Manaaki Whenua Landcare Research

Greater Wellington Te Pane Matua Taiao

Results from a pilot pesticide monitoring programme in the Greater Wellington region

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Results from a pilot pesticide monitoring programme in the Greater Wellington region

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Summary

Project and client

- Greater Wellington Regional Council contracted Manaaki Whenua – Landcare Research to provide scientific analysis and reporting on the results of a pilot pesticide monitoring programme undertaken on soil samples from the State of the Environment (SoE) soil quality monitoring programme.

Objectives

- To review the results from the pilot pesticide monitoring programme and provide comment, including:
  - identification of potential concentrations of concern for terrestrial environmental impact
  - the influence of land use.
- To provide recommendations for further monitoring, including frequency of sampling relative to the risk profile of relevant pesticides.

Methods

- Samples that provided spatial coverage of the Wellington region across a range of land uses were selected from previous SoE soil quality monitoring and analysed for pesticides, including acidic herbicides and glyphosate residues, by Hill Laboratories and AsureQuality.
- Internet searching of international pesticide databases and peer-reviewed literature was undertaken to identify potential concentrations of concern for the pesticides detected.

Results

- Pesticides were detected in 14 of the 22 samples. Pesticide residues were detected in all market garden and mixed cropping sites, but in only one horticulture site. Residues were detected in two of the four forestry and drystock sites and in the single dairy site sampled. Market garden sites had the greatest number of detections per site, while the majority of other sites had only one or two detections.
- Glyphosate and/or its metabolite, AMPA, were the most frequently detected residues and were the only residues detected at four sites. Residues of the legacy pesticide DDT were the next most frequently detected residues and were the only residues detected in two sites. Herbicides were the most frequently detected pesticide class (five), followed by fungicides (three) and insecticides (two).
- The pesticides present at the highest concentrations were glyphosate, AMPA and DDT residues.
- No regulatory soil guideline values were identified for the detected pesticide residues, except for the legacy organochlorine pesticide DDT. Therefore, information on potential concentrations of concern was primarily drawn from toxicity studies that have been undertaken for pesticide registration purposes; only acetochlor at one site slightly exceeded the nominal concentration of concern.

Conclusions

- This study has provided a useful insight into the pesticide residues present in soils in the Greater Wellington Region. The greater frequency of detections and range in residues detected in samples from market garden and mixed cropping land uses is not surprising, given the generally greater application of pesticides for these types of land uses.
- There were limited data to assess the potential impact on the terrestrial environment for many pesticides. However, the pesticide database from the University of Hertfordshire provides a useful resource for rapidly identifying relevant toxicity information. Useful information is also available from European Chemical Agency (ECHA) substance information cards, when available, for the specific pesticide.
- Based on available soil quality guidance and identified nominal concentrations of concern, there is not anticipated to be any negative environmental impacts arising from the concentrations detected, with only acetochlor at one site slightly exceeding the nominal concentration of concern.
- Further monitoring is required to provide a more comprehensive assessment.

Recommendations

Recommendations for further monitoring are dependent on the intended objectives of the monitoring. The recommendations below identify different objectives that could be considered for a proposed pesticide monitoring programme.

- The multi-residue pesticide screen and glyphosate analyses appear to be the most useful analyses, given the absence of acidic herbicide residues detected in the samples analysed. The acidic herbicides screen may be useful in a more intensive investigation of pesticide residues.
- Monitoring of pesticides residues in market gardens and mixed cropping sites through the SoE monitoring programme will provide insight into the range of more persistent pesticide residues. Providing further insight into the persistence of the less persistent pesticides would require a more intensive monitoring programme, including information on the timing and rates of pesticide application.
- To provide an assessment of baseline concentrations of DDT residues across the region, sites that were likely to have been under pasture in the 1960s and 1970s would be targets for monitoring.
- Additional monitoring of pastoral sites may provide a better estimate of residues present in these sites, given that the samples analysed had been stored for 4 years.
- Further monitoring of horticultural sites is a lower priority, given the low frequency of detection of pesticide residues in samples analysed.
- Preliminary assessment of the risk to waterways could be evaluated through a desk-top study linking land use with estimates of off-site movement of soil (e.g. through P-loss models) to identify waterways at higher risk of receiving pesticide residues, which could be subsequently monitored.

1 Introduction

A pilot pesticide monitoring programme was undertaken by Greater Wellington Regional Council in 2019 to inform further monitoring of pesticide residues in the region. Selected samples collected during State of the Environment (SoE) soil quality monitoring over 2016–2018 were analysed for pesticide residues. Sites selected provided spatial coverage of the region and encompassed a range of land uses. Greater Wellington Regional Council asked Manaaki Whenua – Landcare Research to provide scientific analysis and reporting on the results of the pilot programme.

2 Objectives

- To review the results from the pilot pesticide monitoring programme and provide comment, including:
    - identification of potential concentrations of concern for terrestrial environmental impact, including any existing environmental and/or human soil guideline values
    - the influence of land use.
- To provide recommendations for further monitoring, including the frequency of sampling relative to the risk profile of relevant pesticides.

3 Methods

3.1 Sample sites and chemical analysis

Samples for the pilot pesticide monitoring programme were selected from those previously collected for Greater Wellington Regional Council's SoE soil quality monitoring programme. Details of the individual sites selected in this pilot programme, and of the field methods used, are reported in council SoE reports (Drewry 2015, 2016, 2017; Gordon 2018). Briefly, at each site a 50 m transect was used to take 10 cm-depth soil cores, approximately every 2 m. Individual cores were bulked and mixed to obtain a representative sample for chemical and trace element analyses. Samples used in this pilot project had been received back from the laboratory, air-dried and sieved, and stored in standard laboratory containers.

These samples were typically stored dry in a non-temperature-controlled shed that has very limited natural light. The 22 samples selected for analysis provided spatial coverage of the region (Figure 1) and covered a range of land uses (Table 1).

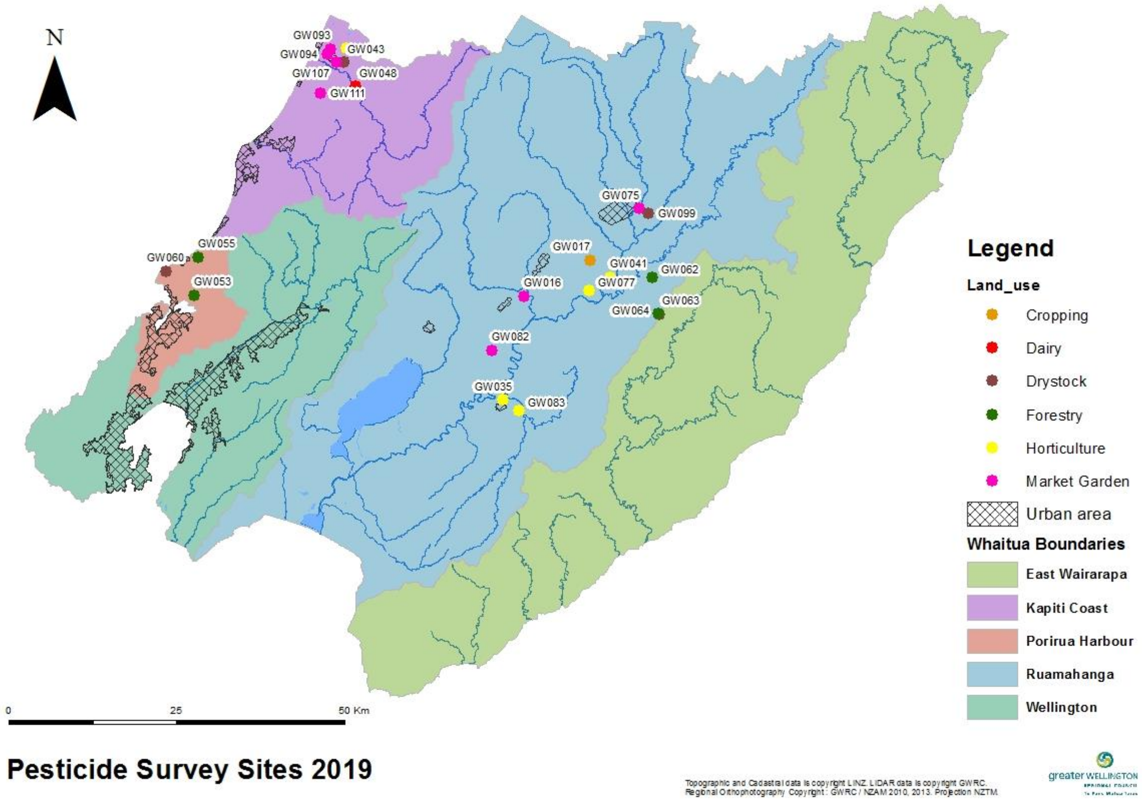

Figure 1. Location of sample sites selected for inclusion in the pilot pesticide monitoring programme.

Table 1. Summary of original sample collection date, land at the time of sampling, in addition to the date of site establishment and the land use at the time of establishment, for samples analysed in the pilot pesticide monitoring programme

Site	Date of sampling	Land use at time of sampling	Land-use comments at time of sampling
GW016*	3/05/2017	Mixed cropping	Cropping. Maize stubble. Autumn 2017 grass, spring 2016 radish for seed, autumn 2016 grass, spring 2015 peas.
GW017*	1/05/2017	Mixed cropping	Cropping. Drilled into oats 3 days prior to sampling. Sampled between drill rows to avoid fertiliser. Recent years grass, barley, wheat, peas, pasture
GW035	15/05/2018	Horticulture	Grapes
GW041	16/05/2018	Horticulture	Grapes
GW043*	5/05/2015	Drystock	
GW047	7/06/2018	Horticulture	Strawberry field – tilled
GW048	28/04/2016	Dairy	
GW053	1/06/2018	Forestry	Pinus radiata 5 years post-harvest, gorse understory
GW055	1/06/2018	Forestry	*Pinus radiata* – mid maturity
GW060*	1/05/2015	Drystock	
GW062	29/05/2018	Forestry	*Pinus radiata* plantation nearing maturity
GW063*	29/04/2015	Drystock	
GW064	16/05/2018	Forestry	*Pinus radiata* plantation nearing maturity
GW075*	8/05/2017	Market garden	Market garden. Currently fallow/weeds
GW077	16/05/2018	Horticulture	Grapes
GW082*	4/05/2017	Mixed cropping	Cropping. Currently silverbeet for seed, no stock. Previous years barley, rocket, vegetable and arable seeds.
GW083	15/05/2018	Horticulture	Grapes
GW093*	2/05/2017	Market garden	Market garden. Currently fallow area, other parts of garden in beans, cabbage, etc.
GW094*	2/05/2017	Market garden	Market garden. Previously fallow, brassicas, kale, cauliflower, cabbage, etc
GW099*	29/04/2015	Drystock	
GW107*	8/05/2017	Market garden	Market garden. Kale, lettuce, etc
GW111*	2/05/2017	Mixed cropping	Cropping. Now pasture. Was maize a year ago, previously peas/maize.

*Subset of samples analysed for glyphosate residues and acidic herbicides.

All samples were analysed by Hill Laboratories using their multi-residue (MR1) pesticide residues screen. Briefly, samples were extracted via sonication and analysed by gas-chromatography-mass spectrometry. Due to insufficient sample amounts, only a subset of 12 samples were also analysed for acidic herbicides by Hill laboratories and glyphosate and its key metabolite aminomethylphosphonic acid (AMPA) by AsureQuality.

For acidic herbicides, samples were extracted via sonication and analysed by liquid chromatography-mass-spectrometer-mass-spectrometer (LCMSMS). For glyphosate and AMPA, samples were extracted and derivatised prior to analysis by (LCMSMS). The compounds included in the analyses are shown in Appendix 1.

3.2 Potential concentrations of concern

To provide context for the significance of the concentrations at which pesticides were detected, a brief internet search was undertaken to identify regulatory soil guideline values. In addition, as most pesticides have undergone a registration process that often includes carrying out toxicity tests on soil organisms, the following databases and websites were searched to identify the regulatory status of detected pesticides and any relevant toxicity data:

- the New Zealand Environmental Protection Agency chemical classification and information database: https://www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/
- European Union Pesticides database: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database
- European Chemical Agency website: https://echa.europa.eu/information-on-chemicals
- University of Hertfordshire Pesticide Properties database: https://sitem.herts.ac.uk/aeru/ppdb

Where required, additional searching of the scientific literature was undertaken using internet searching and literature databases.

4 Results

4.1 Frequency of detection and concentrations

Pesticides were detected in 14 of the 22 samples (Table 2). Pesticide residues were detected in all market garden and mixed cropping sites but only in one horticulture site. Residues were detected in two of the four forestry and drystock sites, and in the single dairy site included in the analysis. Market garden sites had the greatest number of detections per site, while the majority of other sites had only one or two detections.

Table 2. Frequency of detection of pesticide residues in samples, grouped by land use

Land-use category	Total n	Number of sites with pesticide residues	Range in number of residues detected per site
Dairy	1	1	3
Drystock	4	2	1–2
Forestry	4	2	1–4
Horticulture	5	1	2
Market garden	4	4	2–8
Mixed cropping	4	4	2–4
Total	**22**	**14**	

Glyphosate, and/or its metabolite, AMPA, was detected in 8 of the 12 samples analysed for glyphosate residues (Table 2) which made these the most frequently detected residues. At four sites these were the only residues detected. The high rate of detection in analysed samples suggests that glyphosate residues would probably have been present in at least some of the remaining samples.

Residues of the legacy organochlorine pesticide DDT were the next most frequently detected residues, with 4-4-DDE being present in 8 of the 22 samples analysed. For two sites, DDT residues were the only residues detected.

Herbicides were the most frequently detected pesticide class (glyphosate, alachlor, acetochlor, pendimethalin, terbumeton), followed by fungicides (procymidone, chlorothalonil, difenoconazole) and then insecticides (dimethoate, pirimiphos-methyl). No acidic herbicides were detected.

Table 3. Concentration (mg/kg soil) and number of pesticide residues above detection limits in individual samples, grouped on the basis of land use

		Concentration (mg/kg)														
		Dairy	*Drystock*		*Forestry*		*Horti-culture*	*Market garden*				*Mixed cropping*				
Pesticide residue	Pesticide class	GW 048	GW 060	GW 099	GW 053	GW 055	GW 035	GW 075	GW 093	GW 094	GW 107	GW 016	GW 017	GW 082	GW 111	No. of detections
4,4'-DDE	legacy	**0.04**	**0.012**	<0.010	<0.012	**0.29**	**0.038**	<0.010	**0.033**	**0.041**	**0.011**	**0.018**	<0.010	<0.010	<0.010	8
2,4'-DDT	legacy	<0.017	<0.010	<0.010	<0.012	**0.031**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	1
4,4'-DDT	legacy	**0.023**	<0.010	<0.010	<0.012	**0.137**	**0.015**	<0.010	**0.025**	**0.031**	<0.010	**0.014**	<0.010	<0.010	<0.010	6
∑ DDT isomers	legacy	<0.10	<0.06	<0.06	<0.08	**0.46**	<0.06	<0.06	<0.06	**0.07**	<0.06	<0.06	<0.06	<0.06	<0.06	2
Endosulfan sulphate	legacy	<0.017	<0.010	<0.010	<0.012	<0.013	<0.010	<0.010	<0.010	**0.021**	**0.018**	<0.010	<0.010	<0.010	<0.010	2
Procymidone	fungicide	**0.028**	<0.006	<0.006	<0.008	<0.008	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	1
Chlorothalonil	fungicide	<0.02	<0.006	<0.006	<0.015	<0.016	<0.006	<0.006	<0.006	**0.007**	**0.009**	<0.006	<0.006	<0.006	<0.006	2
Difenoconazole	fungicide	<0.014	<0.010	<0.010	<0.011	<0.012	<0.010	<0.010	<0.010	**0.036**	<0.010	<0.010	<0.010	<0.010	<0.010	1
Terbumeton	herbicide	<0.010	<0.006	<0.006	**0.013**	<0.008	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	1
Alachlor	herbicide	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	**0.007**	<0.006	**0.025**	<0.006	<0.006	<0.006	**0.024**	3
Diuron	herbicide	<0.010	<0.006	<0.006	<0.008	<0.008	<0.006	<0.006	<0.006	<0.006	**0.008**	<0.006	<0.006	<0.006	<0.006	1
Pendimethalin	herbicide	<0.010	<0.006	<0.006	<0.008	<0.008	<0.006	<0.006	<0.006	<0.006	**0.27**	<0.006	<0.006	<0.006	**0.008**	2
Acetochlor	herbicide	<0.010	<0.006	<0.006	<0.008	<0.008	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	**0.01**	1
Glyphosate	herbicide	NA	<0.020	<0.020	NA	NA	NA	**0.95**	**0.02**	**0.051**	<0.020	**0.067**	**0.31**	**0.053**	**0.031**	6
AMPA	metabolite	NA	<0.020	**0.27**	NA	NA	NA	**0.95**	**0.18**	**0.48**	**0.31**	**0.35**	**0.51**	**0.77**	**0.43**	8
Dimethoate	insecticide	<0.02	**0.024**	<0.012	<0.015	<0.016	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	1
Pirimiphosmethyl	insecticide	<0.010	<0.006	<0.006	<0.008	<0.008	<0.006	<0.006	<0.006	<0.006	0.014	<0.006	<0.006	<0.006	<0.006	1

NA – not analysed

Glyphosate and AMPA were present at the highest absolute concentration of all residues (0.95 mg/kg) at a market garden site (GW075), while AMPA ranged from 0.18 to 0.77 mg/kg at the remaining sites. DDT residues were present at the next highest concentrations (∑DDT 0.46 mg/kg) at a forestry site (GW055), which probably reflects the prior usage of the land for grazing (Table 4): DDT was widely used as a pasture insecticide to control grass grub (*Costelytra zealandia*) and porina (*Wiseana sp.*) caterpillars until the early 1970s (Buckland et al. 1998). The herbicide pendimethalin was the next highest at 0.27 mg/kg in a market garden site (GW107). All other residues were present at less than 0.05 mg/kg.

The sites tested have been largely under the same land use since the time of establishment of the monitoring site over 2000 to 2004, and in a number of cases for many years beforehand (Table 4). The main exception is that some sites previously identified as market gardens are now identified as mixed cropping sites.

The presence of a range of residues in the market garden and mixed cropping sites is not overly surprising, given that generally there is greater application of herbicides and fungicides for crop production. Further, many of the sites currently identified as mixed cropping sites had previously been market gardens (Table 4). The range of residues will depend on the crops being grown and the weed management approach, which can vary between growers. A higher usage of pesticides might also be expected at horticultural sites, but there was a low frequency of detection, suggesting any pesticides used have degraded. The presence of pesticide residues at the pastoral sites is potentially underestimated, as these samples had been collected in 2015 and some degradation of residues may have occurred during storage.

Table 4. Summary of the land use of monitoring sites used for the pilot programme at the time of sample collection and at the time of site establishment, and date of site establishment

Site	Land use at time of sampling	Land use at time of establishment	Land use notes at time of establishment*	Date of establishment
GW016	Mixed cropping	Market garden	20 years market gardening	21/11/2000
GW017	Mixed cropping	Cropping	10 years cropping	22/11/2000
GW035	Horticulture	Horticulture	Vineyard over 20 years old. Village square	4/12/2001
GW041	Horticulture	Horticulture	Has been in drystock, now converted to vineyard	5/12/2001
GW043	Drystock	Drystock	Has had none or little fertiliser in the last 10 years	10/04/2002
GW047	Horticulture	Horticulture	Orchard, raspberries, quite intensively used	11/04/2002
GW048	Dairy	Dairy	Has been in dairying for 40 years, recently started spraying with dairy shed effluent. Had some lime recently	11/04/2002
GW053	Forestry	Forestry	*Pinus radiata* (20 years), first rotation after pasture	21/10/2003
GW055	Forestry	Forestry	*Pinus radiata* (12 years), first rotation after pasture	21/10/2003
GW060	Drystock	Drystock	Pasture for at least 25 years, light annual topdressing with superphosphate	22/10/2003
GW062	Forestry	Forestry	*Pinus radiata* 12 years old, now in second rotation of pines	22/10/2003
GW063	Drystock	Drystock	Pasture for at least 20 years, gets little superphosphate annually	22/10/2003
GW064	Forestry	Forestry	*Pinus radiata* (9 years), grasses and weeds, first rotation after pasture	22/10/2003
GW075	Market garden	Market garden	Has been in market garden for 12 years or more. Fallow after broad beans	26/04/2004
GW077	Horticulture	Horticulture	Vineyard at least 12 years old	26/04/2004
GW082	Mixed cropping	Market garden	Has been in market garden for 15 years or more. Currently growing pumpkins	27/04/2004
GW083	Horticulture	Horticulture	Has been in vineyard for 15 years or more	27/04/2004
GW093	Market garden	Market garden	Has been in market garden for some 60 years. Currently growing courgettes.	29/04/2004
GW094	Market garden	Market garden	Has been in market garden for some 40 years. Currently growing peppers and tomatoes	29/04/2004
GW099	Drystock	Drystock	Superphosphate maintenance topdressing	19/10/2004
GW107	Market garden	Market garden	Long-time market garden (15 years+). Different amounts of phosphate, nitrogen, potassium, some organic compost of vegetables. Currently fallow after corn crop	20/10/2004
GW111	Mixed cropping	Market garden	Fallow after onions, not ploughed yet	20/10/2004

* From Greater Wellington Regional Council records.

4.2 Significance of concentrations

With the exception of DDT, no regulatory soil guideline values were identified for the detected pesticide residues. As a result, information on potential concentrations of concern is primarily drawn from toxicity studies that have been undertaken for pesticide registration purposes. No data were found for endosulfan sulfate, procymidone or terbumeton, and given the low frequency of detection and low concentrations observed, no further literature searching was undertaken. In contrast, given the frequency of detection of glyphosate residues and their comparatively higher concentrations, additional literature searching was undertaken to identify potential concentrations of concern.

With the exception of the organochlorine pesticides residues, all residues detected are active ingredients or metabolites of pesticides that are currently registered in New Zealand, although many of these pesticides are no longer approved in Europe. Further, of the current EU-approved pesticides, only pendimethalin and glyphosate are approved for use past the end of 2020. The European approval status influences the toxicity data available. Specifically, if the pesticide has recently gone through an approval process and/or is currently registered, more recent toxicity data are available. In contrast, toxicity studies used in the registration of New Zealand pesticides are predominantly studies from the US EPA undertaken in the early 1990s.

Table 5 provides a summary of the best estimates for effect concentrations for the most sensitive receptor group (e.g. non-target plants, microbes, soil invertebrates), including existing soil guideline values for ∑DDTs. These should be viewed as indicative concentrations of potential effects rather than hard-and-fast values above which negative effects will occur.

For herbicides, the most sensitive organism is, not surprisingly, non-target plants, although no data were available for the effect of glyphosate on non-target plants. Based on comparison of the values in Table 5 with the observed concentrations in Table 3, DDT residues at all sites were below the Canadian soil quality guideline (CCME 1999), the proposed New Zealand ecological soil guideline value for ecologically sensitive areas (Cavanagh 2019), and the Dutch intervention value (I&W 2013), suggesting limited environmental impacts.

Bioaccumulation of DDT residues in birds may still be the most significant potential impact. A previous New Zealand study identified that DDE, the primary degradation product of DDT, concentrations in road-killed harriers collected in Canterbury were among the highest in predatory birds internationally (Cavanagh et al 2015). While there are limited accessible studies (DDT residues are commonly measured in contaminated land assessments, but these are not easily accessed) reporting DDT concentrations, a maximum value of 0.83 mg/kg in Canterbury soils reported in Buckland et al. 1998 is often used as an indication of maximum background concentrations in the region.

Thereafter, only the concentration of acetochlor at GW111 (0.01 mg/kg) exceeds the nominal concentration of concern shown in Table 5. Any actual negative effect arising from acetochlor would need to be further evaluated.

One further consideration for potential environmental impact is the effect on aquatic systems from the off-site movement of soil containing pesticide residues into waterways: all of the detected pesticides are toxic in aquatic systems at lower concentrations than in soil. This risk is highly site-specific because it depends on the potential for off-site movement into waterways of soil containing pesticide residues. Thereafter, the risk depends on partitioning of the residues between the soil particles and water, with the dissolved fraction being of primary concern.

A preliminary assessment of the potential movement of pesticides into waterways could be undertaken through a desk-top study based on land use and potential loss to waterways; for example, based on models of phosphorus (for which off-site movement is predominantly attached to sediment) loss. This could identify waterways likely to receive higher inputs of pesticides, and could subsequently be sampled for pesticide residues in the sediment.

Table 5. Nominal concentrations of concern identified from various sources

Compound	Nominal concentration of concern (mg/kg)	Basis of value	Source[a]
∑DDTs	0.7	Secondary consumer (bird)	CCME 1999
	1.1	Draft NZ ecological soil guideline value for ecologically sensitive areas	Cavanagh 2019
	4	Dutch intervention value – the concentration at which remediation is required	I&W 2013
Endosulfan sulfate	-	No data	
Acetochlor	0.003	Converted[b] from 0.0013 LB/acre as EC25[c] for ryegrass growth	NZ EPA
Alachlor	0.1	Converted from 0.0013 LB/ acre as EC25[c] for ryegrass growth	NZ EPA
Chlorothalonil	4.8	NOEC[d] for microbial carbon and nitrogen mineralisation	UH PPDB
Difenoconazole	0.2	NOEC[d] for worm reproduction	UH PPDB
	>0.02	Converted from an ER50[e] of >10 g/ha for non-target plant species	UH PPDB
Dimethoate	2.5	NOEC[d] standard springtail reproduction test	UH PPDB
Diuron	0.12	Lowest NOEC[d] for growth of 6 non-target plant species	ECHA
Glyphosate	>28	NOEC[d] standard earthworm reproduction test	UH PPDB
	3	Reduced root colonisation by arbuscular mycorrhizae	Helander et al. 2018
AMPA	>2.5	Worm reproduction	Dominguez et al. 2016
Pendimethalin	0.84	Converted from ER50[e] of 402 g/ha for seedling emergence of tomatoes	UH PPDB
Pirimiphos-methyl	41.9	EC50[f], converted from LC50[f] for earthworm mortality using a safety factor of 10	NZ EPA
Procymidone	-	No ratings for terrestrial ecotoxicity	NZ EPA
Terbumeton	-	Toxicity effects terrestrial vertebrates reported only	NZ EPA

[a] NZ EPA: https://www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/

ECHA European Chemical Agency: https://echa.europa.eu/information-on-chemicals, substance information card

UH PPDB – University of Hertfordshire Pesticide Properties database: https://sitem.herts.ac.uk/aeru/ppdb

[b] Assuming residues are mixed in the top 5cm of soil, using a bulk density of 1,000 kg/m^3

[c] EC25 – concentration at which a 25% effect is observed

[d] NOEC – no observed effect concentration

[e] ER50 – rate of application (g/ha) at which a 50% effect is observed

[f] EC50, LC50 – concentration at which a 50% effect (E) or mortality (L, lethal) is observed

5 Conclusions

This study has provided a useful insight into pesticide residues present in soils in the Greater Wellington Region. Market garden and mixed cropping land use had the greatest frequency of detections and range of residues detected. This is not surprising given the generally greater application of pesticides for these types of land use. Horticultural sites had the lowest frequency of detection, while residues were detected in about half of the pastoral and forestry sites.

Glyphosate, and its metabolite AMPA, were most frequently detected, and were typically present at the highest concentrations of all residues. While glyphosate is the focus for many recent studies on environmental impact in the terrestrial environment, the data remain equivocal. The most sensitive effect appears to be effects on root colonisation by mycorrhizal fungi.

Residues of the legacy organochlorine pesticide DDT were the next most frequently detected, and were found in sites under most types of land use at concentrations higher than most other residues except glyphosate and AMPA.

There were limited data available to assess potential impact on the terrestrial environment for many pesticides. However, the pesticide database from the University of Hertfordshire, in particular, provides a useful resource for rapidly identifying relevant toxicity information. Useful information is also available from European Chemical Agency (ECHA) substance information cards, when available. Based on identified available guidance and nominal concentrations of concern, there is not anticipated to be any negative environmental impacts arising from the concentrations detected, with only acetochlor at one site slightly exceeding the nominal concentration of concern.

Off-site movement of soil containing pesticide residues into waterways may pose a higher environmental risk because residues are often toxic at lower concentrations in aquatic systems than in soil. This risk is highly site-specific as it depends on the potential for off-site movement of soil containing pesticide residues into waterways, although a preliminary desk-top study linking land use with estimates of offsite movement of soil (e.g. through P-loss models) could help to identify waterways at higher risk of receiving pesticide residues, which could be subsequently monitored.

Overall, pesticide concentrations assessed in this study suggest it is unlikely there is a significant negative environmental impact arising from the residues. However, further monitoring is required to provide a more comprehensive assessment.

6 Recommendations

Recommendations for further monitoring are dependent on the intended objectives of the monitoring. The recommendations below identify the different objectives that could be achieved.

- The multi-residue pesticide screen and glyphosate analyses appear to be the most useful analyses for further monitoring, given the absence of acidic herbicide residues detected in the samples analysed to date. The acidic herbicides screen may be useful in a more intensive investigation of pesticide residues.
- Monitoring of pesticides residues in market gardens and mixed cropping sites under the SoE monitoring programme will provide insight into the full range of more persistent pesticide residues. Concentrations are likely to be variable over time, as they will be dependent on the recent application history. To provide more insight into the persistence of the less persistent pesticides that are more commonly in use requires a more intensive monitoring programme, closely coupled with information on timing and rates of application of the different pesticides.
- To provide an assessment of baseline concentrations of DDT residues across the region, sites that were likely to have been under pasture in the 1960s and 1970s (if these can be identified) would be targets for monitoring.
- Additional monitoring of pastoral sites may provide a better estimate of residues present in these sites, given the samples analysed had been stored for 4 years.
- Further monitoring of horticultural sites is a lower priority given the low frequency of detection of pesticide residues in the samples analysed. However, these sites may warrant testing for glyphosate residues, given that this was not undertaken on these sites during the pilot programme.
- Preliminary assessment of the potential risk to waterways could be evaluated through a preliminary desk-top study linking land use with estimates of off-site movement of soil (e.g. through P-loss models) to identify waterways at higher risk of receiving pesticide residues, which could be subsequently be monitored.

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Appendix 1 – Multiresidue pesticide screen

Table A1(a). Non-organochlorine compounds analysed in the multiresidue pesticide screen

Acetochlor	Deltamethrin (including Tralomethrin)	Imazalil	Prochloraz
Alachlor	Demeton-S-methyl	Indoxacarb	Prometryn
Atrazine	Diazinon	Iodofenphos	Propachlor
Atrazine-desethyl	Dichlobenil	IPBC[1]	Propanil
Atrazine-desisopropyl	Dichlofenthion	Isazophos	Propazine
Azaconazole	Dichlofluanid	Isofenphos	Propetamphos
Azinphos-methyl	Dichloran	Kresoxim-methyl	Propham
Benalaxyl	Dichlorvos	Leptophos	Propiconazole
Bendiocarb	Dicofol	Linuron	Prothiofos
Benodanil	Dicrotophos	Malathion	Pyrazophos
Bifenthrin	Difenoconazole	Metalaxyl	Pyrifenox
Bitertanol	Dimethoate	Methacrifos	Pyrimethanil
Bromacil	Dinocap	Methamidophos	Pyriproxyfen
Bromophos-ethyl	Diphenylamine	Methidathion	Quintozene
Bromopropylate	Disulfoton	Methiocarb	Quizalofop-ethyl
Bupirimate	Diuron	Metolachlor	Simazine
Buprofezin	EPN	Metribuzin	Simetryn
Butachlor	Esfenvalerate	Mevinphos	Sulfentrazone
Captafol	Ethion	Molinate	Sulfotep
Captan	Etrimfos	Myclobutanil	TCMTB[2]
Carbaryl	Famphur	Naled	Tebuconazole
Carbofenothion	Fenamiphos	Nitrofen	Tebufenpyrad
Carbofuran	Fenarimol	Nitrothal-isopropyl	Terbacil
Carboxin	Fenitrothion	Norflurazon	Terbufos
Chlorfenvinphos	Fenpropathrin	Omethoate	Terbumeton
Chlorfluazuron	Fenpropimorph	Oxadiazon	Terbuthylazine
Chlorothalonil	Fensulfothion	Oxychlordane	Terbuthylazine-desethyl
Chlorpropham	Fenthion	Oxyfluorfen	Terbutryn
Chlorpyrifos	Fenvalerate	Paclobutrazol	Tetrachlorvinphos
Chlorpyrifos-methyl	Fluazifop-butyl	Parathion-ethyl	Thiabendazole
Chlortoluron	Fluometuron	Parathion-methyl	Thiobencarb
Chlozolinate	Flusilazole	Penconazole	Thiometon
Coumaphos	Fluvalinate	Pendimethalin	Tolylfluanid
Cyanazine	Folpet	Permethrin	Triadimefon
Cyfluthrin	Furalaxyl	Phorate	Triazophos
Cyhalothrin	Haloxyfop-methyl	Phosmet	Trifluralin
Cypermethrin	Hexaconazole	Phosphamidon	Vinclozolin
Cyproconazole	Hexazinone	Pirimicarb	
	Hexythiazox	Pirimiphos-methyl	

[1](3-Iodo-2-propynyl-n-butylcarbamate); [2][2-(thiocyanomethylthio)benzothiazole, Busan]

Table A1(b). Organochlorine pesticides analysed in the multi-residue pesticide screen

Aldrin
alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
cis-Chlordane
trans-Chlordane
Total Chlordane [(cis+trans)*100/42]
2,4'-DDD
4,4'-DDD
2,4'-DDE
4,4'-DDE
2,4'-DDT
4,4'-DDT
Total DDT Isomers
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan sulphate
Endrin
Endrin aldehyde
Endrin ketone
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Methoxychlor

Appendix 2 – Acidic herbicides screen

Table A2. Compounds included in the acidic herbicides screen

Acifluorfen
Bentazone
Bromoxynil
Clopyralid
Dicamba
2,4-Dichlorophenoxyacetic acid (24D)
2,4-Dichlorophenoxybutyric acid (24DB)
Dichlorprop
Fluazifop
Fluroxypyr
Haloxyfop
2-methyl-4-chlorophenoxyacetic acid (MCPA)
2-methyl-4-chlorophenoxybutanoic acid (MCPB)
Mecoprop (MCPP; 2-methyl-4-chlorophenoxypropionic acid)
Oryzalin
Pentachlorophenol (PCP)
Picloram
Quizalofop
2,3,4,6-Tetrachlorophenol (TCP)
2,4,5-trichlorophenoxypropionic acid (245TP,Fenoprop, Silvex)
2,4,5-Trichlorophenoxyacetic acid (245T)
Triclopyr