6</sup> or EC10<sup>7</sup> is used. Other endpoints may be used, such as the LOEC<sup>8</sup> or EC30<sup>9</sup>.

The actual values for Eco-SGVs are determined by decisions that are made about the toxicological data used (i.e. the effect level) and the level of protection afforded by the Eco-SGVs. These decisions are more a matter of policy and consensus rather than science, and should take into account the intended application of the Eco-SGVs. As a result, the intended application, effect levels and level of protection were determined through the advisory group, which comprised central and local government representatives, established for the project, and workshops with regional councils. Eco-SGVs were developed using EC30 data for different land uses, which provided different levels of protection of the soil biota. Feedback on the proposed approach was also sought through workshops with the organic waste sector and contaminated land practitioners.

### 3 Objectives

- To review the Eco-SGVs in view of recent international developments in the derivation of threshold values, specifically the use of geometric mean (geomean) data for microbial toxicity endpoints.
- To review the Eco-SGV for boron to consider its application/relationship to water-soluble boron.
- To update the technical guidance supporting these Eco-SGVs where the previous review had indicated areas that were unclear, where this could be readily undertaken.

### 4 Methods

A brief review was undertaken of the approaches to deriving soil thresholds outlined in the OECD guidance (*Guidance on the Incorporation of Bioavailability Concepts for Assessing the Chemical Ecological Risk and/or Environmental Threshold Values of Metals and Inorganic Metal Compounds*) and in a background document for the threshold calculator (Oorts 2018). These approaches were compared with the approach used to derive the Eco-SGVs, with the results and any changes to the Eco-SGVs provided in this report.

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<sup>6</sup> NOEC = no observed effect concentration.

<sup>7</sup> EC10 = effective concentration at which there is a 10% reduction in the endpoint (e.g. shoot growth, root elongation) being measured.

<sup>8</sup> LOEC = lowest observed effect concentration.

<sup>9</sup> EC30 = effective concentration at which at which there is a 30% reduction in the endpoint (e.g. shoot growth, root elongation) being measured.

A brief literature review was undertaken to look at alternative methods for expressing the boron Eco-SGV.

Finally, areas where review (Kim 2018) had indicated a lack of clarity and that could be readily updated were identified and changes made to the respective documents.

This report provides a discussion and summary of the changes made to the Eco-SGVs and to the guidance documents. Changes to the previous guidance document (Cavanagh and Munir 2016, Cavanagh 2016) were made in tracked changes, with track-change and clean versions provided separately.

## 5 Results

### 5.1 Review of the Eco-SGV methodology and underlying data

The methodology used to derive Eco-SGVs drew on methods used to develop ecological investigation levels in Australia (NEPC 2013), and methods used for risk assessments of metals under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) process. In 2017, as a result of the significant amount of research that had been undertaken for the REACH process, *Guidance on the Incorporation of Bioavailability Concepts for Assessing the Chemical Ecological Risk and/or Environmental Threshold Values of Metals and Inorganic Metal Compounds*<sup>10</sup> was published by the OECD<sup>10</sup>. This guidance document consolidates what was learnt from the REACH process, in which slightly different approaches had been used to undertake the risk assessments and derive predicted no effect concentrations (PNEC).

The document provides a general overview of the steps used to incorporate bioavailability into threshold values for metals and inorganic metal compounds in water, sediments and soil. For soil, it covers how to incorporate long-term effects on metal bioavailability, the use of bioavailability models, and the use of alternative approaches to assess bioavailability. The models used are typically empirical regression relationships that link physico-chemical soil properties (commonly pH, CEC, organic carbon content) with metal toxicity. These models are useful for normalising effects data to a specific soil of interest.

Separately, the spreadsheet model used to develop PNECs for the metals cadmium, cobalt, copper, lead, molybdenum, nickel and zinc under REACH was extended to provide a 'flexible tool .... that can be used in various parts of the world to derive soil type-specific ecotoxicological thresholds for different protection goals' (Oorts 2018) for these elements. The threshold calculator is accompanied by a background document outlining the basis of the calculator (Oorts 2018). The information for soils in the OECD guideline and in the Oorts background document are very similar, although the background document

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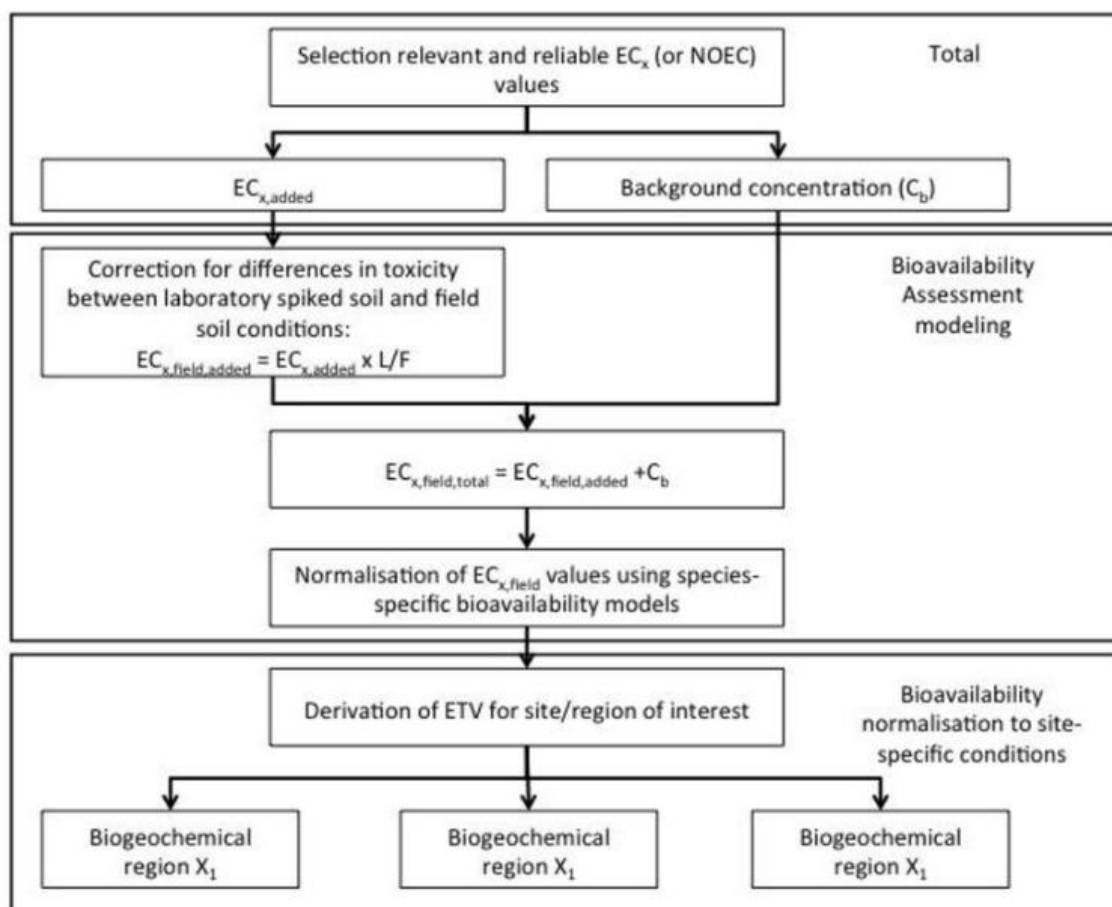
<sup>10</sup> <https://www.oecd.org/publications/guidance-on-the-incorporation-of-bioavailability-concepts-for-assessing-the-chemical-ecological-risk-and-or-environmental-9789264274839-en.htm>

contains more specific information about the data (including toxicity-based regression equations) used in the threshold calculator.

The general approach for incorporating bioavailability into threshold values for soil is shown in Figure 1. This is the same general process used to develop the Eco-SGVs (see the 'Background' section above, and Cavanagh & Munir 2016). However, at the time of developing the Eco-SGVs, two different approaches to the use of microbial data had been used:

- a species composition approach, in which each data point was considered separately because each soil has a unique microbial community
- a function-oriented approach, in which the geomean of data for the same function is used.

The former approach was used in developing the Eco-SGVs, while the latter is the approach outlined in the OECD guidelines and adopted in the threshold calculator. The geomean (of species or microbial processes) should only be used on data that can be normalised (i.e. where the influence of soil properties on toxicity can be taken into account), and so differences in toxicity are attributable to intra-species variation. Where the toxicity data cannot be normalised, differences in toxicity may be attributable to differences in soil properties as well as intra-species differences, and individual toxicity data should be used.



**Figure 1. Framework for implementation of bioavailability factors in soil limits derivation (Figure 9 in OECD 2017).**

This approach is consistent with that used for deriving the Eco-SGVs, except for copper and zinc, for which relationships between soil properties and toxicity were developed (i.e. the data can be normalised). To assess the impact of this variation in the methodology, the previously determined added concentration limits (ACLs, a key step in developing Eco-SGVs, see section 2) for copper and zinc (which used individual microbial data) for the typical soil (see section 2) were compared with ACLs using geomeans of the microbial data (Table 3). ACLs derived using the geomean of microbial data were generally higher than those calculated using individual microbial data, with a greater relative difference typically observed at the higher levels of protection, particularly for zinc.

**Table 3. Comparison of typical soil ACL<sub>EC30aged</sub> for copper and zinc determined using individual microbial data (EC30ind), geomean (EC30geo) of the microbial data. In all cases the geomean for individual plant and invertebrate species was used**

% protection	Copper ACL (mg/kg)		Zinc ACL (mg/kg)	
	EC30ind	EC30geo	EC30ind	EC30geo
99	12	38	4.2	102
95	61	95	35	152
90	126	145	86	195
80	264	231	217	273

Further, because the approach used to develop the Eco-SGVs is similar to that used to develop the threshold calculator, which also uses the data collated in the EU REACH dossiers that were used as a starting point for the Eco-SGV work, the revised (i.e. with microbial data used as geomeans, EC30geo) ACLs for the typical soil were also compared to the copper and zinc values generated from the threshold calculator for the same toxicological endpoints and levels of protection (Table 4). Also, data taken directly from the threshold calculator were used in the BurrliOZ programme, which was used to derive the ACLs to assess any influence of the SSD approaches – this provides the most direct comparison between the data used for the ACLs and that used in the threshold calculator.

There were differences in the EC30geo values and the calculator values (TCEC30), with the calculator values higher at the lower levels of protection, although in reasonable agreement at the 95% protection level. There were differences between the calculator values (TCEC30) and those derived using the calculator data in the BurrliOZ programme (TCEC30B), particularly for copper at the higher protection level and zinc at the 80% protection level. This indicates that the different SSD methodology contributes to variation in the values generated from different sources, but the extent of this variation is probably also dependent on the data being used. For example, Xu et al. (2015) found that the Burr Type III model often provided the best fit for data, while Liu et al. (2019) found different models behaved similarly for ammonia in water. The BurrliOZ programme is used to derive the Australian and New Zealand WQGs (ANZECC & ARMCANZ 2000, Warne et al 2018), and so is maintained as the programme of choice for the derivation of ACLs, and therefore Eco-SGVs.



**Table 4. Comparison of the typical soil ACL<sub>EC30aged</sub> for copper and zinc determined using the geomean (EC30geo) of the microbial data with threshold values determined from the threshold calculator (TCEC30), and from threshold calculator data used in the BurriOZ programme (TCEC30B)<sup>1</sup>**

% protection	Copper ACL (mg/kg)			Zinc ACL (mg/kg)		
	EC30geo	TCEC30	TCEC30B	EC30geo	TCEC30	TCEC30B
99	38	54	142	102	74.5	72
95	95	126	202	152	150	162
90	145	190	251	195	218	237
80	231	300	337	273	331	363

<sup>1</sup> In all cases the geomean of plant and invertebrate data was used.

Nonetheless, the difference between the ACLs and the TCEC30B values, which nominally use the same data and SSD method, suggests there are also some differences in the data being used. Closer inspection of the data used in the threshold calculator revealed that while the same studies had often been used, in the calculator (where possible) toxicity data were refitted using the three-parameter log-logistic equation using the US Environmental Protection Agency TRAP programme, and data for EC10, EC20, EC30 and EC50 are provided in the associated database. Effect level concentrations derived from a dose-response curve are more robust than effect concentrations derived using conversion factors (as used for the Eco-SGV work). Re-fitting of the data using the same method to determine the dose-response removes additional variability.

Not surprisingly, there were also some differences in the studies used, which will contribute to the variation in derived values. For copper it was differences in the invertebrate data that primarily drove the difference in derived values, and specifically the exclusion of some (converted) data used in the Eco-SGVs from the calculator data. For zinc, it was differences in the data used for plants that primarily drove the difference in derived values, and specifically the exclusion of some (converted) data in the calculator results.

In both cases these converted results provide data for additional species that would otherwise not be included, and their inclusion is considered to provide greater robustness of the derived value being protective of a wider range of species. As a result, the ACLs for copper and zinc have been rederived using the geomean of microbial data. Additionally, for copper the revised values included correction for some errors identified in the normalisation of the original microbial data. The revised ACL values for the typical soil are shown in Tables 5 and 6, with the revised values for the sensitive and tolerant soils shown in Appendix 1. These revised ACLs result in changes to the respective Eco-SGVs with the revised Eco-SGVs for all soils shown in Table 7. Changes to the methodology have been incorporated into the technical guidance (on p. 21), with the revised values inserted into the relevant tables (identified below, and in Appendix 1).

**Table 5. Added concentration limits (ACLs) derived for copper using NOEC/EC10 and LOEC/EC30 toxicological endpoints for fresh and aged contamination for the typical New Zealand reference soil<sup>1</sup>**

Land use (% protection)	ACL <sub>(EC10fresh)</sub> (mg/kg)	ACL <sub>(EC10aged)</sub> (mg/kg)	ACL <sub>(EC30fresh)</sub> (mg/kg)	ACL <sub>(EC30aged)</sub> (mg/kg)
Areas of ecological significance (99%)	10	24	19	38
Non-food production land (95%)	29	62	47	95
Agricultural land (plants, 95%)	70	142	109	218
Agricultural land (soil processes and invertebrates, 80%)	72	145	110	220
Urban residential/public open space (80%)	79	154	116	231
Commercial/industrial (60%)	145	276	209	417

<sup>1</sup>Revised Table 28 in Technical guidance

**Table 6. Added concentration limits (ACLs) derived for zinc using NOEC/EC10 and LOEC/EC30 toxicological endpoints for fresh and aged contamination for the typical New Zealand reference soil<sup>1</sup>**

Land use (% protection)	ACL <sub>(EC10fresh)</sub> (mg/kg)	ACL <sub>(EC10aged)</sub> (mg/kg)	ACL <sub>(EC30fresh)</sub> (mg/kg)	ACL <sub>(EC30aged)</sub> (mg/kg)
Areas of ecological significance (99%)	25	68	30	102
Non-food production land (95%)	37	100	55	152
Agricultural land (plants, 95%)	46	110	70	166
Agricultural land (soil processes and invertebrates, 80%)	52	140	79	407
Urban residential/public open space (80%)	68	177	110	273
Commercial/industrial (60%)	116	295	187	463

<sup>1</sup>Revised Table 41 in Technical guidance

**Table 7 Eco-SGVs developed for fresh and aged copper (Cu) and zinc (Zn) contamination in the three New Zealand reference soils, using the lowest median background concentration for Cu and Zn<sup>1</sup>. Eco-SGVs should be based on background concentrations relevant to the site under assessment<sup>2</sup>. The fresh values are applicable where discharge of stormwater or non-organic liquid wastes onto soil is being assessed<sup>3</sup>**

Land use (% protection)	Cu Eco-SGV <sub>(EC30)</sub> Typical soil		Cu Eco-SGV <sub>(EC30)</sub> Sensitive soil		Cu Eco-SGV <sub>(EC30)</sub> Tolerant soil		Zn Eco-SGV <sub>(EC30)</sub> Typical soil		Zn Eco-SGV <sub>(EC30)</sub> Sensitive soil		Zn Eco-SGV <sub>(EC30)</sub> Tolerant soil	
	fresh	aged	fresh	aged	fresh	aged	fresh	aged	fresh	aged	fresh	aged
Areas of ecological significance (99%)	25	45	25	45	25	45	50	120	60	110	70	160
Non-food production land (95%)	55	100	45	85	65	120	800	170	75	150	95	230
Agricultural land (95% plants, 80% microbes and invertebrates)	110	220	80	150	170	340	95	190	75	130	120	265
Residential/recreational area (80%)	120	240	95	180	170	340	130	300	90	260	160	380
Commercial/industrial (60%)	220	420	160	320	320	630	210	480	110	430	250	620

<sup>1</sup>Median background concentration range for Cu: 7 – 25 mg/kg; Median background concentration range for Zn: 24 – 44 mg/kg.

<sup>2</sup>This may be the median background concentration for the relevant geological grouping obtained from <https://iris.scinfo.org.nz/>, or other site-specific information, if available

<sup>3</sup>Revised Table 53 in the technical document and revised Table 6 in user guide

One other change has been made to the existing ACLs, which arose from review comments (Kim 2018) about the adversity of the toxicological endpoints used, such as mortality (p. 32). Mortality data are preferentially not used to derive ACLs. However, where mortality data are available for species for which no other data are available, and which indicate effects in the concentration range of sub-lethal effects for other species, they may be used. This was the case for arsenic, for which mortality data were used for some earthworm species.

However, in view of the severity of this endpoint, an additional factor – effectively an acute to chronic ratio, which is commonly used in the derivation of water quality guidelines for contaminants that have limited toxicity data (Warne et al. 2018) – was applied. In this case a factor of 5 was applied to the mortality data, and the ACLs were rederived, although the resultant ACLs are only marginally different from the original ACLs (Table 8).

**Table 8. Original and revised ACLs for arsenic for NOEC/EC10 and LOEC/EC30 endpoints, and final Eco-SGV<sup>1</sup> based on the lowest median background concentration<sup>2</sup>**

Land use	ACL <sub>(EC10)</sub> (mg/kg)	ACL <sub>(EC10<sub>new</sub>)</sub> (mg/kg)	ACL <sub>(EC30)</sub> (mg/kg)	ACL <sub>(EC30<sub>new</sub>)</sub> (mg/kg)	As Eco-SGV <sub>(EC30)</sub> (mg/kg)
Areas of ecological significance (99%)	2.2	0.65	5.6	4.5	6
Non-food production land (95%)	6.4	4.3	18	15	20
Agricultural land (95% plants)	6	6	16	16	20
Agricultural land (soil process and invertebrates 80%)	48	42	185	135	
Residential/recreational area (80%)	22	24	62	55	60
Commercial/industrial (60%)	58	69	158	144	150

<sup>1</sup>Rounded values; <sup>2</sup>Eco-SGVs should be based on the background concentration range relevant to the site being investigated; Median background concentration range: 2.2-4 mg/kg

## 5.2 Boron

The review of the Eco-SGVs (Kim 2018) included the following recommendation for boron (p. 32):

*that the recommendation to use acid-extractable boron as the basis for guideline comparison be reconsidered, on the basis of boron's chemistry, past practice in New Zealand, and international practice.*

The review recommendation was made on the basis that hot-water-soluble boron is typically lower than the acid-extractable boron and has been relatively widely used in the assessment of contaminated land, as previous contaminated land guidance set guideline values for boron on this basis (MfE 2011).

As noted in Cavanagh & Munir 2016, available toxicity data were most commonly expressed on the basis of spiked boron concentrations, and so the derived ACLs were based on the nominal boron concentrations. The acid-extractable boron concentrations were recommended as a point of comparison because they were considered to provide a better representation of spiked boron concentrations.

However, given the common use of hot-water-soluble boron for contaminated land assessments, investigation was undertaken to determine how it could be used as the basis for the ACLs. Fortunately, Alberta Environment and Parks had recently undertaken a considerable amount of research on the toxicity of boron in soils, which included establishing the relationship between the toxicity of boron and different analytical methods for determining boron concentrations: hot-water-soluble boron and saturated paste boron (AEP 2016).

While boron measured as a saturated paste was found to provide a better measure of toxicity in different soils, these authors also assessed the relationship of the two measures to spiked boron concentrations. They found a good relationship between hot-water-soluble boron and spiked boron for two agricultural soils (equations 1 and 2). As a result, these equations were used as the basis for deriving ACLs as hot-water-soluble boron concentrations. Specifically, these relationships were combined to form equation 3, given the closeness of the relationships in the two soils, and this was used to convert the derived ACLs to ACLs based on hot-water-soluble boron (Table 9). In this case, it is assumed there is a negligible contribution from background concentrations of boron, so the hot-water-soluble (HWS) ACLs can be used directly as the Eco-SGVs. Confirmation that background boron does provide a negligible contribution is required.

$$\text{HWS boron (mg/kg)} = 0.8732B + 1.3871 \quad R^2 = 0.9979, \text{ clay soil} \quad (1)$$

$$\text{HWS boron (mg/kg)} = 0.8932B - 2.6223 \quad R^2 = 0.9981, \text{ sandy soil} \quad (2)$$

Where boron = spiked boron concentrations (mg/kg)

$$\text{HWS boron (mg/kg)} = 0.0.8732B + 1.3871 \quad (3)$$

During review, additional data for the toxicity of boron to microbial processes were also found. Given the limited data on toxicity to microbial processes, this was used to update the ACL for boron shown in Table 9; this resulted in only a slight change to the values for non-food production land and areas of ecological significance.

**Table 9. Eco-SGVs for boron, based on LOEC/EC30 ACLs expressed as hot-water-soluble boron concentrations**

Land use	ACL <sub>(EC30)</sub> (mg/kg)	HWS ACL <sub>(EC30)</sub> (mg/kg)	Eco-SGV <sup>1</sup> <sub>(EC30)</sub>
Areas of ecological significance (99%)	5.8	3.9	4
Non-food production land (95%)	9.7	7.3	7
Agricultural land (95% plants, 80% microbes and invertebrates)	8.0	5.8	6
Residential/ recreational areas (80%)	10	13.8	15
Commercial/industrial (60%)	20	17.3	15

<sup>1</sup> Values have been rounded; contribution of background HWS boron is considered to be negligible.

### 5.3 Additional amendments to the technical guide and user guide

The areas from the review that were unclear and could be readily addressed through update of the text in supporting documents, are summarised in Table 10, along with the response made.

**Table 10. Summary of review comments that have been addressed in this update**

Review comment	Response
There are contradictory statements from MWLR about whether the SSD approach was or was not used to derived added contaminant limits for boron and fluorine. (p. 29)	Incorrect text in Cavanagh & Munir 2016, p. v and Cavanagh 2016, p.18, has been replaced with text confirming that the SSD approach was used for fluorine and boron.
It is unclear to the reader <ul style="list-style-type: none"> <li>whether (for copper or zinc) the guideline would apply fresh or aged. (p. 26)</li> </ul>	It is stated in section 4.3 of the user guide that the fresh values are considered to apply to storm water or non-organic liquid discharges (and this is mentioned in the technical guide in the section on copper and zinc). To improve clarity, the following statement has been added to the captions of Table 6 in the user guide and Table 54 in the technical guide:  'The fresh values are applicable where discharge of stormwater or liquid wastes onto soil is being assessed'.
<ul style="list-style-type: none"> <li>whether bio-magnification should/could be accounted for. (p. 26)</li> </ul>	Discussion on when this should be included is in the methods section, and also in the section for the individual contaminants. The use of this approach for cadmium has been made clearer by removing the non-BM values for cadmium from the table, and for both cadmium and lead by including a footnote to Tables 5 and 53 in the user guide and technical document, respectively.

Review comment	Response
<ul style="list-style-type: none"> <li>whether backgrounds are fixed-point or a range. (p. 26)</li> </ul>	<p>It is already stated in the methods that the median background concentration should be used. The following footnote has been added to Table 6, and Tables 53 and 54, in the user guide and technical document respectively, to aid clarity:</p> <p>‘This may be the median background concentration for the relevant geological grouping obtained from <a href="https://iris.scinfo.org.nz/">https://iris.scinfo.org.nz/</a>, or other site-specific information, if available’.</p>
<ul style="list-style-type: none"> <li>the degree of protection afforded</li> <li>for production land, the degree of protection afforded for different receptors in the same calculation (95% for plants, but only 80% for other soil receptors).</li> </ul>	<p>This is clearly stated in the method described in both the technical document and the user guide and summarised in Table 2 and Table 3 in the respective documents. However, to provide more clarity the level of protection has been included in the summary tables (Tables 53-55) in the technical document, and Tables 5-7 in the user guide.</p>
<p>Recommendation 3</p> <p><i>For fluorine:</i> ACLs or Eco-SGVs suggested for fluorine not be used for regulatory purposes, because more development is needed to be confident about levels associated with various degrees of harm to ecological soil receptors. (p. 32)</p>	<p>Agreed: the uncertainty surrounding the fluorine value was articulated in the section on fluorine but was not carried through to the summary and conclusions. This has now been done by removing the fluorine values from the final summary table and including the following statement in the text</p> <p>‘Provisional ACLs were also developed for F, however given the uncertainty of the estimates, they are not recommended for use.’</p> <p>The following has also been included at the end of the fluorine section to provide a more explicit statement about use of the derived values:</p> <p>‘.....and are not recommended for use.’</p>
<p><i>For boron:</i> that the recommendation to use acid-extractable boron as the basis for guideline comparison be reconsidered, on the basis of boron’s chemistry, past practice in New Zealand, and international practice. (p.32)</p>	<p>See section 5.2 in this document. Text has been modified accordingly in section 4.2.4 of technical guidance, and tables 5 and 53 in user guide and technical guidance respectively</p>
<p>Section 3.4 Choice of toxicological threshold. (p. 32)</p>	<p>The review comments seemed to indicate a lack of clarity around the nature of the toxicity data used to consider what the effects might actually be. To provide greater clarity, and thus help in the broader consideration of the toxicological threshold (effect level) used, an additional paragraph has been included in section 3.2.3 of the technical guide.</p>
<p>Recommendation 8: That an ecological guideline value not be implemented as a regulatory limit if it exceeds (p. 51)</p>	<p>This was always the intent in the application of Eco-SGVs, and the following text has been included in the user guide to make this clear (p. 24):</p> <p>‘It is not intended that Eco-SGVs override other existing regulatory or management values, such as soil contaminant standards for the protection of human health, and trigger values used in the Tiered Fertiliser Management System for cadmium. It is likely most appropriate that the lowest of the applicable values determines the ultimate action required at any site.’</p>

Another aspect that Dr Kim considered might be unclear to readers was that in setting thresholds for different types of land uses we varied the species covered. This relates to both the general receptors considered (shown in Figure 1 in the user guide and the

technical document, and discussed in sections on the individual contaminants), but more specifically to the available toxicity data. The species covered varied for individual contaminants, and the user will always need to refer to the raw data used for individual contaminants to identify the species used. No further changes have been made as it is considered that the current information is adequate.

Finally, a large part of the review (Kim 2018) related to the policy and regulatory context of the development and application of the Eco-SGVs, which is beyond the scope of this project. Some additional responses to the review have previously been provided and are included as Appendix 1 of this report. It should be noted that the intended application, effect levels and level of protection were determined through the advisory group, which comprised central and local government representatives, established for the tools project and workshops with regional councils. Feedback on the proposed approach was also sought through workshops with the organic waste sector and contaminated land practitioners. The policy and regulatory context should be considered as part of any further consultation and discussion to ensure the proposed application is consistent with current New Zealand policy and legislation.

## **6 Summary and recommendations**

The method used to derive Eco-SGVs developed by Cavanagh and Munir (2016) is generally consistent with the recent OECD guidance, except that the geomean for normalised microbial data (copper and zinc) was not used. Further evaluation of the data and values derived indicated that differences in the data used contributed to further variation. For copper and zinc, this primarily related to the inclusion of converted (i.e. using a factor to convert from EC10 or EC50 to EC30) data for species for which no other data were available. This is considered to be more robust for providing protection for the wide range of species present in the environment than simply excluding the data. Therefore, the copper and zinc values were rederived using the geomean for the microbial data. Arsenic values were rederived after applying an additional factor to account for the use of mortality data for some invertebrate species.

The literature review identified good relationships between hot-water-soluble boron (HWS B), a commonly used method of analysis of boron in New Zealand, and spiked boron concentrations, commonly used to express toxicity data for boron, and used to derive added concentration limits for boron by Cavanagh and Munir (2016). This relationship was used to express the spiked boron-derived ACLs as HWS B ACLs. It is anticipated that the contribution of HWS B is likely to be negligible, and so these ACLs can be used directly as Eco-SGVs. Confirmation that background HWS B is negligible is required.

Amendments have been made to the technical guidance and to the user guide to reflect the above changes, and also to improve clarity in specific areas identified through the review by Kim (2018). These changes are summarised in this report, and tracked changes and final versions of the respective updated documents have also been provided.

However, as identified in the review (Kim 2018) and the user guide (Cavanagh 2016) further consultation and assessment are required to ensure appropriate and effective



implementation of the Eco-SGVs and to ensure the proposed application is consistent with current New Zealand policy and legislation. It should also be noted that Eco-SGVs simply provide *estimates* of the potential effect of toxicants on the environment, subject to the desired level of protection and the currently available data. This uncertainty should be borne in mind during further discussions on the application of the Eco-SGVs.

Recommended next steps include:

- wider consultation with regional councils, industry groups (e.g. contaminated land practitioners, the waste industry, the organic waste sector) and other stakeholders on the currently proposed application for background soil concentrations and Eco-SGVs
- the development of national policy for the protection of soil quality and contaminated land management that includes the protection of terrestrial biota.

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## Appendix 1 – Revised ACLs for sensitive and tolerant soils

**Table A1. Added concentration limits (ACLs) derived for copper using LOEC/EC30 toxicological endpoints for fresh and aged contamination for the sensitive and tolerant New Zealand reference soils<sup>1</sup>**

Land use (% protection)	ACL <sub>(EC30fresh)</sub> sensitive (mg/kg)	ACL <sub>(EC30aged)</sub> sensitive (mg/kg)	ACL <sub>(EC30fresh)</sub> tolerant (mg/kg)	ACL <sub>(EC30aged)</sub> tolerant (mg/kg)
Areas of ecological significance (99%)	19	38	20	40
Non-food production land (95%)	40	80	60	120
Agricultural land (plants, 95%)	73	146	168	337
Urban residential/public open space (80%)	88	177	166	333
Commercial/industrial (60%)	158	315	313	625

<sup>1</sup>Revised Table 29 in Technical guidance

**Table A2. Added concentration limits (ACLs) derived for zinc using LOEC/EC30 toxicological endpoints for fresh and aged contamination for the sensitive and tolerant New Zealand reference soils<sup>1</sup>**

Land use	ACL <sub>(EC30fresh)</sub> sensitive (mg/kg)	ACL <sub>(EC30aged)</sub> sensitive (mg/kg)	ACL <sub>(EC30fresh)</sub> tolerant (mg/kg)	ACL <sub>(EC30aged)</sub> tolerant (mg/kg)
Areas of ecological significance (99%)	34	87	44	133
Non-food production land (95%)	50	131	72	203
Agricultural land (plants, 95%)	49	109	94	240
Urban residential/public open space (80%)	62	236	133	361
Commercial/industrial (60%)	84	404	223	597

<sup>1</sup>Revised Table 42 in Technical guidance

## **Appendix 2 – Response to review of work to determine background concentrations and develop ecological guideline values for soil contaminants in New Zealand undertaken as Medium Advice Grant 1847-MDC139**

Jo Cavanagh, August 2018.

### **Overview**

This document provides a response to the review of work to determine background soil concentrations and develop ecological guideline values for soil contaminants in New Zealand undertaken by Dr Nick Kim under Envirolink Medium Advice Grant 1847-MLDC139. The documents reviewed by Dr Kim were those developed under the Envirolink Tools Project (C09X1402): Background concentrations and soil guideline values for the protection of ecological receptors and were:

- Cavanagh JE, McNeill S, Arienti C and Rattenbury M, 2015. *Background soil concentrations of selected trace elements and organic contaminants in New Zealand*
- Cavanagh JE, and Munir K, 2016. *Development of soil guideline values for the protection of ecological receptors (Eco-SGVs): Technical document*
- Cavanagh JE, 2016. *User Guide: Background soil concentrations and soil guideline values for the protection of ecological receptors (Eco-SGVs) – Consultation draft.*

Review of these documents was recommended in the User Guide as the first of three next steps<sup>11</sup> required prior to implementation of the tool (background soil concentrations and ecological soil guideline values). Dr Kim indicated review was undertaken as the work was new, and local authorities have a duty to exercise due diligence around the exercise of their functions and duties.

This response does not provide a detailed response to all the comments made by Dr Kim, but rather picks up on some key points that appear misleading or for which the context for the work may not have been clearly understood. This may partly be the result of the fact it is now two years since the completion of the project and/or these aspects were not stated sufficiently explicitly in the final documents. The aspects covered in this response are those viewed as important to understand to progress this work appropriately and are:

- Project structure and the policy/regulatory context
- Toxicological values
- Status of background soils work
- Specific additional comments

A more detailed response to all outstanding review comments can be provided if deemed appropriate.

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<sup>11</sup> Section 6 of the User Guide and excerpted in Appendix 1.

## Project structure and policy/regulatory context

With the exception of section 3.4, section 3 of the review fundamentally addresses different aspects of the policy or regulatory context for the ecological soil guideline values. The reference to “MW-LR projects” or MW-LR through the review gives the impression this was a researcher-led project with minimal input from policy or regulatory stakeholders. Further, Dr Kim suggests that the “..suggestions on implementation go beyond a technical remit, but were in response to regulatory stakeholders requesting such guidance...” (p.27). These assumptions are both incorrect. Specifically, as identified in the original proposal for the project “.... It will be important first to clarify the intended application of Eco-SGVs (e.g. for managing contaminated land, determining acceptability of cleanfill/managed fill, when applying biosolids to land) since this will influence how they are derived and how we determine which methodologies are relevant.” Further, the impetus for this project was strongly driven by Council needs<sup>12</sup>.

Determining the intended application, and thus the policy and regulatory context, shaped the way in which the project was undertaken, as well as the final methodology that was developed. The approach taken included the formation of an advisory group for the project comprised of representatives from

- Regional Waste and Contaminated Land Forum
- Land Monitoring Forum
- Land Managers Special Interest Group
- Ministry for the Environment
- Ministry for Primary Industries

A key role of this group was to provide policy and regulatory oversight and input for the project and included seeking input more widely from the groups or organisations represented, as required. Meetings were held on a 6-monthly basis, included in the first instance determining the ecological receptors to be considered in developing the methodology, and the priority contaminants for which Eco-SGVs were to be developed; and secondly, considering workshop feedback (see next para) in the determination of the final methodology (see Appendix 1 for minutes associated with the meetings at which these aspects were discussed). Other meetings largely focussed on progress of the project.

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<sup>12</sup> As stated in the original proposal “The lack of an effective tool for ecological risk assessment results in patchy and inconsistent approaches to environmental protection. As a result, developing national guidelines to protect the environment is a top priority for the Regional Waste and Contaminated Land Forum (RWCLF, refer Document #1779443 *Research priorities: Regional Council Waste and Contaminated Land Forum* October 2010 held by the Waikato Regional Council). Furthermore, determining the extent of soil contamination and how to manage it are identified as a critical issue for both the Land Monitoring Forum (LMF) and the Land Management Group (LMG, *Alignment of Land Special Interest Groups and the National Land Resource Centre Priorities*, Weeks & Collins 2013).”

In addition to advisory group input, workshops to consider aspects of implementation were held initially with regional council staff, and subsequently Contaminated Land Practitioners and Organic waste sector representatives as key end-users potentially influenced by the implementation of these guideline values by regional councils. A discussion document was provided prior to the workshops with the document provided to Contaminated Land Practitioners and the Organic Waste Sector outlining the proposed implementation identified from the Regional Council workshop (these documents can be provided upon request). Feedback from these latter stakeholders was intended to provide a perspective on the “workability” of derived guideline values, to assist councils in consideration of requirements for implementation. Presentations were also given at Regional Council Compliance and Enforcement, Policy Managers and Consent Managers Special Interest Group meetings to both raise awareness of the project and seek wider input with regards policy or regulatory considerations for implementation. The overwhelming response from these presentations was that in order for councils to implement these guidelines consistently and in a timely manner, national endorsement or direction was needed. Ministry for the Environment representatives were also present at some of these meetings. Finally, a survey was distributed to councils via the RCWCLF and LMF to elicit additional considerations around the implementation of Eco-SGVs, although only six councils returned responses.

However, while there was significant focus given to eliciting the appropriate regulatory and policy context associated with developing the Eco-SGVs within the project, this does not mean that the approach used within the tools project was effective in covering all aspects nor that it was the best approach. Dr Kim perhaps provide more of a top-down perspective and raises some useful points for consideration in the further consideration of this work.

It should also be highlighted, particularly with regards to Dr Kim’s comments around cleanfills and movement of soils between mineralised and non-mineralised areas, that the tools project was undertaken at the same time as two other related projects (Waste disposal to land and Beneficial use of organic waste – see section 2.4 in the user guide); the former guideline was more specifically addressing criteria for application to landfills including cleanfills, for which cleanfill criteria were noted to be based on background concentrations in the location of the cleanfill.

Finally, it should be noted that the User guide included a short section on considerations around implementation (excerpted in Appendix 2), and recommended three key steps be undertaken prior to the use of the background concentrations and Eco-SGVs determined through the project:

- International peer review of the derivation methodology for the Eco-SGVs, taking into account the intended applications.
- Wider consultation with regional councils, industry groups (e.g. contaminated land practitioners, waste industry, organic waste sector) and other stakeholders on the currently proposed application for background soil concentrations and Eco-SGVs. The latter would ensure complementarity and consistency with other sector developed guidelines, including *Technical Guidelines for Disposal to Land* (WasteMinz 2016), and guidelines for the beneficial use of organic waste (under development).

- Ultimately, the development of national policy for the protection of soil quality and contaminated land management that is inclusive of protection of terrestrial biota to enable effective and consistent uptake and use of the background soil concentrations and Eco-SGVs developed in this work.

The review undertaken by Dr Kim, effectively represent the first step, with the comments provided helping the second step in relation to wider consultation with regional councils. We strongly endorse Dr Kim's recommendation 9, which echoes our recommended third step.

### **Toxicological values**

The discussion on toxicological values in the review is singled out for comment here due to the seemingly inter-changeable use of the abbreviations of LCx and ECx when discussing toxicological values in the review, and usage of the term serious adverse effects when referring to toxicity endpoints. The abbreviations have different meanings, specifically LCx refers the lethal concentration at which x% of the test population dies while ECx refers to the effect concentration at which either x% of the test population experiences a specified effect (often referred to as endpoints) or the response of the test population is reduced by x% compared to the response in the control population. For the latter, these effects are sub-lethal effects and include endpoints such as growth, yield, reproduction (primarily for soil invertebrates) and for soil microbes measures of nutrient cycling such as respiration or nitrate formation, or production of specific enzymes. In terms of the significance of effects, and in particular whether it is an adverse effect, consideration should be given to both the nature of the endpoint and the proportion of the test population affected, or extent of the effect. In most cases these effects will be considered relatively benign, although people may have varying views on how adverse a reproduction response is.

The use of LC in the review is erroneous and gives the impression that the endpoints considered were typically more serious than those actually considered. This is compounded by usage of the term "serious adverse effect" (p.34) and the statement that "In many of the reported studies ..the end point was lethality...." (p.33). This is incorrect. In total, 13 entries, which reduced to 5 datapoints (1 each for arsenic, cadmium, DDT, Total Petroleum Hydrocarbons (TPH) fractions F1 and F2) were based on mortality (all for invertebrates). For arsenic, data were also available for more sensitive endpoint (reproduction) for earthworms hence mortality data was not used. Further, using the SSD approach, these single datapoints have little influence on the derived contaminant limits where there is abundant data, although will have more of an influence where there is more limited data e.g. for TPH.

From a separate perspective, and through discussion with international researchers involved in the development ecological soil guideline values, the decision in the tools project to not use geomeans for the microbial data has potentially biased the derived values towards the microbial data and resulted in lower Eco-SGVs than otherwise would have been obtained. From this perspective, as a next step it is recommended that the Eco-SGVs are re-derived using a geomean for microbial endpoints and compared with Eco-SGVs developed through the tools project (this rederivation is actually currently being undertaken by MWLR as part of preparation of a journal manuscript on this research).

## **Status of background soils**

Dr Kim has provided a thorough review of the Background soils concentration, although greater emphasis appears to be placed on the “definitiveness” of the determined values, even though the estimated concentrations were stated to “...provide a first-pass estimate of trace element background concentrations across most of New Zealand...<sup>13</sup>”.

Dr Kim notes (p.13) that “...the method developed was not transparent or accessible enough to be automatically applied to any other element..”, and that “... estimates of the type made by MW-LR will always be superseded by direct measurement of local soils...” The context for the background soils work was that prior to the Envirolink Tools project, estimates of background soil concentrations had been developed on a regional basis using different soil and/or geological classifications thus limiting the inter-regional use of the data to provide a broader estimates of background soil concentrations. Further, it can be difficult to determine background soil concentrations at a given site due to anthropogenic disturbance, and the cost to determine site-specific background soil concentrations may not be warranted. The intent of developing a methodology for determining background soil concentrations was to illustrate a method that could be used to maximise existing data and provide as far as possible national estimate of background concentrations. From this perspective, the main methodological development was consideration of available data at a national level, and utilising databases to enable extrapolation of estimates to areas where limited or no data was available. The specifics on how this is undertaken will depend on the available data. We wholeheartedly agree that agree that these estimates will (and should) be superseded by more recent data and provided the recommendation that “Additional sampling and analysis is required to further develop and refine these estimates of background concentrations of trace elements, particularly in areas for which no or limited data are available.” In the background soil concentration report. Data such as that generated from GNS studies is very useful for the further development of background soil concentrations, with a national grid-based survey the “ultimate” in developing more robust estimates of background soil concentrations.

The focus on linking soil concentrations to geological data was primarily because this was the only dataset available at a national level; a parameter called rock-type-of fines (from S-Map), which combines geological and pedological processes would likely be the most relevant parameter, however this is unavailable on a national basis.

### **Specific additional comments:**

We support the recommendation that the Eco-SGV for soil fluorine (present as fluoride) is not used – as noted in the technical document the Eco-SGV for fluorine was considered to be provisional due to the limited robust data. However, the “provisional” status of this Eco-SGV was not stated in the User Guide. A subsequent report undertaken for the

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<sup>13</sup> P. x From summary of Cavanagh et al 2017 , and also in overview for LRIS website.



Fertiliser Association of New Zealand also provides a more extensive discussion on the existing literature on the toxicity of soil fluorine.

We agree with Dr Kim's Recommendation 8<sup>14</sup>, and observe that it was never intended that the Eco-SGVs would over-ride soil guideline values developed to protect other receptors (e.g. humans) where these were more sensitive (e.g. see minutes from Regional Council workshop in Appendix 2), although acknowledge this was not specifically mention in the final documents.

### **Summary**

Dr Kim undertook a thorough and comprehensive review of work undertaken within the Envirolink Tools project, with the comments provided being very useful to consider in the progression of this work. However, these comments should be considered alongside the responses provided in this document to make fully informed progress. A more detailed response to all outstanding review comments can be provided if deemed appropriate as a next stage. Alongside this it is also recommended that Eco-SGVs derived using geomeans for microbial data are compared with the Eco-SGVs developed through the tools project to understand whether this will significantly change the values, and thus what might be the implications of those changes.

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<sup>14</sup> That an ecological guideline value not be implemented as a regulatory limit if it exceeds pre-existing human health guideline or standards for the either the same land-use or a foreseeable land-use

## Appendix 1: Excerpt from the user guide

### Section 6: Implementation

To assist in further understanding council needs and drivers for implementation and use of the Eco-SGVs and background concentrations, a short survey was distributed to councils via the Regional Waste and Contaminated Land Forum and Land Monitoring Forums (Appendix B). Three questions were asked to elicit feedback:

- Does the outlined application cover the needs for your council? Please consider the needs for policy, regulation, environmental protection, SOE, remediation functions, etc.
- Given your council's processes for managing contaminated land and soil quality, where and how would you anticipate these guideline values would be used?
- What is needed by your council's policy and planning staff to implement these values?

Responses were received from six councils. It is hoped that this document addresses some of the points raised by the councils, particularly in relation to providing greater guidance around intended use, clarity of where this work sits in relation to other contaminated land management guidelines, and specification of the problem that is intended to be addressed. A consistent comment in the feedback was the need for national endorsement or direction in the approach to enable implementation and consistency in application across region; this point was also made during feedback from presentations given to regional council Policy Managers Special Interest Group (SIG), Compliance & Enforcement SIG and the Consent Managers SIG.

Some aspects raised have not been covered and are beyond this project although they require resolution. For example, how should a site that exceed Eco-SGVs but for which no action is required, be listed on contaminated sites registers? It is recognised that different councils can have different views on the extent to which environmental protection of soil biota and other terrestrial biota is currently taken into account, and whether it is sufficient. A consensus view between councils and central government on this is required to fully ascertain the scale of the problem being addressed by this project. This is also because there is currently no restriction on protection of terrestrial biota being taken into account in the management of contaminated land; for example HAIL category I requires that environmental risk be considered in confirming whether land that has concentrations above background concentration requires management under the NES. Further, the ability to grow plants is arguably a key component of residential land being 'fit for purpose'<sup>15</sup>. Nonetheless, to date, protection of terrestrial biota is rarely considered in the management of contaminated land. In some cases the environmental risk can be taken to mean the risk to ground or surface water arising from off-site discharge from a contaminated site as opposed to the environmental risk posed to terrestrial biota.

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<sup>15</sup> The term 'fit for purpose' is an expression used based on requirements that territorial authorities have responsibilities that include the control of any actual or potential effects of the use, development, or protection of land, including contaminated land under Section 31 of the Resource Management Act.

Similarly, in the assessment of soil quality, the biological impact of trace elements and other contaminants is rarely considered. Instead, physico-chemical parameters are largely used, with one measure of microbial activity (mineralisable-N) used to provide a biological measure of soil quality. Thus, there is a gap in the assessment of soil quality as determined by soil biology.

## **6.1 Next steps**

Three key next steps are recommended prior to the use of these background concentrations and Eco-SGVs:

- International peer review of the derivation methodology for the Eco-SGVs, taking into account the intended applications.
- Wider consultation with regional councils, industry groups (e.g. contaminated land practitioners, waste industry, organic waste sector) and other stakeholders on the currently proposed application for background soil concentrations and Eco-SGVs. The latter would ensure complementarity and consistency with other sector developed guidelines, including *Technical Guidelines for Disposal to Land* (WasteMinz 2016), and guidelines for the beneficial use of organic waste (under development).
- Ultimately, the development of national policy for the protection of soil quality and contaminated land management that is inclusive of protection of terrestrial biota to enable effective and consistent uptake and use of the background soil concentrations and Eco-SGVs developed in this work.