Sources of AgVet Data (Monitoring) in Australia

A consideration of monitoring information, gaps in available data and future monitoring requirements.

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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Tables

1 Introduction

The pesticides and veterinary medicines regulatory framework provides important protection for the Australian community. Responsibility for the current regulatory system is shared between the Commonwealth, state and territory governments. The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the independent statutory authority responsible for assessing and registering pesticides and veterinary medicines for supply in Australia. State and territory governments are responsible for controlling the use of pesticides and veterinary medicines beyond the point of retail sale. The Department of Agriculture, Forestry and Fisheries, is responsible for Australian Commonwealth policy on pesticide and veterinary medicines regulation.

The agricultural and veterinary (agvet) chemicals regulatory system aims to ensure that the agvet chemicals used in Australia are safe and effective. The department is currently investigating how they can better monitor the effectiveness of the agvet chemicals regulatory system and provide assurance that the controls on these products are effective and not leading to poor environmental or human health outcomes.

The project consists of several stages:

1) Identification of relevant sources of data on the use and fate of agvet chemicals in Australia;
2) Assessment of the data sources to determine how relevant they are to the department's requirements;
3) Identification of gaps in the sources of data; and
4) Provision of final recommendations to the department on which data sources should be included and where new data gathering programs should be developed.

Data sources consisted of state and national government data bases and literature papers describing (generally) environmental monitoring programs. Data format, accessibility, costs and any other impediments to obtaining the data have been considered.

2 Initial identification of data sources

The report covering identification of data sources in Australia is provided as Appendix 1: Research and analysis of pesticides and veterinary medicines data sources. In some cases, requests for information were sent to several areas within one overall organisation. The data sources that were considered acceptable for this project following assessment (see Section 3) are listed here. The full details for the monitoring programs and the links to the data sources are provided in Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources.

- 2009/2010 Pesticide Residue Water Sampling and Analysis Program: Emigrant Creek and Wilsons River Water Supply Systems.
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- Food monitoring programs (Department of Health, Government of Western Australia).
- Fredericks D and Palmer D. Assessment of Pesticides in Aquatic Organisms – Ord River WA. Department of Environment, Government of Western Australia, Water Resource 2008. Technical Series Report No 40.
- FSANZ, 25th Australian Total Diet Study.
- Hook S, Doan H, Gonzago D, Musson D, Du J, Kookana R, Sellars M and Kumar A. The impacts of modern-use pesticides on shrimp aquaculture: An assessment for north eastern Australia, Ecotoxicology and Environmental Safety, 2018, Volume 148 770-780.
- Kennedy K., Bentley C, Paxman C, Heffernan A, Dunn A, Kaserzon S and Mueller J. Final Report - Monitoring of organic chemicals in the Great Barrier Reef Marine Park using time integrated monitoring tools (2009-2010). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox) 2010.
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- Murray Irrigation – Compliance and monitoring.
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- QLD Government – Reef 2050 Water Quality Improvement Plan.
- Rose G, Zhang P, Bui A, Allen D and Allinson G. Melbourne Water and DPI agrochemicals in Port Philip catchment project report 2009-10. A report to the Centre for Aquatic Pollution, Identification and Management (CAPIM), the University of Melbourne. Future Farming Systems Research, DPI Queenscliff Centre, Queenscliff, Victoria. 2011.
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- Smith R, Turner R, Vardy S, Huggins R, Wallace R and Warne M. An evaluation of the prevalence of alternate pesticides of environmental concern in Great Barrier Reef catchments: RP57C, 2016.
- Targeted AgChem Residue Program (Agriculture Victoria).
- The Bundaberg Regional Council (BRC) Drinking Water Quality Management Plan (DWQMP).
- The Pesticide Detectives: national assessment of pesticides in waters.
- Vic EPA - “Emerging contaminants in recycled water project, 2021”.
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- Yoshikane M, Kay W, Shibata Y, Inoue M, Yanai T, Kamata R, Edmonds J and Morita M. Very high concentrations of DDE and Taxaphene residues in crocodiles from the Ord River, Western Australia: An investigation into possible endocrine disruption. Journal of Environmental Monitoring. 2006, Volume 8, 649-661.

3 Assessment of data sources

The data sources were assessed for their reliability, relevance and representativeness for the purposes of this project. Outcomes of this assessment were used to determine their suitability for monitoring the effectiveness of the agvet chemicals regulatory system.

3.1 Summary of results

The largest number of data sources are for environmental monitoring. However, only a small number of these represent long-term monitoring and the results available are generally for local scenarios (limited geographic range) and as a “snapshot” in time (limited by no temporal analysis available). The results are summarised in tabular form below. Currently, the most comprehensive monitoring program underway in Australia in terms of geographic area, linking to land use, sampling frequency and duration of the program is the QLD Government – Reef 2050 Water Quality Improvement Plan. However, this program only monitors a small number (n = 22) of pesticides. Some finalised monitoring programs in other states were more comprehensive in terms of the number of sites or the number of chemicals, but these programs were only performed for a short period of time.

While there were only a small number of produce data sources identified, these tend to be quite comprehensive. The National Residue Survey is a very large and structured monitoring program with data available for a long period of time. It considers residues for >600 individual chemicals in a large range of plant and animal food matrices. The FSANZ 25th Australian Total Diet Study is comprehensive, assessing for >130 chemicals. These residue surveys also tested for veterinary medicines in meat products. It is also understood that industry undertakes routine monitoring of produce for contaminants (for example, Coles and Woolworths). While some private organisations were contacted, no further information was provided to this project.

No suitable data sources were identified for monitoring agvet chemicals in humans. Work health and safety (WHS) laws require that workers health be monitored and WHS regulators be notified when workers are exposed to unsafe levels of hazardous chemicals, including agvet chemicals. However, WHS regulators were not able to provide useful information about workers exposure to agvet chemicals. Similarly, those public health authorities who responded to enquiries did not hold useful information about human exposure to agvet chemicals. Further work may be needed to engage these organisations, and make any data they hold reportable and usable. Alternatively, if the department wishes to obtain human health monitoring data directly it could consider initiating its own monitoring programs (see Section 4 – analysis of data gaps). The analysis of each data source that passed the screen for reliability, relevance and representativeness is provided in Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources. The results are summarised in Section 3.2 below for the range of environmental monitoring data sources.

3.2 Overview of environmental data sources

3.2.1 National monitoring

Table 1 National sediment sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
04	Highly diverse (national program)	>100	110	43	National	Bifenthrin

- **Surface/groundwater** – None identified
- **Urban stormwater** – None identified
- **Drinking water** – None identified
- **Soil** – None identified
- **Wildlife** – None identified

3.2.2 Queensland

Table 2 Queensland surface/groundwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
32	Agriculture, tropical/subtropical	7	29	17	Regional	Diuron, 2,4-D, Atrazine, Hexazinone, Metolachlor.
43	Agriculture (grazing)	1	8	4	Local	Atrazine, Tebuthiuron, Diuron
40	Agriculture (intensive)	55	66	26	Local	Atrazine, Hexazinone, Diuron, Chlorpyrifos
57	Conservation, dryland cropping, forestry, grazing,	28	22	8	Regional	Diuron, Imidacloprid, Atrazine, Metolachlor, Hexazinone

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
	tropical/subtropical cropping (bananas, sugarcane, horticulture).					
59	Conservation, grazing, sugarcane and horticulture.	6	151	51	Regional	Diuron, Atrazine, 2,4-D, Metribuzin, Metolachlor, Isoxaflutole, MCPA
38	Inshore reef areas (marine)	12	33	18	Regional	Diuron, Atrazine, hexazinone, simazine, chlorpyrifos.

Table 3 Queensland urban stormwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
30	Residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture.	2	15	6	Regional	Diuron, Simazine, 2,4-D, MCPA, Triclopyr

Table 4 Queensland drinking water sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
39	Drinking water supply catchment	3	64	38	Local	None exceeding guideline levels
41	Catchment wide - grazing, irrigated sugar cane	15	≥9	≥4	Local	Atrazine, diuron.
45	Drinking water supply catchment	10	≥5	≥5	Local	Atrazine, Hexazinone, Bromacil, 2,4-D
46	Drinking water supply catchment	36	41	25	Regional	Atrazine, Metsulfuron-methyl, Simazine, 2,4-D, Hexazinone, Metolachlor, Propiconazole, Tebuthiuron, Endosulfan, DDT

Table 5 Queensland sediment sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
25	Urban, intensive agriculture, forestry, broadacre cropping.	151	82	39	Regional	DDE, DDT, Aldrin, Chlordane, Dieldrin, Chlorpyrifos, Simazine, Diazinon

- **Soil** – None identified
- **Wildlife** – None identified

3.2.3 New South Wales

Table 6 New South Wales surface/groundwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
31	Mixed (residential, orchards, mixed farms, turf farm, golf course)	13	5	5	Local	Specific for neonicotinoids. Acetamiprid, Imidacloprid, Thiacloprid.
33	Agriculture (horticulture)	6	168	55	Local	Imidacloprid, Methomyl, Dimethoate, Terbuthylazine, Terbutryn, Omethoate, Pyrimethanil, Triadimenol.
27	Agricultural irrigation area	2	3	2	Local	
34	Agricultural irrigation area	6	11	8	Local	Atrazine, metolachlor, simazine
35	Agricultural irrigation area	5	10	7	Local	Diuron, Atrazine, Metolachlor

Table 7 New South Wales urban stormwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
30	Residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture.	2	15	6	Regional	Diuron, Simazine, 2,4-D, MCPA, Triclopyr

Table 8 New South Wales drinking water sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
28	Water filtration plants	10	11	8	Local	None above limit of reporting.
36	Drinking water supply catchment	4	27	19	Local	None above limit of reporting.

Table 9 New South Wales soil sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
47	Historic - cotton use	3	8	7	Local	DDT (as DDD and DDE), Endrin, Endosulfan.

- **Sediment** – None identified
- **Wildlife** – None identified

3.2.4 Victoria

Table 10 Victorian surface/groundwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
21	Agriculture (pasture)	17	39	16	Local	Prometryn, Simazine
22	Agriculture (horticulture), water supply	18	10	4	Local	Simazine, Atrazine, Pendimethalin
23	Agriculture (horticulture), water supply	18	24	6	Local	Myclobutanil, Trifloxystrobin, Metalaxyl, Difenoconazole, Pyrimethanil
48	Mixed (urban and agriculture)	4	n/a	n/a	Local	Simazine, Atrazine.

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
50	Urban, Peri-urban	29	52	31	Local	Simazine, Atrazine, Metalaxyl, Imidacloprid, Prometryn
53	Background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial.	101	n/a	n/a	Statewide	Simazine

Table 11 Victorian urban stormwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
19	Urban (housing, industrial, mixed)	5	31	7	Local	Simazine, MCPA, Diuron, Atrazine.
20	Urban, Peri-urban	24	24	14	Local	Simazine, Atrazine, Metalaxyl, Terbutryn.
30	Residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture.	2	15	6	Regional	Diuron, Simazine, 2,4-D, MCPA, Triclopyr
06	Urban, Suburban, constructed wetlands, regional town	8	29	7	Local	Atrazine, Simazine, Diuron, 2,4-D, MCPA, Triclopyr.

Table 12 Victorian drinking water sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
42	Drinking water supply catchment	13	105	51	Regional	Atrazine, Simazine, 2,4-D, Triclopyr.

Table 13 Victorian soil sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
48	Mixed (urban and agriculture)	4	n/a	n/a	Local	Dieldrin
53	Background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial.	101	n/a	n/a	Statewide	p'p-DDE; Dieldrin.

Table 14 Victorian sediment sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
05	Urban	111	32	14	Regional	Diuron, permethrin, bifenthrin, triclosan and carbaryl.
20	Urban, Peri-urban	24	17	10	Local	Bifenthrin
21	Agriculture (pasture)	17	39	17	Local	Prometryn
22	Agriculture (horticulture), water supply	18	10	4	Local	Simazine
23	Agriculture (horticulture), water supply	18	24	6	Local	Myclobutanil, Pyrimethanil

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
48	Mixed (urban and agriculture)	4			Local	Dieldrin, DDT (as p,p'-DDE)
50	Urban, Peri-urban	48	52	31	Local	Simazine, Bifentrhin, Dieldrin, DDT (as p,p'-DDE)
53	Background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial.	101	n/a	n/a	Statewide	Bifentrhin, Dieldrin, DDT, p,p'-DDE

Table 15 Victorian wildlife sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
63	Powerful owl	18	181	69	Statewide	Brodifacoum, Bromadiolone, Pindone. DDT (as breakdown product p,p'-DDE)

3.2.5 Tasmania

Table 16 Tasmanian surface/groundwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
15	Mixed (state government structured program)	83	26	14	Statewide	2,4-D, Simazine, MCPA, Metalaxyl.

Table 17 Tasmanian wildlife sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
62	Tasmanian wedge tailed eagle	50	8	8	Regional	Specific for anticoagulant rodenticides. Brodifacoum, Flocoumafen, Bromadiolone.

- **Urban stormwater** – None identified
- **Drinking water** – None identified
- **Soil** – None identified
- **Sediment** – None identified

3.2.6 South Australia

Table 18 South Australian surface/groundwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
26	Agriculture (horticulture, orchards)	2	14	7	Local	Chlorpyrifos, Carbaryl, Fenarimol, Penconazole, Procymidone, Pirimicarb

Table 19 South Australian sediment sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
25	Urban; intensive agriculture (market gardening,orchards, vines); forestry; broadacre cropping	151	82	19	Regional	DDT, aldrin, chlordane, chlorpyrifos, simazine, diazinon.

- **Urban stormwater** – None identified
- **Drinking water**– None identified
- **Soil** – None identified
- **Wildlife** – Non identified

3.2.7 Western Australia

Table 20 Western Australian surface/groundwater sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
10	Mixed (industrial, residential, conservation, agriculture.)	10	25	12	Local	Diuron, Simazine, Atrazine

Table 21 Western Australian drinking water sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
09	Drinking water supply catchment	>100	99	50	Statewide	n/a

Table 22 Western Australian sediment sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
24	Urban, Peri-urban	4	21	21	Local	Dieldrin
12	Historic agriculture prior to urbanisation	20	15	10	Local	Dieldrin, DDT (as p,p'-DDE)

Table 23 Western Australian wildlife sources

Data source ID	Catchment description	Number of sites / samples	Number of pesticides monitored	Number of pesticides listed	Scale	Pesticides most detected
07	Crocodiles	40	10	10	Local	DDT, hexachlorobenzene, heptachlor, dieldrin, chlordane, mirex.
14	Southern Boobook (owl)	73	8	8	Regional	Specific for anticoagulant rodenticides. Brodifacoum, Bromadiolone, Difenacoum.
08	Fish	47	-	-	Local	DDT (including its breakdown products) were found in 100% of samples, dieldrin in 97% of samples and mirex in 90% of samples. Aldrin, chlordane heptachlor and HCB were found in 70-80% of samples.

- **Urban stormwater** – None identified
- **Soil** – None identified

4 Analysis of data gaps

This project is being undertaken to determine how the department can better monitor the effectiveness of the agvet chemicals regulatory system and provide assurance that the controls on these products are effective and not leading to poor environmental or human health outcomes. The ability to link monitoring data to controls placed on active constituents and their chemical products during regulatory assessment is seen as one way of being able to monitor the effectiveness of the system.

While a large number of data sources have been identified, it is apparent that there are significant gaps in terms of what has been monitored, matrices monitored and being able to link detections back to regulatory controls. To elucidate on reasons for this, gaps are considered both in terms of active constituents and monitored media; and in terms of the regulatory assessments themselves.

4.1 Gaps in current existing data for agvet chemical surveillance

The accepted data sources including information on their access and availability are described in more detail in Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources. Several sources are from published literature and these often require subscriptions for access, or are required to be purchased. The department has obtained access for this project so holds all published literature data sources. Some sources owned by various state government departments/agencies require a request but will generally be made available. In some cases, the data may be held by the testing laboratories rather than the department/agency reporting the data. For data sources obtained during this project, no significant access issues were identified.

4.1.1 Limitations in data described in data sources

The data sources identified are only considered in this project in terms of the chemicals looked for, and the chemicals found. Detections of chemicals are not meant to imply that they pose a risk to humans and the environment, only that they are found outside their area of application and within a monitoring program. Contemporary controls such as runoff restraints and downwind buffer zones are not designed to prevent all chemical moving off site. They are designed to ensure the chemical does not move off site at an exposure level that exceeds an acceptable toxicity/ecotoxicity level. Findings in the data sources as reported do not correlate exposure with effects.

While some data sources considered extensive suites of chemicals, there is no way of tracking back the products that were actually used in the monitored catchments over the monitoring period because no corresponding use data exist. Therefore, it is not clear (and can’t be identified) whether all active constituents would actually have been used during the monitoring program. A zero detection therefore, does not necessarily mean the substance will not move off-site. Conversely, it is not known if all active constituents used in a particular catchment over a monitoring period were actually monitored for. This increases overall uncertainty in results.

4.1.2 Gaps in sources of data

Gaps can be considered absolute or partial. Absolute data gaps are those where no sources of data were identified. These are as follows where no data sources in Australia over the last 20 years have been identified:

- Human biomonitoring (1 study only was obtained – See Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources). In Australia, in certain circumstances, the model Worker Health and Safety (WHS) Regulations place duties on persons conducting business or undertakings (PCBUs) to provide health monitoring to workers. These requirements arise if the worker is carrying out work with hazardous chemicals including lead and asbestos. In addition, the work being carried out must be the kind of work specified in the WHS Regulations. A PCBU has the duty to determine if health monitoring is required. This can include pesticides, and, for example, Safe Work Australia provides a health monitoring guide for organophosphate pesticides.[1] While only one study was obtained through this project for human biomonitoring, such information would be useful to monitor exposure from various activities including pest control operators (for example, mixing and loading chemical products; applying products), and for workers who may be exposed following application when working in treated crops.
- Veterinary medicines outside residues analysis in meat produce. While limited information is available on some veterinary medicines present in meat produce, other forms of contamination may be present. Exposure to land and water may occur from topical treatment to animals from wash-off, or from excretion following oral or injection treatment. Apart from potential residues in the target animal, assessment of such medicines considers exposure to soil, water and often, dung from treated animals. Some monitoring following veterinary treatments would help determine the suitability (or otherwise) of standard assessment assumptions.
- Environment – atmospheric monitoring. Pesticides can move through the atmosphere as spray (droplet) drift at the time of application, or in some cases, as vapour where they are sufficiently volatile to lift off the target area of application. This can have implications for human exposure and unintended off-target damage, for example, if volatile herbicides are exposed to non-target vegetation.
- Environment – all matrices (water, soil, sediment, air) generally associated with broadacre (dryland) cropping regions. There is a general lack of monitoring data in the different environmental matrices that can be used to link back to use in large acreage cropping, for example, cereals and pastures. Monitoring to fill this gap would be useful to support the need for reviews, or determine the suitability of standard exposure assessment assumptions depending on the substance being monitored and when monitoring is undertaken.

[1] Health monitoring, Guide for organophosphate pesticides

With respect to human biomonitoring, while only one study was obtained for the 20-year time frame applied in this project, it is clear activity has been undertaken in the past. In their 2005 performance outcomes monitoring report, the APVMA has significant information related to monitoring public health impacts from agvet chemical use with data drawn from the Australian Bureau of Statistics, Poisons Information Centres. Data relating to calls related to pesticide use and data relating to hospital admissions held by the Australian Institute of Health and Welfare relating to admissions due to acute pesticide poisoning. The information was reported for the years 1997-2001.

In a recent study, monitoring of cholinesterase in red blood cells (AChE) is reported.[2] This was not reviewed as a data source because it did not directly measure for pesticides. However, AChE inhibition may be a symptom of organophosphate (OP) insecticide toxicity.

Partial data gaps are considered for areas where data sources are identified, but gaps remain in the monitoring programs or their findings. This is a difficult issue to resolve because monitoring programs are undertaken generally for a specific purpose. The most comprehensive long term environmental monitoring program currently in Australia is the QLD Government – Reef 2050 Water Quality Improvement Plan. This program is designed to meet the requirements of the QLD government and the list of chemicals assessed for reflects this. However, for the purposes of the current DAFF project, the Reef 2050 Water Quality Improvement Plan only analyses samples for 22 pesticides which is a fraction of the number considered "priority" based on identified concerns for human health and the environment. The Reef 2050 Water Quality Improvement Plan provides excellent work linking detections back to land use, but only within the small suite of substances being analysed for, and within a specific geographic region.

Monitoring that can't be directly linked back to use patterns have limited use other than to note their presence and off-site movement and more fit for purpose data could be developed through targeted baseline monitoring (for example, to understand expected levels in humans, produce and the environment from current use patterns for particular substances) and operational monitoring (for example, to understand levels in different matrices following assessment and regulatory action). Such targeted monitoring can be undertaken on both spatial and temporal scales if needed. For substances where registration assessments pre-date current methodology, monitoring results do not allow an analysis of the effectiveness of contemporary regulatory assessments and may be difficult to interpret without the chemicals in question going through a chemical review.

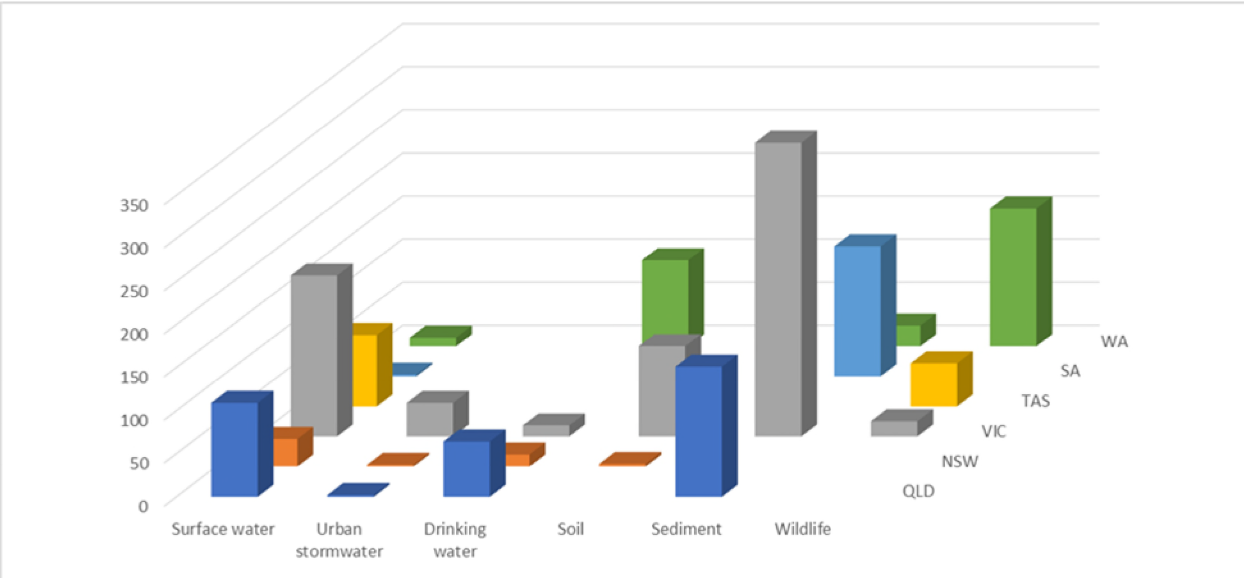
It is not surprising that none of the identified data sources, with the possible exception of the food residues monitoring programs, can directly be used by DAFF to assess the effectiveness of the regulatory system, because they were not specifically developed for this purpose. It is clear that some (generally published literature) were developed to prosecute the case for regulatory action, for

[2] Cotton, J., Edwards, J., Rahman, M.A. et al. Cholinesterase research outreach project (CROP): point of care cholinesterase measurement in an Australian agricultural community. Environ Health 2018. 17, 31.

example, monitoring anticoagulant rodenticides in predator wildlife or neonicotinoids in urban stormwater runoff.

In terms of the number of sites monitored in different states, monitoring was dominated in Victoria and Queensland over the last 20 years (see Figure 1). In Victoria, there were >300 sites where sediment monitoring occurred. These were mainly around Melbourne and Port Phillip Bay, which also dominated the surface water and soil measurements taken in this state. There was one national program considering sediment sampling where approximately 110 sites were sampled around the country (not shown in Figure 2).

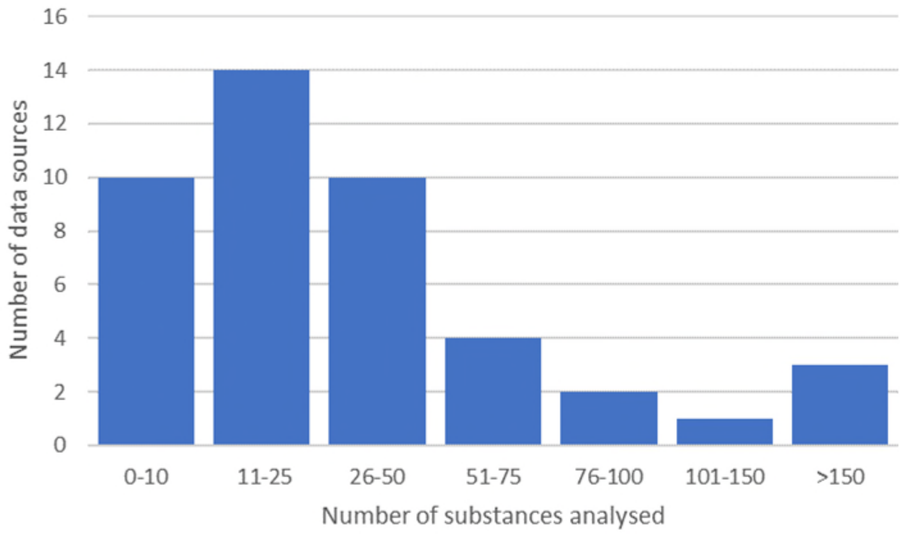
Figure 1 Environmental monitoring – number of sites over 20 years for different matrices



Apart from the national sediment monitoring program, no sediment sampling results were identified for NSW or TAS. Surface water monitoring results were identified in all states, but the number of sites was generally low, particularly in NSW, SA and WA, and these included drinking water catchments, not just sites linked to agricultural activities. Data sources with measurements in soil were generally low.

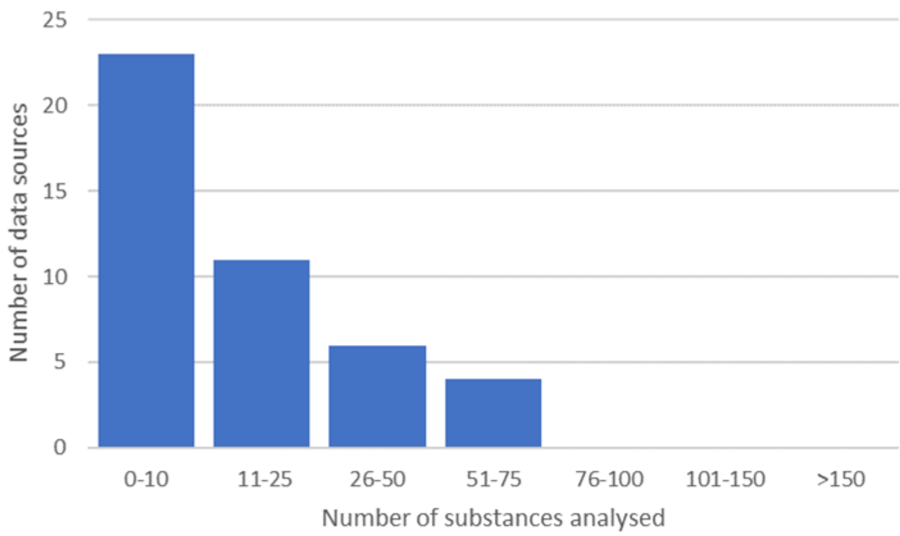
While the overall number of sites may assist in understanding the scale of available monitoring, an important factor in further interpretation relates to the number of pesticides that were analysed. Generally, the overall number in a given monitoring program was relatively low. Around 55% of data sources for environmental monitoring analysed for <25 substances (see Figure 3), and many of these were not identified as having a concern to human health or the environment based on the list provided in Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns. Future surveillance systems could take this issue into account in further prioritising substances for monitoring activities.

Figure 2 Environmental monitoring – number of substances analysed for in different sources



Approximately 77% of sources only analysed for up to 25 substances identified in Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns (Figure 3).

Figure 3 Environmental monitoring – number of listed* substances analysed for in different sources



* Listed substances for this project as identified in Appendix A1.2

4.1.3 Data sources that meet the criteria set out by the department

The programs identified that analyse produce for residues, in particular the National Residue Survey with support from the FSANZ 25th Australian Total Diet Study, can be considered to meet the department's needs for this project. The National Residue Survey is a nationwide monitoring program that analyses for >600 individual active constituents and is undertaken annually thereby providing long term results.

No other single monitoring source could be identified as meeting the department's needs for this project with the possible exception of the Queensland Government Reef 2050 – Water Quality Improvement Plan. However, the results from this program are limited in geographic range and in the number of pesticides analysed for.

This finding is not surprising given monitoring programs are not generally not devised for this specific purpose. If the aim of a particular program is to support the veracity of the National Registration Scheme regulatory assessment process and effectiveness of regulatory controls, more targeted approaches are probably needed. These are expected to be most effective when performed for specific substances and in a number of local release scenarios. A possible exception may be where substances have concerns over volatility and wider exposure may require a more regional approach.

Future work may consider the ability to apply data sources more holistically than in isolation. From the information obtained during this project, such an approach will not be easy because monitoring programs differ in their purposes and are generally not coordinated with other programs in different areas of the country. It will be difficult to consider findings around the country as a collective data source where programs are short lived and undertaken at different times in different regions.

Importantly, the data sources identified may be useful in determining what substances have been detected in different matrices, but they generally are not suitable for issues important to DAFF in determining effectiveness of the regulatory scheme for the following reasons:

1) Substances that are shown to be present are not able to be linked to risk. Regulatory assessments performed in the National Registration Scheme are risk-based meaning that a substance can be present but the risk remains acceptable if the level is below that deemed to result in a potential risk. Current monitoring results do not link exposure to effects, and the regulatory acceptable level is something determined during scientific assessment of a substance by the APVMA;

2) The available monitoring, while often being able to associate presence of chemicals with overall land use, are generally not suitable for linking back to point sources. Further, the monitoring information represents a snapshot at the time of sampling. There is no information available on where and when substances detected were applied. For example, duration between application and sampling is unknown so actual levels determined can't be correlated with application activities. Nonetheless, future work could initially benefit from a more detailed collation and analysis of the monitoring information identified in this report which may provide a starting point to deliver on some of the recommendations from the "Final Report of the Independent Review of the Pesticides and Veterinary Medicines Regulatory System in Australia".

3) There is no ability to assess the range of agricultural chemical products that were used in areas where sampling has occurred so if a monitoring program only assesses for a small number of substances, it is possible a larger number may have been applied during the sampling period but these substances are not being looked for.

4) Further, without an understanding of the range of products used during a sampling program, the suite of chemicals assessed for may include a range of substances that were not actually used. Therefore, non-detects in such situations will not allow a conclusion that such substances will not be present off site following their use.

4.2 Programs for potential response and resolution – point source contamination

Programs that direct potential response and resolution to point source contamination issues, agricultural industry practices and stewardship are discussed in this section.

Point source pesticide monitoring in key countries that Australian regulators, government and community consider reputable and adopting leading standards of regulation and pesticide monitoring are summarised as benchmarks for potential future programs in Australia.

4.2.1 Produce monitoring systems

Produce monitoring provides a measurable and traceable indicator of the type of pesticides used in agricultural production, while also providing evidence or absence of harmful pesticide residues in locally produced or imported food product. Produce monitoring can be used as a measurable indicator of pesticides and veterinary medicines used (often at trace or levels close to the limit of quantification) within a production or catchment area, regardless of the reported pesticide or veterinary medicine product use declared in reporting by producers. Crop and animal food products in most cases, can also be easily traced back to the point source of production, particularly with most Australian hoofed animal meat products supported through the National Livestock Identification System. [3]

Most grains, and animal meat products and some horticultural products exported from Australia are part of the National Residue Survey with results widely publicised, however the sources or location of products which test positive for pesticide residues is kept confidential and managed through internal commercial industry processes. In some countries such as the United Kingdom for example, there is considerable transparency around where food product is found with pesticide residues exceeding maximum residue limits (MRL).

Netherlands - Conducts produce monitoring of fruit and vegetables.[4] *The residue monitoring focuses largely on the growing phase. Before harvest, samples of diverse types of fruit and vegetables are taken and checked for about 25 pesticides. The results of the residue analysis are used to determine when the crop can be harvested. About 20 per cent of the batches sampled in the cultivation phase are checked again after the harvest. A second round of sampling takes place on the auction floor and is intended as a method of monitoring the first sampling. Auction samples, unlike the samples taken in the cultivation phase, can be seen as representative of the products that enter the market.*

[3] National Livestock Identification System

[4] National Institute for Public Health and the Environment Ministry of Health , Welfare and Sport, monitoring programmes

United Kingdom - Produce monitoring[5] is carried out In the United Kingdom (UK) with specific product and site of sale breaches publicly tabled.[6] *In 2021 the Department for Environment, Food and Rural Affairs, Expert Committee on Pesticide Residues in Food (PRiF) program tested 397 different pesticides in each of the foods surveyed, with 1,085 samples of 25 different foods tested*.

USA – *The United States (US) Food and Drug Administration (FDA) selectively tests a broad range of imported and domestic commodities for approximately 800 pesticide residues.[7] FDA may also carry out focused sampling surveys for specific commodities or selected pesticide chemical residues of special interest. In addition, FDA monitors the levels of pesticide chemical residues in foods prepared for consumption in its Total Diet Study (TDS), an ongoing program that monitors contaminants and nutrients in the average US diet.*

Canada - The Canadian Food Inspection Agency (CFIA) residue-monitoring program provides assurance of the safety of supply of fresh produce. The most recent annual report covers 2018-2019.[8] *The proper use of pesticides is monitored through federal government evaluation programs which include residue testing. The National Chemical Residue Monitoring Program (NCRMP) is an annual CFIA regulatory surveillance program, which verifies compliance in foods to Canadian standards and guidelines for chemical residues and contaminants. Over 115,000 tests for residues of veterinary drugs, pesticides, metals, and contaminants were performed on approximately 16,800 NCRMP and Food Safety Oversight (FSO) monitoring samples*.

In addition to the published Australian National Residue Survey reports focussed on export product, local fruit and vegetable product testing is conducted. FreshTest[9] is an Australian Chamber of Fruit and Vegetable Industries or Fresh Markets Australia (FMA) initiative to provide low cost MRL (chemical residue) and microbial testing for wholesalers and their growers in Australia's central markets. These tests in contrast to overseas programs are however confidential and are used for verification for food safety and Quality Assurance systems. In addition, major Australian supermarkets conduct mandatory pesticide residue testing of food products as part of their supplier certification, however this residue testing is also confidential.[10]

[5] Gov UK Pesticide residues in food: quarterly monitoring results for 2021

[6] Department for Environment, Food and Rural Affairs, Report on the pesticide residues monitoring

[7] U.S. Food and Drug Administration, Pesticide Residue Monitoring Program Questions and Answers

[8] Government of Canada, National Chemical Residue Monitoring Program and Chemistry Food Safety Oversight Program Annual Report 2018-2019

[9] The Australian Chamber of Fruit and Vegetable Industries Limited, FreshTest

[10] Woolworths Food Safety

4.2.2 Environment and water monitoring

Environment and water monitoring for pesticides is characterised by government water regulators and agricultural authorities, which are generally structured surveys, such as in the case of the Netherlands, but in some cases unstructured such as in Canada.

Netherlands – Water Boards monitor the use of pesticides in agriculture and horticulture.[11] *An integral task of water boards is to manage and maintain sufficient quality of surface water as a source for drinking water. Dutch water boards have a well-established program for monitoring pesticide contamination of surface waters. These results link the use of plant protection products to pesticide concentrations in surface water.*

The Dutch Board for the Authorisation of Plant Protection Products and Biocides (CTGB)[12] assess whether plant protection products and biocidal products are safe for humans, animals and the environment before these products can be sold and used in the Netherlands. The Netherlands publicly publishes environmental survey findings in a Pesticide Atlas,[13] which is updated following the release of the land use correlation. The Netherlands CTGB always uses the most recent monitoring data in order to ascertain whether there are exceedances of the authorization threshold.

In the Pesticides Atlas, it can be found which active substances and metabolites occur in the Dutch surface waters, based on monitoring data of water managing bodies. The Pesticide Atlas contains information regarding exceedances of thresholds, long-term trends in concentration and the link with land use.

European Union – The European Union (EU) funded H2020 FAIRWAY Project[14] aims to review approaches for the protection of drinking water resources from pollution by nitrogen and pesticides. The program aims to: *identify and further develop cost-effective and innovative measures and governance approaches that will protect drinking water supplies while increasing agricultural sustainability. FAIRWAY took a multi-actor approach to facilitate effective cooperation between actors from different sectors and levels including: farmers, advisors, drinking water companies, scientists and policy makers. The practical experiences from 13 case studies in 12 countries were analysed in five research themes to identify the barriers and success factors associated with achieving water quality targets*.

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[11] ctgb, Authorisation of Plant Protection Products and Biocidal Products (Ctgb), Monitoring Compliance and Enforcement

[12] Authorisation of Plant Protection Products and Biocidal Products (Ctgb)

[13] The Netherlands publicly publishes environmental survey findings in a Pesticide Atlas

[14] Fairway Farm systems management and governance for producing good water quality for drinking water suppliers - the objective of Fairway

United Kingdom - Pesticides are actively monitored in UK drinking water and is reported annually by the Drinking Water Inspectorate.[15] *The reports cover water quality testing and results, public confidence in drinking water, events and technical audit activity. They also contain a summary of all results of the water companies regulatory sampling program and a list of all the cautions and prosecutions carried out by the Inspectorate. Published reports cover private water supplies in England and Wales. The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) place controls on the storage of pesticides and their use in the proximity of the water environment in Scotland*. The Scottish Drinking Water Protection Scheme targets specific areas for monitoring, including pesticide contamination within drinking water catchments.[16]

USA – *The US EPA, along with US states, implements regulations that protect US drinking water from source to tap*[17] *– EPA requires community water systems to deliver a Consumer Confidence Report, also known as an annual drinking water quality report, sent annually to their customers, providing information about local drinking water quality*. This includes reports on specific pesticide contamination at identified water catchments and wells.[18]

Canada - Water catchment monitoring[19] appears to have reduced in formal intensity since 2011 studies.[20] The Pesticides Indicator[21] (official name: Indicator of the Risk of Water Contamination by Pesticides) managed by Agriculture and Agri-Food Canada *evaluates the relative risk of water contamination by pesticides across agricultural areas in Canada. It can be used to assess pesticide inputs to cropland and the amount of pesticide transported to surface and ground water. This indicator has tracked pesticide risk associated with Canadian agricultural activities from 1981 to 2011*. The Canadian government has been unable to update this indicator for 2016, due to a delay in availability of proprietary data required by this model.

The focus of these international water monitoring programs is on drinking water and associated water catchments. While much of the Australian water monitoring for pesticides is also focussed on drinking water catchments, in contrast there has been a considerable broader Australian environmental pesticide monitoring focus in key catchment areas such as the Great Barrier Reef. There is currently limited producer industry-levy funded and agricultural industry agency delivered

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[15] Drinking Water Inspectorate, reports

[16] Scottish Water, Scotland, Drinking Water Protection Scheme

[17] United States Environmental Protection Agency, Drinking Water and Pesticides

[18] United States Environmental Protection Agency, Safe Drinking Water Act: Consumer Confidence Reports (CCR)

[19] Government of Canada, Water, Pesticides Indicator

[20] Government of Canada, Report, Presence and levels of priority pesticides in selected Canadian aquatic ecosystems

[21] Government of Canada, pesticides indicator, overall state trend

environmental monitoring programs, with the AUSVEG EnviroVeg pilot project[22] being an example of potential future programs.

4.2.3 Producer pesticide use monitoring

Users of pesticides and veterinary medicine products in most agricultural applications are regulated in most developed countries to record use, crop stage, key weather or animal health conditions when using products. In most countries, only manual hand-written records are required, however some countries, in particular the Netherlands and California USA require detailed reporting use of pesticide and plant nutrient inputs. There is considerable risk of inaccurate or falsified reporting by users and producers to surveys and reporting of use to regulators. In most countries, there is no regulatory requirement for recording or reporting of home garden use of pesticides except for certified pesticide application contractors.

> **Netherlands** – Producers must have a crop protection monitoring system and must keep track of all pesticide use measures taken each growing season.[23] *This includes recording the use of biological agents or mechanical weed control, crop rotation, choice of crops and basic planting material, emission reduction measures, and use of crop protection agents*. These data are summarised in a comprehensive pesticide use survey conducted every few years.[24],[25]

> **United Kingdom** - *Pesticide usage monitoring forms part of an obligation under the Food and Environment Protection Act (1985) for post-registration monitoring of pesticides approved for use. FERA Pesticide Usage Surveys[26] presents pesticide usage data relating to Great Britain from 1990 onwards and for the United Kingdom from 2010 onwards. The program of pesticide usage surveys[27] is commissioned by the independent Expert Committee on Pesticides and funded by the charge on the agrochemicals industry. Data is collected by the Pesticide Usage Survey Teams at FERA Science Ltd, the Scottish Agricultural Science Agency and the Agri-Food and Biosciences Institute of Northern Ireland. Since 2010 the surveys have followed a biennial cycle with arable, potato storage, soft fruit and orchards being conducted in even years (2010, 2012, 2014, 2016 etc.) and outdoor vegetable and edible protected crops in odd years (2011, 2013, 2015, 2017 etc.). Surveys of grassland & fodder crops (last survey 2017) and amenity situations (last survey 2016) are conducted every four years. The Pesticide Usage Monitoring Group (PUMG) records the use of crop protection products in Northern Ireland.[28]*

[22] Ausveg, piloting digital remote monitoring to improve environmental performance

[23] Business.gov.nl, regulation crop protection products biocides

[24] cbs, use of pesticides in agriculture, survey

[25] cbs, less pesticide used in agriculture, article

[26] fera, Pesticide usage surveys

[27] Agri-food and Biosciences Institute, Pesticide usage monitoring reports

[28] Agri-food and Biosciences Institute, Pesticides usage monitoring surveys

This cyclical program examines pesticide usage in all sectors of the agricultural and horticultural industries. Principally, the data collected provides information for consideration by the UK Expert Committee on Pesticides. The data may also be used by those involved in residue testing, environmental impact studies, public information, evaluation and regulation of trends in pesticide usage.

USA - The National Agricultural Statistics Service (NASS) Agricultural Chemical Use Program[29] is USDA's official source of statistics about on-farm chemical use and pest management practices. *Since 1990, NASS has surveyed US farmers to collect information on the chemical ingredients they apply to agricultural commodities through fertilizers and pesticides. On a rotating basis, the program currently includes fruits; vegetables; major field crops such as cotton, corn, potatoes, soybeans, and wheat; and nursery and floriculture crops. The program also collects information on the pest management practices farmers implement to reduce their dependence on agricultural chemicals (e.g., practices that make pesticides more effective or are an alternative to pesticides). Historically, data has also been periodically collected on chemicals used post-harvest and in livestock production*. Detailed summaries of the volume of pesticide product use per crop is publicly available.

California, USA – In 1990, California became the first state to require full reporting of agricultural pesticide use[30] in response to demands for more realistic and comprehensive pesticide use data. *Under the program, all agricultural pesticide use must be reported monthly to county agricultural commissioners, who in turn, report the data to the California Department of pesticide Regulation. California has a broad legal definition of "agricultural use" so the reporting requirements include pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, plus along roadside and railroad rights-of-way. In addition, all postharvest pesticide treatments of agricultural commodities must be reported along with all pesticide treatments in poultry and fish production as well as some livestock applications. The primary exceptions to the reporting requirements are home-and-garden use and most industrial and institutional uses*. Pesticide use summary reports are published annually, as well as GIS spatial data of pesticide use by township and section.

Canada – Only limited pesticide use information has been nationally collected in the Canadian Farm Environmental Management Survey, the most recent from 2011.[31] Pesticide

[29] United States Department of Agriculture, National Agricultural Statistics Service, Agricultural Chemical Use Program

[30] California Department of Pesticide Regulation, Pesticide Use Reporting

[31] Statistics Canada, Farm Environmental Management Survey

use surveys in Canada are less structured, with some provinces such as Ontario conducting surveys of use in agricultural crops[32] and Alberta publishing pesticide sales.[33]

Australian pesticide use reporting is limited to the annual report of product sales data by the APVMA[34] generated by registrant reporting to the regulator. This is however de-identified and aggregated sales data that is categorised into agricultural or veterinary product types, each containing greater than 5 products to ensure individual product holders or companies are not identifiable in the publication of annual product sales data reports. There is clearly a considerable difference in the transparency of use of individual pesticide product in Australia compared with the USA and EU, however there is limited information available as a detailed national data set in Canada.

[32] Farm and Food Care Ontario, Survey of Pesticides use in Ontario

[33] Government of Alberta, Pesticide Sales in Alberta

[34] Australian Pesticides and Veterinary Medicines Authority, Annual Product Sales Data

5 Future surveillance delivery and reporting systems

There is considerable global debate around reporting options to represent current practice and improvement of agricultural pesticides and veterinary medicines. Pesticide use frequency indices are being used in Europe as a measure of change or improvement in pesticide use. There has been discussion around the use of these indices in Australian agricultural sustainability frameworks, however the issues with these indices detailed below suggest they do not reflect or encourage change to best practice pesticide stewardship.

5.1 Treatment frequency indices

Treatment frequency indices (TFI) were developed by Denmark in 2008 and replaced the simple measurements of the applied pesticide volume as indicator.[35] It has since been in use in several other countries worldwide as a national or regional indicator or as part of projects. The TFI is:

> *Calculated by the theoretical number of pesticide treatments per hectare, based on standard dose rates of active ingredients, and the amount of pesticides sold yearly. An advantage of the TFI is that the indicator can be aggregated into a single value, e.g. a TFI of 1 is equivalent to one full dose applied on a certain agricultural area. As the TFI is not related to the active substances used, no relation can be established to elevated concentrations of single substances in raw water. One constraint of the TFI is that progress towards products with lower toxicity cannot be covered by the indicator: the TFI does not account for the chemical or toxic properties of some specific substances of the pesticide. Additionally, ecological effects or damages cannot directly be assigned to pesticide applications, since interactions and intermediate steps often have a major influence on pesticide environmental behaviour. Consequently, a reduction in treatment frequency is not sufficient to reach conclusions regarding trends in environmental and health risks, even though a correlation is commonly assumed.*

The French Indicator of Frequency of Treatment (IFT),[36] which is similar to the Dutch TFI, is used to measure the use of pesticides on farms and its evolution over time.

The Environmental Yardstick for Pesticides (EYP)[37] has been developed as a tool for farmers in the EU to select pesticides with the least environmental impact and to quantify the impact of their use. For

[35] Fairway Information System, Treatment frequency indices

[36] Directorate General for the Economic and Environmental Performance of Enterprises, Indicator of frequency of treatment

[37] Fairway Information System, Treatment frequency indices

each pesticide the yardstick assigns environmental impact points for the risk to water organisms, the risk of groundwater contamination and the risk to soil. There are three EYP output values:

> *Acute risk to water organisms (most sensitive organism); risk of groundwater contamination; acute and chronic risk to soil organisms. The potential risk is expressed in environmental impact points (EIPs). The more EIPs a pesticide gets, the higher its impact on the environment. The EIPs are based on the predicted environmental concentration (PEC) in a certain compartment and the maximum permissible concentration (MPC) set by the Dutch government. The EIP are initially assigned for a standard application of 1 kg active ingredient per hectare. For different rates of application, the number of EIP is multiplied by the actual dose.*
>
> *The score on the yardstick depends on chemical properties (persistence and mobility in soil, toxicity) of both active ingredient and principal metabolites, dose rate, organic matter content of the soil (influences transportation in soil), time of application (influences degradation and transportation in soil), method of application (influences the amount of emission to surface water) and distance to surface water (influences the amount of emission to surface water). The data on degradation rates, adsorption coefficients, toxicity to aquatic organisms and toxicity to soil organisms are drawn from data sheets compiled by the Dutch Regulatory Committee for agrochemicals.*
>
> *As the name indicates the EYP only considers environmental effects of pesticides. EYP is not as widely used, as for example as the Environmental Impact Quotient (EIQ), but has been applied to assess the impact of pesticide use in integrated and conventional potato production in the Netherlands. EYP calculates PEC values but rather than comparing these values to LC/LD/EC/ED50 and NOEC values they are multiplied by pesticide toxicity data to produce Environmental Impact Points.*

There has been significant Australian agricultural industry discussion and concern with the suggested use of a single multi-criteria indicator or TFI approach. A pesticide treatment frequency index (TFI) is not likely to be an appropriate path forward as an industry indicator as the agricultural industry will continue to use new generation safer and environmentally safe synthetic pesticides and the volume of product use could well increase with scale of industry expansion. Also, the type of pesticide, relative toxicity and environmental risks will change (i.e. it could either be a synthetic/natural/biological/biochemical pesticide used in either conventional or organic systems). For example, organic agriculture in the coming years is likely to see an increase in the use of natural and biological pesticides. It has been suggested that the ratio of control measures (mechanical, biological pesticides, genetic technology, natural or organic pesticides, synthetic pesticides etc) is a more appropriate indicator.

5.2 Australian industry sustainability frameworks and pesticide use reporting

There has been clearly identified Australian agricultural industry strategic intent to improve and report to stakeholders and markets on defined sustainability frameworks, including the use of agricultural pesticides and veterinary medicines.

Grains - industry sustainability framework includes responsible stewardship[38] throughout the value chain,[39] caring for our environment and protecting Australia's biosecurity underpin our productivity, profitability and global reputation. Core objectives include the industry being engaged in incentivised environmental stewardship programs, plus redesign, reduce and/or develop alternative chemical use whilst ensuring productivity, safety and environmental outcomes. Targets include:[40] *Demonstrate science-based best practices in pest, weed and disease control while ensuring productivity, safety and environmental outcomes. Desired outcome: Australian grain productivity and market access is enhanced by demonstrating best practice crop protection*.

It is noted industry submissions to the *Independent review of the pesticides and veterinary medicines regulatory system in Australia*[41] that the grains industry and Australian state farming member organisations in-principle collectively support environmental pesticide monitoring based on agreed international scientific standards with effective solutions to identify cause of issues identified through monitoring. This includes consideration to industry funding support, as per the existing National Residue Survey model[42] with capability to identify the source of a problem.

Horticulture - industry sustainability framework includes ensuring movement of soil, nutrients and chemicals into the environment are minimised.[43] Indicators include:

- *Container production uses growing medium that minimises nutrient loss*
- *Use of erosion management strategies on drains and drainage areas in high risk run-off areas e.g. minimal slope, sealed or grassed or vegetated*
- *Use of systems to filter run-off water from container-grown production systems and packing sheds*
- *By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment*

Red Meat Industry - Australian beef and lamb producer's industry sustainability framework has a veterinary medicine focus on antimicrobial stewardship,[44] feedlots covered by an antimicrobial

[38] Graingrowers, Australian grains industry sustainability framework

[39] Australian Grain Industry, Sustainability Framework July 2020

[40] Australian Grains Industry, Sustainability Framework January 2021

[41] Department of Agriculture, Fisheries and Forestry, Independent review of the pesticides and veterinary medicines regulatory system in Australia

[42] Grain Producers Australia, submission to independent Review Panel - Draft Report of the

[43] Hort Innovation, Australian Grown, Horticulture Sustainability Framework June 2021

[44] Red Mead Advisory Council, Australian Beef Sustainability Framework, 2021

stewardship plan, compliance with antibiotic MRLs and vaccination rates for clostridial diseases.[45] The outcome is *maintaining the efficacy of antimicrobials so that infections in humans and animals remain treatable is of critical importance. This priority looks at industry use of antibiotics and surveillance programs to detect resistance to them. The particular surveillance focus is antimicrobial resistance of bovine respiratory disease pathogens*.

5.3 Integration with current and future pesticide user reporting systems

Farm management software for use in business management is an essential component of best management practice. For example, over 90% of agronomists and over 80% of Australian grain production is managed using Agworld[46] with 40+ million ha use globally.

All major global tractor and agricultural equipment manufacturers have adopted the AgGateway Ag Data Application Programming Toolkit (ADAPT toolkit) to integrate machine control and software systems. The Australian developed cloud based farm software Agworld is just one of 240+ agricultural machine manufacturers and software providers working towards this common standard.[47] ADAPT provides industry standard tools to simplify communication between growers, their machines, and their software partners. It is the product of many years' work by more than a dozen companies and experts collaborating through AgGateway. This has clearly become the dominant global standard and it will be the platform on which all field sprayer control interfaces will communicate with farm management software and pesticide use recording and reporting systems in the future.

AgGateway is also leading the Closed Loop Spray Charter[48] which aims to support, farmers and contractors the best possible use and application of crop protection products. Principally to "help growers avoid mistakes," to achieve "compliance and traceability," and prove out good "stewardship of product usage." "Closed Loop Spray" means "end-to-end documentation and resource identification" and not "real-time feedback-driven control." It should be noted that AgGateway is now collaborating with the EU based ATLAS Agricultural Interoperability and Analysis System.[49] The goal of ATLAS is the development of an open interoperability network for agricultural applications and to build up a sustainable ecosystem for innovative data-driven agriculture.

The Closed Loop Spray Charter initiative is being led by AgGateway Europe, however the intended scope is global and is in the early stages of establishing an international working group.[50] The aim is

[45] Red Meat Advisory Council, Australian Beed Sustainability Framework, 2022

[46] EY, Doug Fitch, Western Region National Finalist

[47] AgGateway Europe, ADAPT for agricultural data

[48] AgGateway Europe, Europe Update, Regional Update

[49] Agricultural Interoperability and Analysis System

[50] AgGateway, Working Group Priorities for 2022

to support producers of chemical crop protection products, contractors, and farmers in the use and application of crop protection products. This approach will require elabels such as Syngenta's proprietary Smart eLabel system[51] to capture pesticide label information at the correct level of data to meet regulatory and stewardship needs.[52]

There are limited examples of digital data recording systems in animal health and application of veterinary medicine. Accurate weight is crucial for effective dosing of individual animals and for reporting antimicrobial usage.[53] Automated weight and dose systems such as Automed[54] are examples of integrated solutions. Smart ear tag sensors can track the feeding, temperature, behaviour and movement of livestock and monitor vital signs for early indications of illness. Animal ID, particularly with smart tags is a core component of supporting application and digital recording of veterinary medicine use in animals.[55]

These systems in development in the future will provide efficient and accurate automated recording of pesticide use in agricultural field operations and allow future opportunity for seamless and non-corruptible electronic reporting, particularly using block chain technologies, to demonstrate stewardship of best management practices and meet regulatory obligations. It is realistic to expect that these systems will start to become standardised and widely adopted in the next 5+ years.

[51] Syngenta, Digitization of Label Information

[52] Syngenta, Digitization of Label Information

[53] National Library of Medicines, Data Driven approach to using individual cattle weights to estimate mean default dairy cattle weight, Schubert H, Wood S, Reyher K, Mills H.

[54] Automed, medication delivery system

[55] Health for Animals Global Animal Health Association, Digital Revolution in Animal Health report

6 Future environmental surveillance options and technologies including near real-time sensor measurement of off-target environmental impacts

Traditional laboratory-based analysis techniques do not currently provide fast and efficient technology frameworks to support real-time or near-real-time detection of pesticides. Current advances in pesticide detection sensors focus on improving sensitivity and selectivity through the use of nanomaterials, in sensor assemblies and new biosensors, including electrochemical, optical, nano-colorimetric, piezoelectric, chemo-luminescent and fluorescent techniques.[56] In addition there has been considerable progress in development of micro gas chromatography for chemical detection[57] and laser-induced breakdown spectroscopy to discriminate pesticide-contaminated products in a rapid manner.[58] While there are no current commercial examples of field based real-time sensor based surveillance systems for agricultural pesticide detection, the following summary review of technologies highlights the opportunity for future development and deployment of sensor based pesticide detection in the atmosphere, water catchments and soil.

6.1 Real-time pesticide detection in the atmosphere

Off-target spray drift damage and potential impacts on food safety and trade issues affect all agricultural industries, across a broad range of pesticides. There is also wider environmental impacts on native remnant vegetation and vegetation adjacent to production systems.[59] The financial impact on agricultural industry is also significant for off-target spraying, with phenoxy spray drift costing an estimated $18 million in annual cotton production losses,[60] up to $7 million loss from a single drift event affecting vineyards[61] and $1 million loss in tomato crops.[62] Cotton, viticulture and horticulture crops are particularly sensitive to spray drift from Group 4 herbicides (phenoxy herbicides including 2,4-D) which are high value crops that if impacted can catalyse social license challenges for the grains

[56] National Library of Medicine, What are the Main Sensor Methods for Quantifying Pesticides in Agricultural Activities? Zamora-Sequeira R, Starbird-Pérez R, Rojas-Carillo O and Vargas-Villalobos S.

[57] US Department of Energy, Office of Scientific and Technical Information, Micro Gas Analyzer - Sandia

[58] National Library of Medicine, Detection of Nutrient Elements and Contamination by Pesticides in Spinach and Rice Samples Using Laser-Induced Breakdown Spectroscopy (LIBS). Kim G, Kwak J, Choi J and Park K.

[59] ABC Landline 25 September 2022

[60] Contton Australia, Spray Drift and Satacrop

[61] ABC News, farmer chemical spray-drift multi million dollar payout

[62] ABC News, million dollar crop loss warning for herbicide users

industry. Therefore, there is a need for a technology that not only detects risks of herbicide spray drift from phenoxy herbicides such as 2,4-D, but also can be used as a tool to manage herbicide stewardship and protection of surrounding sensitive crops, and in turn strengthening industry social license.

Direct contact off-target pesticide drift remains an issue that is principally managed through determination of spray buffer zones for a given sprayer setup. Vapour drift is however the final frontier in pesticide spray drift science. Conventional drift is relatively well understood to be a function of droplet size, release height, wind speed, influence of surface temperature inversions and to a lesser extent temperature, relative humidity, crop interactions and evaporation rates. Vapour drift on the other hand is not well understood and unlike droplet drift does not appear to be a generic phenomenon across all pesticides. Vapour drift management has been a challenge to all stakeholders for decades and there are no commercially available tools to measure this in real-time. Existing approaches involve sample collection and subsequent processing back at the laboratory, by which time impacts may have occurred at a landscape scale.

Gas chromatography (GC) has been used for organic and inorganic gas detection with a range of applications including screening for chemical warfare agents, breath analysis for diagnostics or law enforcement purposes, and air pollutants/indoor air quality monitoring of homes and commercial buildings.[63] Metal-organic frameworks (MOFs) as stationary phases for chromatography, the application of MOFs for one- and two-dimensional micro-gas chromatography (µGC and µGC × µGC) has demonstrated determination of the partition coefficients for toxic industrial chemicals, using µGC and µGC × µGC systems.[64] Using these µGC sensors with capillary columns with the first using a 0.50-µm film of nonpolar dimethyl polysiloxane and the second using a 0.25-µm film of polar trifluoropropylmethyl polysiloxane, operated with atmospheric pressure air as the carrier gas enabled the complete separation of an 18-component vapour mixture of common solvents in air in 3.5 min.[65]

This µGC technology has developed further[66] *resulting in a small, consumable-free, low-power, ultra-high-speed comprehensive µGC×µGC system consisting of microfabricated columns,*

[63] MDPI, Monolithically-Integrated µGC Chemical Sensor System Sensors 2011, Manginell RP, Bauer JM, Moorman MW, Sanchez LJ, Anderson JM, Whiting JJ, Porter DA, Copic D and Achyuthan KE. A .

[64] National Library of Medicine, Metal-Organic Framework Stationary Phases for One- and Two-Dimensional Micro-Gas Chromatographic Separations of Light Alkanes and Polar Toxic Industrial Chemicals. J Chromatogr Sci. 2020 Apr 25, DH, Sillerud CH, Whiting JJ and Achyuthan KE..

[65] ACS Publications, Selectivity enhancement for high-speed GC analysis of volatile organic compounds with portable instruments designed for vacuum-outlet and atmospheric-pressure inlet operation using air as the carrier gas, Whiting J and Sacks R. .

[66] A high-speed, high-performance, microfabricated comprehensive two-dimensional gas chromatograph. Whiting JJ, Myers E, Manginell RP, Moorman MW, Anderson J, Fix CS, Washburn C, Staton A, Porter D, Graf D, Wheeler DR, Howell S, Richards J, Monteith H, Achyuthan KE, Roukes M and Simonson RJ. Lab Chip. 2019 Apr 23;19(9):1633-1643. doi: 10.1039/c9lc00027e. PMID: 30919866.

nanoelectromechanical system (NEMS) cantilever resonators for detection, and a valve-based stop-flow modulator is demonstrated. The separation of a highly polar 29-component chemical mixture in less than 7 seconds, and just over 4 seconds after the ensemble holdup time is demonstrated with a downstream flame ionization detector. The analysis time of the second dimension was 160 ms, and peak widths in the second dimension range from 10–60 ms. Data from a continuous operation testing over 40 days and 20000 runs of the µGC × µGC columns. The µGC × µGC -NEMS resonator system generated second-dimension peak widths as narrow as 8 ms with no discernible peak distortion due to under-sampling from the detector. This µGC × µGC -NEMS technology, which has primarily been developed for field detection of chemical weapons in a battlefield environment, has already been validated to detect more than 42 different security sensitive chemical compounds of interest in real-time to a limit of quantification (LOQ) equivalent to laboratory grade equipment.

Alternatively, a hybrid, nanomaterial based gas-sensing array has also been developed for the detection of chlorpyrifos. Using a sensing array utilising nanoparticles (NPs) as the conductive layer of the device while four distinctive polymeric layers (superimposed on top of the NP layer) act as the gas-sensitive layer.[67]

Cavity ring-down spectroscopy (CRDS) is an established technique for gas sensing that is newly emerging in the field of optical biosensing, which has also been adapted for use in liquids, providing a highly sensitive method for quantitative real-time biosensing.[68] CRDS technology has successfully been used to measure aerosol dispersion of copper chloride and has potential as a sensitive real-time analytical technique for aerosol detection and quantification.[69] This technology has been commercialised by RingIR[70] for real-time gas sensing, including detection of the chemical fumigants phosphine, methyl bromide and sulfuryl fluoride.

6.2 Real-time pesticide detection in catchments and drinking water

Chemical sensors are attractive instruments for real-time water quality and safety analysis. The optimal electrochemical or optical properties of such sensors will depend on the concentration of chemical analytes in a body of water. These types of sensors are already widely applied to the

[67] National Library of Medicine, A sensing approach for automated and real-time pesticide detection in the scope of smart-farming, Computers and Electronics in Agriculture, Volume 178. Skotadis E, Kanaris A, Aslanidis E, Michalis P, Kalatzis N, Chatzipapadopoulos F, Marianos N and Tsoukalas, D, 2020,105759

[68] ScienceDirect, Optical Biosensors (Second Edition), 2008, Elsevier Science, Peter B. Tarsa Ph.D., Kevin K. Lehmann Ph.D.

[69] doi, Aerosol analysis by cavity-ring-down laser spectroscopy, Analytica Chimica Acta, Volume 466, Issue 1, 2002, Pages 1-9Bulatov V, Fisher M and Israel Schechter I.

[70] RingIR, Forensic Identification

analysis of natural and potable water.[71] Gas chromatography–mass spectrometry (GC–MS) has also been widely applied for pesticide monitoring because of its high sensitivity and specificity and for the potential of multi-residue and multi-class analysis.[72]

Real-time autonomous measurement of pesticides that combines continuous sampling and on-site measurements with a high-resolution mass spectrometer has been demonstrated in a small agricultural catchment, continuously measuring 60 pesticide compounds at 20 minutes resolution for 41 days during the growing season.[73]

A recent review of monitoring of pesticides in water matrices and the analytical criticalities[74] details that; *sample pre-concentration and extraction methodologies have advantages and limitations, but all require good operator preparation and almost always special tools involving a large combination of analytical techniques applied in multiple configurations. Increasingly necessary to develop multi-residual methods, reliable, safe for the operator, which request small organic solvent and sufficiently sensitive to reach the standards set by the specific regulations. However, PPPs with more specific chemical structures, such as glyphosate, are excluded from the multi-residual approaches, for which a particular and specific methodology is required. Liquid-liquid extraction (LLE) is a simple method usually used for water samples. The main advantage of this technique is the large availability of studies in the literature, which provide information on the proper selection of organic solvents, the pH and temperature conditions and the achievable LOD/LOQ. It is also a simple and relatively inexpensive method. The evolution of analytical techniques has seen, in recent years, the progressive diffusion of Solid-Phase Extraction (SPE) that uses columns or disks of different materials, able to retain the active substances present in water samples and then release them from the washing action of small quantities of suitable solvents. Similarly to LLE, also regarding SPE, the loss of the most volatile analytes during solvent evaporation can occur, affecting the overall analyte recovery*.

Use of fluorescence-based biosensing has also been demonstrated for the detection of organophosphate (OP) pesticides in water samples and drinkable food using a mutant of the

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[71] Lvova L, Di Natale C and Paolesse R. Chemical Sensors for Water Potability Assessment. In: Grumezescu A., Holban A.M., editors. Bottled Packaged Water. 2019. Volume 7. Elsevier Science; Amsterdam, The Netherlands, 177–208.

[72] National Library of Medicine, Solid-phase micro-extraction-gas chromatography-(tandem) mass spectrometry as a tool for pesticide residue analysis in water samples at high sensitivity and selectivity with confirmation capabilities. Gonçalves C and Alpendurada MF. J Chromatogr A. 2004 Feb 13;1026(1-2):239-50..

[73] la Cecilia D, Dax A, Ehmann H, Koster M, Singer H and Stamm C. Continuous high-frequency pesticide monitoring to observe the unexpected and the overlooked, Water Research X, Volume 13, 2021, 100125.

[74] ScienceDirect, The monitoring of pesticides in water matrices and the analytical criticalities: A review, TrAC Trends in Analytical Chemistry, Volume 144, 2021, 116423, Campanale C, Massarelli C, Losacco D, Bisaccia D, Triozzi M and Felice Uricchio V.

thermostable esterase-2 from Alicyclobacillus acidocaldarius (EST2-S35C) as a bioreceptor for OP pesticides.[75]

In addition, a sensor construct employing a universal FR-4 substrate gold interdigitated electrodes with active sensing elements based on selective antibodies (proteins) and polymeric network structures – poly(3,4-ethylenedioxythiophene) has successfully been developed to detect glyphosate and atrazine, with potential to perform combinatorial assessment and subsequently-multiplexed analysis of pesticide antigens.[76]

A recent detailed review of real-time water sensing technology shows that[77] *there are still many obstacles for having a one sensing approach that would satisfy different situations. The most successful systems based on chemical sensing or its combination with other methods rely on specificity of a coating material that is capable of accurate detection of certain water pollutants, with molecularly imprinted polymers providing an increased flexibility for the designing of those systems. Novel trends include using microwave spectroscopy and chemical materials integration for achieving a higher sensitivity to and selectivity of pollutants in water*.

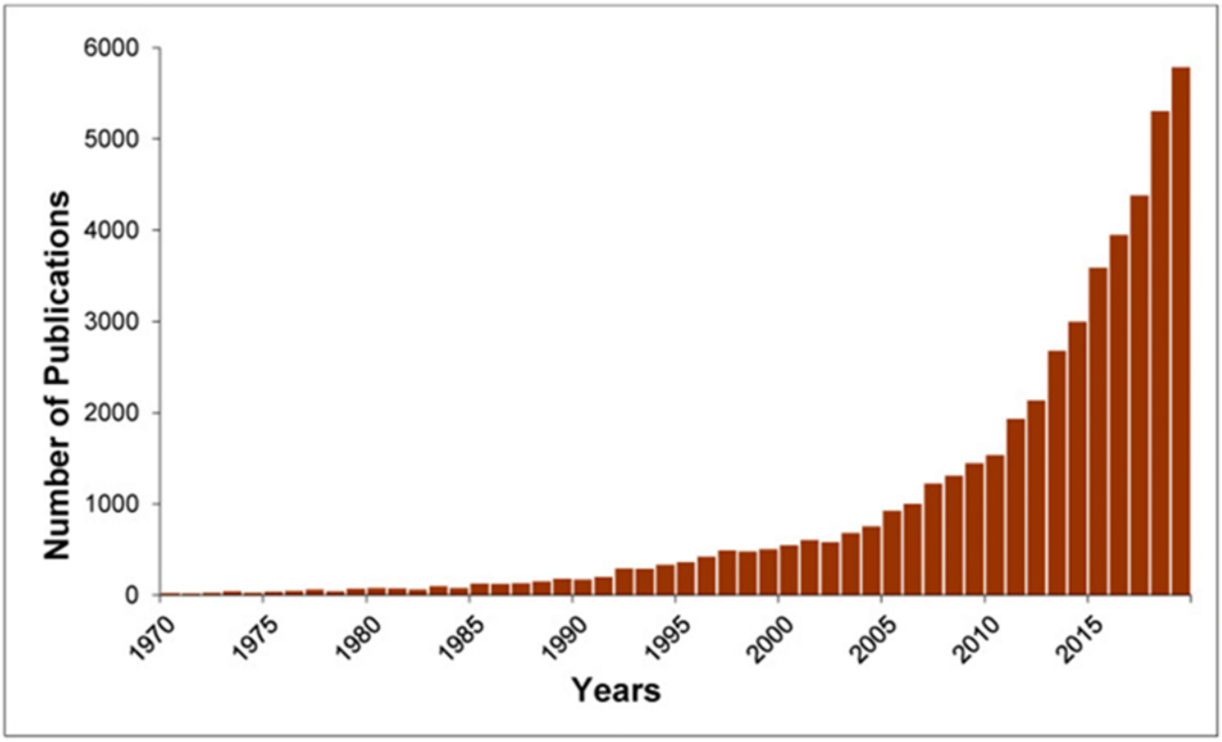
There is exponential growth in the number of publications on real-time water quality monitoring with chemical sensors (Figure 4).

[75] European Food Safety Authority, Monitoring of pesticide amount in water and drinkable food by a fluorescence-based biosensor. Barbieri MV, Rodrigues ACM and Febbraio, F. EFSA Journal 2022; 20(S1):e200403, 9 pp3

[76] Dhamu VN, Poudyal DC, Telang CM, Paul A, Muthukumar S and Prasad S. Office Paper-Based Electrochemical Strips for Organophosphorus Pesticide Monitoring in Agricultural Soil. Electrochem Sci Adv. 2021, 00, e2100128.

[77] Yaroshenko I, Kirsanov D, Marjanovic M, Lieberzeit PA, Korostynska O, Mason A, Frau I and Legin A. Real-Time Water Quality Monitoring with Chemical Sensors. Sensors (Basel). 2020 Jun 17;20(12):3432. doi: 10.3390/s20123432. PMID: 32560552; PMCID: PMC7349867.

Figure 4 Number of publications on "Real-Time Water Quality Monitoring with Chemical Sensors" in the last 50 years[77]



6.3 Near real-time pesticide detection in soils

Traditional soil measurement techniques are primarily laboratory-based analysis such as ion chromatography (IC), inductively coupled plasma-optical emission spectrometry/mass spectrometry (ICP-OES/MS), gas chromatography−mass spectrometry (GC-MS), and chemiluminescence.

Electrochemical biosensors contain biological recognition elements (e.g., microorganisms and enzymes) that specifically reacts with the target of interest, and then converts such changes into electrical signals (e.g., current, voltage, and resistance).[78] Biosensors can achieve low detection limits for contaminants due to the selective binding of the targets. One potential application of electrochemical biosensors in the soil environment is to detect agrochemicals, such as pesticides, herbicides and fertilizers.[79] Specifically, biosensors have been used for the determination of

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[78] Ispas CR, Crivat G and Andreescu S. Review: Recent Developments in Enzyme-Based Biosensors for Biomedical Analysis. Anal. Lett. 2012, 45 (2−3), 168−186

[79] Fan Y, Wang X, Funk T, Rashid I, Herman B, Bompoti N, Mahmud MS, Chrysochoou M, Yang M, Vadas TM, Lei Y and Li B. A Critical Review for Real-Time Continuous Soil Monitoring: Advantages, Challenges, and Perspectives. Environ Sci Technol. 2022 Sep 19. doi: 10.1021/acs.est.2c03562. Epub ahead of print. PMID: 36121207.

organophosphate and carbamate pesticides based on the inhibition of cholinesterase activity.[80] However, the analyte needs certain incubation period (e.g., minutes to hours) to inhibit the activity of the immobilized enzyme, resulting in steadily declining signals over time (e.g., hours).[81]

Using a paper-based substrate, namely, office paper plus a portable electrochemical connection, loading bio-hybrid nanosized probes (Prussian blue, carbon black, and butyrylcholinesterase), has successfully in situ measured pesticide contents in EU agricultural soils, up to 3 µg/mL, characterized by a low detection limit of 1.3 ng/mL, with good correlation in comparison with LC–MS analysis.[82]

Handheld instruments based on laser-induced breakdown spectroscopy (LIBS) are a promising sensor technique for the in-field determination of various soil parameters.[83] LIBS could be used in many aspects, like soil, soil pollution, plant nutrients, cereals and seeds, fruits and vegetables, agri-foods, plant stressed by heavy metals, pesticide residues, etc.[84] The pesticides chlorpyrifos, carbendazim, dimethoate, imidacloprid and cypermethrin have been successfully detected in in green leafy vegetable using LIBS.[85]

6.4 Surveillance options that enable targeted government and industry response to point source issues

Atmospheric sensors such as µGC technology would be particularly useful in detecting chemical volatile trespass in the environment in real-time, such as integration with existing mesonet weather station and air-temperature inversion alert systems,[86],[87] air stability or air-temperature inversions being a major factor in chemical trespass of pesticides, particularly volatiles inkling phenoxy herbicides. The potential deployment of µGC sensors could also be potentially combined with the

[80] National Library of Medicine, What Are the Main Sensor Methods for Quantifying Pesticides in Agricultural Activities? A Review. amora-Sequeira R, Starbird-Pérez R, Rojas-Carillo O and Vargas-Villalobos S. Molecules 2019, 24 (14), 2659.

[81] Das J and Sarkar P. Enzymatic Electrochemical Biosensor for Urea with a Polyaniline Grafted Conducting Hydrogel Composite Modified Electrode. RSC Adv. 2016, 6 (95), 92520–92533

[82] Cioffi A, Mancini M, Gioia V and Cinti S. Environmental Science & Technology 2021. 55 (13), 8859-8865 DOI: 10.1021/acs.est.1c01931

[83] MDPI, Soil Nutrient Detection for Precision Agriculture Using Handheld Laser-Induced Breakdown Spectroscopy (LIBS) and Multivariate Regression Methods (PLSR, Lasso and GPR). Erler A, Riebe D, Beitz T, Löhmannsröben H-G and Gebbers R. Sensors; 2020. 20(2):418.

[84] Yu K, Ren J and Zhao Y. Principles, developments and applications of laser-induced breakdown spectroscopy in agriculture: A review, Artificial Intelligence in Agriculture, 2020. Volume 4, 127-139.

[85] Martino L, D'Angelo C, Marinelli C and Cepeda R. Identification and detection of pesticide in chard samples by laser-induced breakdown spectroscopy using chemometric methods, Spectrochimica Acta Part B: Atomic Spectroscopy, 2021, Volume 177, 106031.

[86] Mid North Mesonet, overview

[87] GoannaAg, Spray Inversion Network

recently commissioned super computing capability from the Bureau of Metrology[88] to interpolate data between sensor towers and potentially triangulate a localised region of point source contamination. The technology could also be potentially used at field borders as a detection alert for sensitive crops or vegetation, with potential for automatic reporting of pesticide trespass. The µGC technology is also likely to be used as a surrogate sensor for monitoring downwind spray volatiles when using autonomous pesticide application systems.

Sensors detailed above highlight that real-time pesticide detection in water is a realistic potential option, particularly if specific pesticide surveillance targets are defined. Some of these sensors in combination with detailed watershed modelling support could potentially be deployed with response teams following initial real-time detection to monitor upstream point source contamination of pesticides to a defined local area.

Traditional laboratory based methods are likely to remain the mainstay for initial detection of pesticides in soils, delivering results with a high level of confidence. Most soils will also generally remain in-situ, aiding detection and point source contamination determination, except in circumstances of significant soil or water erosion. The use of rapid real-time sensor based pesticide detection systems will however support rapid detailed survey of contaminated or affected areas and technology such as LIBS enables simple collection of soil cores for contamination analysis of stratified depths.

[88] Bureau of Meteorology, Supercomputing Programme

7 Recommendations

Section 4.1.3 provides a discussion on data sources identified in this project that meet the Department's requirements. Apart from residues analysis in meat and plant-based food product, the data sources are dominated by environmental matrices (surface water, sediment, wildlife). Assessment of these data sources has identified that, while many may be useful in determining what substances have been detected in different matrices, but they generally are not suitable for issues important to DAFF in determining effectiveness of the regulatory scheme for a number of reasons (see Section 4.1.3). The following recommendations are based around this determination.

7.1 Potential development of new data gathering programs

Recommendation 1: The department considers the discussion in Section 4.1.3 regarding gaps in the current Australian data sources; and the information provided in Section 4.2 with respect to international activities in different data gathering programs.

Recommendation 2: The department considers, as a starting point for future work, and to deliver on some of the recommendations from the "Final Report of the Independent Review of the Pesticides and Veterinary Medicines Regulatory System in Australia", undertaking a more detailed analysis of the monitoring information identified in this report. Such analysis will aid prioritising substances for future surveillance programs.

7.2 Surveillance options enabling targeted government and industry response to point source issues

Recommendation 3: The department considers the future surveillance delivery and reporting systems identified in Section 5 of this report.

Recommendation 4: The department considers the future environmental surveillance options and technologies including near real-time sensor measurement of off-target environmental impacts identified in Section 6 of this report as potential options to inform future monitoring programs.

Recommendation 5: The department recognises that there is no commercial near real-time sensor measurement technology currently available to measure the off-target environmental impacts identified in Section 6 and future deployment will require investment in development of this technology.

Recommendation 6: The department undertakes targeted baseline monitoring to inform chemical review activities.

> It is considered possible to link the need for regulatory assessments to monitoring. Undertaking targeted monitoring, for example, in known use areas for substances prior to a chemical review commencing may assist in identifying whether the chemical of interest is in fact moving off site. Such monitoring could then be redone following implantation of controls at the end of the review.

Recommendation 7: The department undertakes targeted operational monitoring to confirm effectiveness of regulatory controls

For new chemicals no monitoring data will be available prior to a regulatory assessment being completed. The assessment will identify controls based on the data set and proposed use pattern. In order to confirm the effectiveness of these controls, it may be appropriate to undertake targeted monitoring in the first seasons of use following registration. Similarly, such targeted monitoring could be implemented in use areas following completion of chemical reviews to confirm or otherwise the effectiveness of regulatory controls identified during the review.

Appendix 1: Research and analysis of pesticides and veterinary medicines data sources

Methodology

Sources were determined through two mechanisms. The first was a desktop review of available data sources (monitoring; volumes of use) from within Australia over the last 20 years.

The second component included a survey by telephone and/or email potential holders of data (human biomonitoring, animal-based food sources, plant-based food sources, air, soil, surface water, ground water, wildlife) including relevant state and territory departments including those responsible for health, agriculture and environment., APVMA and research institutions.

Through consultation (see Appendix A1.1: Contacts and organisations approach through survey consultation for list) a total of 64 contacts were approached covering government (state and federal), research institutions and private companies. In total, 44 different organisations were contacted.

Responses from 19 contacts were received, representing 18 different organisations. This represents an organisation response of 41% with some additional responses received later.

Sources of data at this stage were separated between literature reports and databases. Essentially, any government agency held information was allocated a “database” designation even if the data were only obtained from short term projects.

The different sources of data were assessed only briefly for this component of the project. The region (down to state/territory level), matrix (see Table 24) and chemicals analysed for were recorded. In many cases, the full list of chemicals is not yet available as often only chemicals detected were reported. In the case of the National Residue Survey, the full list of chemicals has not yet been compiled due to the complexity of this program.

A time frame of 20 years was agreed to base the analysis on as it was considered changes to farming practices in that period make data older than 20 years to lack relevance for this exercise. To date, 54 data sources have been identified that fall within the 20-year timeframe applied for the project.

Chemicals to be considered

The project aims to consider all agvet chemicals currently or previously used in Australia. Specific consideration is to be given to those agvet chemicals listed under the international conventions to which Australia is a party; and to agvet chemicals with known human health and environmental risks.

A list has been developed therefore, for these priority chemicals taking into consideration of pesticides listed in the Rotterdam Convention (Priority Informed Consent chemicals) and Stockholm Convention (Persistent Organic Pollutants), and cross referenced to the APVMA chemical review list of chemicals including those identified in the 2015 consultation round. Chemicals are priorities for review by the APVMA based on health and/or environmental concerns and available monitoring data will also focus on substances in this list.

In considering the APVMA lists, some priority substances were identified as groups, for example, 2nd generation anticoagulant rodenticides and triazole fungicides. The individual chemicals within these groups have been included in the list and groups themselves have been removed. For example, triazole fungicides have been listed individually as difenoconazole, metconazole, myclobutanil, propiconazole, prothioconazole, tebuconazole and triadimefon. There is some limited overlap between chemicals on these different lists. Through cross-referencing, a final list of 167 chemicals was identified for specific consideration. This list is provided at Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns.

Analysis of data sources identified at stage 1

The sources were separated based on the type of data, eg, whether data related to human biomonitoring, residues analysis in food produce, or environmental sampling. These were further separated base on the matrix in which sampling occurred.

For environmental sampling, sources have been assigned a “scale” to reflect whether monitoring has occurred in urban catchments, non-urban catchments, or mixed (both urban and non-urban). This is likely to be refined further in the next phase of the project, for example, to consider whether non-urban catchments relate to agricultural land uses or to drinking water catchments.

The results of this initial investigation are reported in Table 24.

Table 24 Summary of types of data held for different matrices from identified data sources

Type	Matrix	Scale	Number of data sources identified
Human	Blood	n/a	0
Human	Breast milk	n/a	0
Human	Muscle	n/a	0
Human	Other	n/a	1
Produce	Meat	n/a	2
Produce	Plant	n/a	6
Environment	Surface water	Urban	5
Environment	Surface water	Non urban	24
Environment	Surface water	Mixed	11
Environment	Sediment	Urban	3
Environment	Sediment	Non urban	4
Environment	Sediment	Other	7
Environment	Ground water	Urban	0
Environment	Ground water	Non urban	1
Environment	Ground water	Mixed	3
Environment	Soil	Urban	2

Type	Matrix	Scale	Number of data sources identified
Environment	Soil	Non urban	0
Environment	Soil	Mixed	3
Environment	Wildlife	Urban	0
Environment	Wildlife	Non urban	3
Environment	Wildlife	Mixed	1
Environment	Air	-	0

It is seen from Table 24 that no data sources for human biomonitoring or atmospheric monitoring have been found. With respect to human biomonitoring, the APVMA and all relevant state OH&S agencies have been contacted with only two responses received. These were from the APVMA and SafeWork NSW. SafeWork NSW advised that they have undertaken compliance programs in the past to assess and assist agricultural and veterinary chemicals users meet their WHS regulatory obligations but have not undertaken any detailed exposure or health monitoring. Therefore, they do not hold any data sources with respect to monitoring data (including ongoing monitoring programs) for agricultural and veterinary chemicals that can be of assistance.

Available sources are dominated by surface water monitoring. This includes sources from drinking water catchments, urban surface water (eg, stormwater runoff) and surface waters linked to agricultural land uses. Surface water data sets comprise 55% of those data sources identified to date. However, this does not give an idea of scale of monitoring programs. Further, while there are 5 data sets identified with respect to produce monitoring, the National Residue Survey is a large program with extensive data collected over a long period of time so a limited number of data sources should not be related to a general lack of data in a particular area.

Apart from the National Residue Survey, probably the most comprehensive and structured monitoring program currently in Australia is Great Barrier Reef Catchment Loads Monitoring Program (GBRCLMP), which was established in 2006 for monitoring nutrients and total suspended solids to assist in evaluating the progression towards the water quality targets of Reef Plan. Of the 35 GBR catchments, the GBRCLMP monitors 11 catchments in total, nine of which are monitored for pesticides. Information from the Queensland Government with respect to this program is still to be provided. To date, data sources from Queensland relating to monitoring in the GBR catchments identified from 2006 onwards have NOT all been included in the list of data sources as it is expected they will be in the suite of information provided by the Queensland Government in due course.

Table 25 and Table 26 provide an indication of regions (states and territories) from where monitoring activities have been undertaken. These are generally dominated in the eastern states of Queensland, New South Wales and Victoria. It was noted by some state authorities (SA EPA; TAS EPA) that funding for monitoring is not available. While these states used to undertake regular monitoring of water ways, these programs ceased between 2004 and 2014. Nonetheless, interrogation of the data sources for all monitoring does not indicate a discernible trend towards monitoring activities changing substantially over time – see Figure 5.

Table 25 Summary of identified data sources containing produce residues monitoring by region

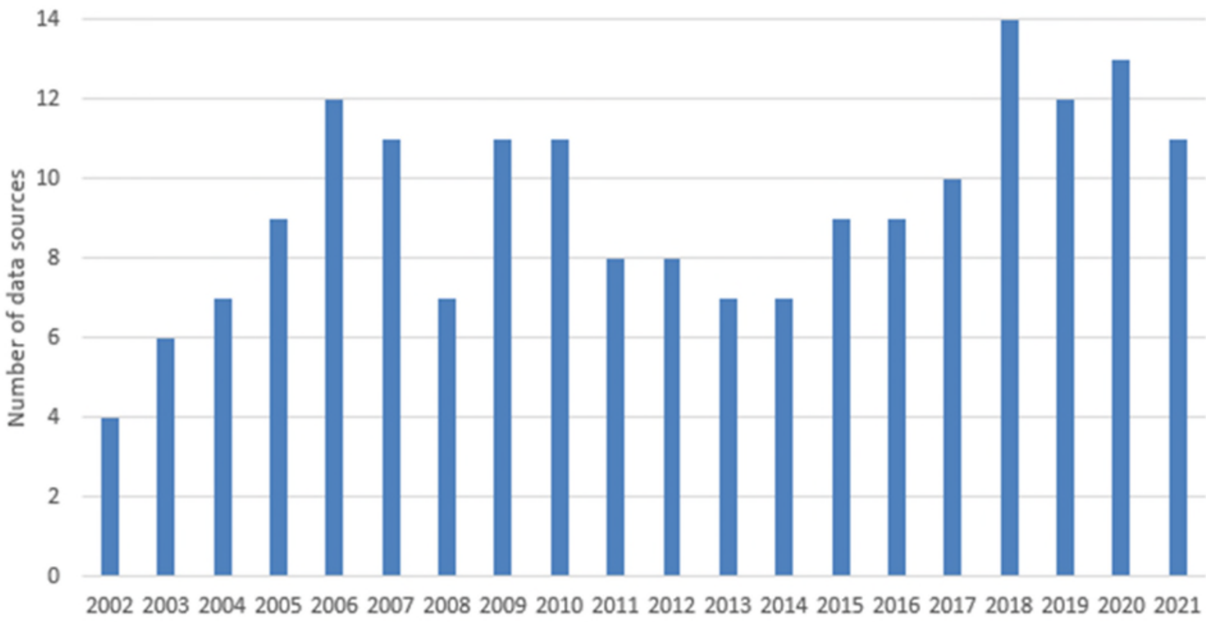
Matrix	QLD	NSW	VIC	TAS	SA	WA	ACT	NT
Meat[1]	2	2	2	2	2	2	2	2
Plant[1]	2	2	3	2	2	5	2	2

1) From the National Residue Survey and FSANZ 25 Australian Total Diet Study where n = 2. The results do not differentiate between different states and territories but random sampling is assumed to cover all states and territories.

Table 26 Summary of identified data sources containing environmental monitoring by region

Matrix	QLD	NSW	VIC	TAS	SA	WA	ACT	NT
Surface water	14	9	13	1	1	2	n/a	n/a
Sediment	1	1	12	1	2	2	n/a	1
Ground water	1	n/a	n/a	n/a	n/a	3	n/a	n/a
Soil	n/a	1	4	n/a	n/a	n/a	n/a	n/a
Wildlife	n/a	n/a	n/a	n/a	n/a	4	n/a	n/a

Figure 5 Number of data sources with monitoring undertaken in different years, 2002-2021



Chemicals monitored within data sources

From all sources, where possible, the range of chemicals analysed for have been included. This list is incomplete because some sources require additional information with only substances detected being reported in the primary source document, or the chemicals themselves not identified. Over 160 substances have been analysed from more than one data source, or in more than one matrix. There are more than 30 substances that have been analysed for in multiple data sources or in multiple matrices within the same data source. These are reported in Table 27.

Table 27 Frequency of pesticides analysed for in data sources where n ≥10

Active	Number of data sources/ matrices
Atrazine	32
DDT (also as p,p'-DDD and p,p'-DDE)	28
Simazine	27
Diuron	24
Chlorpyrifos	21
Hexazinone	18
Metolachlor	18
2,4-D	17
Dieldrin	16
Prometryn	16
Imidacloprid	15
Bifenthrin	14
Chlordane	14
Endosulfan	14
MCPA	13
Heptachlor	12
Malathion	12
Diazinon	12
Dimethoate	12
Propiconazole	12
Pendimethalin	11
Permethrin	11
Aldrin	11
Ametryn	11
Tebuthiuron	11
Metalaxyl	10
Trifluralin	10
Carbaryl	10
Fenamiphos	10
Fipronil	10

Appendix A1.1: Contacts and organisations approach through survey consultation

Organisation	State	Response received
ACT Government	ACT	n/a
Environment, Planning and Sustainable Development Directorate	ACT	n/a
WorkSafe ACT	ACT	-
University of Melbourne (CAPIM)	National	Yes
RMIT (and previously, CAPIM)	National	n/a
Griffith University	National	Yes
APVMA	National	Partial
National Residue Survey	National	Yes
Australian Water Quality Centre	National	n/a
Woolworths	National	n/a
CSIRO	National	Yes
Environment Protection Authority	NSW	n/a
Department of Primary Industries	NSW	n/a
Environment Protection Authority	NSW	n/a
NSW Department of Primary Industries	NSW	n/a
SafeWork NSW	NSW	Yes
Environment NSW	NSW	Yes
Coleambally Irrigation	NSW	Yes
NT Government	NT	n/a
NT WorkSafe	NT	n/a
Department of Agriculture and Fisheries	QLD	n/a
Workplace Health and Safety Queensland	QLD	n/a
TropWATER (James Cook University)	QLD	n/a
Department of Environment and Science	QLD	Yes
University of Queensland	QLD	n/a
Primary Industries and Regions SA	SA	n/a
SafeWork SA	SA	n/a
SA Water	SA	Yes
SA EPA	SA	Yes

Organisation	State	Response received
South Australian Research and Development Institute (SARDI)	SA	n/a
Department of Natural Resources and Environment	TAS	n/a
WorkSafe Tasmania	TAS	n/a
Agriculture Victoria	VIC	Yes
Department of Jobs, Precincts and Regions	VIC	n/a
WorkSafe Victoria	VIC	n/a
EPA VIC	VIC	Yes
Corangamite Catchment Management Authority	VIC	n/a
VIC EPA	VIC	Yes
Melbourne Water	VIC	n/a
RMIT	VIC	n/a
Department of Primary Industries and Regional Development	WA	Yes
Health WA	WA	n/a
Department of Water and Environment Regulation	WA	n/a
Department of Mines, Industry Regulation and Safety	WA	n/a
ChemCentre WA	WA	n/a
Department of Biodiversity, Conservation and Attractions	WA	n/a
Department of Water and Environment Regulation	WA	n/a
Health WA	WA	Yes

Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns

Chemical	Stockholm Convention	Rotterdam Convention	APVMA Review List	APVMA 2015 prioritisation
2,4,5-T	n/a	Yes	n/a	n/a
2,4-D	n/a	n/a	Yes	n/a
Abamectin	n/a	n/a	Yes	n/a
Acephate	n/a	n/a	n/a	Yes
Acetamiprid	n/a	n/a	Yes	n/a
Acrolein	n/a	n/a	Yes	n/a
Alachlor	n/a	Yes	n/a	n/a
Aldicarb	n/a	Yes	Yes	n/a
Aldicarb	n/a	n/a	Yes	n/a
Aldrin	Yes	Yes	n/a	n/a
Alpha-cypermethrin	n/a	n/a	Yes	n/a
Amitrole	n/a	n/a	n/a	Yes
Arsenic timber treatments	n/a	n/a	Yes	n/a
Atrazine	n/a	n/a	Yes	n/a
Avoparcin	n/a	n/a	Yes	n/a
Azinphos-ethyl	n/a	n/a	Yes	n/a
Azinphos-methyl	n/a	Yes	Yes	n/a
Benomyl	n/a	n/a	Yes	n/a
Bifenthrin	n/a	n/a	Yes	n/a
Binapacryl	n/a	Yes	n/a	n/a
Bioresmethrin	n/a	n/a	Yes	n/a
Brodifacoum	n/a	n/a	Yes	n/a
Bromadiolone	n/a	n/a	Yes	n/a
Bromoxynil	n/a	n/a	Yes	n/a
Bromsalans	n/a	n/a	Yes	n/a
Captafol	n/a	Yes	n/a	n/a
Carbaryl	n/a	n/a	Yes	n/a

Chemical	Stockholm Convention	Rotterdam Convention	APVMA Review List	APVMA 2015 prioritisation
Carbendazim	n/a	n/a	Yes	n/a
Carbofuran	n/a	Yes	Yes	n/a
Carbon disulfide	n/a	n/a	Yes	n/a
Chlordane	Yes	Yes	n/a	n/a
Chlordimeform	n/a	Yes	n/a	n/a
Chlorfenvinphos	n/a	n/a	Yes	n/a
Chlorobenzilate	n/a	Yes	n/a	n/a
Chlorothalonil	n/a	n/a	n/a	Yes
Chloroxuron	n/a	n/a	Yes	n/a
Chlorpropham	n/a	n/a	Yes	n/a
Chlorpyrifos	n/a	n/a	Yes	n/a
Chlortetracycline	n/a	n/a	Yes	n/a
Clanobutin sodium	n/a	n/a	Yes	n/a
Clothianidin	n/a	n/a	Yes	n/a
Coumaphos	n/a	n/a	Yes	n/a
Coumatetralyl	n/a	n/a	Yes	n/a
Creosote	n/a	n/a	Yes	n/a
Crystal (gentian) violet	n/a	n/a	Yes	n/a
Cyanazine	n/a	n/a	n/a	Yes
Cypermethrin	n/a	n/a	Yes	n/a
Cyromazine	n/a	n/a	Yes	n/a
DDT	Yes	Yes	n/a	n/a
Deltamethrin	n/a	n/a	Yes	n/a
Demeton-S-methyl	n/a	n/a	Yes	n/a
Diazinon	n/a	n/a	Yes	n/a
Dichlorvos	n/a	n/a	Yes	n/a
Dicofol	Yes	n/a	n/a	n/a
Dicyclanil	n/a	n/a	Yes	n/a
Dieldrin	Yes	Yes	n/a	n/a
Difenacoum	n/a	n/a	Yes	n/a
Difenoconazole	n/a	n/a	n/a	Yes
Difethialone	n/a	n/a	Yes	n/a
Diflubenzuron	n/a	n/a	Yes	n/a
Dimethoate	n/a	n/a	Yes	n/a
Dimetridazole	n/a	n/a	Yes	n/a
Dinitro-ortho-cresol (DNOC) and its salts	n/a	Yes	n/a	n/a
Dinoseb and its salts and esters	n/a	Yes	n/a	n/a

Chemical	Stockholm Convention	Rotterdam Convention	APVMA Review List	APVMA 2015 prioritisation
Dinotefuran	n/a	n/a	Yes	n/a
Diphacinone	n/a	n/a	Yes	n/a
Diquat	n/a	n/a	Yes	n/a
Diuron	n/a	n/a	Yes	n/a
Doramectin	n/a	n/a	Yes	n/a
EDB (1,2-dibromoethane)	n/a	Yes	n/a	n/a
Endosulfan	Yes	Yes	Yes	n/a
Endrin	Yes	n/a	n/a	n/a
Ethidimuron	n/a	n/a	Yes	n/a
Ethylene dibromide	n/a	n/a	Yes	n/a
Ethylene dichloride	n/a	Yes	n/a	n/a
Ethylene oxide	n/a	Yes	n/a	n/a
Fenamiphos	n/a	n/a	Yes	n/a
Fenbutatin oxide	n/a	n/a	n/a	Yes
Fenitrothion	n/a	n/a	Yes	n/a
Fenthion	n/a	n/a	Yes	n/a
Fipronil	n/a	n/a	Yes	n/a
Flocoumafen	n/a	n/a	Yes	n/a
Flumethrin	n/a	n/a	Yes	n/a
Fluoroacetamide	n/a	Yes	n/a	n/a
Glyphosate	n/a	n/a	Yes	n/a
Halquinol	n/a	n/a	Yes	n/a
HCH (mixed isomers)	Yes	Yes	n/a	n/a
Heptachlor	Yes	Yes	n/a	n/a
Hexachlorobenzine	Yes	Yes	n/a	n/a
Hexazinone	n/a	n/a	n/a	Yes
Imidacloprid	n/a	n/a	Yes	n/a
Inorganic arsenic	n/a	n/a	Yes	n/a
Ivermectin	n/a	n/a	Yes	n/a
Kitasamycin	n/a	n/a	Yes	n/a
Levamisole	n/a	n/a	n/a	Yes
Lindane	Yes	Yes	n/a	n/a
Malathion	n/a	n/a	Yes	n/a
Mercury compounds	n/a	Yes	n/a	n/a
Metal phosphides	n/a	n/a	n/a	Yes
Metconazole	n/a	n/a	n/a	Yes
Metham sodium	n/a	n/a	Yes	n/a

Chemical	Stockholm Convention	Rotterdam Convention	APVMA Review List	APVMA 2015 prioritisation
Methamidophos	n/a	Yes	Yes	n/a
Methazole	n/a	n/a	Yes	n/a
Methidathion	n/a	n/a	Yes	n/a
Methiocarb	n/a	n/a	Yes	n/a
Methomyl	n/a	n/a	n/a	Yes
Methyl bromide	n/a	n/a	Yes	n/a
Metoxuron	n/a	n/a	Yes	n/a
Mevinphos	n/a	n/a	Yes	n/a
Milbemycin	n/a	n/a	Yes	n/a
Mirex	Yes	n/a	n/a	n/a
Mirex	n/a	n/a	Yes	n/a
Molinate	n/a	n/a	Yes	n/a
Monocrotophos	n/a	Yes	Yes	n/a
Moxidectin	n/a	n/a	Yes	n/a
Myclobutanil	n/a	n/a	n/a	Yes
Neomycin	n/a	n/a	Yes	n/a
Neonicotinoids	n/a	n/a	Yes	n/a
Nicarbazin	n/a	n/a	Yes	n/a
Oleandomycin	n/a	n/a	Yes	n/a
Omethoate	n/a	n/a	Yes	n/a
Paraquat	n/a	n/a	Yes	n/a
Parathion	n/a	Yes	n/a	n/a
Parathion-ethyl	n/a	n/a	Yes	n/a
Parathion-methyl	n/a	n/a	Yes	n/a
Pentachlorophenol	n/a	Yes	n/a	n/a
Permethrin	n/a	n/a	n/a	Yes
Phenothiazine	n/a	n/a	Yes	n/a
Phorate	n/a	Yes	n/a	Yes
Picloram	n/a	n/a	n/a	Yes
Pindone	n/a	n/a	Yes	n/a
Polihexanide	n/a	n/a	Yes	n/a
Procymidone	n/a	n/a	Yes	n/a
Propargite	n/a	n/a	n/a	Yes
Propetamphos	n/a	n/a	Yes	n/a
Propiconazole	n/a	n/a	n/a	Yes
Prothiconazole	n/a	n/a	n/a	Yes
Robenidine	n/a	n/a	Yes	n/a

Chemical	Stockholm Convention	Rotterdam Convention	APVMA Review List	APVMA 2015 prioritisation
Sheep ectoparasiticides	n/a	n/a	Yes	n/a
Simazine	n/a	n/a	n/a	Yes
Sodium fluororacetate (1080)	n/a	n/a	Yes	n/a
Spinosad	n/a	n/a	Yes	n/a
Streptomycin/Penicillin	n/a	n/a	Yes	n/a
Strychnine	n/a	n/a	Yes	n/a
Sulfadiazine	n/a	n/a	Yes	n/a
Sulfadimidine	n/a	n/a	Yes	n/a
Sulfadoxine	n/a	n/a	Yes	n/a
Sulfaquinoxaline	n/a	n/a	Yes	n/a
Sulfatroxazole	n/a	n/a	Yes	n/a
Sulfonamides	n/a	n/a	Yes	n/a
Sulfur dioxide generating pads or sheets	n/a	n/a	Yes	n/a
Tebuconazole	n/a	n/a	n/a	Yes
Temephos	n/a	n/a	Yes	n/a
Thiacloprid	n/a	n/a	Yes	n/a
Thiamethoxam	n/a	n/a	Yes	n/a
Thiophanate-methyl	n/a	n/a	Yes	n/a
Toxaphene	Yes	Yes	n/a	n/a
Triademefon	n/a	n/a	n/a	Yes
Tribufos	n/a	n/a	Yes	n/a
Tributyl tin compounds	n/a	Yes	n/a	n/a
Trichlorfon	n/a	Yes	n/a	Yes
Triflumuron	n/a	n/a	Yes	n/a
Triforine	n/a	n/a	Yes	n/a
Tylosin	n/a	n/a	Yes	n/a
Vinclozolin	n/a	n/a	Yes	n/a
Virginiamycin	n/a	n/a	Yes	n/a
Warfarin	n/a	n/a	Yes	n/a

Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources

Methodology

Reliability

The reliability of the data is a key initial consideration because without knowledge of how studies have been conducted all other considerations may be irrelevant. Screening for reliability can be done relatively quickly to filter out unreliable studies and enable the end users to focus further resources on those studies considered most reliable.

The assessment approach is based on that suggested in OECD (2000).[89] In undertaking this analysis, a pragmatic approach has been adopted and the following criteria have been modified to those identified in OECD (2000) to better reflect the required use of the monitoring data for the department's objectives.

Table 28 Criteria for assessing reliability of data sources

Criteria	Fully described	Somewhat described	Not described
What has been analysed (substances identified)?	3	2	0
Analytical method (described appropriately)	3	2	0
Minimum level of detection (identified?)	3	2	0
Matrix characteristics (soil, water, sediment etc)	3	2	0
Sample methodology (adequately described?)	3	2	0
Sampling frequency and pattern (adequately described?)	3	2	0
Location specific (identifiable with coordinates?)	4		0

[89] OECD Improving the use of monitoring data in the exposure assessment of industrial chemicals

Criteria	Fully described	Somewhat described	Not described
Location general (generally identifiable)	-	2	0
Dates of sampling adequately identified?	3	2	0

A cut-off score of 16 was assigned to accept the reliability of a data set. However, a degree of flexibility has been applied. For example, data sets that do not specifically describe sampling methodology or identify limits of detection have generally been assigned a score of “Somewhat described” where laboratories performing analysis have been identified as these would be expected to have appropriate analytical methodology and reference chemicals.

Of the data sources identified in phase 1 of this project, the majority were sufficiently described to pass the reliability assessment.

Relevance/representativeness

The relevance and representativeness of the data have been based on scientific judgement as there are no ranking criteria that can be listed as guidance for these attributes. In undertaking the analysis, the department’s main objective with respect to this project has been the most influential factor, that is, how data sources can be applied in monitoring the effectiveness of the agvet chemicals regulatory system and provide assurance that the controls on products are affecting and not leading to poor environmental or human health outcomes.

The following attributes of the data sources were considered for this purpose:

Table 29 Considerations for assessing relevance and representativeness of data sources

Parameter	Explanation
Includes listed?	Listed for this purpose means substances on the list of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns (Appendix A1.2 of Interim Report for Milestone 1).
Catchment type	Required characteristics of the catchment type, for example, urban, peri-urban, agricultural, conservation, drinking water.
Location	General information on the location of the monitoring activity.
Number of sites	How many sites were monitored in a particular monitoring program or research activity?
Temporal	Were the data suitable for a temporal assessment (eg, several seasons in a year, or data available over several years?
Spatial	Were the data suitable for a spatial assessment (monitoring undertaken over a larger geographic area)?
Land use link	Is it possible to link the monitoring results with an associated land use?

From this analysis, data were considered **relevant** if they described monitoring results for pesticides regulated by the APVMA. Relevance was enhanced if the test list included chemicals identified in the priority list established for this project, however, it was not considered a requirement as there may be newer pesticides in a test suite of substances.

Data sets were considered **representative** if they could readily be linked to a land use. It should be noted in this context, association with a land use does not allow particular sources of chemical exposure to be identified. For example, detections of fungicides in horticultural catchments in sampling locations identified by coordinates does not imply observed substances have come from farms adjoining the sampling point. However, it may be inferred that general chemical use for the agriculture in that catchment may be contributing. In general, specific sources of chemicals can't be identified. The exception is for sampling undertaken in irrigation areas where irrigation drains are sampled. However, in these situations, the suite of pesticides analysed is generally quite small and dictated by environmental protection licenses.

The analysis of the different data sources for those that met acceptance criteria for this project are provided below.

Environment

Water

Non-urban surface waters

General Information	
ID	21
Reference	Allinson, G., Allinson, M., Bui, A. et al. Pesticide and trace metals in surface waters and sediments of rivers entering the Corner Inlet Marine National Park, Victoria, Australia. Environ Sci Pollut Res 23, 5881–5891 (2016).
URL	https://doi.org/10.1007/s11356-015-5795-6 Supplementary information available.
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 39)
Analysis/LOD	Yes/Yes (described in detail in supplementary information)
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general)
Dates	Yes
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 16)
Catchment type	Surface water, Agricultural use (pasture) catchment
Location	Corner Inlet catchment, Victoria
Number of sites	17
Temporal	Limited. Samples collected monthly over a 6 month period.
Spatial	No.
Land use link	The sites were selected based on their relative positions within the Corner Inlet catchment or reference locations, e.g., head of catchment, mid catchment, and lower catchment, in known agricultural areas, or in forestry or national parks and were considered to be a broad representation of the wide range of waterways found in the catchment, across the major soil types and land use in the region.
Main substances detected	Prometryn, Simazine

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including agriculture, forestry and national parks.	
Ease of Access	
Reporting format	Results available in tabular form in a Microsoft Word document.
Individual values	Yes (in supplementary information).
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	22
Reference	Allinson G, Bui A, Zhang P. et al. Investigation of 10 Herbicides in Surface Waters of a Horticultural Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2014. 67, 358–373.
URL	https://doi.org/10.1007/s00244-014-0049-z Supplementary information available.
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 10)
Analysis/LOD	Yes/Yes (described in detail in supplementary information)
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general, but overall catchment is specific – same sites as ID 23)
Dates	Yes (spring and summer, September 2008-March 2009
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 4)
Catchment type	Surface water, Mixed use (see “Land use link” below)
Location	Yarra catchment, Victoria
Number of sites	18
Temporal	Limited. 2 seasons.
Spatial	Limited. Within Yarra catchment.
Land use link	Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments
Main substances detected	Simazine, Atrazine, Pendimethalin
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list	

established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF published paper.
Individual values	No. Mean, median, minimum, maximum and frequency of detection reported.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	23
Reference	Wightwick AM, Bui AD, Zhang P. et al. Environmental Fate of Fungicides in Surface Waters of a Horticultural-Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2012. 62, 380–390.
URL	https://doi.org/10.1007/s00244-011-9710-y
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 24)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general, but overall catchment is specific – same sites as ID 22)
Dates	Yes (spring and summer, September 2008-March 2009
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 6)
Catchment type	Surface water, Mixed use (see "Land use link" below)
Location	Yarra catchment, Victoria
Number of sites	18
Temporal	Limited. 2 seasons.
Spatial	Limited. Within Yarra catchment.
Land use link	Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments
Main substances detected	Myclobutanil, Trifloxystrobin, Metalaxyl, Difenoconazole, Pyrimethanil
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF published paper.

Individual values	No. Mean, maximum, 95% CI and frequency of detection reported.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	26
Reference	Oliver D, Kookana R, Anderson J, Cox J, Fleming N, Waller N and Smith L. Off-site transport of pesticides from two horticultural land uses in the Mt. Lofty Ranges, South Australia, Agricultural Water Management, 2012. Volume 106, 60-69.
URL	https://doi.org/10.1016/j.agwat.2011.06.004
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 14)
Analysis/LOD	Yes/No
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general, but overall catchment is specific)
Dates	Yes (2006-2009)
Score	20
Relevance and Representativeness	
Includes listed?	Yes (n = 7)
Catchment type	Surface water, Horticulture (Apple and cherry orchards)
Location	Mt. Lofty Ranges, South Australia
Number of sites	2
Temporal	Yes. Sampling undertaken over several years (2006-2009)
Spatial	No.
Land use link	Yes. The two streams monitored drained from apple and cherry orchards.
Main substances detected	Chlorpyrifos, Carbaryl, Fenarimol, Penconazole, Procymidone, Pirimicarb.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for horticultural land use, specifically, chemical application in apple and cherry orchards.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF published paper.
Individual values	No. Mean, maximum, 95% CI and frequency of detection reported.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	31

Reference	Sánchez-Bayo F and Hyne R, Detection and analysis of neonicotinoids in river waters – Development of a passive sampler for three commonly used insecticides, Chemosphere, 2014. Volume 99, 143-151.
URL	http://dx.doi.org/10.1016/j.chemosphere.2013.10.051
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 5)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identifiable)
Dates	Yes (29 January and 7 February 2013 following high rainfall events)
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 5)
Catchment type	Peri-urban (see Land use link below)
Location	Around Sydney, NSW.
Number of sites	13
Temporal	No.
Spatial	No.
Land use link	Yes. Land uses identified with sampling areas include residential, orchards, mixed farms, turf farm, golf course.
Main substances detected	Acetamiprid, Imidacloprid, Thiacloprid.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for 5 neonicotinoid pesticides regulated by the APVMA, all of which are identified in the priority list established for this project. It is **representative** for urban stormwater runoff.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF report.
Individual values	Yes, provided in the published report.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	32
Reference	Hook S, Doan H, Gonzago D, Musson D, Du J, Kookana R, Sellars M and Kumar A. The impacts of modern-use pesticides on shrimp aquaculture: An assessment for north eastern Australia, Ecotoxicology and Environmental Safety, 2018. Volume 148, 770-780.
URL	https://doi.org/10.1016/j.ecoenv.2017.11.028
Type of monitoring information	
Compartment	Environment

Matrix	Water
Reliability rating	
Substances ID	Yes (n = 29)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Not fully described.
Locations	Yes (Generally identifiable)
Dates	Yes (September 2016 to December 2017)
Score	20
Relevance and Representativeness	
Includes listed?	Yes (n = 17)
Catchment type	Generally agricultural (tropical/sub-tropical)
Location	Wet Tropics in QLD to Clarence catchment in NSW.
Number of sites	7
Temporal	No. Date range was for total sampling, only 1 sampling date per site.
Spatial	Yes. Sampling performed from the Wet Tropics in QLD to Clarence catchment in NSW.
Land use link	Yes. The study was considering water inflows for shrimp farming. Use is in tropical/sub-tropical regions. Multiple land uses upstream (e.g. sugar-cane farming, banana farming, beef cattle and urbanisation) considered possible.
Main substances detected	Diuron, 2,4-D, Atrazine, Hexazinone, Metolachlor.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is **representative** for tropical/sub-tropical agricultural runoff.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF report.
Individual values	Yes, provided in the published report.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	33
Reference	Laicher D, Benkendorff K, White S, Conrad S, Woodrow R, Butcherine P and Sanders C. Pesticide occurrence in an agriculturally intensive and ecologically important coastal aquatic system in Australia, Marine Pollution Bulletin, 2022. Volume 180, 2022, 113675.
URL	https://doi.org/10.1016/j.marpolbul.2022.113675 Supplementary information available.
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 168)

Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Not fully described.
Locations	Yes (Generally identifiable)
Dates	Yes (January to April, 2019)
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 55)
Catchment type	Horticulture (tomato; blueberry) to habitat protected area.
Location	Double Crossing Creek, a coastal waterway in the Sandy Beach and Woolgoolga catchment area in northern NSW, Australia
Number of sites	6
Temporal	No.
Spatial	No.
Land use link	Yes. Sampling was undertaken in areas associated with horticulture (glass house and field – blueberries), and from forested areas.
Main substances detected	Imidacloprid, Methomyl, Dimethoate, Terbuthylazine, Terbutryn, Omethoate, Pyrimethanil, Triadimenol.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is **representative** for comparison of detections to different land uses.	
Ease of Access	
Reporting format	Results available in tabular form in the supplementary information.
Individual values	Yes, provided in the supplementary information.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	43
Reference	Vincente-Beckett V, Noble R, Packet R, Verwey P, Ruddle L, Munksgaard N and Morrison H. Pesticide, polycyclic aromatic hydrocarbon and metal contamination in the Fitzroy Estuary, Queensland, Australia. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. 2006. ISBN 1 921017 62 7
URL	n/a
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 8)
Analysis/LOD	Yes/No
Matrix ID	Yes
Methodology	Yes

Locations	Yes (Generally identifiable)
Dates	Yes (2003/4 and 2004/5 wet seasons)
Score	20
Relevance and Representativeness	
Includes listed?	Yes (n = 4)
Catchment type	Large river basin catchment (non-urban).
Location	Fitzroy catchment, Queensland (Rockhampton).
Number of sites	1
Temporal	Limited. Two wet seasons monitored.
Spatial	No.
Land use link	Partial. The sampling site is end of river flow for the Fitzroy River at Rockhampton which will include runoff from the wider (very large) catchment – dominated by grazing.
Main substances detected	Atrazine, Tebuthiuron, Diuron
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a small number of pesticides regulated by the APVMA, some of which are identified in the priority list established for this project. It is potentially **representative** for agricultural land uses dominated by grazing.	
Ease of Access	
Reporting format	Results available in tabular.
Individual values	Yes, provided in the supplementary information.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	10
Reference	Department of Water. A baseline study of organic contaminants in the Swan and Canning catchment drainage system using passive sampling devices. Water Science technical series Report No 5, December 2009. Government of Western Australia.
URL	n/a
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 25)
Analysis/LOD	Partially/Partially
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identifiable)
Dates	Yes (September 2006 to August 2007)
Score	21
Relevance and Representativeness	
Includes listed?	Yes (n = 12)

Catchment type	Urban and peri-urban stormwater drains (artificial and natural creeks/rivers)
Location	Around Perth, WA
Number of sites	10
Temporal	Limited. Monitoring over several seasons but in one year.
Spatial	No.
Land use link	Yes. The different catchments feeding monitoring sites are well categorized for land use. These are mixed but dominated by different land uses such as industrial, residential, conservation, agriculture.
Main substances detected	Diuron, Simazine, Atrazine
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a small number of pesticides regulated by the APVMA, some of which are identified in the priority list established for this project. It is potentially **representative** for a variety of land uses.	
Ease of Access	
Reporting format	Results available in tabular form in the report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	15
Reference	Pesticide Water Monitoring Results (last updated July 2014)
URL	https://nre.tas.gov.au/water/water-monitoring-and-assessment/pesticide-monitoring https://nre.tas.gov.au/Documents/Baseline%20Monitoring%20Program.pdf
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water)
Reliability rating	
Substances ID	Yes (n = 26)
Analysis/LOD	No/No
Matrix ID	Yes
Methodology	No
Locations	Yes (Specific with coordinates)
Dates	Yes (2005 to 2014)
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 14)
Catchment type	Various – structured monitoring in a large number of streams and rivers throughout the state.
Location	Around Tasmania
Number of sites	83
Temporal	Yes. Pesticide Water Monitoring Program was run from 2005 to 2014

Spatial	Yes. Throughout Tasmania.
Land use link	No.
Main substances detected	Very few detections, but those most often detected included 2,4-D, Simazine, MCPA, Metalaxyl.
Conclusion	
The data set is considered **reliable** for the purpose of this project and was developed as part of a structured state government long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** because it was specifically implemented as a means to increase knowledge and understanding as to the nature and extent of pesticide contamination of rivers and streams in Tasmania.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	40
Reference	Shaw M, Silburn D, Lenahan M and Harris M. Pesticides in groundwater in the Lower Burdekin floodplain. Brisbane: Department of Environment and Resource Management, Queensland Government. 2012. ISBN: 978-1-7423-0953.
URL	https://www.des.qld.gov.au/__data/assets/pdf_file/0026/81935/rti-13045-pesticides-in-groundwater.pdf
Type of monitoring information	
Compartment	Environment
Matrix	Water (Ground water and surface water)
Reliability rating	
Substances ID	Yes (n = 66)
Analysis/LOD	Yes/No
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specifically identified)
Dates	Yes (Single sampling event in August 2011)
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 26)
Catchment type	Agricultural use area on coastal flood plain.
Location	Lower Burdekin floodplain (south east of Townsville, QLD)
Number of sites	53 (bores); 2 (surface water)
Temporal	No.
Spatial	No.
Land use link	Yes. Sampling undertaken in agriculturally intensive area based on map in report.
Main substances detected	Atrazine, Hexazinone, Diuron, Chlorpyrifos.

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for ground and surface water exposure in an agricultural catchment.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes for two water samples, Max and Mean for sediment samples.
Cost/impediments	Nil. Publicly available.

General Information	
ID	48
Reference	Vic EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870 May 2020
URL	https://www.epa.vic.gov.au/-/media/epa/files/publications/1870.pdf
Other information	This report by EPA provides an assessment of pesticides, PFAS, metals and selected industrial chemicals contaminant concentrations in surface soils in areas of the Bellarine Peninsula region and in water and sediments in the Barwon River catchment to further inform assessment of the potential risk for exposure to these environmental contaminants.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water)
Reliability rating	
Substances ID	Somewhat (stated as organochlorines, organophosphates, synthetic pyrethroids, herbicides and fungicides. Specific chemical list not provided.)
Analysis/LOD	No/Yes (Laboratory identified so analytical information would be available if required).
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identified)
Dates	Yes (Single sampling events in June 2019)
Score	18
Relevance and Representativeness	
Includes listed?	Yes (actual number not identified.)
Catchment type	Barwon River Catchment. Residential, but previously used for agriculture.
Location	Bellarine Peninsula (Geelong to Ocean Grove, Victoria).
Number of sites	4 aquatic (water, sediment, soil).
Temporal	No.
Spatial	No.
Land use link	Yes. The provided map (and confirmed with Google Maps) shows the sampling sites to be situated in a mix of urban and agricultural land uses.
Main substances detected	Simazine, Atrazine.

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an urban and peri-urban catchment.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	50
Reference	Rose G, Zhang P, Bui A, Allen D and Allinson G. Melbourne Water and DPI agrochemicals in Port Philip catchment project report 2009-10. A report to the Centre for Aquatic Pollution, Identification and Management (CAPIM), the University of Melbourne. Future Farming Systems Research, DPI Queenscliff Centre, Queenscliff, Victoria. 2011.
URL	https://www.vgls.vic.gov.au/client/en_AU/search/asset/1146643/0
Other information	The study focused on the assessment of agrochemical loads and the impacts within the peri-urban and urban fringes of Melbourne. Although primarily focusing on unprotected catchments, two reference sites (protected catchments) for the Yarra (Donnelly's weir and Starvation Creek), and two sites of significant urban impact (Darebin and Merri Creeks) were included.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water)
Reliability rating	
Substances ID	Yes (n = 52)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identified)
Dates	Yes (2009-2010)
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 31)
Catchment type	Urban and peri-urban fringes
Location	Melbourne, VIC (including Port Philip Bay sub-catchments)
Number of sites	29 surface water. NB, this study also describes results for 24 constructed urban wetland sites. These are reported in "Urban Stormwater" below as Source ID 20.
Temporal	No.
Spatial	No.
Land use link	Yes.
Main substances detected	Simazine, Atrazine, Metalaxyl, Imidacloprid, Prometryn

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an urban and peri-urban catchment.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	53
Reference	EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020.
URL	https://www.epa.vic.gov.au/about-epa/publications/1879
Other information	The study was undertaken to enable the EPA to further identify the extent and magnitude of emerging and legacy contaminants across Victoria, to inform where there may be priority areas, regulatory responses, and identify sectors to work with to prevent and reduce environmental pollution.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water)
Reliability rating	
Substances ID	The summary results have been provided by EPA Victoria. The results from the monitoring program are considered reliable for the purpose of this project but full details have not been requested.
Analysis/LOD	
Matrix ID	
Methodology	
Locations	
Dates	
Score	
Relevance and Representativeness	
Includes listed?	Yes (from limited information in overview.)
Catchment type	Agriculture (low intensity- grazing; high intensity – cropping and horticulture); urban residential; urban industrial; background.
Location	Across Victoria
Number of sites	101
Temporal	No.
Spatial	Yes.
Land use link	EPA selected sites representing five land use types: background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial.
Main substances detected	In water, concentrations of pesticides detected ranged from 0.0074 to 1.42 µg/L across all land use types. For example, herbicide simazine was only detected in water (<0.01 – 1.3 µg/L, and most frequently in sites with urban industrial and urban residential land uses.

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in different catchment types. The full data set can be requested from EPA Victoria if required for later use.	
Ease of Access	
Reporting format	Full results available from EPA Victoria.
Individual values	Yes.
Cost/impediments	None identified

General Information	
ID	27
Reference	Murray Irrigation – Compliance and monitoring.
URL	https://www.murrayirrigation.com.au/water/system/compliance-and-monitoring/ Annual compliance reports can be obtained from this site.
Other information	Murray Irrigation undertakes monitoring based on their Environmental Protection Licence[1]. This license only requires three substances to be monitored, namely, Molinate, Thiobencarb and Atrazine.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water – irrigation area drains)
Reliability rating	
Substances ID	Yes (n = 3).
Analysis/LOD	No (probably available on request)
Matrix ID	Yes
Methodology	Somewhat
Locations	Yes
Dates	Yes
Score	16
Relevance and Representativeness	
Includes listed?	Yes (2 of the 3 substances analysed for are listed for this project)
Catchment type	Irrigated agriculture
Location	Murray Irrigation area (around Deniliquin, NSW)
Number of sites	2
Temporal	Yes – Compliance reports available over long term (>10 years)
Spatial	No.
Land use link	Yes – results are specific to an agricultural irrigation area.
Main substances detected	Only three substances tested for. Several years contain no data due to very low flows without monitoring.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for some pesticides regulated by the APVMA, including two identified in the priority list established for this project. It is	

considered **representative** for surface water exposure in an irrigated agricultural system, however, the suite of chemicals tested is very small compared to likely pesticides being used in the irrigation area.	
Ease of Access	
Reporting format	Results reported in PDF document.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

1. https://apps.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=226027&SYSUID=1&LICID=5014

General Information	
ID	34
Reference	Coleambally Irrigation – Water quality monitoring results.
URL	https://www.colyirr.com.au/water-quality (monthly water quality results from 2017 can be downloaded at this site)
Other information	Coleambally Irrigation undertakes monitoring based on their Environmental Protection Licence[1]. This license only identifies the chemicals that require monitoring.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water – irrigation area drains)
Reliability rating	
Substances ID	Yes (n = 11).
Analysis/LOD	No (probably available on request)
Matrix ID	Yes
Methodology	Somewhat
Locations	Yes
Dates	Yes
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 8)
Catchment type	Irrigated agriculture
Location	Coleambally Irrigation area (Riverina region, NSW)
Number of sites	6
Temporal	Yes – Compliance reports available over long term (>10 years)
Spatial	No.
Land use link	Yes – results are specific to an agricultural irrigation area.
Main substances detected	Atrazine, metolachlor, simazine (based on 2017 data used for example).
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an agricultural irrigation area catchment.	
Ease of Access	
Reporting format	Online and downloadable in Microsoft excel spreadsheet.
Individual values	Yes.

Cost/impediments	Nil. Publicly reported

1.https://static1.squarespace.com/static/5af3b1ae70e8023a6ac7a10b/t/5d2d16fbd83c2900011da3f7/1563236092745/EPL+4652+-+Coleambally+Irrigation.pdf

General Information	
ID	35
Reference	Murrumbidgee Irrigation – Water quality results.
URL	https://www.mirrigation.com.au/water/water-quality/water-quality-results/licence-site-monitoring-water-quality-results (monthly water quality results from 2017 can be downloaded at this site)
Other information	Murrumbidgee Irrigation undertakes monitoring based on their Environmental Protection Licence[1]. This license only identifies the chemicals that require monitoring.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water – irrigation area drains)
Reliability rating	
Substances ID	Yes (n = 10).
Analysis/LOD	No (probably available on request)
Matrix ID	Yes
Methodology	Somewhat
Locations	Yes
Dates	Yes
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 7)
Catchment type	Irrigated agriculture
Location	Murrumbidgee Irrigation area (Riverina region, NSW)
Number of sites	5
Temporal	Yes – Compliance reports available over long term (>5 years)
Spatial	No.
Land use link	Yes – results are specific to an agricultural irrigation area.
Main substances detected	Diuron, Atrazine, Metolachlor (based on random sample of monthly reports over time from different sites).
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an agricultural irrigation area catchment.	
Ease of Access	
Reporting format	Online and downloadable in Microsoft excel spreadsheet.
Individual values	Yes.
Cost/impediments	Nil. Publicly reported

1. https://apps.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=182989&SYSUID=1&LICID=4651

General Information	
ID	57
Reference	QLD Government – Reef 2050 Water Quality Improvement Plan
URL	The program is comprehensive. A starting point is found at: https://www.reefplan.qld.gov.au/
Other information	The risk baseline methodology is reported in Warne et al, 2020.[1] This reference describes the suite of chemicals monitored, locations and the base monitoring results by which to report future monitoring outcomes.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water – range of different land uses including tropical/subtropical agriculture)
Reliability rating	
Substances ID	Yes (n = 22).
Analysis/LOD	Yes (probably available on request)
Matrix ID	Yes
Methodology	Yes
Locations	Yes
Dates	Yes
Score	25
Relevance and Representativeness	
Includes listed?	Yes (n = 8)
Catchment type	Varied – well characterized in the monitoring program
Location	Great Barrier Reef catchment areas on Queensland east coast.
Number of sites	28
Temporal	Yes – pesticide concentration data for 2015/2016 to 2017/2018 were used to derive the Pesticide Risk Baseline and are used for comparative purposes for monitoring results obtained in subsequent years.
Spatial	Yes. The reef plan applies to all catchments, from the Burnett Mary to Cape York regions inclusive, that discharge to the Great Barrier Reef.
Land use link	Yes – results for catchments are linked to dominant land uses including conservation, dryland cropping, forestry, grazing, tropical/subtropical cropping (bananas, sugarcane, horticulture).
Main substances detected	Diuron, Imidacloprid, Atrazine, Metolachlor, Hexazinone (data not provided. This is based on the identified risk drivers and assessment in Spilsbury et al, 2020[2]).
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in exposed to a large range of land uses.	
Ease of Access	
Reporting format	Microsoft Excel
Individual values	Yes.
Cost/impediments	None identified. The data set is very large and needs to be requested through the Department of Environment and Science, Queensland Government.

1. https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c65858f9-d7ba-4aef-aa4f-e148f950220f/pesticide-risk-baseline-project-report.pdf?ETag=a9665f53d62acabcddcc9fbe38e025b5;
2. Spilsbury FD, Warne MSJ, Backhaus T. Risk Assessment of Pesticide Mixtures in Australian Rivers Discharging to the Great Barrier Reef. Environ Sci Technol. 2020 Nov 17;54(22):14361-14371. doi: 10.1021/acs.est.0c04066. Epub 2020 Nov 2. PMID: 33136377.

General Information	
ID	59
Reference	Smith R, Turner R, Vardy S, Huggins R, Wallace R and Warne M. An evaluation of the prevalence of alternate pesticides of environmental concern in Great Barrier Reef catchments: RP57C, 2016.
URL	https://www.publications.qld.gov.au/dataset/alternate-pesticides-gbr-catchments/resource/efaa76da-5714-45a5-ba40-30476d9e214e
Other information	n/a
Type of monitoring information	
Compartment	Environment
Matrix	Water (Surface water – range of different land uses including tropical/subtropical agriculture)
Reliability rating	
Substances ID	Yes (n = 151).
Analysis/LOD	Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes
Dates	Yes (1 July 2012 and 30 June 2013)
Score	25
Relevance and Representativeness	
Includes listed?	Yes (n = 51)
Catchment type	Varied – well characterized in the monitoring program
Location	The six sites were the North Johnstone, Tully and Herbert Rivers in the Wet Tropics, Barratta Creek in the Lower Burdekin, and Pioneer River and Sandy Creek in the Mackay-Whitsundays.
Number of sites	6
Temporal	No.
Spatial	Yes.
Land use link	Yes – dominant land uses in different sampling locations included conservation, grazing, sugarcane and horticulture.
Main substances detected	Diuron, Atrazine, 2,4-D, Metribuzin, Metolachlor, Isoxaflutole, MCPA.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in exposed to a large range of land uses.	
Ease of Access	
Reporting format	Graphically presented in PDF.
Individual values	No. The median and ranges are provided graphically for detected chemicals.

Cost/impediments	None identified. The results would be more useable if the raw data could be obtained, which may be requested from the Queensland Government.

General Information	
ID	38
Reference	Kennedy K, Bentley C, Paxman C, Heffernan A, Dunn A, Kaserzon S and Mueller J. Final Report - Monitoring of organic chemicals in the Great Barrier Reef Marine Park using time integrated monitoring tools (2009-2010). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox). 2010.
URL	See Table footnote 1
Other information	n/a
Type of monitoring information	
Compartment	Environment
Matrix	Water (Marine water – 12 inshore sites in the Great Barrier Reef Marine Park)
Reliability rating	
Substances ID	Yes (n = 33).
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes
Dates	Yes (2009-2010)
Score	25
Relevance and Representativeness	
Includes listed?	Yes (n = 18)
Catchment type	Varied – well characterized in the monitoring program
Location	Monitoring was conducted at sites within five major Natural Resource Management Regions (Cape York, Wet Tropics, Burdekin, Mackay Whitsunday, and Fitzroy)
Number of sites	12
Temporal	No.
Spatial	Yes.
Land use link	Yes – dominant land uses in different catchments discharging to the Great Barrier Reef Marine Park vary depending on location and can include conservation, grazing, sugarcane and horticulture.
Main substances detected	Diuron, Atrazine, hexazinone, simazine, chlorpyrifos.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in exposed to a large range of land uses.	
Ease of Access	
Reporting format	Reported in PDF.
Individual values	No. % detect, range and maximum values provided.
Cost/impediments	Nil. Publicly available.

1.https://www.academia.edu/23539827/Final_Report_Monitoring_of_organic_chemicals_in_the_Great_Barrier_Reef_Marine_Park_using_time_integrated_monitoring_tools_2009_2010_

Source ID: 55. In the initial information gathering stage, the Environment Protection Authority, Victoria, advised on an “Emerging contaminants in recycled water project, 2021”. This project contains monitoring data from influent and effluent waters from 30 x wastewater treatment plants and includes pesticides, pharmaceuticals and personal care products, and endocrine disruption chemicals. The control and ownership rests with Vic EPA, contact Dr Minna Saaristo Senior Scientist – Emerging contaminants, Land and Waste Sciences, EPA Science (minna.saaristo@epa.vic.gov.au). However, it was noted that because this project is a collaboration between water corporations and EPA Science, releasing any data will need to be approved by the water corporations involved. The data are maintained in Microsoft Excel and PDF forms.

Urban stormwater

General Information	
ID	19
Reference	Allinson M, Zhang P, Bui A, Muyers J, Pettigrove V, Rose G, Salzman S, Walters R and Allinson G. Herbicides and trace metals in urban waters in Melbourne, Australia (2011–12): concentrations and potential impact. Environ Sci Pollut Res 2017. 24, 7274–7284.
URL	https://doi.org/10.1007/s11356-017-8395-9 Supplementary information available.
Type of monitoring information	
Compartment	Environment
Matrix	Surface water (Urban stormwater)
Reliability rating	
Substances ID	Yes (n = 31)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (generally)
Dates	Yes
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 7)
Catchment type	Urban
Location	In and around Melbourne, Victoria
Number of sites	5
Temporal	Yes, short time frame (6 months)
Spatial	Limited
Land use link	Sites represent the mix of urban land uses in Melbourne i.e. predominantly housing, mixed urban and industrial.
Main substances detected	Simazine, MCPA, Diuron, Atrazine.

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff in surface water for urban land use.	
Ease of Access	
Reporting format	Results available in tabular form in a Microsoft Word document.
Individual values	Yes (in supplementary information).
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	20
Reference	Allinson G, Zhang P, Bui A, Allinson M, Rose G, Marshall S and Pettigrove V. Pesticide and trace metal occurrence and aquatic benchmark exceedances in surface waters and sediments of urban wetlands and retention ponds in Melbourne, Australia. Environ Sci Pollut Res Int. 2015 Jul; 22(13):10214-26.
URL	https://doi.org/10.1007/s11356-015-4206-3
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 24)
Analysis/LOD	Yes/Yes (described in detail in supplementary information)
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general)
Dates	Yes
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 14)
Catchment type	Urban and peri-urban wetlands
Location	In and around Melbourne, VIC.
Number of sites	24
Temporal	No. Samples collected at one time point only.
Spatial	Limited, but greater analysis of detections by site ID will give a degree of spatial analysis from highly urbanized to peri-urban locations.
Land use link	Sites were chosen to obtain broad representation of the wide range of urban stormwater treatment wetland designs found in Melbourne, across the major soils types in the region and representing both new developments and well established suburbs.
Main substances detected	Simazine, Atrazine, Metalaxyl, Terbutryn.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff.	

Ease of Access	
Reporting format	Results available in tabular form in a Microsoft Word document.
Individual values	Yes (in supplementary information).
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	30
Reference	Sidhu J, Gernjak W and Toze S. (Editors). Health Risk Assessment of Urban Stormwater. CSIRO 2012. Urban Water Security Research Alliance Technical Report No. 102.
URL	http://www.urbanwateralliance.org.au/publications/UWSRA-tr102.pdf
Type of monitoring information	
Compartment	Environment
Matrix	Water
Reliability rating	
Substances ID	Yes (n = 15)
Analysis/LOD	Yes/No
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specific with coordinates)
Dates	Yes (May 2011 to February 2012)
Score	25
Relevance and Representativeness	
Includes listed?	Yes (n = 6)
Catchment type	Surface water, Urban stormwater, Brisbane, Melbourne, Sydney.
Location	Brisbane (n = 2), Melbourne (n = 2), Sydney (n = 2).
Number of sites	6
Temporal	Limited. Sampling undertaken over 12 months.
Spatial	Yes.
Land use link	Yes. Land uses associated with stormwater sampling included residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture.
Main substances detected	Diuron, Simazine, 2,4-D, MCPA, Triclopyr
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF report.
Individual values	No. Min, median, max and 25th, 75th and 90th percentages reported along with frequency of detection.
Cost/impediments	Nil. Publicly available.

General Information	
ID	06
Reference	Allinson G, Allinson M, Myers J and Pettigrove V. Use of novel rapid assessment tools for efficient monitoring of micropollutants in urban storm water (SWF Project 8OS – 8100). Centre for Aquatic Pollution Identification Management (CAPIM). The University of Melbourne, Parkville, Victoria 3025, Australia. 2014.
URL	https://waterportal.com.au/swf/images/swf-files/8os---8100-capim-micropollutants-project-m4-final-report.pdf
Type of monitoring information	
Compartment	Environment
Matrix	Water (Storm water)
Reliability rating	
Substances ID	Yes (n = 29)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identifiable)
Dates	Yes (October 2012 to February 2013)
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 7)
Catchment type	Urban sites receiving storm water
Location	Melbourne, VIC
Number of sites	8
Temporal	No.
Spatial	No.
Land use link	Yes. Land uses from the urban catchments included inner urban; suburban; bioretention system for stormwater harvesting and irrigation, wetland system for stormwater harvesting and irrigation, regional town catchment and a rain garden system for storm water harvesting and irrigation.
Main substances detected	Atrazine, Simazine, Diuron, 2,4-D, MCPA, Triclopyr.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for urban stormwater catchments.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

Drinking water

General Information	
ID	09

Reference	Water Corporation (Western Australia)
URL	https://www.watercorporation.com.au/About-us/Our-performance/Drinking-water-quality - Separate annual water quality reports available at this site.
Overall information:	This is an ongoing monitoring program by a water authority. To verify the delivery of safe drinking water and to assess the aesthetic quality of the drinking water, Water Corporation (WA) run an extensive water quality monitoring program. They analyse more than 71,800 samples from water sources, treatment plants and pipe networks that supply our customers, and almost 302,000 individual analyses performed by independent laboratories.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water)
Reliability rating	
Substances ID	Yes (n = 99 – uncertain if this differs per year)
Analysis/LOD	No – but expected to be available from testing laboratory.
Matrix ID	Yes
Methodology	No but expected could be provided if requested.
Locations	Yes (Generally identifiable)
Dates	Yes (Ongoing water authority monitoring program)
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 50)
Catchment type	Drinking water catchments
Location	Western Australia
Number of sites	>100 around the state
Temporal	Yes – on going monitoring program
Spatial	Yes – sampling around Western Australia
Land use link	Yes. Drinking water supply taken from drinking water catchments.
Main substances detected	Not identifiable from internet based sources. The Water Corporation was contacted to determine accessibility of the raw data. Their response simply pointed to the web information, but the raw data may be available if requested by DAFF.
Conclusion	
The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. However, in the publicly available data, the results only refer to exceedances of overall pesticides to health guidelines, not to limits of detection. If the raw data could be obtained, they would be considered **representative** for drinking water catchments.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Not in the publicly available reports.
Cost/impediments	Nil. Publicly available for annual reports. Water Corporation has been contacted through the online query form to obtain information on availability of individual monitoring data including costs and impediments to obtaining these data.

General Information	
ID	39
Reference	Flinders Shire Council
URL	https://www.flinders.qld.gov.au/reporting-water-sewerage/water-sewerage-reporting - Separate annual water quality reports available at this site.
Overall information:	This is an ongoing monitoring program by a water authority. The information is from the Drinking Water Quality Management Plan (DWQMP) report for Flinders Shire Council where reports over several years are available. For pesticides, sampling occurs 4 times per annum with 2-3 samples taken at each sampling stage (based on latest annual report).
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water from bores)
Reliability rating	
Substances ID	Yes (n = 64 – uncertain if this differs per year)
Analysis/LOD	No – but expected to be available from testing laboratory.
Matrix ID	Yes
Methodology	No but expected could be provided if requested.
Locations	Yes (Specifically identified)
Dates	Yes (Ongoing water authority monitoring program)
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 38)
Catchment type	Drinking water catchments with sampling from bores
Location	Hughenden, QLD
Number of sites	3
Temporal	Yes – on going monitoring program
Spatial	No.
Land use link	Yes. Drinking water supply taken from bores.
Main substances detected	The latest available annual report (2020/2021) has been used as a reference point. Of the pesticides analysed for, none exceeded the guideline level (≤0.7 µg/L for all analytes).
Conclusion	
The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. Analyses was also undertaken for many legacy chemicals listed in the Stockholm Convention. However, in the publicly available data, the results only refer to exceedances of overall pesticides to health guidelines, not to limits of detection. If the raw data could be obtained, they would be considered **representative** for drinking water catchments noting these results relate to bore water samples.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes, but only reported as number of samples per chemical exceeding specific water quality criteria.
Cost/impediments	Nil. Publicly available for annual reports.

General Information	
ID	41
Reference	Burdekin Shire Council
URL	https://www.burdekin.qld.gov.au/downloads/file/1455/drinking-water-quality-management-plan - Provides raw water quality results for the period 2013-2020.
Overall information:	The Burdekin Shire Council performs water quality testing at various sites in Ayr, Alva Beach, Brandon, Home Hill, Giru and Mt Kelly. Quarterly water quality sampling is performed at various sites within the Shire. Samples are sent to the Queensland Forensic & Scientific Services laboratory in Brisbane for Heavy Metal, Pesticide and Chemical analysis.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water from bores)
Reliability rating	
Substances ID	Yes (Total number unclear as it appears only positive detections reported)
Analysis/LOD	No – but expected to be available from testing laboratory.
Matrix ID	Yes
Methodology	No but expected could be provided if requested.
Locations	Yes (Specifically identified)
Dates	Yes (2013-2020 in this publication)
Score	17
Relevance and Representativeness	
Includes listed?	Yes (n = 4 out of the 9 pesticides where positive detections were reported)
Catchment type	Drinking water catchments with sampling from bores
Location	Hughenden, QLD
Number of sites	15
Temporal	No. The results cover a sampling period of 8 years, but results are pooled for reporting.
Spatial	No.
Land use link	Yes. The Burdekin Catchment as a whole, over 90% is grazing land. While this impacts the water quality within the Haughton River, this is not the most relevant land use for the water supplies of Ayr, Home Hill and Mount Kelly, where irrigated sugar cane farming dominates.
Main substances detected	Atrazine, diuron.
Conclusion	
The data set is considered **reliable** for the purpose of this project and was developed as part of a structured local council long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. Analyses was also undertaken for many legacy chemicals listed in the Stockholm Convention. However, in the publicly available data, the results only refer to exceedances of overall pesticides to health guidelines, not to limits of detection. If the raw data could be obtained, they would be considered **representative** for drinking water catchments noting these results relate to bore water samples.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	No. Average, maximum and number of positive detections reported.
Cost/impediments	Nil. Publicly available.

General Information	
ID	42
Reference	Central Highlands Water - Water Quality Report (using 2020-21 for reference)
URL	https://www.chw.net.au/community/water-quality - gives access to water quality reports dating back to 2011/12.
Overall information:	A range of pesticides are monitored in untreated source water for each supply on an annual basis.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water from streams, dams and bores)
Reliability rating	
Substances ID	Yes (n = 105)
Analysis/LOD	No – but expected to be available from testing laboratory.
Matrix ID	Yes
Methodology	No but expected could be provided if requested.
Locations	Yes (Specifically identified)
Dates	Generally – single annual samples for analysis
Score	17
Relevance and Representativeness	
Includes listed?	Yes (n = 51)
Catchment type	Drinking water sourced from stream diversions, on-stream storages and groundwater bores
Location	Central Highlands region of Victoria.
Number of sites	13 separate water supply systems
Temporal	Yes – there are water quality reports for several years.
Spatial	Limited – 13 sites throughout the Central Highlands region of Victoria.
Land use link	Yes. Drinking water supply catchments.
Main substances detected	Atrazine, Simazine, 2,4-D, Triclopyr.
Conclusion	
The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for drinking water catchments noting these results relate to bore and surface water samples.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes for substances where a positive detection at any water supply system was identified.
Cost/impediments	Nil. Publicly available.

General Information	
ID	45

Reference	The Bundaberg Regional Council (BRC) Drinking Water Quality Management Plan (DWQMP) - (using 2020-21 for reference)
URL	See table footnote 1 - gives access to water quality reports dating back to 2017/18.
Overall information:	The Bundaberg Regional Council carries out full and comprehensive pesticide analysis on a routine basis. The results available in the annual reports only include detections that have an Australian Drinking Water Guideline Health Value.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water from reservoirs)
Reliability rating	
Substances ID	Yes (positive results only reported. The full suite of chemicals tested for is not reported)
Analysis/LOD	No/Yes – but expected analytical method to be available from testing laboratory.
Matrix ID	Yes
Methodology	No but expected could be provided if requested.
Locations	Yes (Specifically identified)
Dates	Generally – sampling undertaken quarterly
Score	19
Relevance and Representativeness	
Includes listed?	Yes (n = ≥5 – only positive results have been reported)
Catchment type	Drinking water sourced from stream diversions, on-stream storages and groundwater bores
Location	Bundaberg region, QLD.
Number of sites	Up to 10 separate water supply systems
Temporal	Yes – there are water quality reports for several years.
Spatial	Limited.
Land use link	Yes. Drinking water supply catchments.
Main substances detected	Atrazine, Hexazinone, Bromacil, 2,4-D
Conclusion	
The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for drinking water catchments noting these results relate to surface water samples.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes for substances where a positive detection at any water supply system was identified.
Cost/impediments	Nil. Publicly available.

1. https://www.bundaberg.qld.gov.au/water-services/water-supply/3#:~:text=The%20Bundaberg%20Regional%20Council%20(BRC,Safety%20and%20Reliability)%20Act%202008

General Information	
ID	46
Reference	Catchment and Drinking Water Quality Micro Pollutant Monitoring program – Passive Sampling. Report 10 – Summer 2019. Queensland Alliance for Environmental Health Sciences, University of Queensland.

URL	See table footnote 1.
Other information	As the bulk supplier of drinking water to South East Queensland, Seqwater maintains a Catchment and Drinking Water Quality Micro Pollutant Monitoring Program to ensure safe and reliable supply of the region's drinking water source reservoirs. The aim of this program is to identify and understand the presence of micro-pollutants in the source water reservoirs.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water)
Reliability rating	
Substances ID	Yes (n = 41)
Analysis/LOD	Yes/No
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specifically identified)
Dates	Yes (Single sampling events from December 2018 to February 2019)
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 25)
Catchment type	Drinking water catchments, South East Queensland.
Location	South East Queensland
Number of sites	36
Temporal	No.
Spatial	Yes throughout SE Queensland.
Land use link	Yes. Representative of drinking water catchments.
Main substances detected	Atrazine, Metsulfuron-methyl, Simazine, 2,4-D, Hexazinone, Metolachlor, Propiconazole, Tebuthiuron, Endosulfan, DDT (as metabolites). NOTE, these substances were observed in ≥70% of sites. A total of 30 herbicides/ insecticides accumulated in samplers with percent detection at sampling sites ranging from 3% - 97%.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for surface water exposure drinking water catchments.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	No - % detection, minimum and maximum reported for positive detections.
Cost/impediments	Nil. Publicly available.

1. The University of Queensland, Queensland Alliance for Environmental Health Sciences, Catchment and Drinking Water Quality Micro Pollutant Monitoring Program - Passive Sampling 2019

General Information	
ID	28
Reference	WaterNSW – Annual water quality monitoring report. (2020-21 report used as reference).
URL	https://www.waternsw.com.au/water-quality/quality/reports

Other information	WaterNSW publishes an annual water quality monitoring report each year. The reports provide an overview of the WaterNSW's water quality sampling and results throughout the storages and catchments.
Type of monitoring information	
Compartment	Environment
Matrix	Water (Drinking water – water filtration plants monitored)
Reliability rating	
Substances ID	Yes (n = 11)
Analysis/LOD	No – but expected to be available from testing laboratory
Matrix ID	Yes
Methodology	No
Locations	Yes (Water infiltration plants identified)
Dates	Yes (Generally – quarterly sampling)
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 8)
Catchment type	Drinking water catchments, Sydney.
Location	Sydney water catchment
Number of sites	5 water infiltration plants; 10 stations.
Temporal	No.
Spatial	No.
Land use link	Yes. Representative of drinking water catchments.
Main substances detected	None above limit of reporting.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for drinking water monitored in water filtration plants.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	No – Minimum, median, maximum reported.
Cost/impediments	Nil. Publicly available.

General Information	
ID	36
Reference	2009/2010 Pesticide Residue Water Sampling and Analysis Program: Emigrant Creek and Wilsons River Water Supply Systems
URL	https://rous.nsw.gov.au/file.asp?g=RES-XNZ-67-51-23
Other information	This report examines the 2010 results of a targeted pesticide water monitoring program conducted by Rous Water in the Emigrant Creek and Wilsons River water supply systems
Type of monitoring information	
Compartment	Environment

Matrix	Water (Surface water – water supply catchment).
Reliability rating	
Substances ID	Yes (n = 27).
Analysis/LOD	No/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes
Dates	Yes (Spring/summer, 2009/2010)
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 19)
Catchment type	Varied – well characterized in the monitoring program
Location	Rous County Council (Lismore, NSW)
Number of sites	4
Temporal	No.
Spatial	No.
Land use link	Yes – Water supply catchment area.
Main substances detected	No detections exceeding level of reporting.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water in a water supply catchment area.	
Ease of Access	
Reporting format	PDF.
Individual values	No. No detections exceeding level of reporting were identified.
Cost/impediments	Nil. Publicly available.

Groundwater

General Information	
ID	11
Reference	Department of Water. A baseline study of contaminants in groundwater at disused waste disposal sites in the Swan Canning catchment. Water Science technical series Report No 4, December 2009. Government of Western Australia.
URL	https://www.dpaw.wa.gov.au/images/documents/conservation-management/riverpark/reports/a-baseline-study-of-contaminants-in-groundwater-at-disused-waste-disposal-sites-in.pdf
Type of monitoring information	
Compartment	Environment
Matrix	Water (Ground water)
Reliability rating	
Substances ID	Yes (n = 32)
Analysis/LOD	Partially/Partially
Matrix ID	Yes

Methodology	Yes
Locations	Yes (Generally identifiable)
Dates	Yes (May 2006 to May/June 2007)
Score	21
Relevance and Representativeness	
Includes listed?	Yes (n = 17)
Catchment type	Urban and peri-urban stormwater drains (artificial and natural creeks/rivers)
Location	Around Perth, WA
Number of sites	3
Temporal	Limited. Monitoring over several seasons but in one year and only 3 sampling times.
Spatial	No.
Land use link	Yes. The sites were disused waste disposal sites.
Main substances detected	No pesticides were detected.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a small number of pesticides regulated by the APVMA, some of which are identified in the priority list established for this project. It is **not considered representative** because it relates to waste disposal sites that are no longer used. There is no ability to identify wastes or link these to historic use.	
Ease of Access	
Reporting format	Results available in tabular form in the report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

Soil

General Information	
ID	47
Reference	Weaver T, Ghadiri H, Hulugalle N and Harden S. Organochlorine pesticides in soil under irrigated cotton farming systems in Vertisols of the Namoi Valley, north-western New South Wales, Australia, Chemosphere, 2012. Volume 88, Issue 3, 336-343.
URL	http://dx.doi.org/10.1016/j.chemosphere.2012.03.008
Type of monitoring information	
Compartment	Environment
Matrix	Soil
Reliability rating	
Substances ID	Yes (n = 8)
Analysis/LOD	Yes/No
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specific, with coordinates)
Dates	Yes (2000-2002)
Score	22

Relevance and Representativeness	
Includes listed?	Yes (n = 7)
Catchment type	Agriculture (cotton)
Location	Lower Namoi Valley, NSW
Number of sites	3
Temporal	No.
Spatial	No.
Land use link	Yes. Legacy chemicals used in agriculture in the sampled area prior to their use ceasing.
Main substances detected	DDT (as DDD and DDE), Endrin, Endosulfan.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a legacy substances listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** for describing continual levels of legacy chemicals.	
Ease of Access	
Reporting format	Results available in tabular form in the PDF published report.
Individual values	No. Mean and range provided in publication.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	48
Reference	Vic EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870 May 2020
URL	https://www.epa.vic.gov.au/-/media/epa/files/publications/1870.pdf
Other information	This report by EPA provides an assessment of pesticides, PFAS, metals and selected industrial chemicals contaminant concentrations in surface soils in areas of the Bellarine Peninsula region and in water and sediments in the Barwon River catchment to further inform assessment of the potential risk for exposure to these environmental contaminants.
Type of monitoring information	
Compartment	Environment
Matrix	Soil
Reliability rating	
Substances ID	Somewhat (stated as organochlorines, organophosphates, synthetic pyrethroids, herbicides and fungicides. Specific chemical list not provided.)
Analysis/LOD	No/Yes (Laboratory identified so analytical information would be available if required).
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identified)
Dates	Yes (Single sampling events in June 2019)
Score	18
Relevance and Representativeness	
Includes listed?	Yes (actual number not identified.)

Catchment type	Barwon River Catchment. Residential, but previously used for agriculture.
Location	Bellarine Peninsula (Geelong to Ocean Grove, Victoria).
Number of sites	4 aquatic (water, sediment, soil) plus 4 public areas for additional soil.
Temporal	No.
Spatial	No.
Land use link	Yes. The provided map (and confirmed with Google Maps) shows the sampling sites to be situated in a mix of urban and agricultural land uses.
Main substances detected	Dieldrin.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for soil exposure from previous agricultural land use and current mixed use.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	53
Reference	EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020.
URL	https://www.epa.vic.gov.au/about-epa/publications/1879
Other information	The study was undertaken to enable the EPA to further identify the extent and magnitude of emerging and legacy contaminants across Victoria, to inform where there may be priority areas, regulatory responses, and identify sectors to work with to prevent and reduce environmental pollution.
Type of monitoring information	
Compartment	Environment
Matrix	Soil
Reliability rating	
Substances ID	The summary results have been provided by EPA Victoria. The results from the monitoring program are considered reliable for the purpose of this project but full details have not been requested. These can be obtained including the monitoring results from: Dr Minna Saaristo Senior scientist – Emerging Contaminants, Land & Waste Sciences Email: minna.saaristo@epa.vic.gov.au
Analysis/LOD	
Matrix ID	
Methodology	
Locations	
Dates	
Score	
Relevance and Representativeness	
Includes listed?	Yes (from limited information in overview.)
Catchment type	Agriculture (low intensity- grazing; high intensity – cropping and horticulture); urban residential; urban industrial; background.
Location	Across Victoria

Number of sites	101
Temporal	No.
Spatial	Yes.
Land use link	EPA selected sites representing five land use types: background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial.
Main substances detected	In soils, insecticide p'p-DDE was detected from <1 up to 150 µg/kg, and dieldrin from <1 up to 38 µg/kg across all land use types.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in different catchment types. The full data set can be requested from EPA Victoria if required for later use.	
Ease of Access	
Reporting format	Full results available from EPA Victoria.
Individual values	Yes.
Cost/impediments	None identified

Sediment

General Information	
ID	05
Reference	Marshal S, Sharley D, Jeppe K, Sharp S, Rose G and Pettigrove V. Potentially Toxic Concentrations of Synthetic Pyrethroids Associated with Low Density Residential Land Use. Frontiers in Environmental Science, 22 November 2016. Vol 4 (75).
URL	https://www.frontiersin.org/articles/10.3389/fenvs.2016.00075/full http://journal.frontiersin.org/article/10.3389/fenvs.2016.00075/full#supplementary-material
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 32)
Analysis/LOD	Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (specific with coordinates)
Dates	Yes
Score	25
Relevance and Representativeness	
Includes listed?	Yes (n = 14)
Catchment type	Urban wetlands aligned with subterranean stormwater drains.
Location	In and around Melbourne, Victoria
Number of sites	111
Temporal	No. Samples collected between February and April in 2015.

Spatial	Limited.
Land use link	Catchment land use was dominated by residential, parkland, and commercial use, with smaller proportions of institutional and industrial use.
Main substances detected	Highest concentrations in sediment were observed for diuron, permethrin, bifenthrin, triclosan and carbaryl.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including 14 substances identified in the priority list established for this project. It is **representative** for urban stormwater runoff with partitioning to sediments for urban land use.	
Ease of Access	
Reporting format	Values within supplementary information – tabulated in Microsoft Word document
Individual values	Yes (in supplementary information)
Cost/impediments	Free – open access article

General Information	
ID	20
Reference	Allinson G, Zhang P, Bui A, Allinson M, Rose G, Marshall S and Pettigrove V. Pesticide and trace metal occurrence and aquatic benchmark exceedances in surface waters and sediments of urban wetlands and retention ponds in Melbourne, Australia. Environ Sci Pollut Res Int. 2015 Jul;22(13):10214-26.
URL	https://doi.org/10.1007/s11356-015-4206-3
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 17)
Analysis/LOD	Yes/Yes (described in detail in supplementary information)
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general)
Dates	Yes
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 10)
Catchment type	Urban and peri-urban wetlands
Location	In and around Melbourne, VIC.
Number of sites	24
Temporal	No. Samples collected at one time point only.
Spatial	Limited, but greater analysis of detections by site ID will give a degree of spatial analysis from highly urbanized to peri-urban locations.
Land use link	Sites were chosen to obtain broad representation of the wide range of urban stormwater treatment wetland designs found in Melbourne, across the major soils types in the region and representing both new developments and well established suburbs.

Main substances detected	Bifenthrin.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff with partitioning to sediments for urban land use.	
Ease of Access	
Reporting format	Results available in tabular form in a Microsoft Word document.
Individual values	Yes (in supplementary information).
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	21
Reference	Allinson, G., Allinson, M., Bui, A. et al. Pesticide and trace metals in surface waters and sediments of rivers entering the Corner Inlet Marine National Park, Victoria, Australia. Environ Sci Pollut Res 2016. 23, 5881–5891.
URL	https://doi.org/10.1007/s11356-015-5795-6 Supplementary information available.
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 39)
Analysis/LOD	Yes/Yes (described in detail in supplementary information)
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general)
Dates	Yes
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 16)
Catchment type	Surface water, Agricultural use (pasture) catchment
Location	Corner Inlet catchment, Victoria
Number of sites	17
Temporal	Limited. Samples collected monthly over a 6 month period.
Spatial	No.
Land use link	The sites were selected based on their relative positions within the Corner Inlet catchment or reference locations, e.g., head of catchment, mid catchment, and lower catchment, in known agricultural areas, or in forestry or national parks and were considered to be a broad representation of the wide range of waterways found in the catchment, across the major soil types and land use in the region.
Main substances detected	Prometryn

Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including agriculture, forestry and national parks.	
Ease of Access	
Reporting format	Results available in tabular form in a Microsoft Word document.
Individual values	Yes (in supplementary information).
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	22
Reference	Allinson G, Bui A, Zhang P. et al. Investigation of 10 Herbicides in Surface Waters of a Horticultural Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2014. 67, 358–373.
URL	https://doi.org/10.1007/s00244-014-0049-z Supplementary information available
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 10)
Analysis/LOD	Yes/Yes (described in detail in supplementary information)
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general, but overall catchment is specific)
Dates	Yes (spring and summer, September 2008-March 2009
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 4)
Catchment type	Surface water, Mixed use (see “Land use link” below)
Location	Yarra catchment, Victoria
Number of sites	18
Temporal	Limited. 2 seasons.
Spatial	Limited. Within Yarra catchment.
Land use link	Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments
Main substances detected	Simazine
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list	

established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF published paper.
Individual values	No. Mean, median, minimum, maximum and frequency of detection reported.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	23
Reference	Wightwick AM, Bui AD, Zhang P. et al. Environmental Fate of Fungicides in Surface Waters of a Horticultural-Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2012. 62, 380–390.
URL	https://doi.org/10.1007/s00244-011-9710-y
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 24)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (general, but overall catchment is specific – same sites as ID 22)
Dates	Yes (spring and summer, September 2008-March 2009
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 6)
Catchment type	Surface water, Mixed use (see “Land use link” below)
Location	Yarra catchment, Victoria
Number of sites	18
Temporal	Limited. 2 seasons.
Spatial	Limited. Within Yarra catchment.
Land use link	Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments
Main substances detected	Myclobutanil, Pyrimethanil
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF published paper.

Individual values	No. Mean, maximum, 95% CI and frequency of detection reported.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	24
Reference	Lettoof DC, Bateman PW, Aubret F. et al. The Broad-Scale Analysis of Metals, Trace Elements, Organochlorine Pesticides and Polycyclic Aromatic Hydrocarbons in Wetlands Along an Urban Gradient, and the Use of a High Trophic Snake as a Bioindicator. Arch Environ Contam Toxicol 2020. 78, 631–645.
URL	https://doi.org/10.1007/s00244-020-00724-z
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 21 organochlorine pesticides, identified in supplementary material)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specifically, with coordinates)
Dates	Yes (spring and summer, September 2008-March 2009
Score	25
Relevance and Representativeness	
Includes listed?	Yes (organochlorine pesticides)
Catchment type	Urban, Peri-urban lakes.
Location	Perth, Western Australia
Number of sites	4
Temporal	No. Single time collection (December 2018)
Spatial	Limited – 4 sites down an urban gradient.
Land use link	Urban, peri urban (heavily modified to minimally modified locations)
Main substances detected	Dieldrin
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a legacy substances listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** for describing continual levels of legacy chemicals.	
Ease of Access	
Reporting format	Results available in tabular form in the main PDF published paper.
Individual values	No. Mean, maximum, 95% CI and frequency of detection reported.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	12
Reference	Department of Water. A baseline study of contaminants in the sediments of the Swan and Canning estuaries. Water Science technical series Report No 6, February 2009. Government of Western Australia.
URL	https://www.water.wa.gov.au/__data/assets/pdf_file/0007/3130/83909.pdf
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 15)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specific with coordinates)
Dates	Yes (September 2006 to August 2007)
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 10)
Catchment type	Sites in this study were generally located downstream from stormwater drains and/or in the vicinity of disused waste disposal sites that were identified as priority areas in a previous investigation.
Location	Around Perth, WA
Number of sites	20
Temporal	Limited. Monitoring over several seasons but in one year.
Spatial	No.
Land use link	No. The OC pesticides assessed for were likely applied in agricultural uses prior to the urbanization around many of the sample sites.
Main substances detected	Dieldrin, DDT (as p,p'-DDE)
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of legacy chemicals listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** in that it demonstrates the continual persistence of legacy chemicals, but these detections are not able to be liked directly to land use.	
Ease of Access	
Reporting format	Results available in tabular form in the report.
Individual values	No. Only values exceeding a sediment quality guideline were reported.
Cost/impediments	Nil. Publicly available.

General Information	
ID	04
Reference	The Pesticide Detectives: national assessment of pesticides in waters.

URL	https://www.rmit.edu.au/about/schools-colleges/science/research/research-centres-groups/aquatic-environmental-stress/pesticide-detectives
Description	Funded by the Department of Industry, Innovation and Science, Pesticide Detectives is a collaborative project combining the scientific expertise of RMIT University's Aquatic Environmental Stress Research Group (AQUEST) scientists and Citizen Science volunteers in the collection of sediment samples from waterways across Australia. The program has now concluded.
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 110)
Analysis/LOD	No/Yes Analysis method expected to be available from RMIT. LODs reported in interactive map for chemicals screened at sampling sites.
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Identifiable to location on interactive map: https://www.google.com.au/maps/d/viewer?mid=1wfAfAHIq5OFugMZzjVIR3Nj-ds2zRFUc&ll=-27.082741497285035%2C137.49261074777033&z=5)
Dates	Yes (2019-2020)
Score	19
Relevance and Representativeness	
Includes listed?	Yes (n = 43)
Catchment type	Sampling performed by volunteers around the country. A large variety of catchments have been sampled (rural, conservation, peri-urban, urban).
Location	Around Australia
Number of sites	>100
Temporal	No – single samples per site.
Spatial	Yes. Sampling sites around the country.
Land use link	Potentially. Land uses for individual sampling locations can be identified on the interactive map by scrolling in. (https://www.google.com.au/maps/d/viewer?mid=1wfAfAHIq5OFugMZzjVIR3Nj-ds2zRFUc&ll=-27.082741497285035%2C137.49261074777033&z=5)
Main substances detected	Bifenthrin
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is possibly **representative** for considering sediment contaminants for a large range of land uses, however, considerable additional work would be required to establish any such links.	
Ease of Access	
Reporting format	Results available in Microsoft excel (https://www.rmit.edu.au/content/dam/rmit/rmit-images/research/institutes-centres-and-groups/aquest/tabulated-results-all-pesticide-detections-sep-2019-to-jul-2020.xlsx).
Individual values	No. Only values for substances detected have been reported. Sampling sites from the interactive map appear to report all substances screened for at a site, however, so individual values could be extracted.
Cost/impediments	Nil. Publicly available.

General Information	
ID	48
Reference	Vic EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870 May 2020
URL	https://www.epa.vic.gov.au/-/media/epa/files/publications/1870.pdf
Other information	This report by EPA provides an assessment of pesticides, PFAS, metals and selected industrial chemicals contaminant concentrations in surface soils in areas of the Bellarine Peninsula region and in water and sediments in the Barwon River catchment to further inform assessment of the potential risk for exposure to these environmental contaminants.
Type of monitoring information	
Compartment	Environment
Matrix	Soil
Reliability rating	
Substances ID	Somewhat (stated as organochlorines, organophosphates, synthetic pyrethroids, herbicides and fungicides. Specific chemical list not provided.)
Analysis/LOD	No/Yes (Laboratory identified so analytical information would be available if required).
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identified)
Dates	Yes (Single sampling events in June 2019)
Score	18
Relevance and Representativeness	
Includes listed?	Yes (actual number not identified.)
Catchment type	Barwon River Catchment. Residential, but previously used for agriculture.
Location	Bellarine Peninsula (Geelong to Ocean Grove, Victoria).
Number of sites	4 aquatic (water, sediment, soil) plus 4 public areas for additional soil.
Temporal	No.
Spatial	No.
Land use link	Yes. The provided map (and confirmed with Google Maps) shows the sampling sites to be situated in a mix of urban and agricultural land uses.
Main substances detected	Dieldrin and DDT (as *p,p′*-DDE).
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for soil exposure from previous agricultural land use and current mixed use.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	50
Reference	Rose G, Zhang P, Bui A, Allen D and Allinson G. Melbourne Water and DPI agrochemicals in Port Philip catchment project report 2009-10. A report to the Centre for Aquatic Pollution, Identification and Management (CAPIM), the University of Melbourne. Future Farming Systems Research, DPI Queenscliff Centre, Queenscliff, Victoria. 2011.
URL	https://www.vgls.vic.gov.au/client/en_AU/search/asset/1146643/0
Other information	The study focused on the assessment of agrochemical loads and the impacts within the peri-urban and urban fringes of Melbourne. Although primarily focusing on unprotected catchments, two reference sites (protected catchments) for the Yarra (Donnelly's weir and Starvation Creek), and two sites of significant urban impact (Darebin and Merri Creeks) were included.
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 52)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Generally identified)
Dates	Yes (2009-2010)
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 31)
Catchment type	Urban and peri-urban fringes
Location	Melbourne, VIC (including Port Philip Bay sub-catchments)
Number of sites	24 from surface systems plus 24 constructed urban wetland sites.
Temporal	No.
Spatial	No.
Land use link	Yes.
Main substances detected	Simazine, Dieldrin, DDT (as p,p'-DDE), Bifenthrin (surface system samples) DDT (as p,p'-DDE), Bifenthrin, Simazine (urban wetland samples).
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for aquatic sediments exposure in an urban and peri-urban catchment.	
Ease of Access	
Reporting format	Results available in tabular form in PDF report.
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

General Information	
ID	53
Reference	EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020.
URL	https://www.epa.vic.gov.au/about-epa/publications/1879
Other information	The study was undertaken to enable the EPA to further identify the extent and magnitude of emerging and legacy contaminants across Victoria, to inform where there may be priority areas, regulatory responses, and identify sectors to work with to prevent and reduce environmental pollution.
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	The summary results have been provided by EPA Victoria. The results from the monitoring program are considered reliable for the purpose of this project but full details have not been requested. These can be obtained including the monitoring results from: Dr Minna Saaristo Senior scientist – Emerging Contaminants, Land & Waste Sciences Email: minna.saaristo@epa.vic.gov.au
Analysis/LOD	
Matrix ID	
Methodology	
Locations	
Dates	
Score	
Relevance and Representativeness	
Includes listed?	Yes (from limited information in overview.)
Catchment type	Agriculture (low intensity- grazing; high intensity – cropping and horticulture); urban residential; urban industrial; background.
Location	Across Victoria
Number of sites	101
Temporal	No.
Spatial	Yes.
Land use link	EPA selected sites representing five land use types: background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial.
Main substances detected	In sediments, the insecticide bifenthrin, a key ingredient in termiticides for residential housing, was detected in 34% of sites from <1 up to 79 µg/kg. The insecticide DDT was detected from <1 to 200 µg/kg and its metabolite p'p-DDE was detected from <1 to 170 µg/kg. Dieldrin was detected at 26% of sites with concentrations ranging from <1 to 39 µg/kg,
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in different catchment types. The full data set can be requested from EPA Victoria if required for later use.	
Ease of Access	
Reporting format	Full results available from EPA Victoria.
Individual values	Yes.
Cost/impediments	None identified

General Information	
ID	25
Reference	South Australia EPA. A snapshot of pesticides in South Australian Aquatic Sediments
URL	https://www.epa.sa.gov.au/files/8537_aquatic_pesticides.pdf
Other information	This project provided a snapshot survey of pesticides in aquatic sediments across South Australia, conducted in 2003 with 151 sediment samples collected. These sites represented (a) a cross-section of the state's inland and estuarine waters and (b) a diversity of catchment land uses.
Type of monitoring information	
Compartment	Environment
Matrix	Sediment
Reliability rating	
Substances ID	Yes (n = 82).
Analysis/LOD	No/No
Matrix ID	Yes
Methodology	Yes
Locations	Yes
Dates	Yes (July 2003)
Score	19
Relevance and Representativeness	
Includes listed?	Yes (n = 39)
Catchment type	Sites representative of a range of landuses including urban; intensive agriculture (market gardening,orchards, vines); forestry; broadacre cropping.
Location	Around South Australia
Number of sites	151
Temporal	No.
Spatial	Yes.
Land use link	Yes – Urban, intensive agriculture, forestry, broadacre cropping.
Main substances detected	Historically used pesticides were found at several sites. The most common was DDE (14 sites), which is a breakdown product of DDT. The other historical pesticides found were aldrin (3 sites), chlordane (2 sites), dieldrin (3 sites), lindane (1 site), DDT (1 site) and DDD (2 sites). Currently used pesticides found in sediments included chlorpyrifos (3 sites), simazine (4 sites) and diazinon (1 site).
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for sediments in aquatic systems with exposure from a large range of land uses.	
Ease of Access	
Reporting format	Tabular in PDF.
Individual values	Yes, for positive detections.
Cost/impediments	Nil. Publicly available.

Wildlife

General Information	
ID	07
	Yoshikane M, Kay W, Shibata Y, Inoue M, Yanai T, Kamata R, Edmonds J and Morita M. Very high concentrations of DDE and Taxaphene residues in crocodiles from the Ord River, Western Australia: An investigation into possible endocrine disruption. Journal of Environmental Monitoring. 2006, Volume 8, 649-661.
URL	http://xlink.rsc.org/?DOI=b518059g Supplementary information available.
Type of monitoring information	
Compartment	Environment
Matrix	Wildlife (livers and body fat from estuarine crocodiles)
Reliability rating	
Substances ID	Yes (n = 10, mixed isomers or degradates for parent actives counted as 1)
Analysis/LOD	Yes/no
Matrix ID	Yes
Methodology	Yes
Locations	Yes (specific with coordinates)
Dates	Yes
Score	22
Relevance and Representativeness	
Includes listed?	Yes (n = 10). All actives tested for were OP legacy chemicals
Catchment type	Irrigation area catchment including downstream and upstream
Location	Three locations along the Ord River in Western Australia.
Number of sites	3 covering samples from 40 individual animals
Temporal	Yes in that the results report current detections of chemicals where use ceased almost 30 years before sampling.
Spatial	No.
Land use link	Yes. Legacy chemicals used for cotton growing in the irrigation catchment area between 1964 and 1974.
Main substances detected	DDT, hexachlorobenzene, heptachlor, dieldrin, chlordane, mirex.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a legacy substances listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** for describing continual levels of legacy chemicals identified in tissues of wildlife decades are cessation of use. It is not representative in terms of linking exposure to current land use.	
Ease of Access for Monitoring Data	
Reporting format	Values in supplementary information provided in PDF format.
Individual values	Yes, reported in supplementary information.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	14
Reference	Lohr M. Anticoagulant rodenticide exposure in an Australian predatory bird increases with proximity to developed habitat. Science of the Total Environment 2018. 643: 134-144.
URL	https://doi.org/10.1016/j.scitotenv.2018.06.207
Type of monitoring information	
Compartment	Environment
Matrix	Wildlife (Livers, Southern Boobook (owl species), *Ninox boobook*)
Reliability rating	
Substances ID	Yes (n = 8)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Somewhat (described but not identified on map or by coordinates)
Dates	Not identified (apparently recorded but not provided in publication)
Score	17
Relevance and Representativeness	
Includes listed?	Yes (n = 8; first and second generation anticoagulants).
Catchment type	Varied – native, agricultural, peri-urban, urban.
Location	Yes (73 birds, most originating in more densely settled urban and peri-urban areas in the south-west of Western Australia in and around the city of Perth.)
Number of sites	73 individual liver samples.
Temporal	Yes. The difference in AR exposure observed between boobook carcasses recovered in winter and those recovered in summer potentially reflects increased risk of exposure during winter when rodents make up a larger proportion of the diet.
Spatial	Yes – sampling was taken from a wide geographic region.
Land use link	Yes. Exposure of predator avian wildlife to second generation anti-coagulants is only expected to occur through consumption of contaminated prey.
Main substances detected	Brodifacoum, Bromadiolone, Difenacoum.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in a predator avian species for first and second generation anticoagulant rodenticides that are regulated by the APVMA and in the priority list established for this project. It is **representative** for identifying exposure from a use pattern. It is not representative for determining exposure from a known use quantity.	
Ease of Access	
Reporting format	PDF publication
Individual values	No. Minimum, maximum and mean levels reported. Individual values may be available from lead author (m.lohr@acu.edu.au)
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	62

Reference	M. Pay J, Katzner T, Hawkins C, Barmuta L, Brown W, Wiersma J, Koch A,. Mooney N and Cameron E. Endangered Australian top predator is frequently exposed to anticoagulant rodenticides, Science of The Total Environment, 2021, Volume 788, 2021, 147673.
URL	https://doi.org/10.1016/j.scitotenv.2021.147673 Supplementary information available
Type of monitoring information	
Compartment	Environment
Matrix	Wildlife (Livers, Tasmanian wedge-tailed eagle Aquila audax fleayi)
Reliability rating	
Substances ID	Yes (n = 8)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (generally identifiable)
Dates	Yes (Eagles were collected as carcasses found opportunistically throughout Tasmania between 1996 and 2018).
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 8; first and second generation anticoagulants).
Catchment type	Mainland Tasmania.
Location	Mainland Tasmania
Number of sites	50 individual liver samples.
Temporal	No.
Spatial	Yes – sampling was taken from a wide geographic region.
Land use link	The following agricultural land use categories were grouped within the total land area used in the spatial analysis: Land use category: • Dairy sheds and yards • Horse studs • Piggeries • Poultry farms • Saleyards/stockyards • Grazing native vegetation • Native and exotic pasture mosaic • Woody fodder plants • Pasture legumes • Pasture legumes and grass mixture • Sown grasses • Irrigated woody fodder plants • Irrigated pasture legumes • Irrigated pasture legumes and grass mixture • Irrigated sown grasses • Cropping • Perennial horticulture • Seasonal horticulture

	• Irrigated cropping • Irrigated perennial horticulture • Irrigated seasonal horticulture • Unclassified agriculture • Farm buildings and infrastructure
Main substances detected	Brodifacoum, Flocoumafen, Bromadiolone.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in a predator avian species for first and second generation anticoagulant rodenticides that are regulated by the APVMA and in the priority list established for this project. It is **representative** for identifying exposure from a use pattern. It is not representative for determining exposure from a known use quantity.	
Ease of Access	
Reporting format	PDF publication with supporting information in Microsoft Excel and Microsoft Word
Individual values	Yes – supplementary Microsoft Excel spreadsheet.
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	63
Reference	Cooke R, Whiteley P, Jin Y, Death C, Weston M, Carter N and White J, Widespread exposure of powerful owls to second-generation anticoagulant rodenticides in Australia spans an urban to agricultural and forest landscape, Science of The Total Environment, 2022. Volume 819, 2022, 153024.
URL	http://dx.doi.org/10.1016/j.scitotenv.2022.153024 Supplementary information available
General Information	
ID	08
Reference	Fredericks, DJ and Palmer, D W 2008, Assessment of Pesticides in Aquatic Organisms – Ord River WA., Department of Environment, Government of Western Australia, Water Resource Technical Series Report No 40.
URL	See table footnote: (1)
Type of monitoring information	
Compartment	Environment
Matrix	Wildlife (Liver and muscle, Powerful owl, *Ninox strenua*)
Reliability rating	
Substances ID	Yes (n = 181)
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Yes (generally identifiable)
Dates	Yes (Eight found dead in 2020/21; 10 collected over 2004-2019).
Score	23
Relevance and Representativeness	
Includes listed?	Yes (n = 69).

Catchment type	Across Victoria with 1 sample from New South Wales.
Location	Generally across Victoria
Number of sites	18 individual liver or muscle samples.
Temporal	No.
Spatial	Yes – sampling was taken from a wide geographic region.
Land use link	The following land use categories were grouped within the total land area used in the spatial analysis: Land use category: • Peri-urban with agriculture (n = 6) • Urban fringe, low roads (n = 5) • Urban fringe, moderate roads (n = 2) • High urbane (n = 2)
Main substances detected	Brodifacoum, Bromadiolone, Pindone. DDT (as breakdown product p,p’-DDE)
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in a predator avian species for first and second generation anticoagulant rodenticides that are regulated by the APVMA and in the priority list established for this project. It is **representative** for identifying exposure from a use pattern. It is not representative for determining exposure from a known use quantity.	
Ease of Access	
Reporting format	PDF publication with supporting information in Microsoft Word
Individual values	No – Only detections reported
Cost/impediments	Cost of publication. Department has already obtained this publication.

General Information	
ID	08
Reference	Fredericks DJ, and Palmer DW. 2008, Assessment of Pesticides in Aquatic Organisms – Ord River WA., Department of Environment, Government of Western Australia, 2008, Water Resource Technical Series Report No 40.
URL	See table footnote: (1)
Type of monitoring information	
Compartment	Environment
Matrix	Wildlife (Fish)
Reliability rating	
Substances ID	Yes (n = 8)
Analysis/LOD	Partially
Matrix ID	Yes
Methodology	Yes
Locations	Yes (Specific)
Dates	Yes (2005-2006).
Score	16
Relevance and Representativeness	
Includes listed?	Yes (n = 8).

Catchment type	Agricultural irrigation area.
Location	In and downstream of the Ord River Irrigation Area (around Kununurra, WA).
Number of sites	7 exposure, 11 reference; 29 fish samples
Temporal	No.
Spatial	No.
Land use link	Yes. The sampling is centered around the Ord River Irrigation Area where Ops were used in cotton prior to 1974.
Main substances detected	All chemicals tested for were found in fish samples. DDT (including its breakdown products) were found in 100% of samples, dieldrin in 97% of samples and mirex in 90% of samples. Aldrin, chlordane heptachlor and HCB were found in 70-80% of samples.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in aquatic organisms for a range of OC chemicals listed in the Stockholm Convention and identified in the priority list for this project. It is **representative** continuing to demonstrate the persistence and accumulative potential of the legacy chemicals analysed.	
Ease of Access	
Reporting format	PDF publication with supporting information in Microsoft Word
Individual values	Yes.
Cost/impediments	Nil. Publicly available.

1.https://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/4013033cb21f13c1ee5fe0bf4825847900043329/$file/tp-3033.pdf

Produce

General Information	
ID	61
Reference	National residue Survey results and publication
URL	https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/nrs-results-publications
Other information	The Department of Agriculture, Fisheries and Forestry (DAFF) publish the results of all animal and plant products tested under the National Residue Survey. Test result information is available through residue testing data sets (published each financial year) and commodity/summary brochures for the most recent year.
Type of monitoring information	
Compartment	Produce (residues in food)
Matrix	Plant and animal food types.
Reliability rating	
Substances ID	Yes (n = 614 in 2020-21).
Analysis/LOD	Yes/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Not applicable for residues monitoring.
Dates	Yes
Score	21

Relevance and Representativeness	
Includes listed?	Yes (n = 60 in 2020-21)
Produce type	Comprehensive and well characterised. Plant produce residue monitoring including produce type monitored available at: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/plant-product-testing Animal produce residue monitoring including produce type monitored available at: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/animal-residue-monitoring
Number of sites	Not defined
Temporal	Potentially through comparison of results from different years.
Spatial	No. The origin of samples is not defined.
Land use link	Not applicable for residues results.
Main substances detected	Can be obtained from analysis of monitoring datasets for years of interest. Available at: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/nrs-results-publications
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure.	
Ease of Access	
Reporting format	Available online. Release of NRS data is governed by the National Residue Survey Administration Act 1992.
Individual values	Yes. Available online.
Cost/impediments	Nil. Publicly available.

General Information	
ID	64
Reference	FSANZ, 25th Australian Total Diet Study
URL	https://www.foodstandards.gov.au/publications/Pages/25th-Australian-Total-Diet-Study.aspx
Other information	The Australian Total Diet Study is Australia's most comprehensive monitoring survey of chemicals, nutrients and other substances in the Australian diet. Food samples are collected in capital cities and selected regional areas in all Australian states and territories. They are purchased from a range of retail outlets including supermarkets, grocers, butchers, poultry shops, seafood markets, cafes and takeaways. Foods are purchased over two sampling periods (i.e. winter and summer) to account for any seasonal variation in the food supply.
Type of monitoring information	
Compartment	Produce (residues in food)
Matrix	Plant and animal food types.
Reliability rating	
Substances ID	Yes (n = 136 in 2013-14). Also includes 12 veterinary medicines (anthelmintics).
Analysis/LOD	Partially. Full information would be available from testing laboratories.

Matrix ID	Yes
Methodology	Yes
Locations	Not applicable for residues monitoring.
Dates	Yes
Score	21
Relevance and Representativeness	
Includes listed?	Yes (n = 39 in 2013-14)
Produce type	Comprehensive and well characterised.
Number of sites	Not defined
Temporal	Can compare summer and winter sampling within the 12 month period
Spatial	No. The origin of samples is not defined.
Land use link	Not applicable for residues results.
Main substances detected	Reported in Appendix to full report[1]
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure.	
Ease of Access	
Reporting format	Available online as Microsoft word or PDF format.
Individual values	No. % detections, mean, minimum, maximum, median reported by commodity.
Cost/impediments	Nil. Publicly available.

Appendix downloadable at:
https://www.foodstandards.gov.au/publications/Documents/25th%20Australian%20Total%20Diet%20Study%20appendices.pdf

General Information	
ID	56
Reference	Targeted AgChem Residue Program (Agriculture Victoria).
URL	https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp-20152019 (summary of results published on internet).
Other information	Agriculture Victoria undertakes a Targeted AgChem Residue Program (TARP) on a yearly basis. The testing program measures chemical residues against maximum residue limits (MRL) to assist in verifying if agricultural and veterinary chemical products are being used appropriately.
Type of monitoring information	
Compartment	Produce (residues in food)
Matrix	Plant and animal food types
Reliability rating	
Substances ID	Yes (Full list not available).
Analysis/LOD	Yes/Yes
Matrix ID	Yes

Methodology	Yes
Locations	Not applicable for residues monitoring.
Dates	Yes
Score	20
Relevance and Representativeness	
Includes listed?	Yes (full list not available)
Produce type	2015-2019 online results available at: https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp#h2-0. This lists product types with unacceptable residues, identifies the chemical with unacceptable residues and reports the concentration detected.
Number of sites	Not defined
Temporal	Potentially through comparison of results from different years.
Spatial	No. The origin of samples is not defined.
Land use link	Not applicable for residues results.
Main substances detected	Can be obtained from analysis of monitoring datasets for 2015-19 as reported online. Available at: https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp#h2-0.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure, or detected where no MRL exists. HOWEVER, only results from 2015-2019 appear publicly available.	
Ease of Access	
Reporting format	Maintained in SharePoint database. Reports can be exported into excel etc.
Individual values	Yes. Limited years available online.
Cost/impediments	None identified.
Other comments	Victorian privacy and data protection requirements will apply to the data. Main contact: Maresa Heath (maresa.heath@agriculture.vic.gov.au; Tel: 0436 680 395).

General Information	
ID	16, 17, 18
Reference	Food monitoring programs (Department of Health, Government of Western Australia)
URL	https://ww2.health.wa.gov.au/Articles/F_I/Food-monitoring-program. (Survey findings for 2009, 2011, 2013, 2018 and 2020).
Other information	As part of Government and industry efforts to safeguard agriculture produce within Western Australia, the Department of Health, with support from local governments, monitors chemical residues in fresh fruit and vegetables in addition to various other food surveys conducted under the Western Australian Food Monitoring Program. Local Government environmental health officers collect a wide variety of fruit and vegetables from growers, packers, wholesale and retail markets for this purpose.
Type of monitoring information	
Compartment	Produce (residues in food)
Matrix	Plant and animal food types
Reliability rating	
Substances ID	Yes (n = 108 identified over several years)

Analysis/LOD	No/Yes
Matrix ID	Yes
Methodology	Yes
Locations	Not applicable for residues monitoring
Dates	Yes
Score	17
Relevance and Representativeness	
Includes listed?	Yes (n = 52 identified over several years)
Produce type	Identified in https://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/food/PDF/Monitoring-agricultural-chemical-residue-levels-updated18Feb.ashx)
Number of sites	Not defined
Temporal	Potentially through comparison of results from different years.
Spatial	No. The origin of samples is not defined.
Land use link	Not applicable for residues results.
Main substances detected	Can be obtained from analysis of monitoring datasets for 2015-19 as reported online. Available at: https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp#h2-0.
Conclusion	
The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure, or detected where no MRL exists.	
Ease of Access	
Reporting format	Online documents available at https://ww2.health.wa.gov.au/Articles/F_I/Food-monitoring-program
Individual values	Yes. Limited years available online.
Cost/ impediments	None identified.
Other comments	The identity of the organisation who has control of the data is stated as “The WA Department of Health, Environmental Health Directorate owns the data” (email received 14/7/2022, Kim Unwin). However, the raw data can only be accessed through the ChemCentre WA if these are still maintained in the laboratory. It is unlikely that there would be costs associated with the data although it is stated that all data would need to be de-identified.

Human biomonitoring

One study only was identified. Campbell et al, 2022[90] characterised concentrations of glyphosate and its metabolite, AMPA in urine of Australian and New Zealand populations. Pooled urine samples from the Australian general population (n = 125 pools representing >1875 individuals) and individual urine samples (n = 27) from occupationally exposed New Zealand farmers were analysed. Glyphosate was detected above the LOD (0.20–1.25 µg/L) in 8% of the Australian population pooled urine samples with most detections in the 45–60 years age group. Furthermore, glyphosate (0.85 to 153 µg/L) and AMPA (0.50 to 3.35 µg/L) were detected in 96 % and 33 % of farmers, respectively.

In a recent study, monitoring of cholinesterase in red blood cells (AChE) is reported.[91] This was not reviewed as a data source because it did not directly measure for pesticides. However, AChE inhibition may be a symptom of organophosphate (OP) insecticide toxicity. The study explored integration of AChE monitoring into routine health checks for those at risk and also to examine any association between AChE activity and agrichemical use in a Victorian farming community in Australia. This was a prospective cohort study, where farmers and non-famers were compared on the levels of AChE at four time points of baseline, 3–4 weeks, 6-weeks and at 9-weeks. Study participants (N = 55) were residents from South West Victoria, aged between 18 and 75 years. Testing of AChE was repeated for all participants with a maximum of three times over 10 weeks. There was no significant difference in average AChE activity between farming and non-farming participants in the study. There was no significant difference between personal use of agricultural chemicals on farm and the levels of AChE at baseline (measurement 1) or any of the follow up periods. However, the mean activity of AChE was significantly lower within follow up periods. There was a significant reduction of AChE between the follow up at 3-weeks and 6-weeks period.

[90] National Library of Medicine, Characterisation of glyphosate and AMPA concentrations in the urine of Australian and New Zealand populations. Science of the Total Environment. 15 November 2022. Vol 857, 157585. Campbell G, Mannetje A, Keer S, Eaglesham G, Wang X, Lin C, Hobson P, Toms L-M, Douwes J, Thomas K, Mueller J and Kaserzon S.

[91] Cotton, J., Edwards, J., Rahman, M.A. et al. Cholinesterase research outreach project (CROP): point of care cholinesterase measurement in an Australian agricultural community. Environ Health 2018. 17, 31.