



technical memorandum

TO Nigel Donovan FROM Graeme Proffitt, Natalie Webster
Ministry for the Environment DATE 1 July 2020
RE WasteMINZ Landfill Guidelines – Proposed Class 3 and 4 WAC Summary Table

Attached is a summary table for the proposed waste acceptance criteria (WAC) for Class 3 (Controlled) and Class 4 (Managed) fills. We understand this will be passed to the WasteMINZ Technical Guidelines for Disposal to Land working group for consideration.

In the table the proposed criteria are compared with the existing Class 4 WAC from the Guidelines and to the theoretical Class 3 WAC if these had been derived using the leaching pathway derivations from the Guidelines.

The detail of the proposed heavy metal WAC derivations is set out in PDP memorandum W01820600M006 *Waste Acceptance Criteria from Analysis of SPLP and Total Concentration Data for Inorganic Contaminants*, dated 11 June 2020. The organic compound WAC derivations are set out in PDP memorandum W01820600M007 *WasteMINZ Landfill Guidelines – Proposed Class 3 and 4 WAC for Organic Compounds*, dated 1 July 2020. For convenience, both memoranda are attached.

Limitations

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Table 1: Class 3 (Controlled Fill) and Class 4 (Managed Fill) WAC as per Guidelines and Proposed Revised (mg/kg)

Contaminant	Class 3 Using Guideline Class 4 Derivation	Proposed Class 3	Class 4 from Guidelines	Proposed Class 4
Arsenic	310 ¹	140	17 ³	17
Cadmium	10 ²	10 ⁵	0.8	0.8
Chromium	630	150	290	150
Copper	>44 or soil background	280	>44 or soil background	220 ⁴
Lead	1,000	460	>60 or soil background	160
Mercury	160	3 ⁵	0.7	0.7
Nickel	310	320 ⁵	310	320 ⁵
Zinc	400	2,700	400	190
TPH C ₇ – C ₉	No Practical Limit ⁶	Not Calculated ⁷	120	110
TPH C ₁₀ – C ₁₄	No Practical Limit ⁶	No Practical Limit ⁶	58	58
Benzene	0.2	0.11	0.2	0.11
Ethylbenzene	66	10	59	10
Toluene	50	19	50	19
Total Xylene	29	25	30	25
Benzo(a)pyrene (eq) ⁸	54	125	Interim based on soil background = 2	2.8
Dieldrin	0.2	0.10	0.2	0.10
Total DDTs ⁹	26	2.0	0.7	1.9

Notes:

1. Blue shading indicates drinking water pathway is limiting.
2. Green shading indicates aquatic pathway is limiting.
3. Grey shading indicates human health agricultural land use or rural residential land use is limiting.
4. Orange shading indicates soil quality for protection of ecological receptors (minimal risk / protective of agricultural land use) is limiting.
5. Not calculated. Based on SPLP – total concentration dataset and professional judgement.
6. Not calculated in the Guidelines but if calculated using Guidelines parameters, value very large and unlikely to be encountered on real world sites (no practical limit).
7. Not calculated because no available aquatic guidelines. Limited toxicity data for TPH components suggest an indicative value of a few thousand mg/kg.
8. Equivalent benzo(a)pyrene concentrations calculated as a toxicity-weight sum of the nine carcinogenic PAHs in the standard PAH analytical suite.
9. Sum of the concentrations of the six DDT, DDD and DDE isomers.

**Appendix A: PDP Technical
Memorandum – W01820600M006**



technical memorandum

TO Nigel Donovan FROM Harry Sparkes, Natalie Webster,
Graeme Proffitt

Ministry for the Environment DATE 11 June 2020

RE Waste Acceptance Criteria from Analysis of SPLP and Total Concentration Data for
Inorganic Contaminants

1.0 Introduction

This memorandum provides supplementary discussion to technical memorandum W01820600M005, *WasteMINZ Landfill Guidelines – Option for Class 3 and 4 WAC Derivation*, PDP, 2019. The earlier memorandum discussed the difficulties of developing waste acceptance criteria (WAC) to be protective of groundwater and surface water via leaching using distribution coefficient (K_d) values for the inorganic contaminants. An alternative approach is to use the synthetic precipitation leaching procedure (SPLP) to simulate leaching and use this test to determine whether a waste is acceptable. However, this approach is less convenient and the laboratory analysis more expensive than using simple total recoverable concentrations (TRC). It would be advantageous to both the waste disposal facility operators and the facility users to be able to infer the suitability of a waste for disposal from the TRC values obtained during the site investigation process, and/or from verification sampling undertaken once waste has arrived at a disposal site.

The earlier memorandum therefore proposed using existing SPLP data available from testing laboratories to attempt to come up with SPLP-TRC relationships for each of the elements within the commonly used heavy metal suite (8 elements) in order to arrive at total concentration WAC. This memorandum presents the development of such relationships. It is noted that this process has been carried out for a range of common inorganic contaminants (metals), but not for organic contaminants. This is because the review of the WAC derivation process that is described in the PDP, 2019 technical memorandum W01820600M005 found that the data used to support the WAC derivation for organics was less variable; and hence further revision of those WAC was unnecessary (other than correcting an error that has been subsequently found for one of the values).

The TRC WAC should be set at a level that provides sufficient reassurance to unlined managed fill (Class 3) operators and regulators that the resulting leachate generated by these soils would not pose a significant risk to nearby receptors (groundwater and surface water bodies) if accepted into the waste facility. The calculated WAC are intended to provide a generic value for Class 3 facilities to consider when determining the requirement for supplementary SPLP analysis.

To achieve the above, TRC and corresponding SPLP data pairs from a variety of soil types and from around the country were compared to a calculated target value for contaminants of concern. Several hundred and in some cases more than a thousand data pairs were available for this exercise. Further details on the analysis methodology are provided in Section 2 below.

2.0 Analysis Methodology

2.1 SPLP-TRC Dataset

Class 3 WAC have been derived for eight contaminants of concern (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc). The combined SPLP-TRC dataset provided by two New Zealand based laboratories (Hill Laboratories and Analytica Laboratories) is summarised in Table 1 below. It is expected that these two laboratories carry out the majority of SPLP analysis in New Zealand. The data represents up to 10 years of analyses results, which is the length of time for which the data was readily available when the data were obtained in December 2019.

Table 1: Contaminant of Concern Dataset Summary			
Contaminant	Total number of data pairs (TRC and SPLP)	Range	
		Total Recoverable Concentration (mg/kg)	SPLP Concentration (mg/L)
Arsenic	1,259	<0.2 – 111,101	<0.0011 - 305
Cadmium	721	<0.01 – 1,005	<0.000053 – 0.081
Chromium	981	0.12 – 7,629	<0.00053 – 0.99
Copper	1,141	<0.2 – 101,309	<0.005 – 3.68
Lead	930	0.29 – 42,379	<0.00011 – 21.47
Mercury	366	<0.01 – 161	<0.00008 – 0.011
Nickel	861	0.16 – 37,029	<0.00053 – 0.229
Zinc	979	0.0759 – 42,107	<0.0011 – 10.476

2.2 Calculating SPLP Target Values

To determine if contaminant concentrations posed a risk to the receiving environment, target SPLP values were derived for each contaminant. These target values were established by taking the lower (more conservative) of either the Drinking Water Standards for New Zealand (MfE, 2005)(DWSNZ) Maximum Acceptable Values (MAV) for the protection of groundwater; or the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) for the protection of 95% of species; and then multiplying this value by a dilution and attenuation factor (DAF). A DAF of x20 was applied to the DWSNZ MAVs and x100 for ANZG to account for the reduction in contaminant concentrations during leachate

percolation between the waste site and nearby receptors¹. These DAF are the same as were used in Appendix C.4 of the August 2018 version of the WasteMINZ technical guidelines. The target SPLP values are presented in Table 2 below.

Table 2: Target SPLP Values for Deriving WAC ¹				
Contaminant	Groundwater		Aquatic	
	DWSNZ MAV ²	Target Concentration = MAV x20 = SPLP Limit	ANZG 95% ³	Target Concentration = ANZG x100 = SPLP Limit
Arsenic	0.01	0.2	0.013	1.3
Cadmium	0.004	0.08	0.0002	0.02
Hexavalent Chromium	0.05	1	0.001	0.1
Trivalent Chromium	0.05	1	0.0033 ⁴	0.33
Copper	2	40	0.0014	0.14
Lead	0.01	0.2	0.0034	0.34
Mercury	0.007	0.14	0.0006	0.06
Nickel	0.08	1.6	0.011	1.1
Zinc	1.5	30	0.008	0.8

Notes:

- All values in mg/litre
- Drinking Water Standards for New Zealand – Maximum Acceptable Values, Ministry for the Environment, 2005.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) for the protection of 95% of species.
- Low quality guideline based on data for few species.

BOLD denotes the lower of the two values and therefore the applied target SPLP value.

Two target SPLP values are provided for chromium, one for trivalent and one for hexavalent forms. Trivalent chromium (Cr(III)) is considered to be the more relevant form of chromium to consider, although hexavalent chromium (Cr(VI)) is more toxic to both people and the aquatic environment than the trivalent form. Both hexavalent and trivalent forms can occur in the environment, but trivalent forms are more common in the soil environment as hexavalent chromium in soil is generally rapidly reduced to trivalent forms by organic material in the soil.

¹ The dilution factor is based on sorption, absorption and attenuation of a contaminant during its migration from source (waste facility) to receptor (groundwater and/or surface water) as well as dilution with cleaner soils and/or water sources during the migration process.

2.3 Calculating TRC WAC

To determine an appropriate WAC based on TRC, the SPLP results were plotted against their respective TRC concentrations to establish if there was a TRC below which there could be a reasonable level of confidence that the SPLP concentration would comply with the calculated target value.

For most of the contaminants there were a few high SPLP results for low TRCs, which meant that it was not possible to have all SPLP results below some WAC without having the WAC being unreasonably low. To get around this, a trial approach was taken, selecting a WAC and then calculating the percentage of SPLP results exceeding the target SPLP from the set of TRC values which were below the trial WAC. This was repeated for a range of potential WAC (refer to Section 3 for detail) with percentage exceedances calculated for each trial up to about 3% SPLP target exceedances. The percentages were calculated relative to the total dataset.

As a matter of judgement, the WAC can then be selected so as not to have too many (too high a percentage of) SPLP exceedances. The acceptable percentage of instances in which an exceedance of the target SPLP would occur for a given WAC is discussed further in Section 3 below. However, the philosophy is that some small number of SPLP exceedances can be tolerated on the basis that, on average, all soil would comply if it were to be mixed (not a practical proposition given that soil arrives at different times); and even if a slightly more leachable parcel of soil was to be disposed of, it would be co-disposed with or on top of other less leachable soil so that by the time leachate from various parcels of soil reached the water table it would, on average, be compliant. The question then becomes, what (low) proportion of exceedances can be tolerated while maintaining confidence that the bulk emplaced soil will not result in discharges that could cause adverse effects to drinking water or aquatic receptors? It should also be borne in mind that the SPLP test is conservative as an estimate for leachability, as are the DAFs used in the derivation of the leachate target.

3.0 WAC Derivations

A range of potential WAC values and associated percentage of samples exceeding the target SPLP values are presented in the following sections for each contaminant of concern. The data populations for each contaminant are heavily left-skewed due to a greater frequency of occurrence of low contaminant values than high values. To allow for better visual representation of the data distribution, the higher values² within the dataset have been omitted from graphs but not from exceedance percentage calculations. The uppermost value presented on the graphs (cut-off value) is referenced in the below sections for each contaminant.

Greater detail is provided for arsenic, so as to illustrate the process, but a similar process was worked through for all contaminants. For cadmium, mercury and nickel the leachability was found to be low. In these cases, the trial approach was not necessary, as is explained in the relevant sections below.

A range of possible TRC WAC values are provided for each contaminant at the end of the respective derivation sections. A summary of recommendations is provided in Section 4.0.

3.1 Arsenic

The applicable SPLP target value for arsenic was calculated at 0.2 mg/L derived from the DWSNZ MAV (indicated by the horizontal red line on the graph below). For clarity of presentation a maximum TRC value

² A statistical assessment has not been completed on these datasets to determine which high values might represent outliers, as SPLP-TRC pairs with TRC values above the chosen WAC are not important to the derivation method. This is because any waste that has a TRC value that exceeds the chosen WAC will need to undergo additional SPLP testing to determine its acceptability.

of 300 mg/kg has been used (i.e. all TRC values greater than 300 mg/kg are not presented). Approximately 96% of the laboratory-supplied dataset is <300 mg/kg.

The scatter plot shows that only a relatively small number of arsenic results exceed the SPLP target value of 0.2 mg/kg where TRC <300 mg/kg, suggesting that in the majority of cases, the leachable portion of the total recoverable arsenic is low. There is a weak correlation of increasing TRC to increasing SPLP, however, there are also many instances where similar TRC values result in quite different SPLP values (and vice versa) e.g. in one sample a TRC of arsenic of 122 mg/kg produced an SPLP <0.001 mg/L, while in another sample a TRC of 142 mg/kg produced an SPLP of 0.98 mg/L (almost 5 times the target value).

Because of the scatter, it is not possible to establish a TRC WAC for arsenic with no SPLP exceedances above the 0.2 mg/L screening value without the WAC being very low. For the current dataset, this value would be about 25 mg/kg, which is only a little higher than the residential soil contaminant standard and would mean most waste soils with elevated arsenic would require SPLP testing. This reduces the usefulness of a TRC WAC. However, it is clear from the plot that most soil would comply with the SPLP screening value at much higher TRC values.

Adopting the trial TRC approach as described above, the proportion of the total dataset that exceeded the SPLP target was calculated. The different trial TRC concentrations are also shown on the plot below, with the exceedances visually represented by the dots above the SPLP target and to the left of the various trial TRC WAC values (the vertical lines).

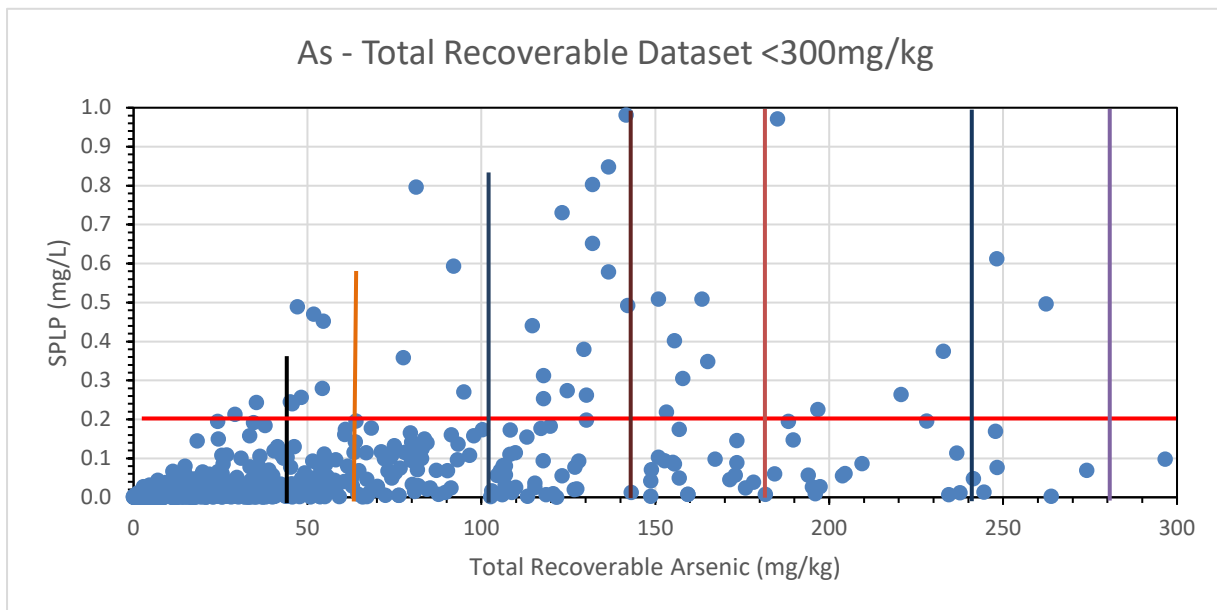
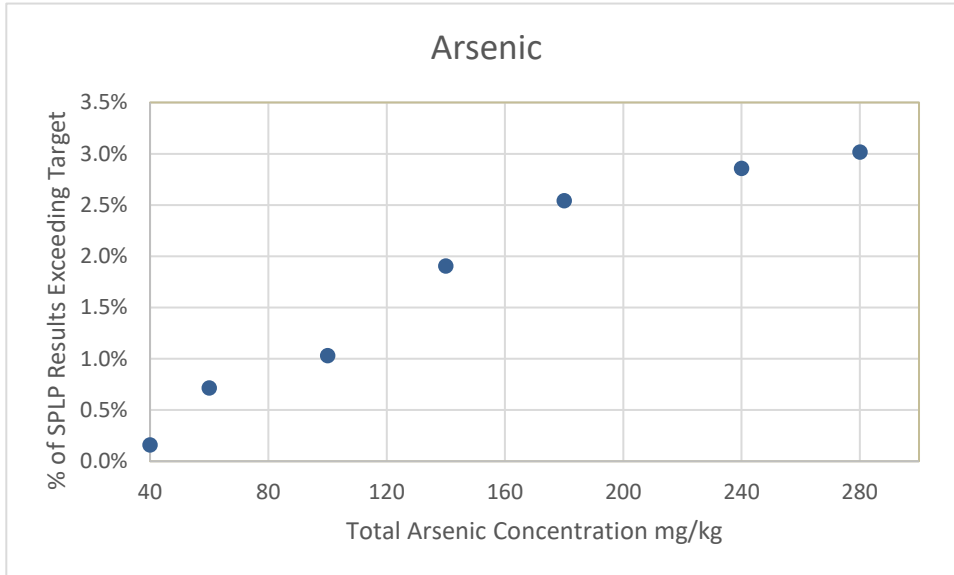


Table 3 below presents a range of trial WAC and the associated SPLP exceedance percentages up to about 3%.

Table 3: Arsenic Total Concentrations Versus Percentage of Dataset Exceeding SPLP Target Value								
Proposed WAC (mg/kg)	40	60	100	140	180	240	280	300
% Results Exceeding SPLP Target Value (0.2 mg/L)	0.16%	0.71%	1.03%	1.91%	2.54%	2.86%	3.02%	3.02%

Table 3 is represented graphically below so as to allow estimation of the likely percentages for other TRC values. It is notable that the graph flattens out at about 3% exceedance between about 270 mg/kg and 350 mg/kg,

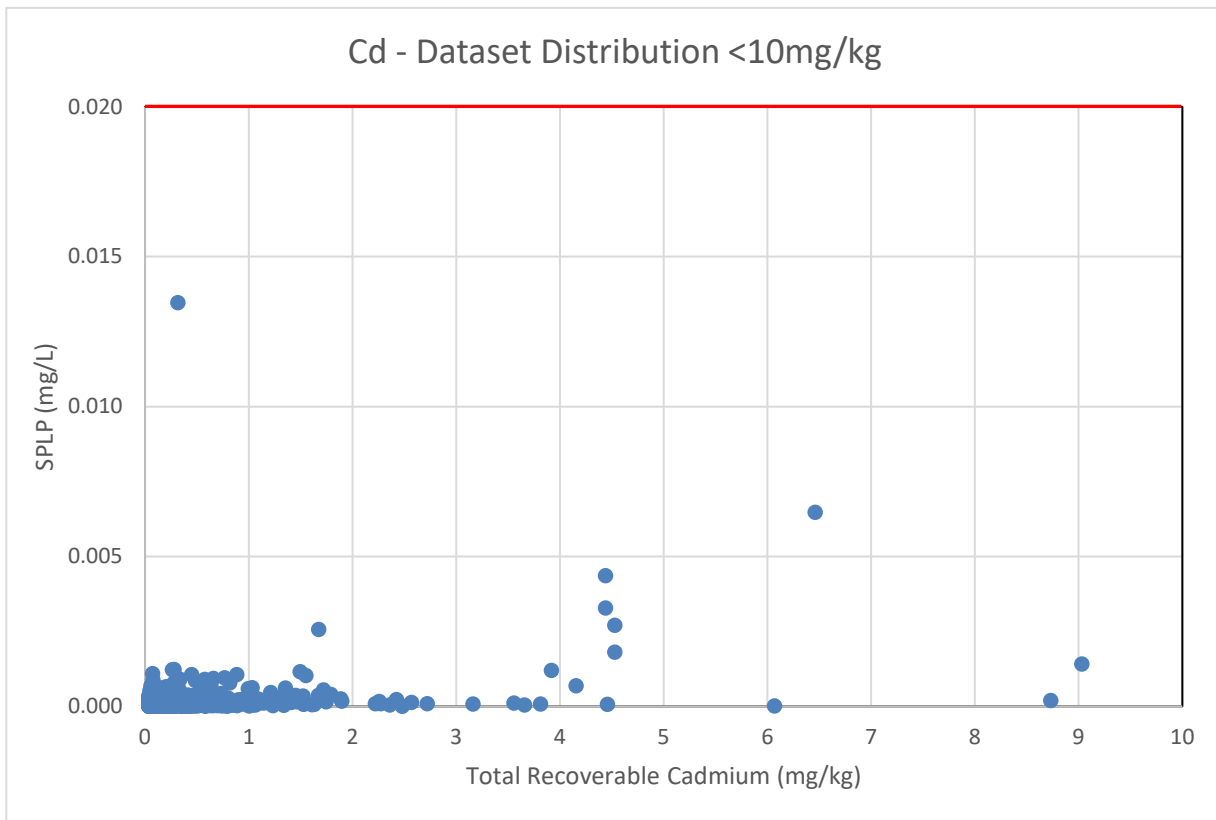


What constitutes an acceptable percentage of relatively more leachable soil is subjective and may vary between contaminants. If 1% is deemed to be an acceptable level of non-compliance then the WAC for arsenic could be set at 100 mg/kg (nearest round number) but this may not be suitable for certain localities where the natural background concentration of arsenic (e.g. for some volcanic soils) may make such soils unacceptable for disposal at Class 3 waste facilities without SPLP testing. If 2% were chosen, then the arsenic WAC would be around 140 mg/kg. It is observed that at 2.5% the arsenic WAC would be around 180 mg/kg, and at 3% it would be about 280 mg/kg.

3.2 Cadmium

The graph below presents the distribution of the cadmium dataset. For the purpose of data presentation, a TRC cut-off of value of 10 mg/kg has been applied (i.e. the 17 values greater than 10 mg/kg are not shown; equating to approximately 97.6% of the total dataset being shown).

The applicable target SPLP value for cadmium was calculated at 0.02 mg/L derived from the DWSNZ MAV (indicated by the red line on the below graph). Of the 721 data pairs in the cadmium dataset, only one SPLP value (0.08 mg/L from a TRC of 11.45 mg/kg) exceeds this target (noting that this value is not shown on the graph below as the TRC is above the displayed values). This suggests that the likelihood of cadmium contaminated soils generating a leachate that exceeds the target SPLP is low. Further, the leachability of the cadmium appears to be variable with little correlation to total concentration. For example, the two highest SPLP values (0.08 and 0.01 mg/L) were derived from TRC values of 11.45 and 0.32 mg/kg cadmium respectively.



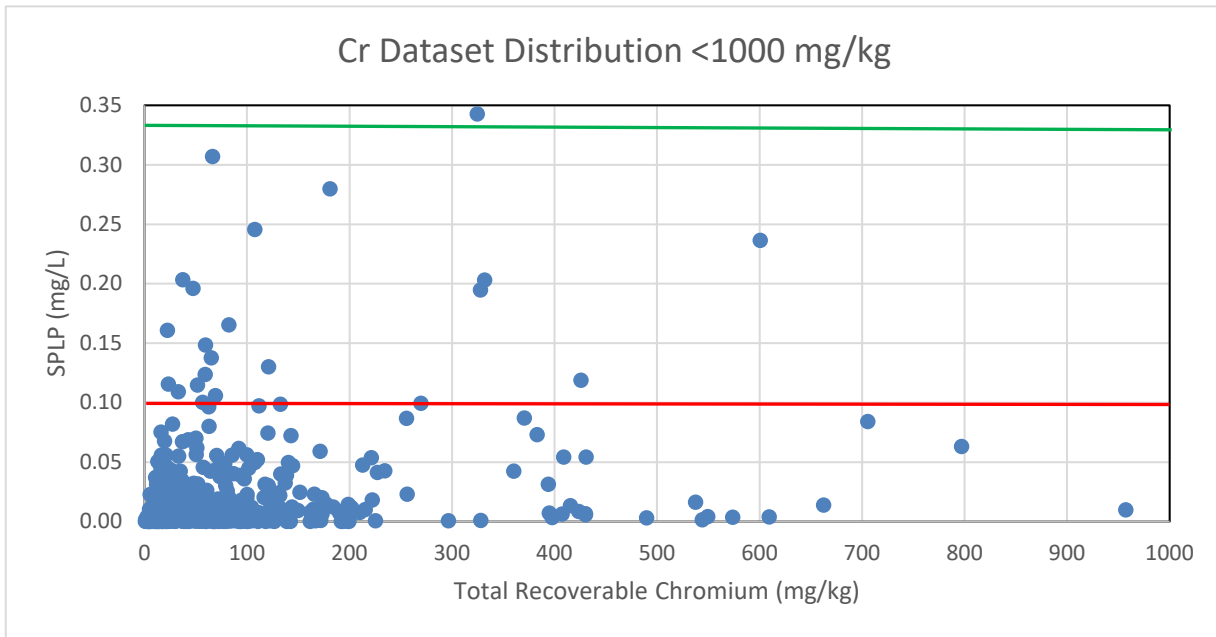
On the basis of the above, calculating the percentage of SPLP values exceeding the target concentration for different WAC values is of no benefit. Instead, a WAC must be selected as a matter of judgement. Any value up to the maximum dataset value of approximately 1000 mg/kg could be chosen, with the one value that exceeds the target being only 0.14% of all values. If the maximum value as displayed of 10 mg/kg was chosen as the TRC WAC, with soil with concentrations greater than this requiring SPLP testing, of the 17 values within the dataset above this value, approximately 94% of instances (16 out of 17) of the SPLP results would still comply with the target value.

3.3 Chromium

As noted previously the target SPLP value for chromium may be calculated two ways, depending on whether the trivalent or hexavalent form is used. The TRC and SPLP results, reported as total chromium, do not differentiate between the forms of chromium. Depending on what form is actually present, the two targets may be conservative or unconservative.

In general, the trivalent form is mainly expected to be present in soil, which means using the hexavalent target would be conservative by a factor of 3.3. Given this, the trivalent would generally be recommended. However, if the source of waste soil is an industrial site where hexavalent chromium could be present, for example a timber treatment site using the CCA treatment process, hexavalent chromium may be more appropriate.

The target SPLP value for hexavalent chromium was calculated at 0.1 mg/L derived from the ANZG for the protection of 95% species (indicated by the red line on the below graph). The target SPLP value for trivalent chromium is 0.33 mg/L (indicate by the green line on the graph below), based on a low-quality value from ANZG, as insufficient data were available to develop values for different levels of protection. For chromium a cut-off of value of 1,000 mg/kg has been used for graphical display of the results. This cut-off value incorporates approximately 98% of the dataset of 981 values.

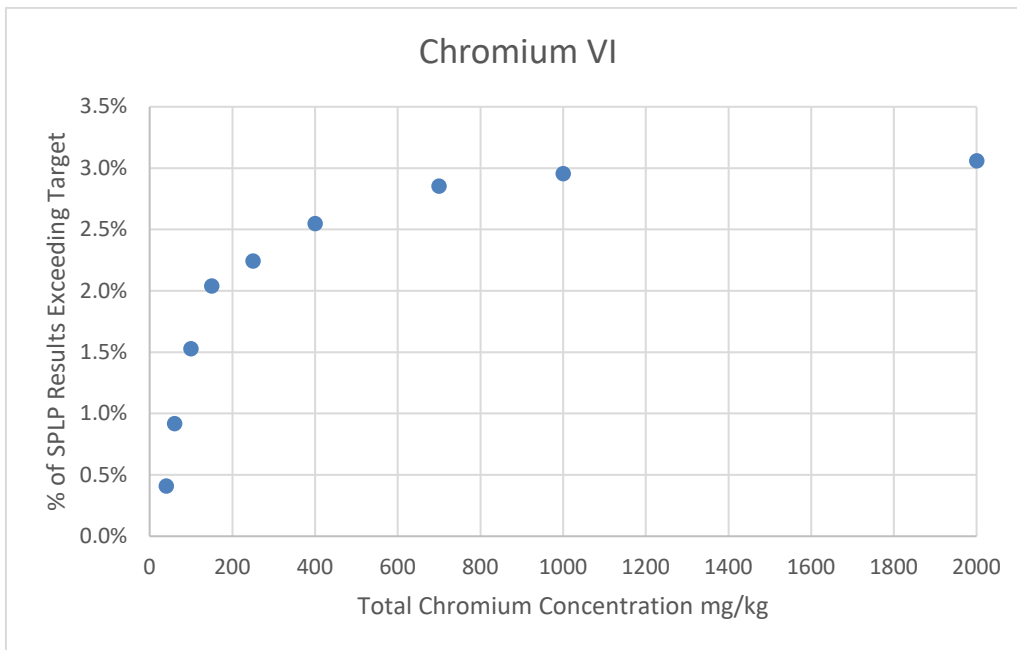


Below approximately 22 mg/kg there are zero exceedances of the SPLP target value for Cr(VI). Above this there is greater scatter in the dataset and exceedances begin to occur. For Cr(III) there are few exceedances of the target, the first at about 325 mg/kg.

The number of exceedances within the dataset is low overall suggesting that the chromium generally has low leachability. There is a weak correlation of increasing TRC to increasing SPLP value between approximately 50 mg/kg and 300 mg/kg but this tends to break down toward the higher values within the dataset which may be reflective of the low number of values in the dataset that reported high TRC. As with the other contaminants, there are a number of instances where a low TRC and a very high TRC have very similar SPLP values (e.g. 0.04 mg/L SPLP and 0.037 mg/L SPLP from 7,629 mg/kg and 10.9 mg/kg respectively).

Table 4 below presents a range of trial WAC and the associated exceedance percentages for Cr(VI) (if the assumption is made that the data is representative of Cr(VI)). These are plotted on the graph further below.

Table 4: Hexavalent Chromium Total Concentrations Versus % of Dataset Exceeding SPLP Target Value									
Proposed WAC (mg/kg)	40	60	100	150	250	400	700	1,000	2,000
% Results Exceeding SPLP Target Value (0.1 mg/L)	0.41%	0.92%	1.53%	2.04%	2.24%	2.55%	2.85	2.96	3.06



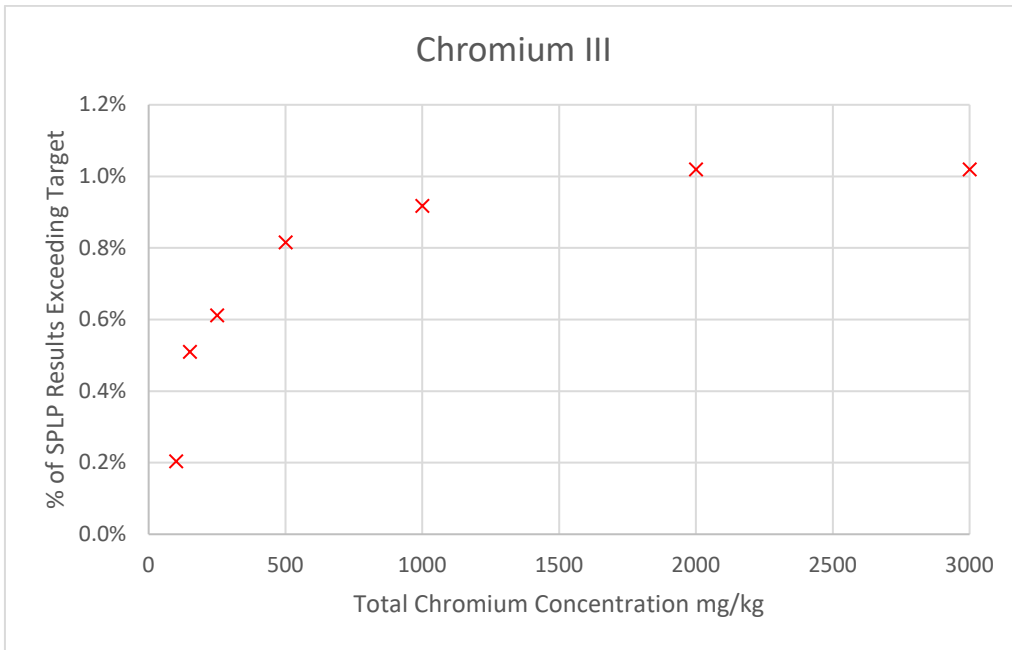
At 60 mg/kg (75% of the total dataset) the percentage is approaching 1% of the SPLP results exceeding the target value. However, this may be restrictive for some naturally occurring soils e.g. volcanic origin materials. At 2% exceedances the WAC would be close to 150 mg/kg (95% of the total dataset). Past this concentration the number of SPLP exceedances decreases significantly with 3% exceedances equating to a very high value of about 1,500 mg/kg and 97.8% of the dataset.

Table 5 below presents a range of trial WAC and the associated exceedance percentages for Cr(III) (if the assumption is made that the data is representative of Cr(III)). These are plotted on the graph further below.

Proposed WAC (mg/kg)	100	150	250	500	1,000	2,000	3,000
% Results Exceeding SPLP Target Value (0.33 mg/L)	0.20%	0.51%	0.61%	0.82%	0.92%	1.02%	1.02

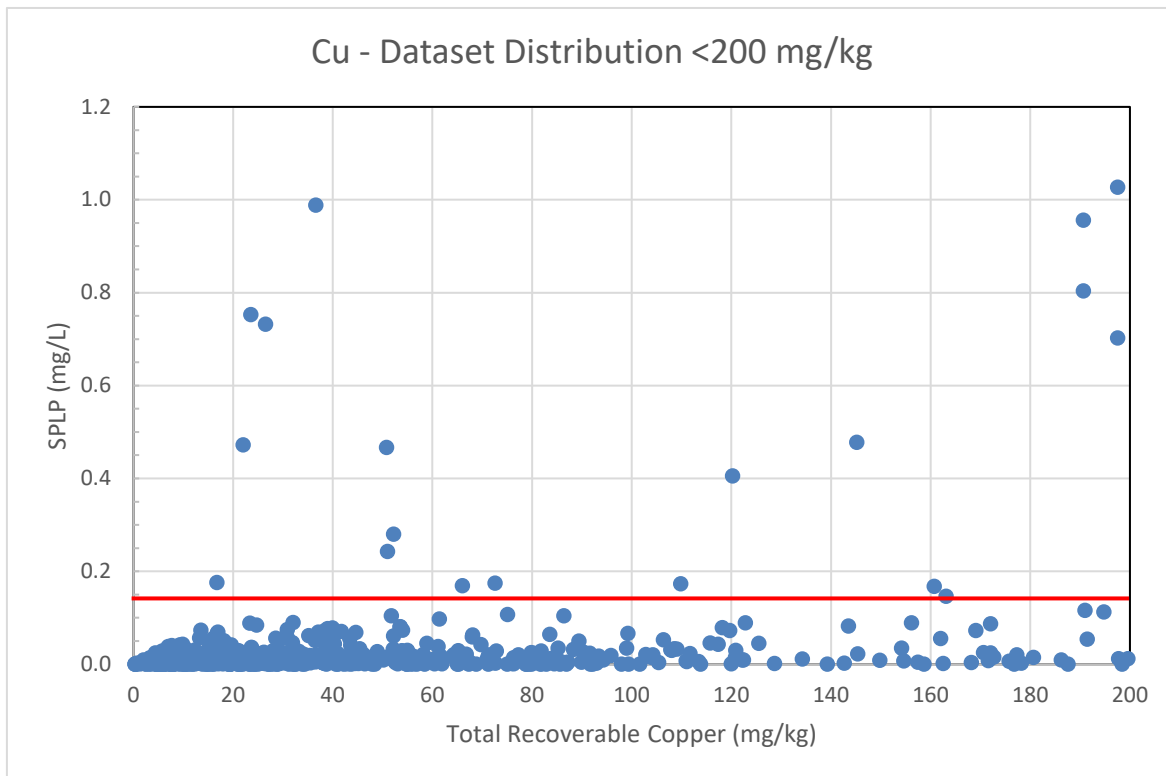
The same rapid “flattening” of the curve as occurs with CR(VI) also occurs with Cr(VI) but because of the higher SPLP target, at lower concentrations. This results in 1% exceedance of the SPLP target occurring at about 1,800 mg/kg (99% of the dataset) with so few higher values in the dataset that it is not possible to calculate a percentage exceeding higher than 1.02%.

While, as noted earlier, Cr(III) is more commonly encountered and should provide the better SPLP target, the low leachability as measured by total chromium possibly suggests having a single WAC defined by Cr(VI) for both Cr(VI) and CR(III) would be expedient (and conservative), rather than using such a high Cr(III) WAC. This is discussed further in Section 4.0.



3.4 Copper

The applicable target SPLP value for copper was calculated at 0.14 mg/L derived from the ANZG for the protection of 95% species (indicated by the horizontal red line on the graph below). A TRC cut-off of value of 200 mg/kg has been used for presentation purposes on the graph. This incorporates approximately 87% of the dataset of 1,141 data pairs.



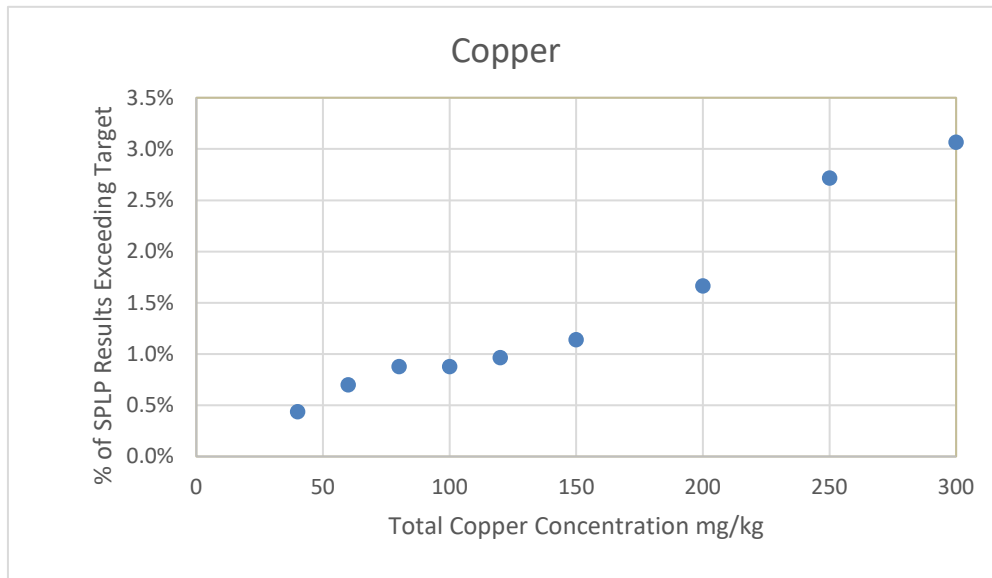
The scatter in the plot shows little if any correlation between increasing TRC and SPLP concentration for copper, suggesting that a wide range of TRC values can have a significant leachable proportion. For no instances of target SPLP value exceedance within the dataset a WAC of <16mg/kg would be required. This is below typical background concentration for many soils and would nullify the benefits of a TRC WAC.

While there are exceedances of the target SPLP for a range of TRC values, they are relatively infrequent in the context of the total dataset (i.e. of the 1,141 data pairs only 75 (6.6%) reported SPLP values above the target value). Table 6 below presents the range of trial WAC and the associated exceedance percentages up to 3% exceedances.

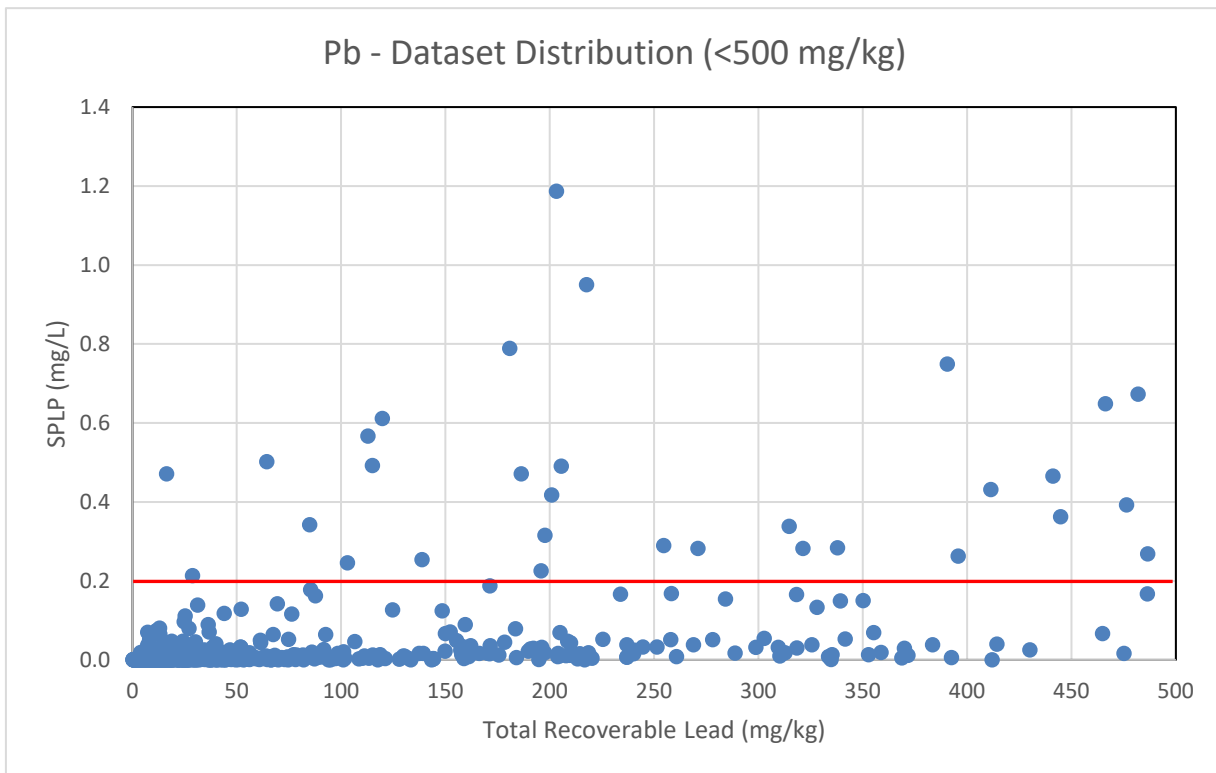
Table 6: Copper Total Concentrations Versus % of Dataset Exceeding SPLP Target Value									
Proposed WAC (mg/kg)	40	60	80	100	120	150	200	250	300
% Results Exceeding SPLP Target Value (0.14 mg/L)	0.44%	0.70%	0.88%	0.88%	0.96%	1.14%	1.67%	2.72%	3.07%

At 130 mg/kg (83% of the total dataset) about 1% of the SPLP results exceeded the target value. Above 1% the percentage exceedance increases rapidly for relatively small increases in TRC with 2% exceedance occurring at about 220 mg/kg (88% of the dataset) and 3% occurring at about 280 mg/kg (91% of the dataset).

3.5 Lead



The applicable target SPLP value for lead was calculated at 0.2 mg/L derived from the DWSNZ MAV (indicated by the red line on the below graph). For lead an initial cut-off of value of 500 mg/kg has been used for presentation purposes. This incorporates approximately 84% of the 930 pairs in the dataset.



This scatter plot shows a weak correlation of increasing TRC to increased likelihood of SPLP target value exceedance. There are also some notable anomalous results where a low TRC corresponds to a high SPLP value e.g. a TRC of 16.4 mg/kg with a corresponding SPLP concentration of 0.47 mg/L. These occurrences are the exception and not representative of the ‘typical’ soils represented by the laboratory-supplied dataset. As such, these are likely to be representative of a small volume of the soil which may be accepted into a landfill facility over the waste facility’s lifetime. Below a TRC of approximately 100 mg/kg there is a very low instance of SPLP target value exceedance. Exceedances increase above approximately 180 mg/kg. In the context of the total dataset the number of SPLP exceedances is low (approximately 89% of the SPLP results are below the target value).

Because of the scatter, a TRC WAC for lead with no SPLP exceedances above the 0.2 mg/L screening value would equate to approximately 16 mg/kg, which is below natural background levels for many soils and therefore not useful. However, it is clear from the plot that most soil would comply with the SPLP screening value at much higher TRC values. Some trial WAC and the associated percentage of SPLP exceedances are presented in Table 6 below.

Table 7: Lead Total Concentrations Versus % of Dataset Exceeding SPLP Target Value									
Proposed WAC (mg/kg)	100	125	150	200	250	300	350	400	480
% Results Exceeding SPLP Target Value (0.2 mg/L)	0.43%	0.86%	0.97%	1.40%	1.83%	2.04%	2.37%	2.58%	3.12%

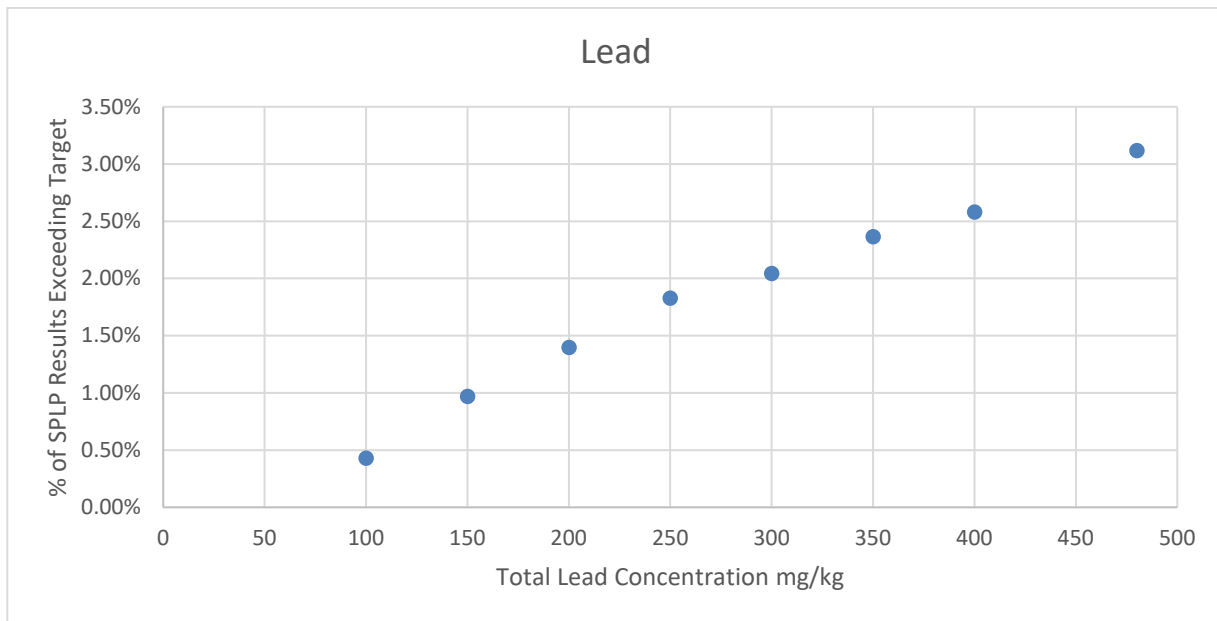


Table 6 and the above graph show that there is a reasonable linear trend (at least for values <400 mg/kg) of increasing TRC value to increasing percentage of SPLP exceedances. An exceedance target of 1% results in a WAC of 150 mg/kg. This may be exceeded occasionally by naturally occurring soils. An exceedance target of 2% results in a WAC of approximately 290 mg/kg (80% of the dataset) and 3% of the SPLP results exceeding the target results in 460 mg/kg (83% of the dataset).

Lead is frequently the driver for soil remediation during redevelopment of older residential suburbs and therefore much of the soil requiring disposal will exceed the residential human health soil contaminant standard (SCS) of 210 mg/kg. In order to obtain the cheapest soil disposal option, it is common to establish leachability-TRC relationships. More often than not, such analysis would demonstrate, on average, the acceptability of soil well in excess of 210 mg/kg, which is also demonstrated by the current analysis.

3.6 Mercury

The applicable target SPLP value for mercury was calculated at 0.06 mg/L derived from the ANZG for the protection of 95% species. No exceedances of this target concentration were identified within the dataset of 366 values. The lower number of data pairs relative to the other contaminants and the low TRC generally encountered (92% of the dataset was < 2mg/kg and only 12 values – 3% of the dataset – exceeded 10 mg/kg) suggest that mercury is not a commonly encountered contaminant, and then at generally low concentrations. At the encountered concentrations mercury had low leachability. The highest SPLP concentration encountered (0.01 mg/L) was only 18% of the target value suggesting that an exceedance of the target value is highly unlikely for soils arising from a 'typical' site, as represented by the laboratory-supplied dataset.

In the absence of any exceedances we are unable to calculate a TRC WAC using the methodology described in Section 2. Instead a TRC WAC must be selected as a matter of judgement. For the dataset this suggests any value up to 160 mg/kg, and even higher, could be used. As a comparison, the residential SCS for mercury is 310 mg/kg.

3.7 Nickel

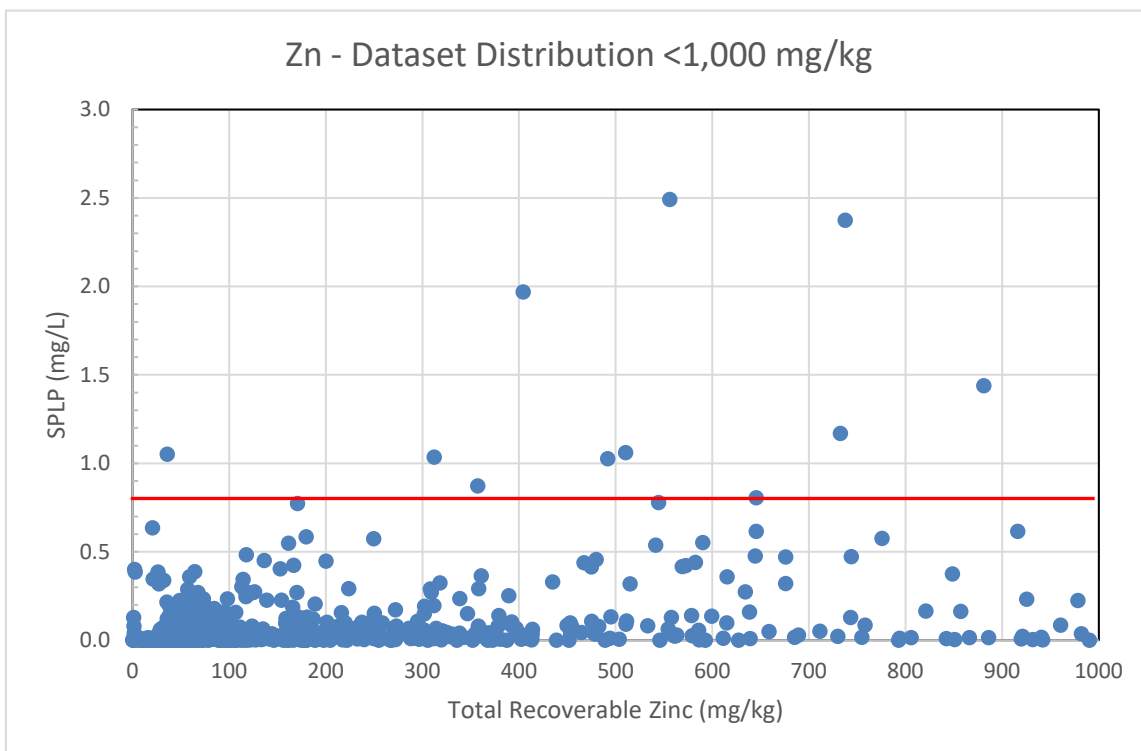
The applicable target SPLP value for nickel was calculated at 1.1 mg/L derived from the ANZG for the protection of 95% species. No exceedances of this target concentration were identified within the dataset of 861 values. If the laboratory-supplied dataset is considered to represent a range of 'typical' soils in New Zealand the absence of SPLP exceedances and that 95% of the TRC values for nickel are below 100 mg/kg, suggest that nickel is rarely encountered in high and/or highly leachable concentrations in New Zealand.

The highest SPLP concentration encountered (0.23 mg/L, associated with a TRC of 61 mg/kg) was only 21% of the target value. Even the highest concentrations of nickel in the dataset (approximately 37,000 mg/kg and 6,900 mg/kg) produced SPLP concentrations below the target value (0.05 mg/L and 0.09 mg/L, respectively). This suggests that an exceedance of the target value is highly unlikely under most circumstances.

In the absence of any exceedances we are unable to calculate a TRC WAC using the methodology described in Section 2.2. A recommended value is provided in Section 4.0.

3.8 Zinc

The applicable target SPLP value for zinc was calculated at 0.8 mg/L derived from the ANZG for the protection of 95% species (indicated by the red line on the below graph). A cut-off value of 1,000 mg/kg has been used for presentation purposes. This incorporates approximately 88% of the dataset of 979 values.



The scatter plot shows that there is a weak correlation of increasing TRC to increasing SPLP, however, there are also some notable anomalous results where a low TRC corresponds to an SPLP value exceeding the target concentration e.g. 36 mg/kg TRC with 1.05 mg/L SPLP. These occurrences are an exception, not representative of a 'typical' site as represented by the laboratory-supplied dataset, and are likely to be

representative of only a small volume of the soil which may be accepted into a landfill facility over the facility’s lifetime.

Because of the scatter, a TRC WAC for zinc with no SPLP exceedances above the 0.8 mg/L screening value would equate to about 35 mg/kg, which is significantly below natural background levels for many soils. However, it is clear from the plot that most soil would comply with the SPLP screening value at much higher TRC values. Some trial WAC and the associated percentage of SPLP exceedances are presented in Table 8 below.

Table 8: Zinc Total Concentrations Versus % of Dataset Exceeding SPLP Target Value									
Proposed WAC (mg/kg)	600	800	1,000	1,500	2,000	3,000	4,000	6,000	8,000
% Results Exceeding SPLP Target Value (0.8 mg/L)	0.72%	1.02%	1.12%	1.33%	1.43%	1.94%	1.94%	2.15%	2.35%

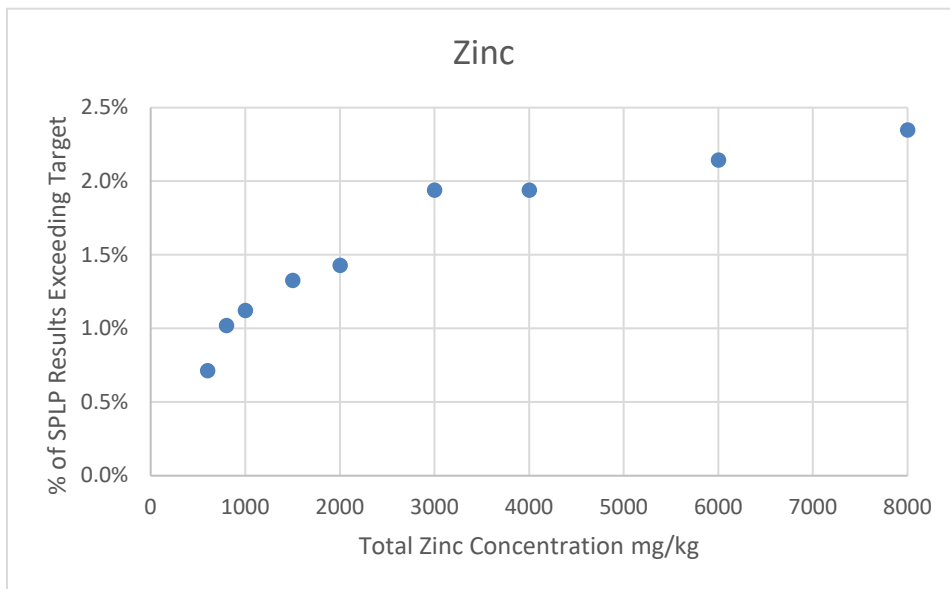


Table 8 and the above graph show that there is a reasonably linear trend of increasing percentage of SPLP exceedances with increasing TRC for TRC values between 800 and 3,000 mg/kg, with the percentage changing little above 3,000 mg/kg. It was not possible to calculate a 3% percentage exceedance, with the maximum value being at 2.35% at a TRC of about 7,300 mg/kg.

For <1% of the accepted soils to exceed the target value a WAC of approximately 800 mg/kg could be used. This is likely to be suitable for most soils, however, a less conservative WAC of 2,000 mg/kg would still only represent 1.5% SPLP exceedances. A 2% SPLP exceedance occurs at about 4,200 mg/kg.

4.0 Recommendations

What constitutes an acceptable percentage of relatively more leachable soil is subjective and may vary between contaminants. As noted previously, possible TRC WAC have been calculated up to a non-compliance within the datasets of up to 3%, where possible. For trivalent chromium and zinc, percentages exceedances of more than 1.02% and 2.35 %, respectively, could not be calculated.

For the low-leachability metals mercury, cadmium and nickel, all the SPLP results in the datasets were below the respective targets. This means that, in theory, even the highest recorded TRC values in each dataset, and possibly higher, would be acceptable as the respective WAC.

A summary of the potential calculated WAC values is provided in Table 9, below, for integer values of percentage exceeding (1%, 2% and 3%). The table includes the percentage of the datasets that the various calculated values represent. In addition, to provide some context, the table has the residential SCS and the ANZ low and high freshwater aquatic sediment guidelines. The guideline values are not relevant to setting the WAC but provide some “feel” for where possible WAC values lie.

Table 9: Summary of TRCs for % Exceeding SPLP Targets (mg/kg) and % of Dataset these Represent (%)

Contaminant	1%	2%	3%	Residential SCS	ANZ Sediment Guidelines	
					Low	High
Arsenic	100 (88%)	140 (92%)	280 (96%)	20	20	70
Cadmium	nc ¹	nc	nc	3	1.5	10
Chromium III	1,800 (99%)	nc	nc	No Limit ²	80	370
Chromium VI	60 (75%)	150 (95%)	1,500 (98%)	460		
Copper	130 (83%)	220 (88%)	280 (91%)	No Limit	65	270
Lead	150 (73%)	290 (80%)	460 (83%)	210	50	220
Mercury	nc	nc	nc	310	0.15	1
Nickel	nc	nc	nc	400	21	52
Zinc	800 (86%)	4,200 (97%)	nc	7400	200	410

Notes:

1. nc indicates no value could be calculated.
2. No Limit indicates concentration above 10,000 mg/kg are acceptable and impose no practical limit.

4.1 Decision-making Hierarchy

There is no particular consistency between the various contaminants with respect to percentage exceeding the SPLP targets and the percentage of the dataset that these values represent. The choice of WAC values is therefore necessarily a matter of judgement. To assist this judgement, a decision-making hierarchy has been developed by PDP, taking into account factors such as the prevention of unacceptable adverse effects, and including practical considerations (e.g. ensuring where possible that there is differentiation between Class 3 and 4 landfills; ensuring the ability of a Class 3 landfill to dispose of waste soils from sites where it may most commonly be generated). The decision-making hierarchy is as follows:

1. The WAC must be above the background concentration.
2. The WAC should preferably be above the residential SCS on the basis that residential development will be the source of much waste soil and avoiding excessive SPLP testing for this common source is preferable.
3. As a matter of judgement, where percentages exceeding the SPLP could be calculated, a WAC in the range 2 to 3% should be chosen as giving reasonable values while ensuring adequate protection of the environment.

4. Given the scatter in the SPLP versus TRC plots at high TRC values and, in some cases, extreme values still being within the SPLP targets, as a matter of judgement the WAC should not exceed the 95th percentile and preferably not exceed the 90th percentile of the respective datasets.
5. As a “nice to have”, the WAC should not exceed the ANZG “high” sediment guideline, with the effect that a non-compliance of stormwater sediment controls would be less significant, if poorly treated stormwater runoff reaches an aquatic environment. It should be noted that engineered controls to prevent significant sediment reaching an aquatic environment with the primary goal to prevent smothering effects should also avoid contaminant effects.
6. Existing consented landfill WAC have not been considered, as these have many site-specific and regional plan issues factored in.

4.2 Arsenic

A WAC value of 140 mg/kg is recommended for arsenic, which is the 2% exceeding value. This is the equivalent of 92% of the dataset, which falls between the 90 – 95% guideline. The 3% value of 280 mg/kg exceeds the 95% of the dataset guideline. It is not possible to stay within the ANZG sediment guideline but going above 2% exceeding (e.g. to 2.5% which would result in a WAC of 180 mg/kg) does not seem prudent.

4.3 Cadmium

Given the low leachability of cadmium, any value within the dataset could have been chosen (up to 1,000 mg/kg). A value of 10 mg/kg is recommended as a matter of judgement. This represents 97.6 % of the data set, which is higher than the dataset percentage guideline range, but given the low leachability of cadmium at higher concentrations this is not considered a problem. The value is, coincidentally, the same as the ANZG high sediment value and has the advantage of being an easily remembered round value.

4.4 Chromium

The recommendation for chromium was difficult. Ideally, a value for trivalent chromium would have been selected, but the single value able to be calculated (1,800 mg/kg at 1% exceeding) represents 99% of the dataset, which is considered too high. Despite the hexavalent chromium values being considered conservative, the 2% exceeding value of 150 mg/kg represents 95% of the dataset, which is the top of the recommended range and has therefore been chosen as the WAC. It falls comfortably below the ANZG high sediment guideline.

4.5 Copper

A WAC for copper of 280 mg/kg is recommended. This is the 3% exceeding value and it represents 91% of the dataset, at the top and towards the bottom of the respective recommended ranges for these values. The value is slightly above the ANZG high sediment guideline.

4.6 Lead

A WAC of 460 mg/kg is recommended. This is the 3% exceedance value but represents only 83% of the dataset. The higher percentage exceedance has been chosen to avoid an unnecessarily high percentage of waste soil needing to undergo SPLP testing. The value is above the ANZG high sediment guideline, but less so, relatively, than arsenic.

4.7 Mercury

Mercury has low leachability and any value, or higher, could have been chosen from the data set (the highest TRC value being 160 mg/kg). A value of 3 mg/kg is recommended, as being 93% of the dataset.

4.8 Nickel

Nickel has low leachability and any value up to the highest value (37,000 mg/kg) in the dataset complied with the SPLP target. The 95th percentile of the dataset is 100 mg/kg, which is below background concentration for some soils. The WAC should be set at a value that will not prevent the disposal of natural soils with background soil concentrations. Volcanic soils in Auckland can be up to 320 mg/kg, and this value is recommended. Approximately 98% of the dataset falls below this value.

4.9 Zinc

A WAC for zinc of 2,700 mg/kg is recommended. This is the dataset's 95% percentile and represents only 1.7% of the results exceeding the SPLP target, which is below the recommended range. The value is also below the residential guideline of 7,400, however, it is considered more important to stay within the 95% of the dataset guideline.

5.0 Conclusions

The datasets summarised in this memorandum are considered to be sufficiently extensive for the purpose of developing Class 3 TRC WAC for the considered heavy metals, and incorporate the available data from two of the largest laboratories in New Zealand over the past 10 years. The SPLP target values have been calculated based on the principles given in Appendix C.4 of the August 2018 version of the WasteMINZ technical guidelines and are considered to be appropriate for the protection of groundwater and surface water receptors in the vicinity of a typical managed fill facility.

The datasets used to calculate the recommended criteria, set out in Table 10 below, account for different soil types, contaminant sources and locations around New Zealand, and are therefore considered to be applicable to a wide range of waste contaminated soils likely to be disposed of at landfills. However, if there are reasonable grounds to suspect that a contaminant present in soils may be prone to greater leaching than is typical (on the basis of contaminant source, soil type, soil pH and other considerations) then SPLP analysis should still be undertaken as an added precaution to help minimise the frequency and magnitude of the SPLP results exceeding the target value. A Site Management Plan should be prepared for all fill sites which contains sufficiently robust waste acceptance procedures that such circumstances can be recognised.

In general, the proportion of SPLP target exceedances between 2 – 3% has been considered appropriate, with the added criteria of the selected WAC falling within 90 – 95% of the respective datasets. While there are obvious risks associated with allowing too many exceedances of the SPLP target value, the conservative nature of the SPLP test and the WAC derivation means this risk is generally small. On the other hand, it is appropriate to not go too high within a dataset, because how representative of the “real world” high values of TRC are gets increasingly uncertain.

While some of the WAC values appear high, it should also be borne in mind that there is an averaging effect within landfill, with soil being physically mixed, leachate mixing and being adsorbed within other soil in the landfill, and mixing within groundwater. This means that occasional SPLP exceedances will not actually eventuate in a risk to drinking water or an aquatic environment.

For cadmium, mercury and nickel, very few or no exceedances of the SPLP target value were identified in the laboratory-supplied dataset and, as such, the data indicate that these elements are unlikely to leach at concentrations posing a risk to groundwater and/or surface water receptors (apart from unusual

contamination conditions). Further, the low volume of soils that do exceed the SPLP target value for these elements are likely to be mitigated by the far greater volume of low SPLP value soils.

Table 10: Proposed Total Recoverable Concentration Waste Acceptance Criteria		
Contaminant	Proposed TRC WAC ¹	Percentage of Exceedances ²
Arsenic	140	2%
Cadmium	10	N/A ³
Chromium	150	2%
Copper	280	3%
Lead	460	2%
Mercury	3	N/A ³
Nickel	320	N/A ³
Zinc	2,700	1.7%
Notes: <ol style="list-style-type: none"> All values in mg/kg. Percentage of samples that would still exceed the target SPLP value based on the current dataset. Due to a low number or absence of SPLP values exceeding the target value it was not possible to calculate the likely percentage of samples that would exceed the target SPLP value. 		

If adopted, the TRC WAC in Table 10 would allow for a simpler disposal process for contaminated soils whilst not compromising the ability of the waste facility and/or regulators to determine an associated level of risk to nearby receptors. The benefits of this streamlined process are considered to outweigh the small possibility that a soil capable of producing leachate at a concentration in excess of the target value will be disposed of to Class 3 waste facilities. As stated in the WasteMINZ 2018 Landfill Guidelines, waste acceptance procedures such as an assessment of the nature and source of the waste, and a sufficient amount of TRC analysis, must be implemented to ensure that only soils that meet the WAC are accepted.

6.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Hill Laboratories Limited and Analytica Laboratory. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This memorandum has been prepared by PDP on the specific instructions of Ministry for the Environment for the limited purposes described in the memorandum. PDP accepts no liability if the memorandum is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

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**Appendix B: PDP Technical
Memorandum – W01820600M007**



technical memorandum



TO Nigel Donovan FROM Natalie Webster, Graeme Proffitt
Ministry for the Environment DATE 1 July 2020
RE WasteMINZ Landfill Guidelines – Proposed Class 3 and 4 WAC for Organic Compounds

1.0 Introduction

This memorandum sets out proposed waste acceptance criteria (WAC) for organic compounds for Class 3 (Controlled) and Class 4 (Managed) fills. This memorandum is supplemental to our earlier memorandum W01820600M005, *WasteMINZ Landfill Guidelines – Options for Class 3 and 4 WAC Derivation*, PDP, 2019. That memorandum sets out proposed WAC for organic compounds for both Class 3 and 4 fill sites. However, since that time an error has been discovered in the original derivation for the Class 4 WAC for xylene, as presented in Appendix C of the *WasteMINZ Technical Guidelines for Disposal to Land* ('the Guidelines') (draft version dated August 2018). This prompted a review of all the calculations for the Class 4 organic WAC derivations. As some of the Class 3 WAC will be the same as the Class 4 WAC for situations where one of the leaching pathways is critical for Class 4, this review affects both Class 3 and 4 organic WAC values.

The result of the review is new proposed organic WAC values for Class 3 and Class 4 fills.

2.0 Background to Class 3 Organic WAC Derivations

As discussed in our memorandum W01820600M005, the Class 3 WAC for organic compounds only consider the groundwater use and aquatic environment leaching pathways. The calculations are the same for these pathways for Class 4 fills, but for Class 4, other pathways (e.g. residential land use or ecological protection) may be the limiting pathways and become the WAC.

The leaching pathway calculations start with an estimate of leachate concentrations. The assumption is that the leachate concentration is the starting concentration before dilution and attenuation in the groundwater on its way to a drinking-water bore or within a stream that the groundwater discharges to. To obtain a soil concentration-based WAC it is necessary to relate the leachate concentration to the soil concentration. Appendix C in the Guidelines uses a partitioning relationship. In addition, Appendix C uses simple dilution and attenuation coefficients (DAF) to allow for attenuation of the contaminants between the waste, and a hypothetical drinking-water abstraction point at the downgradient boundary of the waste or to a small stream at the downgradient boundary of the waste. For groundwater discharge to a water bore the DAF employed in Appendix C is 20, with this being multiplied by a factor of 5 (to give an overall DAF of 100) for groundwater discharge to a stream, to allow for the additional dilution provided by the stream.

Starting with guideline values for either drinking water or aquatic environment protection, a total soil concentration WAC can be back-calculated. We do not propose to change the derivation process, including the DAFs, but we have checked the drinking-water and aquatic protection guideline values

employed, applied more up-to-date ecological protection values for the Class 4 derivations where available, and examined the parameters used in the partitioning relationship.

The partitioning relationship is expressed in its simplest form as:

$$\text{Soil contaminant concentration (mg/kg)} = K_d \text{ (ml/g)} \times \text{Equilibrium pore water concentration (mg/L)}$$

where K_d is the distribution coefficient (or partition coefficient) for the contaminant.

For organic compounds K_d values can be calculated from an organic carbon-water partitioning coefficient (K_{oc}) for a given fraction of organic carbon (f_{oc}) within the soil. The K_d value is simply the K_{oc} value for the contaminant multiplied by the f_{oc} . While K_d values for heavy metals vary by orders of magnitude between varying soil types, measured K_{oc} values for organic compounds vary much less from soil to soil than K_d values for heavy metals and are typically reported as averaged fixed values.

For the Class 4 derivations an f_{oc} of 1% has been assumed in the Guidelines. This is a reasonable (and conservative) value for most New Zealand soils, but may not be conservative for sandy or other granular soils with low organic carbon content. However, if it is assumed that most waste soil will have at least 1% f_{oc} , then even if some of the soil is sandy, on average the waste mass will have an f_{oc} of 1% or more.

3.0 Revised Derivations

The Class 4 derivations covered a range of petroleum hydrocarbons, including two total petroleum hydrocarbon (TPH) fractions to represent contamination from diesel and petrol; the BTEX compounds (benzene, toluene, ethylbenzene and xylenes) also found in petrol and diesel; two persistent pesticides, DDT and dieldrin; and a polycyclic aromatic hydrocarbon (PAH) compound, benzo(a)pyrene (BaP). Benzo(a)pyrene is associated with petroleum hydrocarbons but is also a by-product of incomplete combustion and is often found as soil contamination in urban and industrial environments. The current Guidelines assume that Class 3 WAC will be derived for the same organic compounds. We have continued with that assumption.

It is worth noting that petroleum hydrocarbons found on typical hydrocarbon-contaminated sites are measured using three TPH fractions, expressed as ranges of carbons to represent the mixtures of compounds in petroleum hydrocarbon products, specifically for C_7-C_9 , $C_{10}-C_{14}$ and $C_{15}-C_{36}$ TPH for light, medium and heavy hydrocarbon mixtures, respectively. The Guidelines have not considered the heavy hydrocarbons. This is acceptable because generally the aliphatic¹ components of the heavy hydrocarbons in fuels are not particularly toxic (they are typically solids such as waxes, when not dissolved in the lighter hydrocarbons) and have low leachability. Calculation of a WAC would result in a high value (tens of thousands of mg/kg) which would be greater than would be found on real-world sites. In effect there is no limit to the allowable concentration of heavy aliphatic hydrocarbons in a waste soil. The more toxic heavy hydrocarbons are typically PAHs, which are represented by BaP (which in turn is used to represent several toxic PAHs as an equivalent BaP value (BAP_{eq}) calculated as a toxicity-weighted sum of the concentrations of the several PAHs).

All the organic compounds except the two TPH fractions have drinking-water guidelines (originally NZDWS, 2005 revised 2008, now revised 2018²), which have not changed since the original derivations. Because C_7-C_9 and $C_{10}-C_{14}$ TPH do not have drinking-water guidelines no attempt was made in the existing guidelines to calculate a WAC for the drinking-water pathway. However, the equivalent of drinking-water

¹ Aliphatic hydrocarbons have carbon and hydrogen atoms in straight chains, branched chains or non-aromatic rings. This is distinct from aromatic hydrocarbons that typically (but not always) have single or multiple six-carbon benzene rings.

² *Drinking-water Standards for New Zealand 2005, Revised 2018*. Ministry of Health, Wellington, December 2018, available <https://www.health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2018>

guidelines for these two TPH fractions are presented in MfE's petroleum hydrocarbon soil guideline document, commonly known as the *Petroleum Guidelines*³. These drinking-water values have been calculated in the same way as values in the NZDWS. Given this, we consider it appropriate to use these values to calculate WAC for the drinking-water pathway for TPH.

Only some compounds had aquatic guidelines in the main tables of the ANZECC 2000 water quality guidelines used for the original derivations, although several more compounds had low quality values presented in appendices to the ANZECC Guidelines. The low-quality values were not used in the original derivations. The ANZECC 2000 document has been superseded by the web-based ANZG, 2018⁴. There are now 95% species protection values presented in ANZG, 2018 for all the organic contaminants except TPH. This provides the opportunity to check whether the drinking-water pathway is actually the critical pathway for the Class 3 WAC for the substances that now have aquatic values.

In addition, it is apparent that the aquatic guideline used for the total xylenes aquatic pathway derivation was in error. There are three xylene isomers, o-, m- and p-xylene. Each have different aquatic guidelines. The existing WAC calculations used a value of 0.55 mg/L as the 95% species protection value, which appears to be the sum of the 95% protection guidelines for the o- and p-xylene isomers. A summation approach does not seem correct, as this would result in a higher (less conservative) WAC than would seem to be appropriate for a mixture of isomers with a range of toxicity, if individual WAC for each isomer are not to be derived. Instead, using an average guideline value seems more appropriate. An averaging approach for total xylenes has been used in the revised derivations.

Finding the error in the xylene WAC prompted a review of all the calculations, including reviewing the Koc values used for the various organic compounds. The source of the Koc values is not reported in the detail provided for the derivations in Appendix C of the Guidelines, however, from back-calculations it is apparent that the source for some of the values was the MfE *Petroleum Guidelines*. These values were compiled in the mid-1990s when the *Petroleum Guidelines* were first developed, and it was decided to look at whether more up-to-date values are now available. In addition, it is not clear where the Koc values for DDT and dieldrin were sourced from. A brief examination of literature values suggested the values used for the Class 4 derivations for dieldrin and DDT were too high, in one case by a factor of more than 10. The effect of this is dieldrin and DDT being modelled as less mobile than reality, with the leaching pathway WAC being too high. A lower Koc value could mean one or other of the leaching pathway WAC values being the limiting value, resulting in a changed WAC.

A non-exhaustive review of the literature has resulted in revised Koc values for all the organic compounds except for the two total petroleum hydrocarbon (TPH) fractions. The Koc values for these hydrocarbon mixtures have been taken from the *Petroleum Guidelines* and are averages of Koc values for representative compounds within these mixtures. In turn, the Koc values for the representative compounds were taken from a report prepared by the United States-based Total Petroleum Hydrocarbons Criteria Working Group⁵, which is considered to have produced the definitive work on TPH fractions to represent the mixtures of hydrocarbons in fuels. For the other Koc values the United States Environmental Protection Agency's (US EPA) online 'Chemical Dashboard' was used as an authoritative source. The database provides a range of measured, average measured and modelled values. Average measured values were used in the revised WAC derivations.

³ *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand* (updated 2011), Ministry for the Environment, Wellington, 2011.

⁴ *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia, 2018, available <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search>

⁵ TPHCWG 1997, *Selection of Representative TPH Fractions Based on Fate and Transport Considerations*. TPH Criteria Working Group, Fate and Transport Technical Action Group, Volume 3, Amherst Scientific, Amherst, Massachusetts.

Table 1 below shows the original and revised values of Koc and water quality guideline values used in the derivations.

Table 1: Class 3 and 4 WAC for Organic Compounds (mg/kg)					
Contaminant	Koc (L/kg)		Drinking-water MAV ³ (mg/L)	95% Aquatic Guideline	
	Original	Revised ¹		Original	Revised ⁴
TPH C ₇ – C ₉	10,000	10,000 ²	18	-	-
TPH C ₁₀ – C ₁₄	1,259,000	1,259,000 ²	0.35	-	-
Benzene	83	56.2	0.01	0.95	0.95
Ethylbenzene	1100	170	0.3	-	0.08
Toluene	302	117	0.8	-	0.18
Total Xylene	240	204 ⁵	0.6	0.55	0.21 ⁵
BaP	389,000	891,000	0.0007	-	0.0002
Dieldrin	21,380	12,000	0.00004	-	0.00001
Total DDT ⁶	2,630,000	204,000	0.001	0.00001	0.00001

Notes:

- All values from US EPA Chemicals Dashboard: <https://comptox.epa.gov/dashboard/> except as shown.
- From Table 4B2 MfE Petroleum Guidelines: <https://www.mfe.govt.nz/publications/hazards/guidelines-assessing-and-managing-petroleum-hydrocarbon-contaminated-sites-new>
- From MoH New Zealand Drinking-water Standards 2005 (Revised 2018): <https://www.health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2018>.
- From Australia and New Zealand Guidelines for Fresh and Marine Water Quality 2018: <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search>.
- Mean value for o-, m- and p-isomers
- Total DDT is the six o,p'- and p,p'- isomers of DDT, DDD and DDE.

For the Class 4 WAC, ecological values protecting plants and soil biota may be limiting. As noted in our earlier memorandum W01820600M005, Landcare Research⁶ has developed more up-to-date values than were used in the current Guidelines for some of the organic compounds. In the revised Class 4 derivations these values have been used where they are different from the original ecological values. Revised ecological guidelines were used for the two TPH fractions, BaP and DDT. Ecological values were not available from the Landcare report for the BTEX group of hydrocarbons and dieldrin.

4.0 Conclusion

The proposed revised WAC for Class 3 and Class 4 are shown in Table 2 below, compared with the values currently in the Guidelines for Class 4 and what would have been derived for Class 3 using the parameters in the current Guidelines. Only one of the Class 4 WAC is the same, that for C₁₀-C₁₄ TPH. Otherwise, all the revised Class 4 WAC were lower except for slightly increased values for BaP and DDT. Five of the nine values have leaching pathways as limiting (four drinking-water and one aquatic value), which means the same values apply to Class 3.

⁶ Updated Development of soil guideline values for the protection of ecological receptors (eco-SGVs): Technical document, Envirolink Tools Grant: C09X1402. Prepared for the Regional Waste and Contaminated Land Forum, Land Monitoring Forum and Land Managers Group, Landcare Research; update prepared for Gisborne District Council, June 2019.

Of the nine Class 3 WAC, five have the drinking-water pathway as limiting and two have the aquatic pathway as limiting. The remaining two contaminants are the TPH fractions. The low mobility of the C₁₀-C₁₄ fraction means there is no practical concentration limit, however a WAC could not be calculated for the C₆-C₇ fraction as no aquatic guideline was available and the drinking-water pathway has no practical limit. A brief review of toxicity of some of the aliphatic components of the C₆-C₇ fraction suggests a WAC of perhaps a few to several thousand mg/kg, although whether this would be the case as a mixture of several compounds is uncertain.

Concentrations of this order would be rarely encountered, although might be encountered after a significant petrol spill or leak. Such high concentrations would smell strongly of hydrocarbons (i.e. like petrol or a solvent). This should be an indication to check for concentrations of the BTEX compounds, which are likely to be the limiting compounds for such soil. It is normal to analyse for TPH for any site that has stored hydrocarbon fuels or solvents, and BTEX analysis would also be expected for many such sites. We recommend that BTEX analysis should be required for hydrocarbon-containing soils if C₆-C₇ TPH exceeds, say, 1000 mg/kg, or if the soil has a strong hydrocarbon odour.

5.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Ministry for the Environment and limited research into the international literature. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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Table X: Proposed Class 3 and 4 WAC for Organic Compounds (mg/kg)

	Class 3 using Guideline Class 4 Derivation	Proposed Class 3 using Revised Parameters	Class 4 from Guidelines	Proposed Class 4
TPH C₇ – C₉	No Practical Limit ⁵	Not Calculated ⁶	120	110 ⁷
TPH C₁₀ – C₁₄	No Practical Limit ⁵	No Practical Limit ⁵	58	58
Benzene	0.2	0.11	0.2	0.11
Ethylbenzene	66	10	59	10
Toluene	50	19	50	19
Total Xylene	29	25	30	25
Benzo(a)pyrene (equivalent)⁸	54	125	2 ⁹	2.8 ⁷
Dieldrin	0.2	0.10	0.2	0.10
Total DDTs¹⁰	26	2.0	0.7 ¹¹	1.9 ⁷

Notes:

1. Blue shading indicates drinking water pathway is limiting.
2. Green shading indicates aquatic pathway is limiting.
3. Grey shading indicates human health agricultural land use or rural residential land use is limiting.
4. Orange shading indicates soil quality for protection of ecological receptors (minimal risk / protective of agricultural land use) is limiting.
5. Not calculated in the Guidelines but if calculated using Guidelines parameters, value very large and unlikely to be encountered on real world sites (no practical limit).
6. Not calculated because no available aquatic guidelines. Limited toxicity data for TPH components suggest an indicative value of a few thousand mg/kg.
7. Landcare (2019)
8. Equivalent benzo(a)pyrene concentrations calculated as a toxicity-weight sum of the nine carcinogenic PAHs in the standard PAH analytical suite.
9. Interim based on soil background.
10. Sum of the concentrations of the six DDT, DDD and DDE isomers.
11. CCME (Canada)