blue environment pty ltd

Final

Hazardous Waste in Australia 2019

3 JUNE 2019

PREPARED FOR

Department of the Environment and Energy

PREPARED IN ASSOCIATION WITH

ASCEND WASTE AND ENVIRONMENT

Report title	Hazardous Waste in Australia 2019
Client	Department of the Environment and Energy
Status	Final
Author(s)	Geoff Latimer
Reviewer(s)	Joe Pickin
Project number	P863
Report date	3 June 2019
Contract date	20 September 2017
Information current to	30 June 2018
Copyright	Department of the Environment and Energy; Blue Environment

Blue Environment prints on 100% recycled paper

Blue Environment Pty Ltd
ABN 78 118 663 997
Suite 209, 838 Collins St, Docklands Vic 3008
Email: blue@blueenvironment.com.au
Web: www.blueenvironment.com.au
Phone: +61 3 9081 0440 / +61 3 5426 3536

Contents

Appendices

Figures

Tables

Abbreviations and glossary

AFFF	Aqueous film forming foams
ANZBP	Australian and New Zealand Biosolids Partnership
ANZSIC	Australian and New Zealand Standard Industrial Classification
Basel Convention	*The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal*. The Convention puts an onus on exporting countries to ensure that hazardous wastes are managed in an environmentally sound manner in the country of import.
Controlled Waste	Waste that falls under the control of the *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998*. Generally equivalent to hazardous waste, although definitional differences of the latter exist across jurisdictions.
Controlled Waste NEPM	*National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998*
CPT	Chemical or physical treatment (facility)
CSG	Coal Seam Gas - a form of natural gas (generally 95 to 97% pure methane, CH_4) typically extracted from permeable coal seams at depths of 300 to 1,200 m. Also called coal seam methane (CSM) or coalbed methane (CBM).
DoEE	The Australian Government Department of the Environment and Energy
Hazardous waste	A hazardous waste, as defined in the Australian Government's *National Waste Policy: Less waste, more resources* (2009), is a substance or object that exhibits hazardous characteristics, is no longer fit for its intended use and requires disposal. According to the Act, hazardous waste means: (a) waste prescribed by the regulations, where the waste has any of the characteristics mentioned in Annex III to the Basel Convention; or (b) wastes covered by paragraph 1(a) of Article 1 of the Basel Convention; or (c) household waste; or (d) residues arising from the incineration of household waste; but does not include wastes covered by paragraph 4 of Article 1 of the Basel Convention.
HWiA 2015	Blue Environment, Ascend Waste and Environment, and Randell Environmental Consulting (2015) *Hazardous Waste in Australia*, prepared for the Department of the Environment, available at: *http://www.environment.gov.au/system/files/resources/9ae68d42-d52e-4b1d-9008-111ad8bacfea/files/hazardous-waste-australia.pdf*
HWiA 2017	Blue Environment and Ascend Waste and Environment (2017), *Hazardous Waste in Australia*, prepared for the Department of the Environment, available at: *http://www.environment.gov.au/protection/publications/hazardous-waste-australia-2017*
HWiA 2019	This report
Key terms and definitions	***Project-specific terms and their definitions, expanded upon further to this glossary in Appendix A of this report***
kt	Kilotonnes (thousands of tonnes)
Mt	Megatonnes (millions of tonnes)
NEPM	*National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998*
PCB	Polychlorinated biphenyl
PFAS	Per- and poly-fluoroalkyl substances
PFOS	Perfluorooctane sulfonate
POP	Persistent organic pollutant
POP-BDE	Persistent organic pollutants - bromodiphenyl ethers (various forms)
SPL	Spent potliner (a waste from the aluminium smelting industry)

Standard	*Australian hazardous waste data and reporting standard – 2017 revision*
Tracking system	Jurisdiction-based hazardous waste tracking systems, which are in place in NSW, Qld, SA, WA and Vic. These tracking systems can be either online, paper-based, or a combination of both these mechanisms.
Tracked data	Hazardous waste collected under the arrangements of a tracking system.
Treatment	Treatment of waste is the removal, reduction or immobilisation of a hazardous characteristic to enable the waste to be reused, recycled, sent to an energy-from-waste facility or disposed.
Waste	(For data collation purposes) is materials or products that are unwanted or have been discarded, rejected or abandoned. Waste includes materials or products that are recycled, converted to energy, or disposed. Materials and products that are reused (for their original or another purpose without reprocessing) are not waste because they remain in use.
Waste arisings	Hazardous waste is said to 'arise' when it causes demand for processing, storage, treatment or disposal infrastructure.
Waste code	Three-digit code typically used by jurisdictions to describe NEPM-listed wastes; for example, N120 (contaminated soils). These are also referred to as 'NEPM codes' although it is noted that the actual codes do not appear in the NEPM itself. These are detailed in the *Waste groups* map of Appendix B.4.
Waste fate	Waste fate refers to the ultimate destination of the waste within the management system. Types of fate may include recycling, energy recovery, long-term storage and disposal, each of which categories can be divided into more specific fates. Treatment, transfer and short-term storage are not fates, but are rather part of the pathway leading to a fate.
Waste generation	The process of creating a waste. In this report *generation* is expressly different to *arisings* because it seeks to exclude the potential for double-counting, by subtracting the following (to the extent the relevant tonnes can be identified): 1. hazardous waste sent to facilities for short-term storage or transfer 2. hazardous waste outputs of hazardous waste infrastructure – only inputs are counted.
Waste groups	The classification system adopted for wastes outlined in this report (closely follows the NEPM category *waste codes*; (see Table 44, Appendix A). Waste groups have also been referred to as 'projection groups' in previous projects where the context refers projections of hazardous waste arisings for the purpose of assessing demand on infrastructure).
Waste management	For the purposes of this report, management of hazardous waste comprises the activities through which it is dealt with in infrastructure approved to receive it. The types of management are recycling, energy recovery, long-term storage, disposal, treatment and short-term storage. The first four of these are a type of fate; the last two are a type of pathway. Therefore, for hazardous waste, tonnes 'managed' = tonnes sent to pathway infrastructure + tonnes sent to fate infrastructure.
Waste pathway	The pathway of hazardous waste covers the various steps in the route between hazardous waste generation and fate, potentially including transfer, storage and/or treatment.
Waste source	The source of a waste describes and categorises where it is generated, which could be the location (i.e., the geographical source), the company, industry sector, or in some circumstances the jurisdiction that produced it.

At a glance

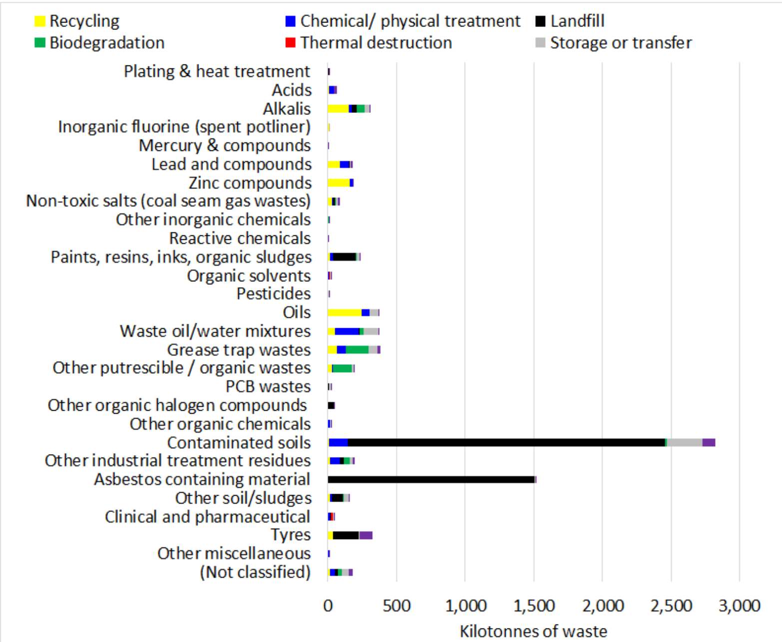
In 2017-18 Australia generated around 7.5 million tonnes of hazardous waste[1], which is about 11% of all waste generated (67 million tonnes) in this period[2]. This is a 34% increase on 2014-15 generation (5.6 million tonnes), reported in the 2017 edition of this report.

Classified into more than 70 detailed waste types, these include:

- contaminated soils and asbestos from development and demolition projects
- wastes from the chemicals, heavy manufacturing and mining industries
- emerging PFAS[+] wastes
- a range of wastes with hazardous characteristics that arise from everyday sources, such as:
  - tyres/oils/oily waters (motor vehicles)
  - grease trap waste (commercial cooking)
  - lead-containing wastes such as lead acid batteries (motor vehicles again) and leaded glass from used TVs and computers
- spent industrial catalysts and other residual wastes, contaminated with heavy metals.

The top 10 wastes[1] produced by weight in 2017-18, were:

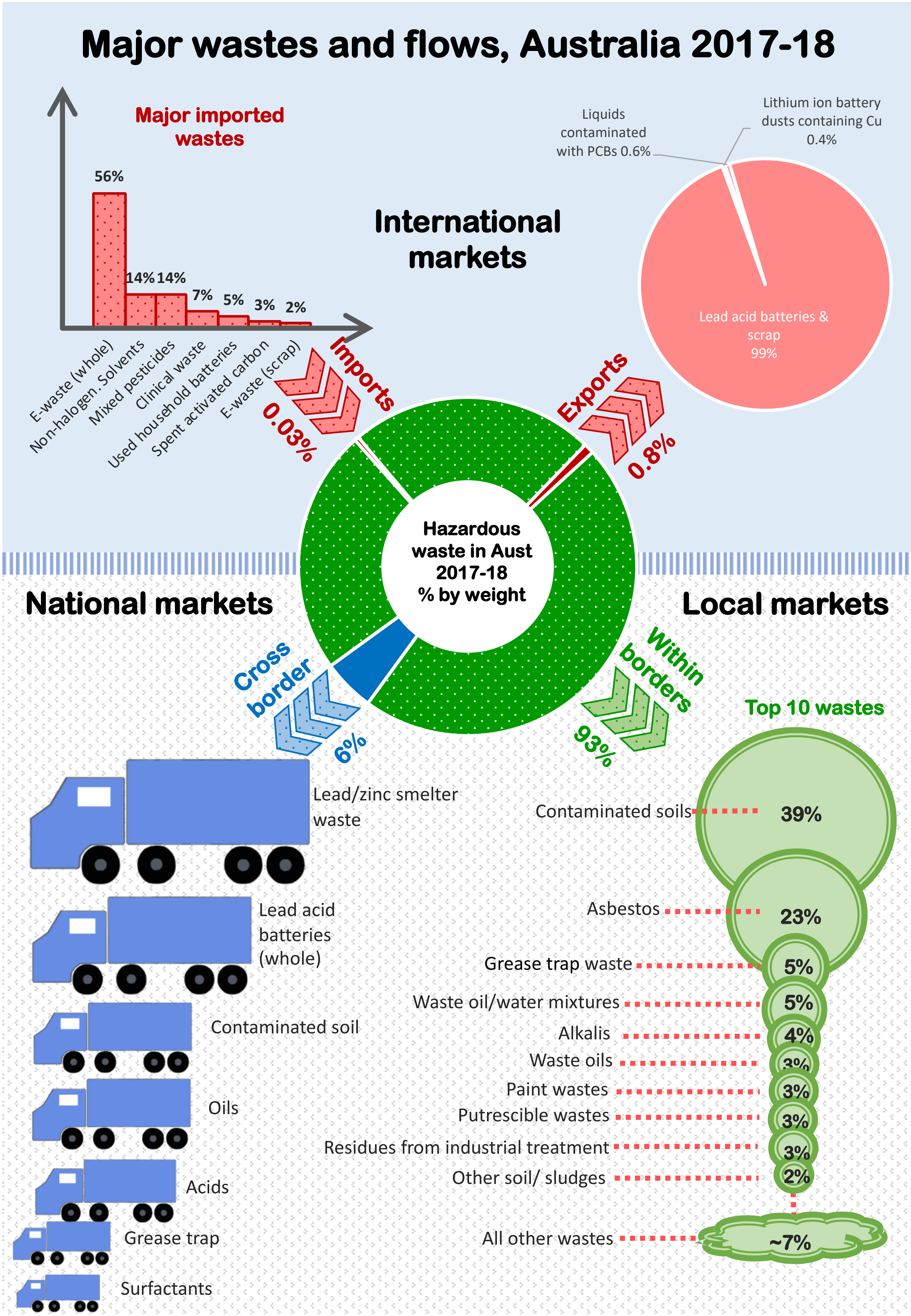
1. Contaminated soils [35%]
2. Asbestos [21%]
3. Tyres [6%]
4. Grease trap wastes [6%]
5. Waste oils [4%]
6. Oil/water mixtures [4%]
7. Alkalis [4%]
8. Animal effluent & residues [3%]
9. Paints, resins, inks, organic sludges [3%]
10. Zinc compounds [2%]



The majority of these wastes were sent to landfill (57%). Another 19% was recycled, 10% underwent specific treatment (to reduce or remove the hazard) and 10% was stored for accumulation and later release into management infrastructure.

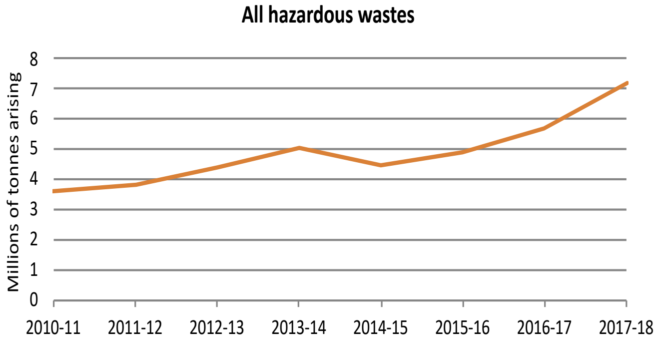
[+] Per- and poly-fluoroalkyl substances
[1] Excluding biosolids, due to their large tonnage and the unresolved and variable nature of their hazard classification.
[2] The *National Waste Report 2018* reports waste data for the 2016-17 year, whereas this report draws data from 2017-18

Hazardous waste in Australia moves in three sub-markets, each associated with different wastes and with distinct scales and issues of interest: **93%** of waste is generated in, and managed by, infrastructure located *within a state/territory border*; **6%** crosses *interstate borders*; and **1%** is *exported* to or *imported* from overseas for management in specialised infrastructure not available (or not economically viable) within the generating jurisdiction.



Hazardous wastes trended strongly upwards in the eight years to 2017-18, increasing at a compound annual growth rate of approximately 9% per year since 2013-14, when all jurisdictions began supplying equivalent data.

This is despite downturns in some types of heavy manufacturing and aluminium smelting, which has reduced traditional wastes like alkalis, aluminium industry wastes and various inorganic chemical residues.



Contaminated soils and asbestos waste have driven this trend, with nationally unprecendented increases in 2017-18. Contaminated soils have increased beyond the recent historical range.

Like the coal-seam gas (CSG) industry of the last decade, ***new wastes are emerging*** due to new industries, new chemicals emerging as contaminants within wastes or increased regulatory understanding of chemical hazards. The most pressing of these are PFAS[3] wastes, and the observations from 2017-18 are that:

- PFAS-contaminated soils have started to arise, volumes of which are projected to become very large and have restricted management options
- PFAS-containing firefighting foams or aqueous film-forming foams (AFFF) have emerged (for disposal) in quantities higher than previously thought
- the environmental risk of PFAS contamination, through the pathway of biosolids applied to land, is real and unmitigated by current and proposed Australian regulatory tools.

Issues with the illegal and unlicensed management of flammable wastes have emerged in Vic in the last 12 months, which indicate risks in traditional hazardous waste management infrastructure such as:

- Illegal storage of hazardous wastes, outside of tracking, licensing or other regulatory controls, could be more significant than previously expected. The network of illegal hazardous waste/ chemical storage warehouses found in Melbourne in December 2018 warehoused 19,000 tonnes of predominantly flammable chemicals, according to media reports. If 19,000 tonnes were flammable chemicals, equivalent to the waste categories that describe such wastes, this find would be equivalent to 85% of the 2017-18 Vic arisings of flammable wastes. This is an alarming level of illegal 'leakage' from the Vic hazardous waste regulatory system, noting that waste sources could equally be from illegal cross border movements into Vic.
- Storage rates in Vic and NSW are reasonably low across all hazardous wastes, which suggests a well-functioning market. Yet 19,000 tonnes were found illegally warehoused. Storage rates in Qld are twice as high, WA three times as high and SA, unusually, were almost five times as high. Noting that both Vic and NSW EPAs have carried out compliance campaigns in this area in the last six months, storage demand (or lack of appropriate infrastructure capability) suggests there remains a high risk of individual sites storing waste above licence limits.

[3] Per- and poly-fluoroalkyl substances

1. Introduction

1.1 Project background and context

Hazardous Waste in Australia 2019 (HWiA 2019) was commissioned by the Australian Government Department of the Environment and Energy (DoEE) and conducted by Blue Environment Pty Ltd, in association with Ascend Waste and Environment Pty Ltd. Building on the inaugural 2015 and subsequent 2017 versions of the report, it seeks to provide:

- an authoritative and current snapshot of hazardous waste generation and management in Australia that includes sources, amounts, trends, types, pathways and fates of hazardous waste in 2017-18
- analysis and commentary on issues with particular wastes and their management, to improve understanding of where policy and management systems work well and where barriers may exist to more effective management of Australia's hazardous wastes.

In addition to the *Abbreviations and glossary section*, ***Appendix A*** provides key terminology definitions critical to understanding of the data and interpretation applied to this project. These include conceptual, classification and coding approaches that will help explain the presentation of, meaning drawn from, and recommendations made from the information supplied in this report.

DoEE's engagement also required the delivery of the *Basel report 2017*, Australia's hazardous waste generation data from all jurisdictions reported to the Basel Secretariat in Geneva Switzerland for the reporting year 2017. Common data was used for both reporting requirements, in different formats, and is provided as ***Appendix B*** to this report.

Australia signed the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* (referred to hereafter as the Basel Convention) in 1992. The Convention regulates the movement of hazardous wastes across international boundaries and puts an onus on exporting countries to ensure that hazardous wastes are managed in an environmentally sound manner in the country of import, as well as in their own country. One hundred and fifty other countries had ratified the Basel Convention as at December 2002.

The Australian Government is obliged to submit an annual report to the Basel Secretariat containing the tonnages of hazardous wastes generated in the country each calendar year. This data provides a baseline and backdrop to discussions about Australia's progress with efforts to better manage its hazardous waste. The data must be reported using the Basel Convention's classification system known as 'Y-codes'. State and territory governments collect this data as part of their regulatory role in managing hazardous waste and its potential for impact on the environment and human health.

1.2 Project outputs

This report includes:

- data on hazardous waste sources (e.g. Australian and New Zealand Standard Industrial Classification (ANZSIC) codes)

- data on hazardous waste management, which includes both fates and pathways (as defined in **Appendix A**)
- historical trend analysis of hazardous waste arisings
- commentary on the data.

The analysis is underpinned by the Microsoft Excel data file, *National hazwaste data collation 2017-18*. This compilation contains hazardous waste data from all states and territories including:

- tonnes by waste type and financial year covering 2017-18 and historical data spanning several years (Qld's data set is the most extensive, reaching back to 1999-2000)
- data on the source industries that generated the hazardous waste (NSW, Qld, SA and Vic only)
- data on the ways hazardous waste was managed (NSW, Qld, SA, Vic and WA only).

The state codes for waste type, source and management vary. The collation file transforms them to a common platform for analysis. The common platform and transformation methods are described in the *Australian hazardous waste data and reporting standard – 2017 revision* ('the Standard').

1.3 Report structure

This report is structured as follows:

- An introduction to the project, its scope and context amongst the other related data projects (**Section 1**). This covers the approach used for the project including differences from its predecessor HWiA 2017 (**Section 1.4**).
- A national overview of the hazardous waste market, including players, pathways, waste flows and trends (**Section 2).**
- A national overview of hazardous waste arisings, sources and management for 2017-18 data, plus summary-level historical trends ranging as far back as jurisdictional data allows (**Section 3**).
- Investigation into wastes for which there are current and emerging challenges, including some that are not well-covered by tracking systems (**Section 4**).
- Summary of findings in the form of the report's key messages (**Section 5**).
- Recommendations (**Section 6**).
- Analysis of each of 28 waste groups in detail: describing the waste, its major sources, 2017-18 arisings, historical arisings trends, fate, and analysis and commentary to provide insight into issues that this data may uncover (**Section 7**).

The appendices to this report provide:

- A summary (in **Appendix A**) of key definitions that are critical to understanding of the data and interpretation applied to this project.
- Underlying data for this report in detail (**Appendix B**).
- Data sources, limitations and quality issues (**Appendix C**).

1.4 Project approach

Data from jurisdictional tracking systems was used extensively where available. Waste tracking systems in Qld, NSW, SA, Vic and WA require companies generating, transporting and managing hazardous waste to provide a record to government of each transaction to which they are a party. These systems were established to ensure hazardous waste is appropriately managed.

Data from these systems was collected, collated and analysed, together with other jurisdictional waste data. Data on quantities, sources and management were collated for 2017-18. Historical quantity data was also collected.

Details about data, terminology, waste groups and how they have been applied are discussed in ***Appendix A***, while data sources used and their respective limitations are discussed in ***Appendix C***.

1.4.1 Changes since the 2017 version

Hazardous Waste in Australia was first published in 2015 and updated in 2017. This third version is issued in accordance with the Department's planned biennial release schedule.

HWiA 2017 included significant changes over its predecessor including improvements and changes to data collection, classification, analysis and compilation methods and definitional approaches. This report is largely aligned with the method of 2017 with the following incremental improvements:

- J100 oils one of several wastes exempt from NSW Government waste tracking requirements if sent to a re-refining fate. This means there is limited data in the NSW tracking system for these wastes. HWiA 2019 uses the Commonwealth Product Stewardship for oil (PSO) program's annually reported oil rebate data to attribute a revised figure for NSW arisings. This provides more reliable (and significantly higher) estimates of waste oil arisings in Australia.
- After HWiA 2017 was completed, SA obtained, customised and adopted NSW's online waste tracking system. This has greatly improved data quality in SA and provided robust data about wastes imported into SA from interstate, which were previously indistinguishable from waste generated in SA. As a large net importer of hazardous wastes, SA's increased data visibility has boosted the reliability of interstate waste volumes recorded throughout this report.
- The extensive report sections on *Key terms and definitions* (HWiA 2017 Section 2.2) and *Data sources and limitations* (HWiA 2017 Section 2.3) have been moved to ***Appendix A*** of this report. This restructure has reduced the bulk of the early sections of the report, allowing the reader to navigate more directly to the key data and findings.
- Deeper analysis has been undertaken for the hazardous waste market by supplementing the national overview with brief characterisations of the two largest sub-markets, NSW and Vic.
- With the implementation of the PFAS (per- and poly-fluoroalkyl substances) National Environmental Management Plan (PFAS NEMP), this HWiA 2019 attempts to investigate the issues with PFAS and other POP (persistent organic pollutant) wastes more deeply, including, where possible, more probing estimates of potential waste arisings.

1.4.2 Waste generation versus arisings

Two slightly different terms are used to describe tonnages of hazardous wastes *arisings* and *generation*.

- ***Wastes arisings*** include all waste that is received by management infrastructure, and its recording in tracking systems may be somewhat duplicative because this could include:
  - wastes that have been generated in other jurisdictions but sent to one jurisdiction (imported) for management (tonnages could be duplicated in sender-state and receiving-state tracking systems)
  - wastes that have been sent to pathway infrastructure, such as storage or chemical or physical treatment (CPT), which could arise a second time when waste is subsequently sent to a (final) fate.
- Waste arisings are the best measure when assessing demand on management infrastructure, because 'multiple counting' is not problematic, since it is important to assess all impacts across the infrastructure set.
- ***Wastes generated*** focuses on where the waste was created and seeks to exclude the potential for multiple counting by:
  - scouring jurisdictional tracking system data for imports from other jurisdictions and reallocating them to the source jurisdiction
  - estimating double-counting in and out of infrastructure by using proportions sent to short-term storage and (out of) CPT, then subtracting these from total arisings estimates.
- Waste generation is the best measure to use when assessing cause-mechanisms of waste – what type of facilities or activities produce it and where it comes from.

These terms and others critical to hazardous waste data understanding are further defined in ***Appendix A***.

2. Hazardous waste market overview

The Australian hazardous waste market is structured according to the following roles:

- *Generators* of hazardous waste: typically, but not exclusively, industrial, mining and infrastructure development operations. This is a diverse and geographically distributed group.
- *Managers* (sometimes known as 'treaters') of hazardous waste: Those companies that manage certain hazardous wastes, either through:
  - intermediate activities, or *pathways*, *en route* to a fate, such as: transfer, storage and/or CPT
  - *fate* infrastructure, the ultimate destination of the waste within the management system, where types of fate include recycling, energy recovery, long-term storage and disposal.
- *Transporters* of hazardous waste: made up of:
  - primarily, the logistics fleets of major hazardous waste management companies
  - distinct waste logistics operators, of typically smaller fleets and, on occasion, single vehicle operators.

State government regulators shape behaviours and structures through regulatory controls such as licensing waste producing and receiving facilities, licensing/ permitting waste transport vehicles, and operating waste tracking and consignment authorisation systems. The Australian Government authorises hazardous waste movements into and out of the country, via the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*.

This section introduces the Australian hazardous waste market, structures within it, key waste flow mechanisms and high-level trends in the nature, volume and management of these wastes. Section 3 has some overlapping themes with this section, but focuses on the waste data aspects of market activity.

2.1 The Australian market

Four major waste companies manage most of the hazardous waste generated in Australia, and tend to offer services for a broad range of wastes:

- Cleanaway Waste Management (formerly Transpacific Industries)
- Toxfree[4]
- Veolia Environmental Services (Australia)
- SUEZ Recycling & Recovery (formerly SITA).

Cleanaway has the most operations nationally (30 facilities that can receive hazardous wastes), mostly covering transfer and storage, CPT and some recycling (typically of oils/ oily waters). Cleanaway also operates the Ravenhall landfill, Melbourne's largest (putrescible waste) landfill, which accepts large quantities of low hazard waste of the 'N' category (mainly low-level contaminated soils, N120 and asbestos, N220).

[4] Toxfree was purchased by Cleanaway in 2018 but each continues to operate under its own corporate brand. They are discussed in this report as distinct entities.

Toxfree is next in terms of numbers of facilities nationally, with approximately 17 sites that, like Cleanaway, mostly cover transfer/storage and CPT. Toxfree also has specialist infrastructure such as a POPs destruction facility and an e-waste reprocessor that can handle mercury.

Veolia has approximately 12 facilities nationally with hazardous waste management capability, with a focus on liquid waste treatment plants for oils/ oily waters, grease trap waste and other industrial liquid wastes such as those from the food and meat processing industries. Veolia's sites are spread between CPT, transfer/ storage, landfills (both hazardous and low-hazard wastes), clinical waste treatment and organics (biological treatment).

SUEZ has approximately six facilities equipped to specifically manage hazardous waste nationally. Importantly, these include the two largest dedicated hazardous waste landfills in Australia: Lyndhurst in Victoria and Kemps Creek in NSW. They also have some relatively small CPT capacity and two dedicated clinical waste facilities, and are a major player in non-hazardous wastes, operating seven advanced resource recovery facilities and eight major composting operations.

All four major waste management companies operate large fleets of waste transport vehicles.

In approximate terms, excluding the vast volumes of low-level contaminated soils and asbestos[5], these four major companies receive in the order of 80% of national hazardous waste flows (by tonnage) into their facilities. When it comes to non-hazardous waste, they also account for a similar percentage of facility numbers in Australia. But the wide variability in hazardous waste types and technologies allows a relatively large number of facilities outside of the 'big four'. Previous work by the authors (BE et al 2017[6]) suggests that the big four cover just 30% of the number of hazardous waste sites.

Next tier (medium sized) operators tend to be either location-specific or technology/waste specific and include:

- JJ Richards, which has multiple sites managing various wastes, including major waste oil re-refining capabilities
- large private landfill operators such as Hanson and Remondis
- specialised companies such as SteriHealth and Ace Waste (clinical waste), Geocycle (solvents, paints, oils, other liquid organics recycling into fuels), Renex (contaminated soils remediation), Regain and Weston Aluminium (spent potliner [SPL] and other aluminium smelting wastes), waste oil re-refining and treatment companies (such as Southern Oil Refining), various large composters, specialist lead recovery facilities (from used lead acid batteries and leaded glass from e-waste) such as Nyrstar, Hydromet and EPSR, and smaller specialists such as CMA Ecocycle (mercury recovery) and solvents/ paints recovery facilities such as Solveco and Planet Paints.

[5] While sites receiving these lower-hazard wastes may also be dominated by the 'big four', such landfills are numerous, very widely dispersed and receive predominantly non-hazardous waste, so are difficult to quantify in this market context.

[6] Blue Environment and Ascend Waste and Environment (2017), *Hazardous Waste in Australia 2017*, prepared for the Department of the Environment, available from: http://www.environment.gov.au/protection/publications/hazardous-waste-australia-2017

The remainder of the market is made up of many small players, with either specific niches (such as hazardous waste packaging recyclers, which deal largely in steel drums) or niche geographic coverages (such as the large number of small regional landfills, that typically may take limited hazard wastes, such as low-level contaminated soils or asbestos).

The e-waste recycling industry comprises operators of varying size. E-waste recycling is a peripheral hazardous waste management operation because, although intact equipment is typically not considered hazardous waste, separated or shredded components may be. Some components contain hazardous materials such as lead, contained in high concentrations in so called 'leaded' or 'CRT' glass, used in cathode ray tubes for long-superseded televisions and computer monitors. E-waste recyclers are being considered for inclusion in facility licensing regimes in some jurisdictions, in recognition of these potential hazards. They are included as an infrastructure type in the analysis of this report but, in terms of historical arisings at least, they would have received minimal material that would have been classified as hazardous waste.

Some other industrial operations are important in hazardous waste management because, while not their main focus, they accept hazardous waste because it is useful to them or as a commercial adjunct. These include cement kilns, metal smelters, clinical waste incinerators and potentially steel and brick works, utilising various wastes for fuel value such as SPL, pesticide wastes, off-spec paints and even tyres. These can be considered examples of industrial ecology at work, or part of the 'circular economy', a term more recently used to describe extracting maximum value from resources whilst in use, then recovering and regenerating products and materials at the end of each service life.

2.1.1 Jurisdictional market analysis #1: NSW

The hazardous waste market in NSW follows a pattern similar to the national market, with three of the four major players similarly placed in terms of market volume share. In NSW, Veolia is a small player, reducing the big four to the big three. These plus other important players are summarised below:

- Cleanaway has 11 facilities, comprising various CPT operations (including the long-standing Homebush Bay liquid waste facility and basic oil recovery facilities) and storage sites:
  - Cleanaway Operations at Albury (licence no. 1224)
  - Cleanaway Operations at Padstow (licence no. 2977)
  - Cleanaway Operations at Homebush Bay (licence no.4560)
  - Cleanaway Operations at Glendenning (licence no.6091)
  - Cleanaway Operations at Kooragang (licence no.6124)
  - Cleanaway Operations at Unanderra (licence no. 10251)
  - Cleanaway Industrial Solutions at Unanderra (licence no. 10771)
  - Cleanaway Operations at Tamworth (licence no.10804)
  - Cleanaway Equipment Services Orange (licence no. 6089)
  - Cleanaway Equipment Services Queanbeyan (licence no. 6090)
  - Cleanaway Wagga Wagga (licence no. 12945).
- Toxfree has five facilities comprising:
  - Tox Free South Windsor (licence no. 4602)
  - Tox Free St Marys 3 sites: licence nos. 12628 (Christie St), 12943 (Links Rd) and 20271 (Charles St)
  - Tox Free Heatherbrae (licence no. 13255).

- Suez has four facilities comprising:
  - Suez Elizabeth Drive Landfill, Kemps Creek (licence no. 4068), which is the only restricted solid waste landfill in NSW
  - Suez Forest Hill (licence no. 10060)
  - Suez's liquid waste facility at Rosehill (licence no. 12242)
  - Suez Revesby (licence no. 20026).
- Veolia has one facility – Veolia Environmental Services at Cameron Park (licence no. 13212).

Of the remaining NSW waste management operators, the most significant by remaining volume are:

- Lead acid battery infrastructure: EPSR, formerly Renewed Metal Technologies (Bomen) is by far the largest, ARA (Alexandria) much smaller and Hydromet similar, with the latter more a 'breaker' of batteries rather than refining/ smelting operation.
- A wide range of further oil CPT and oil/water treatment/ recycling facilities.
- BlueScope Steel and IXOM, both using industrial ecology to deal with acid and alkaline waste solutions.
- A number of drum reconditioning companies.
- Niche market operators that deal with solvents and related liquid wastes (Solveco and Solvents Australia), clinical wastes (Daniels Health) and aluminium industry wastes (Weston Aluminium and Regain) and a small number of composters.

There are more than 100 local landfills scattered across the state, which tend to manage low level contaminated soils and asbestos. The facility analysis above excludes these landfills because, although they are licensed to receive low-level contaminated soil and asbestos, their waste receipts would typically be dwarfed by non-hazardous waste acceptance volumes.

2.1.2 Jurisdictional market analysis #2: Vic

The hazardous waste market in Victoria is also similar to the national market, with the four major players similarly placed in terms of market volume share. Key Vic hazardous waste infrastructure is provided via the following company/ facility breakdowns:

- Cleanaway has nine facilities comprising:
  - 2 CPT facilities
  - 2 storage/ transfer facilities
  - 1 organics processing facility (grease trap specific)
  - 1 oil re-refining facility
  - 3 closed storage/ transfer facilities, awaiting future management decisions.
- Toxfree has three facilities comprising:
  - 1 CPT facility
  - 1 closed CPT facility, awaiting future management decisions
  - 1 e-waste facility.
- Veolia has three facilities comprising:
  - 1 CPT facility
  - 1 oil/water treatment facility
  - 1 organics processing facility (grease trap specific).
- Suez has two facilities (this includes the only dedicated Cat B PIW (hazardous waste) landfill in Victoria (Taylors Rd Lyndhurst) plus a separate soil treatment facility under construction at their Lyndhurst landfill).

- Of the remaining waste managers there are:
  - 2 other CPT facilities
  - 3 clinical waste incinerators and 1 clinical waste (chemical treatment) facility
  - 3 other e-waste facilities (noting that there are also a number of much smaller capacity facilities as well)
  - 2 thermal technology soil treatment facilities (including the potential for POPs management) in the establishment phase
  - 4 tyre recyclers
  - 7 other oil water treatment plants
  - 11 drum recyclers (hazardous waste packing facilities)
  - 1 mercury recycler
  - 2 solvent/paint/organic chemicals reclamation facilities
  - 5 more closed facilities awaiting future management decisions, including:
    - 2 processing facilities related to aluminium smelting industry waste
    - 1 oil/water treatment facility
    - 1 storage/ transfer facility
    - 1 drum recycler (hazardous waste packaging facility).

An important Victorian-specific aspect of the market is the number of developments underway at present involving soil remediation facilities, using thermal technologies. Renex has a thermal waste treatment facility licensed to treat contaminated soils (mainly pyrolysis recovery of hydrocarbons); EnviroPacific has a new thermal contaminated soil treatment facility similar to Renex; and Suez, in partnership with Ventia, is developing a major soil treatment plant at the Lyndhurst landfill site, for thermal desorption/ cement stabilisation of contaminated soils. All three have large design capacities, well in excess of current volumes of contaminated soil sent to the Lyndhurst landfill.

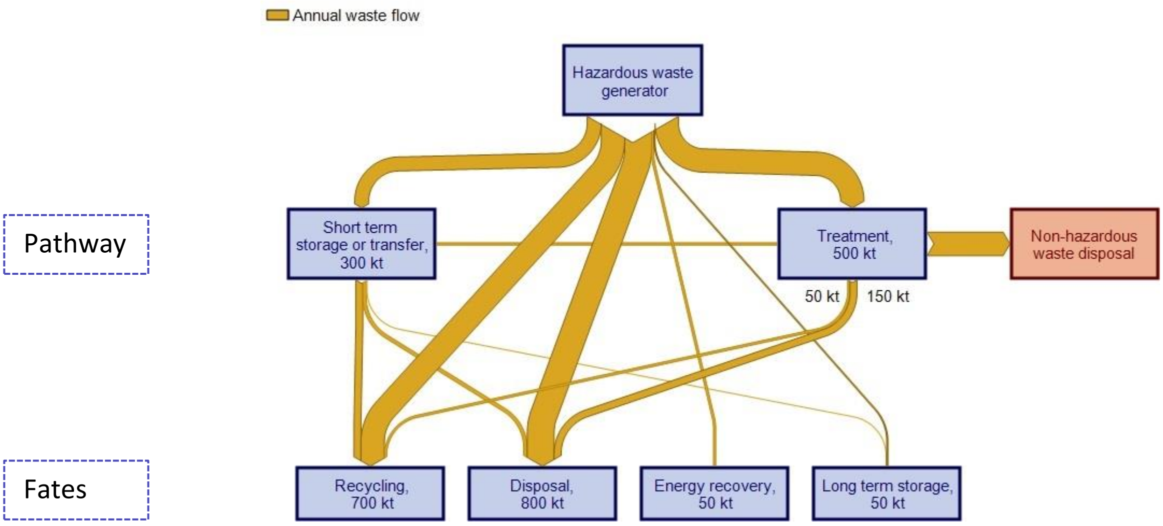
Indications are both Renex and EnviroPacific appear to be positioned as future POPs thermal destruction facilities of scale, relying more on the destructive capacity of their afterburner rather than the pyrolysis kiln. The Suez/ Ventia soil treatment capability is still under development, and is not currently licensed. Indications are that it would use similar technology to Renex and EnviroPacific, so could also be an option for POPs-contaminated solid waste, such as PFAS-contaminated soils.

2.2 Waste pathways: from generation to final fate

Hazardous waste differs from non-hazardous waste in that its inherent hazard can require treatment via an additional step, or steps, in the path to its end fate. The stratified nature of waste producers and management infrastructure can also lead to storage and accumulation points along the way.

Generic hazardous waste flows in the market are explained by the Sankey diagram of Figure 1. (The diagram is simplified – only ‘treatment’ is shown as producing hazardous waste outputs and waste tonnages are nominal.) The thickness of flow lines indicates at a glance the relative significance of each flow and their interconnectivity, from a waste’s generation through its journey to a final fate, which may include intermediate steps such as storage/accumulation or treatment to reduce hazard, separate sub-components for further recycling or immobilise the waste.

Figure 1 A simplified schematic of annual flows of hazardous waste (tonnage figures are indicative only for the purpose of illustrating relative amounts)



Source: BE, REC, AWE: Australian hazardous waste data and reporting standard (2017)

Pathways for some particular wastes are fixed, such as high-hazard wastes in NSW and in Victoria, which cannot be placed in landfill until their hazard has suitably been reduced or contained, via treatment. In other cases, though, pathways are fluid and may be influenced by cost, available infrastructure, or a lack of awareness of alternatives by key decision-makers. Examples of wastes for which varied paths are available include:

- Mineral (lubricating) oils: Through the Australian Government's Product Stewardship for Oil (PSO) program, waste vehicle oils that are re-refined for reuse can attract a rebate for the refiner, to encourage oil recycling. While this results in large volumes of recycled oil, there are still significant quantities going to more rudimentary oil treatment facilities or energy recovery, options lower on the waste hierarchy[7].
- Wastes from used cooking oils and fats extracted from wastewater prior to discharge: Otherwise known as grease trap waste, these materials can be treated and reused or even composted, but poor mixing/ contamination practices (such as with mineral oils) can remove these options, leaving only lower hierarchy (and lower value) alternatives such as energy recovery.
- Solvents: Similar to the above examples, waste solvents can be economically recycled through distillation/ regeneration if kept segregated, but when inappropriately combined with other solvent and oil wastes this path may be closed, leaving only energy recovery or other forms of stabilisation available.
- Asbestos: Waste asbestos-containing materials can be safely and relatively inexpensively stabilised, handled and managed in landfill. However, segregation difficulties or historical management can see asbestos materials contaminate excavated soils or other demolition waste, rendering them all asbestos-contaminated waste. For example, soils contaminated with low levels of petroleum, and suitable for remediation at a low cost, would then become treated as more intractably contaminated, filling up valuable space in hazardous waste landfill.

[7] A set of priorities for the efficient use of resources, where avoidance of the waste is the most preferable and disposal of the waste the least. The waste hierarchy is applied in policies of environmental regulators throughout Australia.

- Flame retardant chemicals in plastics: Brominated flame retardants (BFRs) are added to hard plastic product casings (such as TVs and computers) at high concentrations, to protect against fire. While plastic recycling is an otherwise high-hierarchy choice, if plastics containing BFRs are mixed with non-BFR plastics and on-sold as recyclate for new (completely different) product manufacturing, re-entrainment of BFRs can inadvertently occur back into products where flame retardancy is not required, such as infant toys (DiGangi 2015), creating human health problems and perpetuating the cycle of environmental pollution.

In each of these examples, management is influenced by decisions at different stages of the path to a final fate. Poor choices, in some cases before the waste even enters the hazardous waste management 'system', can unnecessarily lock out options that are higher on the waste hierarchy from later adoption. These poor choices result in lost opportunity and additional overall waste management cost. Some examples are considered in the waste-specific analyses of Section 7.

2.3 Geographic flows – what wastes go where?

The hazardous waste market, for some wastes, can be national or even international, due to niches of technology or scale that do not lend themselves to local replication. This means that hazardous waste may require transport in the following ways to reach its required management destination:

- within jurisdictional borders
- across jurisdictional borders
- via shipment to international facilities, both as exports out of Australia and imports into Australia.

This creates three hazardous waste sub-markets, with distinct scales and issues of interest in each case. Approximate volumes and the nature of each are shown in Table 1.

Table 1 Comparison of hazardous waste sub-market types, 2017-18

Sub-market type	Total arisings (tonnes)	Major wastes and % of sub-market type	
Total flows involving Aust hazardous waste producing & receiving facilities 2017-18			**7,870,000 tonnes**
Cross international borders[8]			
Imports 0.03% of total flows	**2,160 tonnes**	Waste electrical & electronic equipment (whole) (various inc. D220) [56%] Non-halogenated solvents (G160) [14%] Mixed pesticides (H100) [14%] Clinical waste (R100) [7%] Used household batteries (D150) [5%] Spent activated carbon (N205) [3%] Waste electrical & electronic equipment (scrap) (various inc. D190) [2%]	
Exports 0.8% of total flows	**62,200 tonnes[9]**	Used lead acid batteries waste/scrap (D220) [99%] Waste liquids contaminated with PCBs (M100) [0.6%] Dust from waste lithium ion batteries (D190) [0.4%]	
Cross state/territory borders[10]			
Total cross-border flows (2017-18)			**482,000 tonnes** 6% of total flows
Into ACT[11]	1,276 tonnes	942t from NSW : N codes [70%], R [24%], J [6%] 292t from SA: J [100%] 26t from Qld: J [100%] 17t from Vic: J [100%]	
Into NSW	119,376 tonnes	78,032t from Vic: D220 [56%], B100 [26%], D300 [6%], K110 [3%], N205 [3%] 16,800t from Qld: D220 [85%], N100 [3%], N120 [3%], M100 [2%], F100 [2%], J160 [2%] 9,551 from ACT: K110 [53%], J100 [27%], N120 [8%], J120 [3%], R100 [3%] 9,416 from SA: D220 [87%], B100 [7%], D300 [3%] 5,275 from WA: D220 [93%], J100 [3%], N120 [3%] 172t from NT: J120 [54%], D220 [24%], J100 [22%] 130t from Tas: J100 [67%], C100 [16%], D300 [12%]	
Into NT[11]	752 tonnes	619t from WA: J [100%] 133t from Qld: J [100%]	
Into Qld	86,130 tonnes	81,785t from NSW: N120 [38%], J100 [20%], M250 [13%], N220 [9%], D220 [4%], K110 [4%] 2,213t from NT: J100 [55%], J120 [37%], T140 [4%], M160 [2%] 1,521t from Vic: C [69%], J120 [13%], M160 [10%] 398t from Tas: D230 [35%], D110 [19%], J120 [10%], 'Other' [30%] 117t from SA: J120 [36%], M100 [30%], H [11%], M160 [9%] 82t from WA: H [78%], J100 [22%] 13t from ACT: M100 [100%]	
Into SA	248,836 tonnes	212,617t from Tas: D230 [71%], D220 [29%] 21,726t from Vic: D230 [84%], D220 [6%] 11,343t from NSW: D230 [87%], D220 [7%] 2,671t from NT: J100 [21%], C [20%], N100 [18%], F [12%], D220 [11%], J120 [8%], R [5%] 456t from WA: D220 [37%], J100 [23%], J120 [23%], F [14%] 24t from Qld: J120 [100%]	
Into Tas[11]	4,437 tonnes	4,112t from Vic: D wastes [97%], F [3%] 325t from WA: D wastes [100%]	

[8] Data supplied by DoEE for the 2017 year (as part of Australia's annual report to the Basel Convention)

[9] Excludes tyres, as these are specifically not deemed hazardous waste under the Basel Convention

[10] In 2019, the NT undertook analysis of its interstate waste exports and found figures that are inconsistent with those reported here. The cause of the discrepancies is not known and should be investigated in subsequent versions of this report.

[11] Data taken from the National Environment Protection Council (NEPC) 2016-17 Annual Report, (because the 2017-18 NEPC report will not be available until later in 2019), available at: http://www.nepc.gov.au/system/files/resources/afef0a22-b780-41ed-ab10-416162bb201e/files/nepc-annual-report-2016-17.pdf

Sub-market type	Total arisings (tonnes)	Major wastes and % of sub-market type	
		(238t was also received into Tas from external territories, which are excluded from this table)	
Into Vic	19,477 tonnes	13,555t from NSW: F [25%], J120 [17%], Other K [13%], N120 [8%], N205b [7%], G [5%], C [3%] 2,380t from SA: J120 [34%],F [33%], N120 [13%], G [7%], R [7%] 1,833t from Qld: F [61%], G[10%], J100 [8%], N120 [7%] 1,125t from WA: H [30%], F [25%], G [18%], R[12%], J100 [5%] 573t from Tas: G [20%], J100 [14%], N100 [12%], M100 [10%], F [8%] 8t from ACT: F [50%], D120 [50%] 2t from NT: D150 [71%], R120 [29%]	
Into WA	1,400 tonnes	1,400t from NT: K100 [36%], unspecified [24%], N120 [20%], D300 [15%], B100 [4%]	
Within state/territory borders[12]			
		Total within-jurisdiction flows 2017-18	**7,320,000 tonnes** 93% of total flows
Produced and managed in jurisdiction		Top 10 wastes (by weight, kilotonnes) produced and managed within jurisdictions: 1. Contaminated soils (N120) [39%] – 2,736 kt 2. Asbestos containing material (N220) [23%] – 1,608 kt 3. Grease trap wastes (K110) [5%] – 385 kt 4. Waste oil/water mixtures (J120) [5%] – 369 kt 5. Alkalis (C100) [4%] – 304 kt 6. Waste oils (J100 & J160) [3%] – 228 kt 7. Paints, resins, inks, organic sludges (F) [3%] – 225 kt 8. Other putrescible / organic wastes (Other K) [3%] – 197 kt 9. Industrial treatment residues (N205b) [3%] – 186 kt 10. Other soils/ sludges (Other N) [2%] – 148 kt	

Table 1 shows that the bulk of the market volume (93%) is managed within the Australian jurisdiction that the waste is generated in. However, each sub-market type is different, with distinct scales and issues of interest in each case. Each can be summarised as:

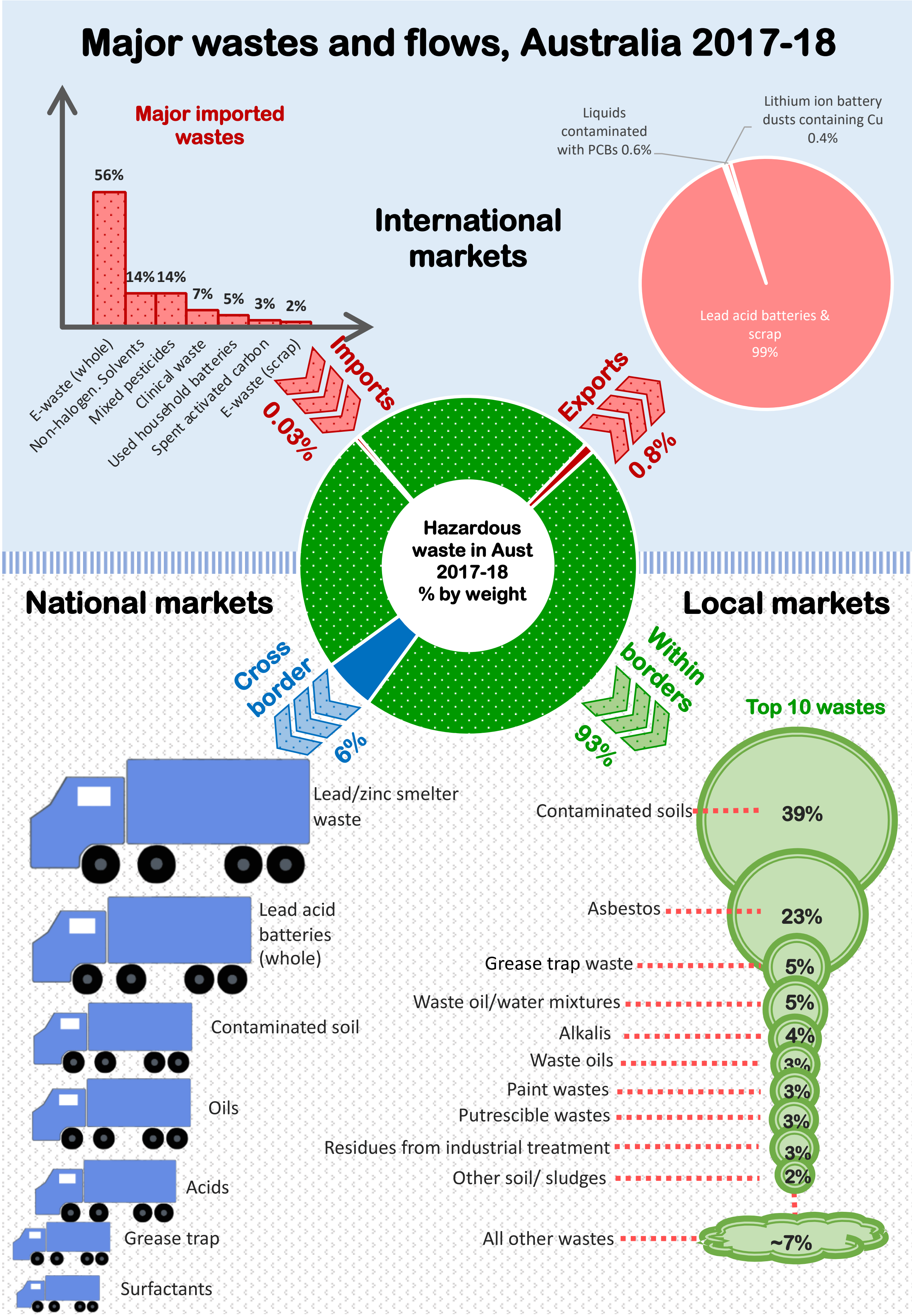
- International imports:
  - small overall and includes a narrow group of wastes (typically from regional neighbours, where suitable management facilities are not present)
- International exports:
  - relatively small overall and also a narrow group of wastes
  - individually, these can be sizeable: for example, 61,600 tonnes of lead waste and scrap derived from used lead acid batteries (ULABs)
- Cross state/territory borders:
  - account for only 6% of total waste flows but clear national market pathways exist for some wastes
  - large volumes of lead and zinc smelter wastes are sent from Tas to SA – these dwarf within-state management for these wastes and represent 44% of all hazardous wastes that move across borders in Australia
  - NSW infrastructure dominates the management of used lead acid batteries and salty wastes like metal smelting slags and dross
  - contaminated soils moving from NSW to Qld (31 kt) were the next largest cross-border movement after zinc and lead in 2017-18
  - significant volumes (by cross border standards) of asbestos waste (7 kt) was also sent from NSW to Qld, which is likely to be asbestos contaminated soils
  - in total, exports of hazardous waste from NSW to Qld have grown from 29kt in 2014-15 to 82kt in 2017-18, a 3-fold increase

[12] Total (within jurisdiction) hazardous waste arisings = Total arisings - Cross state/territory borders arisings

  - a significant proportion of acid wastes are exported from Vic to NSW
  - outside of WA, national arisings of waste solvents are mostly managed in Vic infrastructure
  - pesticide and other organohalogen wastes are sent to either Qld or Vic for destruction or blending prior to destruction
  - in summary, Tas is the largest interstate exporter of waste in Australia at 44% of all interstate movements, followed by NSW and Vic at around 22% each.
- Within state/territory borders:
  - the top 10 wastes by tonnage make up 93% of all waste produced and managed within a jurisdiction's border
  - the largest waste flow, this market includes typical large-volume wastes, where economies of scale are large enough (and sophistication of technology is simple enough) to enable state-based markets to operate
  - these wastes are generally lower on the hazard scale (except for asbestos).

These characteristics are summarised in the infographic of Figure 2 overleaf, which uses various visual approaches to (very approximately) convey relative scales of waste tonnage arising into each sub-market.

Figure 2 Major wastes and flows, Australia 2017-18



3. Data analysis – overview

The primary data for this report is provided in the accompanying Microsoft Excel data file, *National hazwaste data collation 2017-18 – HWiA*, which was compiled from jurisdictional data submitted from tracking systems (NSW, Qld, SA, Vic WA) and Basel workbook templates (ACT, NT and Tas).

Data was collected in six-monthly blocks, allowing aggregation by either 2017-18 financial year or 2017 calendar year. The bulk of the analysis in this report is based on the 2017-18 financial year data set, to align with historical trend data and to be consistent with the other financial year data needs laid out in Table 43 (in ***Appendix C***). The difference between calendar year collation and financial year collation is typically minor overall, but can vary from waste to waste.

This section presents 2017-18 data collated for waste generation, sources and management (fate and pathway infrastructure), plus historical trends in arisings, as a national overview. Detailed investigation of these data for individual waste groups is provided in Section 7.

3.1 Overall waste generation and arisings

Hazardous waste arisings data for Australia has been collected, collated and presented in detail, in Appendix B as follows:

- ***Appendix B (Section B.1)*** provides 2017-18 national hazardous waste generation data, at the detailed classification level of 72 codes set out in the National Environment Protection ((Movement of Controlled Waste between States and Territories) Measure (referred to here as 'the NEPM').
- ***Appendix B (Section B.2)*** provides the 2018 Basel report data, in Basel Y-codes, as well as in six-monthly blocks to allow totals to be added by financial year.

A snapshot of national hazardous waste generation in Australia in 2017-18, by waste group for each jurisdiction[13], is given in Table 2. Biosolids are included in the table but, given the large tonnage they contribute and the unresolved and variable nature of their hazard classification, the totals at the bottom of the table are provided both inclusive and exclusive of biosolids. Table 3, 2017-18 hazardous waste arisings, is also provided for context, particularly since HWiA 2015 and earlier years' data compilations used hazardous waste arisings rather than adjusted generation to estimate annual waste production figures. Figure 3 reproduces the information of Table 2 (excluding biosolids) in graphical form, allowing easier identification of the relative scale and contribution of each waste group, including jurisdiction proportions.

Figure 4 provides a similar graphical breakdown but at the finer grained level of NEPM 75 waste type. Figure 5 and Figure 6 also present tabulated data in graphical form, as total hazardous waste generation per jurisdiction, both including and excluding biosolids.

[13] In 2019, the NT undertook analysis of its interstate waste exports and found figures that are inconsistent with those reported here. The cause of the discrepancies is not known and should be investigated in subsequent versions of this report.

Table 2 Adjusted generation of hazardous waste by waste group, Australia 2017-18 (tonnes by jurisdiction)

Code	Description	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	AUSTRALIA
A	Plating & heat treatment	0	134	0	4,527	36	0	0	767	5,464
B	Acids	0	4,035	28	11,096	2,004	15	45,384	1,101	63,664
C	Alkalis	5	12,888	146	170,237	18,825	10	8,816	57,770	268,698
D110	Inorganic fluorine (spent potliner)	0	12,348	0	11,930	4	3,767	6,363	1	34,413
D120	Mercury & compounds	1	72	3	121	110	0	64	32	404
D220	Lead and compounds	41	13,842	0	30,034	10,069	61,048	54,403	6,490	175,926
D230	Zinc compounds	0	9,912	0	341	9	151,536	18,358	240	180,398
D300	Non-toxic salts	0	19,698	0	8,288	823	21	8,830	37,598	75,258
Other D	Other inorganic chemicals	0	241	0	3,271	129	305	888	158	4,993
E	Reactive chemicals	0	71	0	45	8	3	38	3	168
F	Paints, resins, inks, organic sludges	10	12,425	396	12,854	3,265	66	19,481	166,787	215,283
G	Organic solvents	12	4,190	22	2,560	470	69	2,935	2,790	13,048
H	Pesticides	0	1,529	9	395	935	0	550	575	3,993
J100 & J160	Oils	947	126,390	3,538	38,190	19,219	41	67,656	64,497	320,478
J120	Waste oil/water mixtures	277	69,938	714	128,028	20,482	94	30,959	33,082	283,573
K110	Grease trap wastes	4,917	98,209	3,062	104,472	46,465	6,504	117,339	46,585	427,553
Other K	Other putrescible / organic wastes	0	60,974	1,851	85,410	2,061	3,932	42,422	47,542	244,192
M100	PCB wastes	29	1,468	0	2,304	8,387	48	2,257	32	14,525
M160	Other organic halogen compounds	0	125	23	42,321	11	23	929	275	43,707
Other M	Other organic chemicals	0	17,457	11	2,254	293	4	2,510	543	23,072
N120	Contaminated soils	787	696,915	8,686	988,781	182,769	12,711	761,715	4,519	2,656,884
N205a	Biosolids	94,880	316,266	31,627	347,892	126,506	31,627	490,212	142,320	1,581,328
N205b	Other industrial treatment residues	20	7,499	0	69,509	22,727	0	32,384	40,457	172,596
N220	Asbestos containing material	94,293	1,158,050	5,225	139,982	17,101	3,794	154,295	39,300	1,612,041
Other N	Other soil/sludges	23	16,418	35	15,850	2,226	26	16,638	363	51,579
R	Clinical and pharmaceutical	182	13,141	81	17,261	3,672	33	11,385	2,807	48,562
T140	Tyres	7,435	141,475	4,410	88,672	30,867	9,374	114,037	46,157	442,426
Other T	Other miscellaneous	40	2,688	0	583	1,885	50	679	51	5,976
Other	(Not classified)	0	15,650	0	63,087	17	0	0	87,871	166,625
Totals (inclusive of biosolids)		**203,900**	**2,834,052**	**59,865**	**2,390,294**	**521,377**	**285,101**	**2,011,526**	**830,711**	**9,136,825**
		2.2%	31%	0.7%	26%	5.7%	3.1%	22%	9.1%	
Totals (exclusive of biosolids)		**109,020**	**2,517,786**	**28,238**	**2,042,402**	**394,870**	**253,474**	**1,521,314**	**688,392**	**7,555,498**
		1.4%	33%	0.4%	27%	5.2%	3.4%	20%	9.1%	

Table 3 Arisings of hazardous waste by waste group, Australia 2017-18 (tonnes by jurisdiction)

Code	Description	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	AUSTRALIA
A	Plating & heat treatment	0	14	0	5,468	6	0	32	1,541	7,062
B	Acids	0	24,678	0	11,832	1,420	0	26,195	1,561	65,686
C	Alkalis	0	13,181	0	172,476	19,372	0	8,015	93,437	306,482
D110	Inorganic fluorine (spent potliner)	0	21	0	2,006	8	3,767	5,262	1	11,066
D120	Mercury & compounds	0	107	0	173	70	0	219	172	740
D220	Lead and compounds	0	80,816	0	20,513	65,826	0	9,342	1,545	178,041
D230	Zinc compounds	0	15	0	547	179,734	0	81	257	180,634
D300	Non-toxic salts	0	24,024	0	19,816	579	0	5,008	39,456	88,883
Other D	Other inorganic chemicals	0	411	0	3,694	137	0	1,035	137	5,415
E	Reactive chemicals	0	233	0	54	8	0	57	6	358
F	Paints, resins, inks, organic sludges	0	12,958	0	15,260	3,243	0	34,132	168,186	233,780
G	Organic solvents	0	2,092	0	5,760	397	0	7,867	4,515	20,631
H	Pesticides	0	274	0	2,519	943	0	1,431	1,438	6,606
J100 & J160	Oils	0	42,374	0	61,107	20,562	0	33,043	92,692	249,779
J120	Waste oil/water mixtures	0	70,482	0	177,584	20,022	0	59,415	46,454	373,956
K110	Grease trap wastes	0	9,259	3,062	136,871	47,169	6,504	117,074	71,731	391,670
Other K	Other putrescible / organic wastes	0	24	1,851	97,081	2,040	3,932	45,647	49,086	199,661
M100	PCB wastes	0	1,793	0	2,313	15,211	0	2,432	21	21,770
M160	Other organic halogen compounds	0	67	0	42,488	1	0	952	357	43,865
Other M	Other organic chemicals	0	7,220	0	14,877	368	0	3,189	961	26,615
N120	Contaminated soils	0	666,669	0	1,019,392	361,780	0	764,640	10,716	2,823,197
N205a	Biosolids	94,880	316,266	31,627	347,892	126,506	31,627	490,212	142,320	1,581,328
N205b	Other industrial treatment residues	0	9,784	0	85,612	23,442	0	31,099	41,847	191,784
N220	Asbestos containing material	94,293	1,150,988	5,225	150,036	17,302	0	154,520	39,296	1,611,660
Other N	Other soil/sludges	0	65,750	0	24,443	2,626	0	55,581	1,266	149,666
R	Clinical and pharmaceutical	0	1,630	0	20,152	4,712	0	16,100	2,680	45,274
T140	Tyres	7,435	42,364	4,410	52,853	13,739	9,374	0	0	130,175
Other T	Other miscellaneous	0	5,169	0	893	1,899	0	1,323	190	9,474
Other	(Not classified)	0	14,987	0	74,334	0	0	0	88,210	177,530
Totals (inclusive of biosolids)		**196,608**	**2,563,649**	**46,174**	**2,568,045**	**929,126**	**55,205**	**1,873,904**	**900,079**	**9,132,788**
		2.2%	28%	0.5%	28%	10%	1%	21%	10%	
Totals (exclusive of biosolids)		**101,728**	**2,247,384**	**14,547**	**2,220,153**	**802,620**	**23,578**	**1,383,692**	**757,759**	**7,551,461**
		1.3%	30%	0.2%	29%	11%	0%	18%	10%	

Figure 3 National hazardous waste generation, 2017-18 (tonnes) – by waste group and jurisdiction (excluding biosolids)

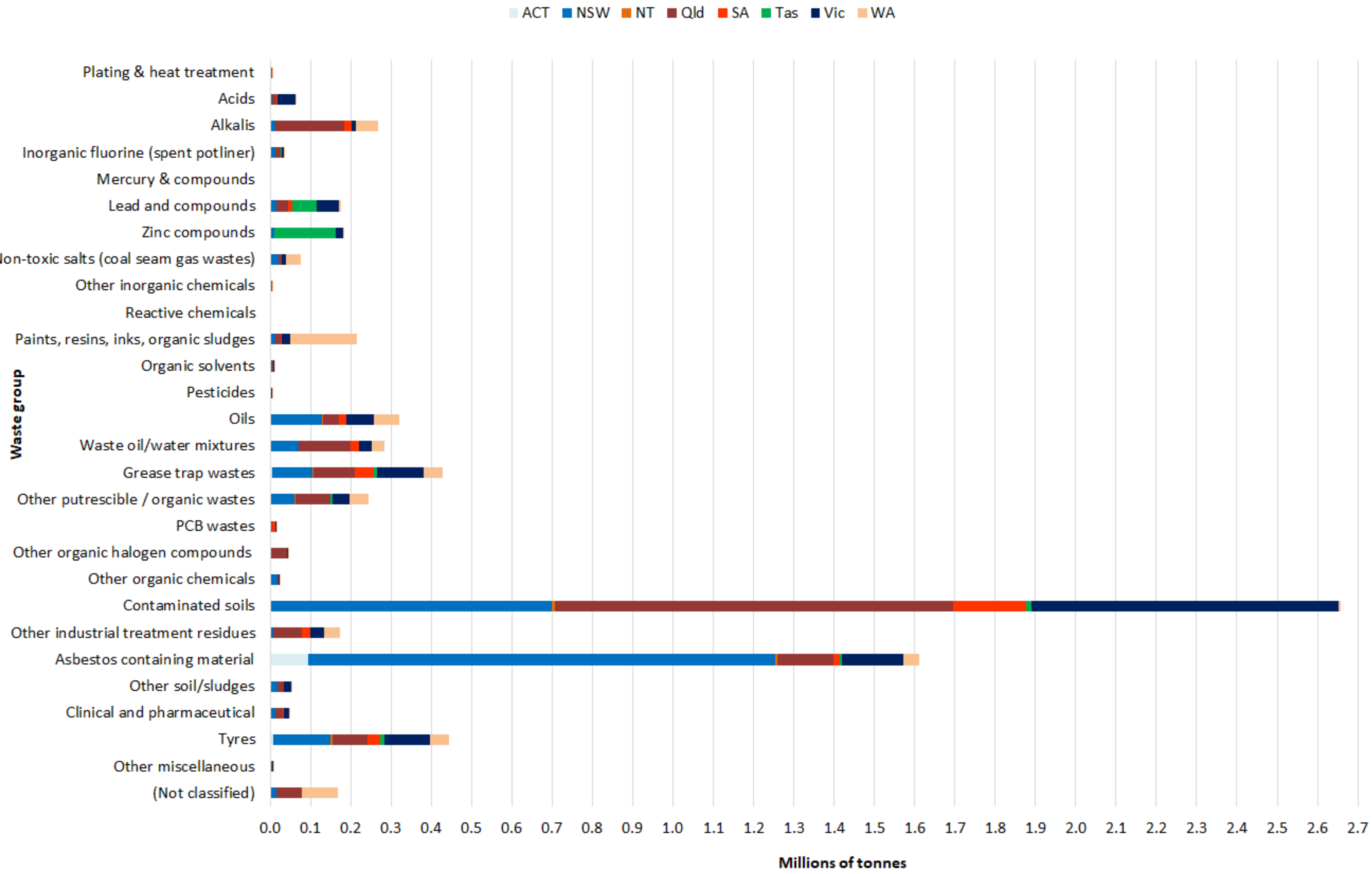


Figure 4 National hazardous waste generation, 2017-18 (tonnes) – by NEPM '75' waste types (top half of chart: linear display; bottom half: logarithmic display)

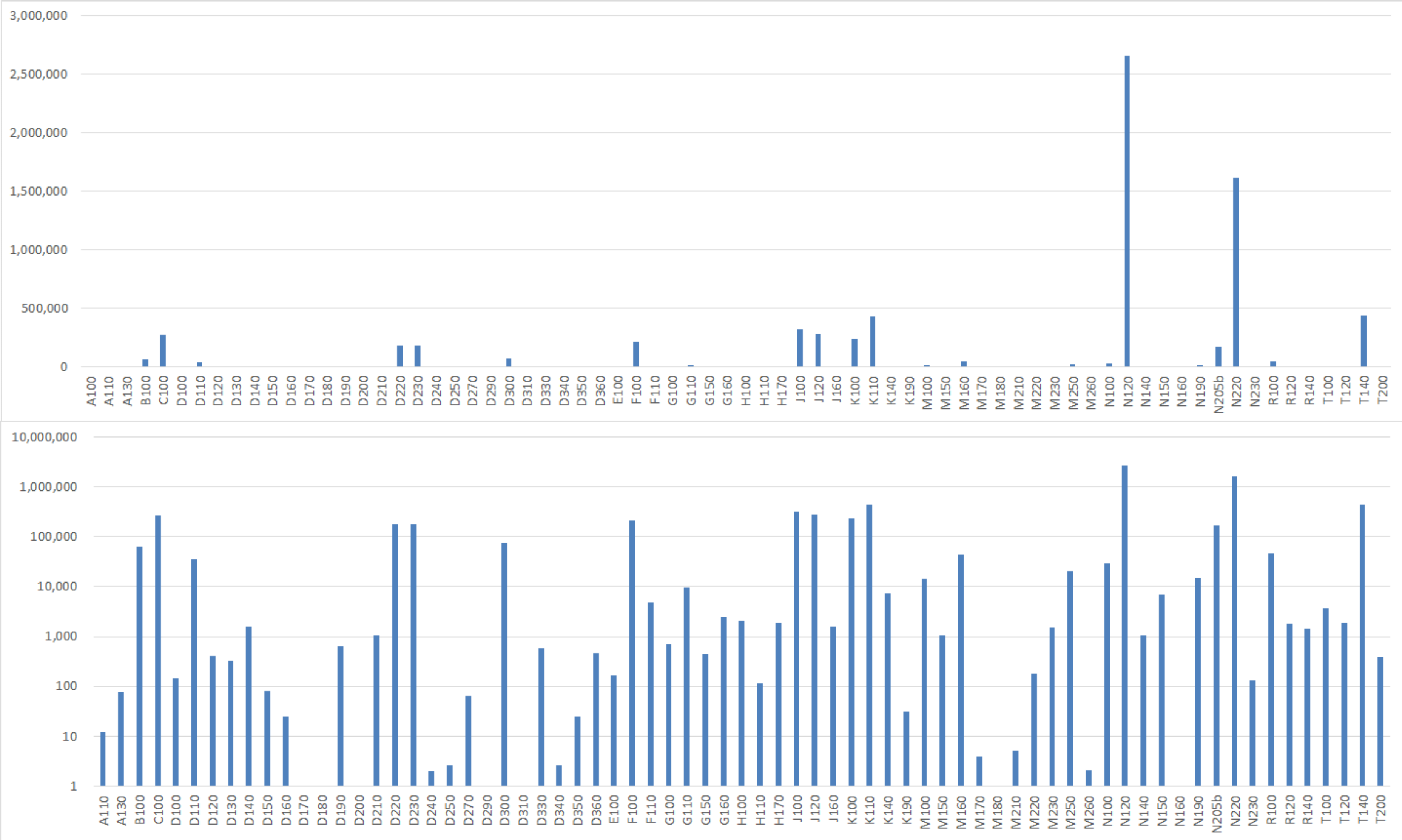


Figure 5 National hazardous waste generation, 2017-18 (tonnes) – by jurisdiction

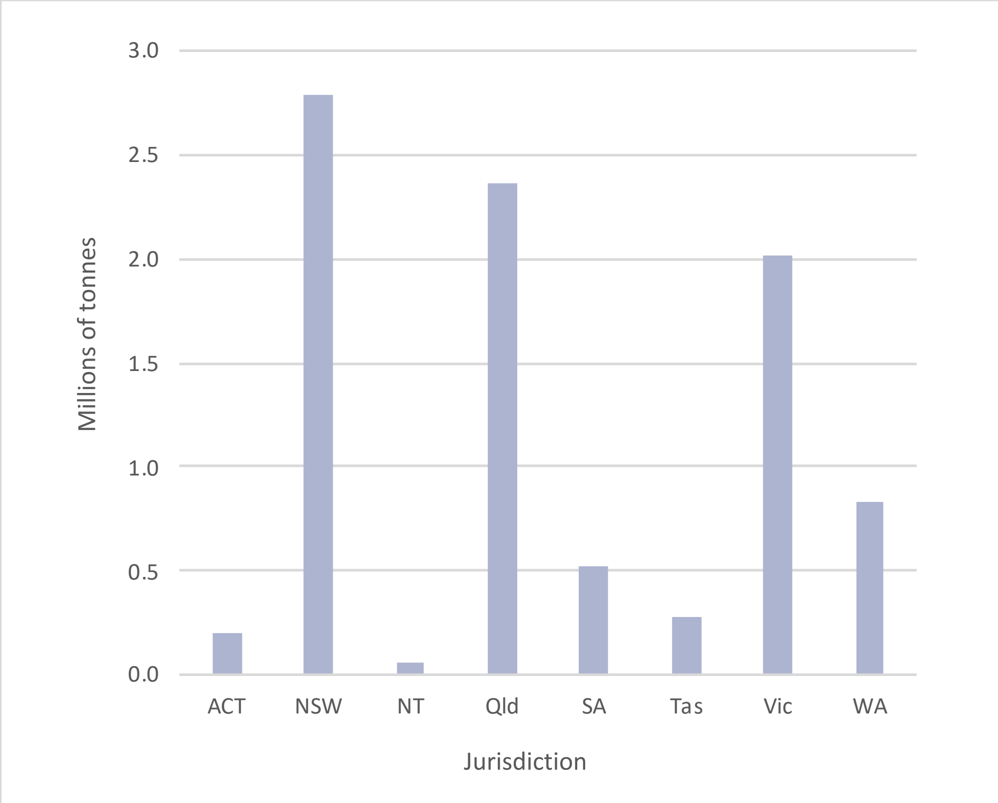
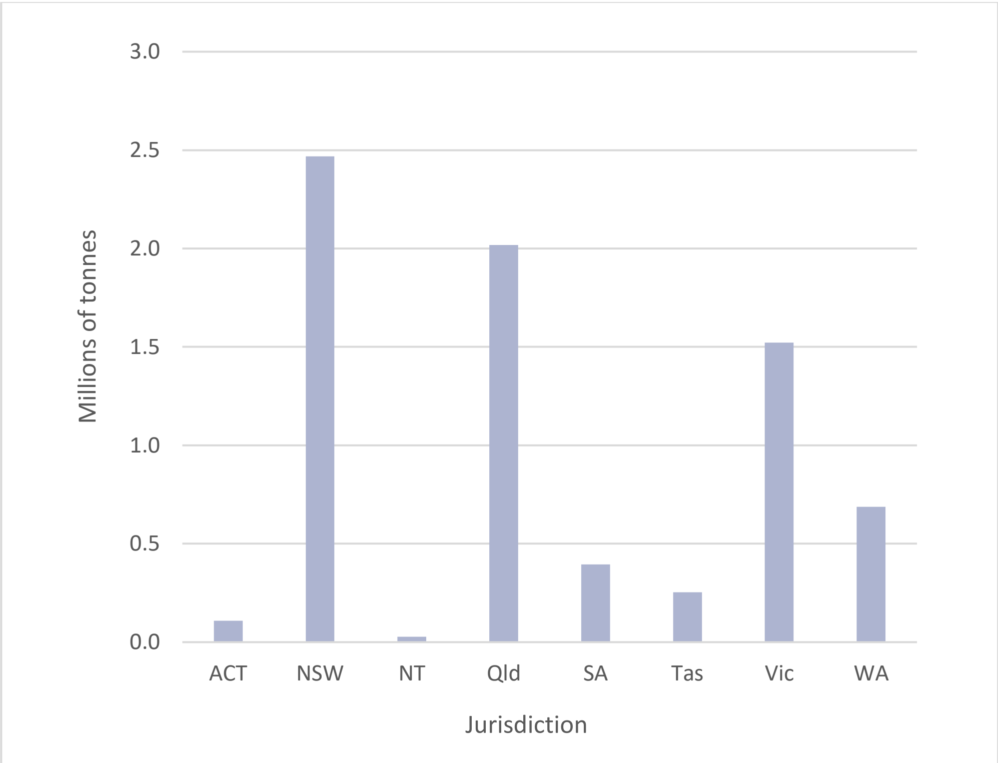


Figure 6 National hazardous waste generation, 2017-18 (tonnes) – by jurisdiction (excluding biosolids)



3.2 Sources of waste arisings

Source industry sector data, in the form of Australia and New Zealand Standard Industrial Classification (ANZSIC) codes, shows which industries generate each waste. This is vital to understand the nature of the market, what might be driving future trends (to enable meaningful projections) and where to focus policy initiatives designed at reducing waste at the source.

ANZSIC codes – generally called 'waste origin codes' on waste transport certificates- was sparingly provided in 2017-18, according to Table 4.

Table 4 Total percentage of tonnes for which source sector is known

Jurisdiction	% tonnes that has source data	Comment
ACT	N/A	No intrastate tracking system
NSW	-	86% of ANZSIC codes are 0 or blank
NT	N/A	No intrastate tracking system
Qld	-	Incomplete dataset for 2017-18 so not analysed for sources
SA	82	Best jurisdictional coverage of source sector data available for 2017- 18
Tas	N/A	No intrastate tracking system
Vic	17	Source sector data insufficiently populated to be useable
WA	0	No source data supplied

Only SA data was of sufficient coverage to attempt quantitative analysis in 2017-18, with 82% of all tonnes generated provided with an ANZSIC code identifier. This means that outside SA, source data recorded in 2017-18 waste transport certificates was not useful for analysis purposes. To counter this we have selectively applied a manual method of sorting tracking data for Vic and NSW. Specifically:

- For NSW and Vic data: (for key wastes) we manually sorted through individual waste transport certificates by major waste generator company names, sufficient to account for circa 80% of the tonnes, then allocated ANZSIC codes to these key generators using research and industry knowledge. Since this has been derived from a highly manual data parsing method, some waste groups' sources have been described in qualitative terms only.
- For Qld data: semi-quantitative analysis of waste transport certificate raw data, with a focus on correlating waste generating company names with their likely industry sectors, listing industry sources in approximate order of highest to lowest generation tonnages.
- For SA data: used source analysis directly from waste transport certificates, listing industry sources in order of highest to lowest generation tonnages.
- For WA data: no source data is supplied so no analysis can be undertaken, apart from that obtained from existing industry knowledge.
- National summary: A collation of the four state source sector lists, with indicative ordering of relative tonnages across the four jurisdictions.

Since Tas, NT and the ACT do not have tracking data no breakdown of their data by source was possible.

This approach has provided a reasonable level of clarity around source sectors. Sections 7.1 - 7.28 provide detailed analysis on a waste group by waste group basis and uses this state-based approach to list main sources, in tabular form. An example for *C. Alkali waste* is shown below.

Table 5 Example summary source analysis, for C Alkalis, 2017-18

NSW	Vic	Qld	SA	National Summary
• 78% Industrial Gas Manufacturing [1811] • 10% Iron Smelting and Steel Manufacturing [2110] • 3% Petroleum Refining & Petroleum Fuel Man. [1701]	• Petroleum Refining and Petroleum Fuel Man. [1701] • Metal Coating and Finishing [2293] • Other Motor Vehicle Parts Manufacturing [2319] • Waste Collection, Treatment and Disposal Services	• Ready-Mixed Concrete Manufacturing • Asphalt manufacturing • Oil & Gas Extraction (CSG/ LNG) • Aluminium refining	• Cement and Lime Man.	• Ready-Mixed Concrete Manufacturing • Asphalt manufacturing • Oil & Gas Extraction (CSG/ LNG) • Aluminium refining[14] • Cement and Lime Manufacturing • Industrial Gas Manufacturing • Petroleum Refining & Petroleum Fuel Man.

ANZSIC code sources of arisings data at the ANZSIC division, sub-division and group levels, as recorded in jurisdictional tracking systems, are provided for NSW, Qld, SA and Vic in the underlying data file, *National hazwaste data collation 2017-18 HWiA*, worksheet 'Sources'. However, as noted in the discussion in this section, jurisdictional input industry source data is mostly unreliable, and as such has not been presented in this report.

3.3 Historical trends in waste arisings

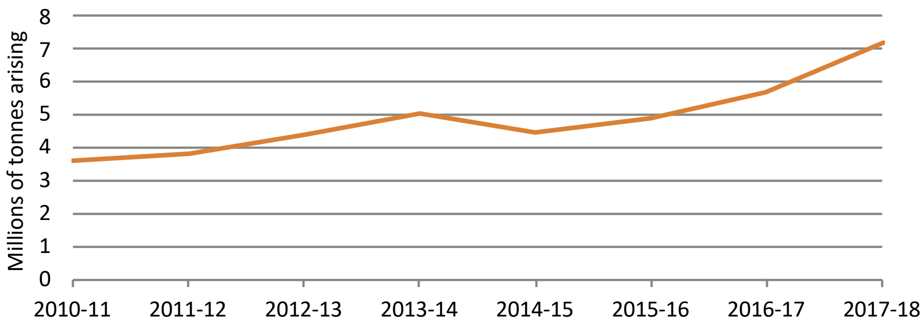
This section discusses trends of reported national hazardous waste arisings over the last eight years. While some jurisdictions have data that goes much further back, this period represents the point from which reasonable confidence in the national dataset can be assured.

A summarised view of this national trend is provided in Figure 7, with a jurisdictional breakdown in Figure 8. The arisings shown in Figure 7 are from tracking system data only, which means data from jurisdictions lacking tracking systems (Tas, ACT and NT) is not included. Also absent are some wastes not well collected by tracking systems such as tyres, grease trap waste and biosolids. A key influence on the NSW line in Figure 8 is the fact that NSW contaminated soils data has been supplied only from 2013-14 onwards. This essentially excludes useful analysis prior to that time (for NSW).

However, Figure 7 serves to illustrate the increasing trend, which calculates to a compound annual growth rate (CAGR) of 9.1% per year over the period 2013-14 to 2017-18.

[14] Although not reflected in WA tracking data, C100 alkali waste in WA is 'red mud', a high-volume waste from aluminium refining in the state.

Figure 7 Historical national arisings of all hazardous wastes tracked in Australia



As discussed in Section 7.21 and 7.24, and scrutinised in detail in Section 0, contaminated soils and asbestos dominate waste tonnages, and their massive recent increases have driven the increasing trend. This has been particularly so in the last two years, where contaminated soils have increased dramatically in Vic, Qld and SA, while the increase in NSW has been sharp compared to the previous year but only marginally above the highest year recorded. WA records very small volumes (the highest level of contamination only) so increases there are not as visible.

Figure 8 Historical national arisings of all hazardous wastes tracked in Australia, by jurisdiction

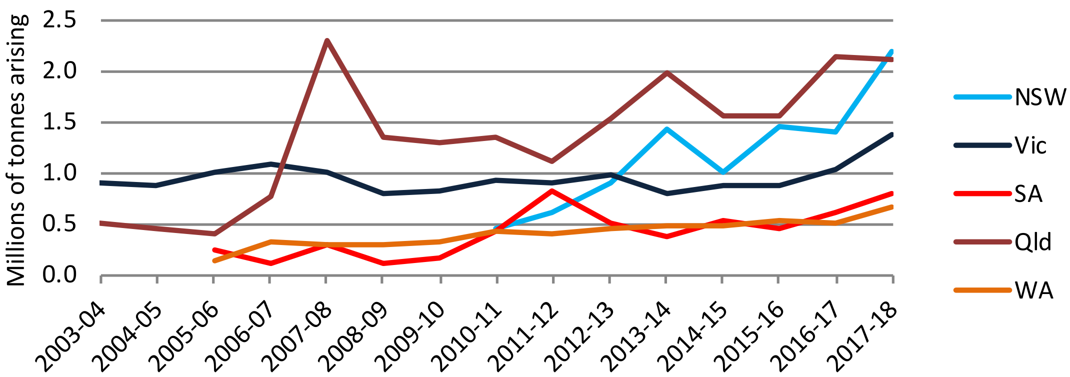
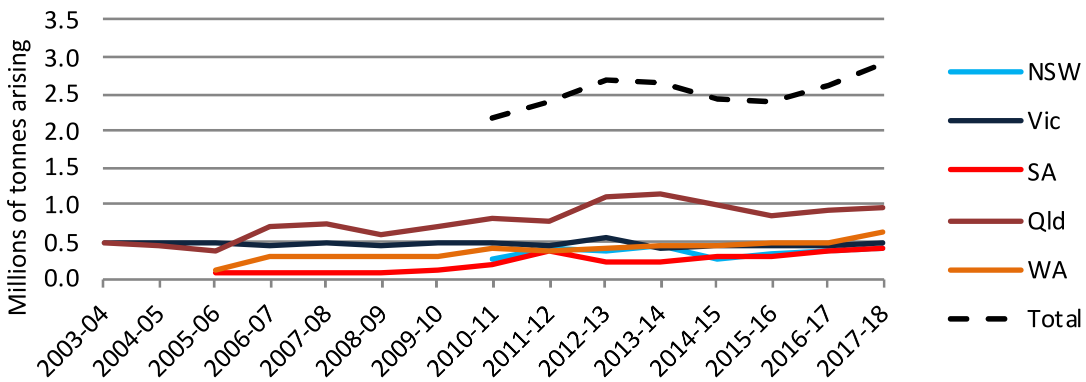


Figure 9 shows the national trend with contaminated soils and asbestos removed. It also shows a rising trend, with some fluctuation along the way, but less pronounced than in Figure 7. The CAGR when contaminated soils and asbestos are excluded (2013-14 to 2017-18) is 2.2% per year.

Figure 9 Historical national arisings of hazardous wastes tracked in Australia, by jurisdiction (excluding contaminated soils and asbestos)



Different factors affect different jurisdictions and their wastes are generated on different scales. Figure 10 and Figure 11 help visualise various jurisdictional contributions.

Despite the overall rising national trend, sectoral shifts have occurred, as industry mixes have changed over time. The Qld graph in Figure 10 is markedly influenced by the rise of the coal seam gas (CSG) industry from around 2009. the industry's drilling mud contributes large quantities of the waste group C alkalis.

As shown in Figure 11, Vic volumes have moved typically lower since about 2009-10, which may reflect some consolidation of the manufacturing sector post the global financial crisis[15], reducing 'traditional' wastes such as alkalis, spent pot liner, non-toxic salts, oily waters and a range of low-volume inorganic wastes. In WA and SA there has been consistent growth in non-soil/ asbestos wastes since about 2009-10, while NSW volumes have varied, but remain relatively flat overall.

Figure 10 Qld historical arisings of hazardous wastes tracked (excluding contaminated soils and asbestos)

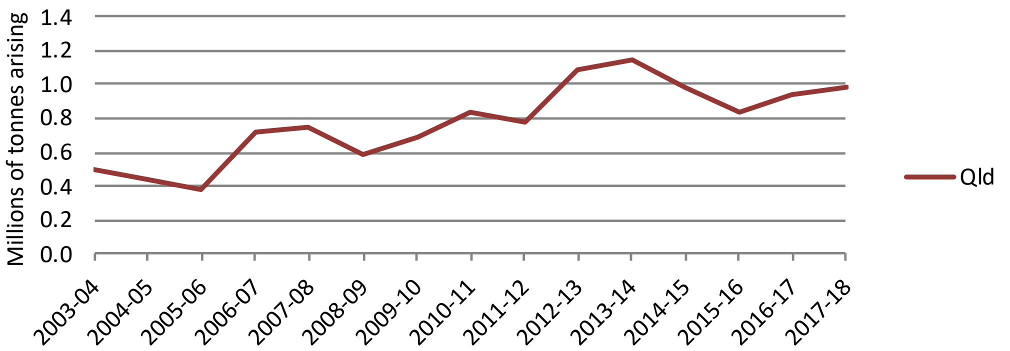
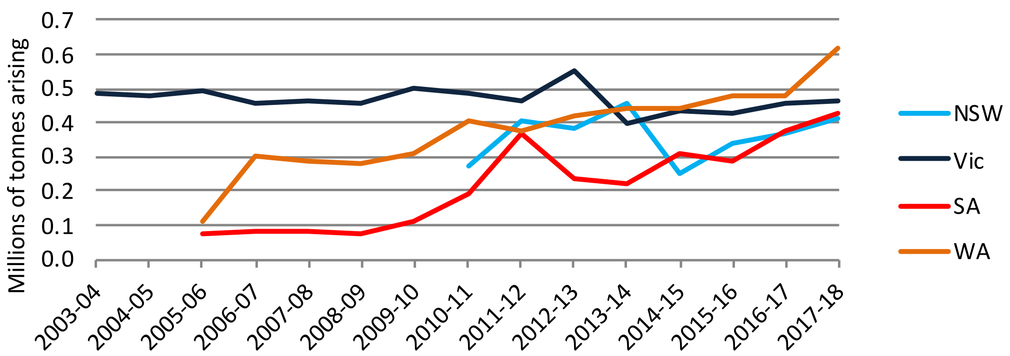


Figure 11 NSW, SA, Vic & WA historical arisings of hazardous wastes tracked (excluding contaminated soils and asbestos)



Steady increases in wastes aligned more directly to domestic activities and the broader economy, such as grease trap waste (from commercial kitchens), waste oils (from vehicle and other engine use), tyres and biosolids (noting their respective absences from Figure 7) are illustrative of population growth.

[15] The Parliament of the Commonwealth of Australia, The Global Financial Crisis and regional Australia, available at: https://www.aph.gov.au/binaries/house/committee/itrdlg/financialcrisis/report/gfc%20final%20report.pdf

The near-future market is likely to see significant further change due to emerging wastes (discussed in Section 4), and a tightening regulatory setting in response. POPs wastes, new concerns about the contaminants in biosolids (due to upstream chemical use) and changing battery technologies (such as the prevalence of lithium-ion) may generate hazardous wastes in significant volumes. In all three of these cases there is currently limited domestic treatment infrastructure.

3.4 Management of hazardous wastes (NSW, Qld, SA, Vic and WA)

Jurisdictional tracking system data has been analysed to determine the 'management types' (fates and pathways to them) recorded for each waste group in the data. Management data was comprehensively available from NSW, Qld, SA, Vic and WA. The overall tonnes by management in these jurisdictions was compiled for 2017-18 and is presented in Table 6 and Figure 12. These tonnages, in relative percentage terms within each waste group, are charted in Figure 13.

Although assembled at a much greater level of detail, some manipulation of Qld and Vic data was needed to establish uniform categories (based on the NSW and SA systems, the lowest common denominator of categories tracked). These management categories do not align neatly with those reported in national waste reporting (recycling, energy recovery and disposal).

The potential for multiple counting should be considered in interpreting the data. For example, waste that is sent to CPT may be landfilled after treatment and the tonnage would be included under both management categories in the figure below.

Figure 14, Figure 15, Figure 16, Figure 17 and Figure 18 plot overall tonnage by management for each of the five jurisdictions where such data is tracked, compiled for 2017-18. Note that the scales for each of these figures differs, to ensure appropriate detail can be seen in each.

Management data is examined in more detail by waste group in Section 7, where a greater understanding can be gained about the management of each waste for Qld and Vic in particular, which track management type to a much finer degree of categorisation.

Table 6 The management fate of tracked hazardous waste in NSW, Qld, SA, Vic and WA, 2017-18 (tonnes)

Code	Description	Recycling	Chemical/ physical treatment	Biodegradation	Landfill	Thermal destruction	Storage or transfer	Other
A	Plating & heat treatment	137	962	127	3,875	326	1,604	32
B	Acids	6,559	35,148	407	640		2,200	20,733
C	Alkalis	152,978	21,592	56,201	34,768	38	37,770	3,135
D110	Inorganic fluorine (spent potliner)	5,265	53	92	1,871		17	0
D120	Mercury & compounds	104	91	12	173	0	334	25
D220	Lead and compounds	89,130	63,556	595	6,211		6,357	12,192
D230	Zinc compounds	157,888	22,220	16	319		95	96
D300	Non-toxic salts	27,493	6,161	6,775	15,662	7	13,409	19,376
Other D	Other inorganic chemicals	87	1,173	554	2,568	0	962	72
E	Reactive chemicals	0	70		0		250	38
F	Paints, resins, inks, organic sludges	16,855	18,085	6,365	167,403	213	18,679	6,180
G	Organic solvents	3,798	4,262	2,792	45	166	8,131	1,437
H	Pesticides	1,116	371	48	1,506		2,710	854
J100 & J160	Oils	248,439	54,756	1,342	1,128	47	62,375	7,574
J120	Waste oil/water mixtures	47,262	174,326	23,247	11,622	424	108,087	8,987
K110	Grease trap wastes	61,686	64,548	169,090	3,610	33	59,860	23,277
Other K	Other putrescible / organic wastes	32,621	2,931	133,906	3,700	20	13,676	7,025
M100	PCB wastes	1,541	1,700	36	2,741	4	15,522	226
M160	Other organic halogen compounds	90	605		42,084	20	411	656
Other M	Other organic chemicals	920	10,242	4,183	2,142	6	3,649	5,474
N120	Contaminated soils	10,015	137,507	9,788	2,309,264	0	259,589	97,034
N205b	Other industrial treatment residues	13,315	73,408	43,929	31,443	28	20,777	8,884
N220	Asbestos containing material	97	1,189	280	1,503,863	40	3,982	2,690
Other N	Other soil/sludges	14,072	16,493	1,282	80,052	136	36,178	1,452
R	Clinical and pharmaceutical	18	13,348	156	5,031	17,141	8,173	1,409
T140	Tyres	34,353			191,655		6,251	89,838
Other T	Other miscellaneous	725	4,032	115	566	27	3,848	160
Other	(Not classified)	17,653	31,337	31,017	20,938	538	48,431	27,616
Total		**944,216**	**760,165**	**492,356**	**4,444,881**	**19,213**	**743,329**	**346,471**

Yellow shading indicates management types where a majority (the largest proportion) of a waste type has been sent

Figure 12 Management of tracked hazardous waste in NSW, Qld, SA, Vic and WA, 2017-18 (tonnes

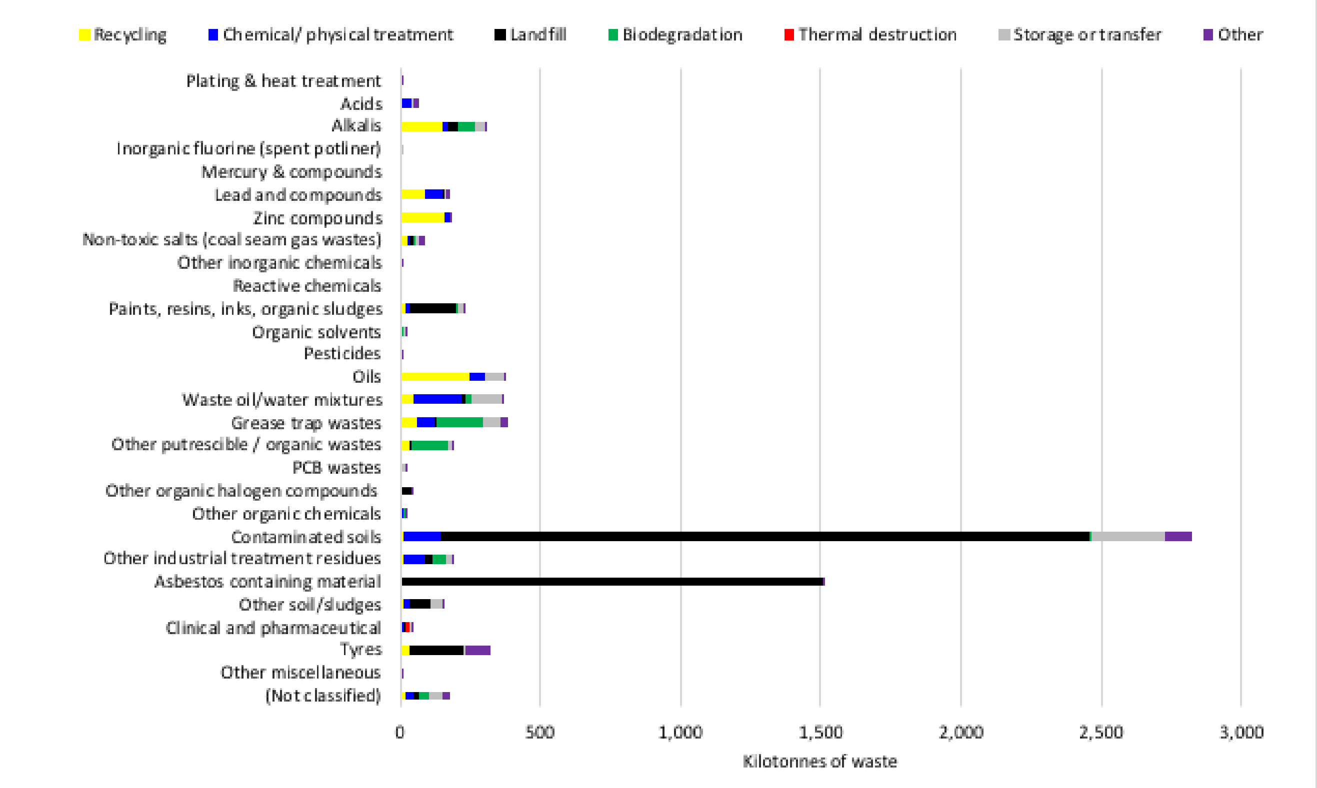


Figure 13 Management of tracked hazardous waste in NSW, Qld, SA, Vic & WA, 2017-18 (percentages)

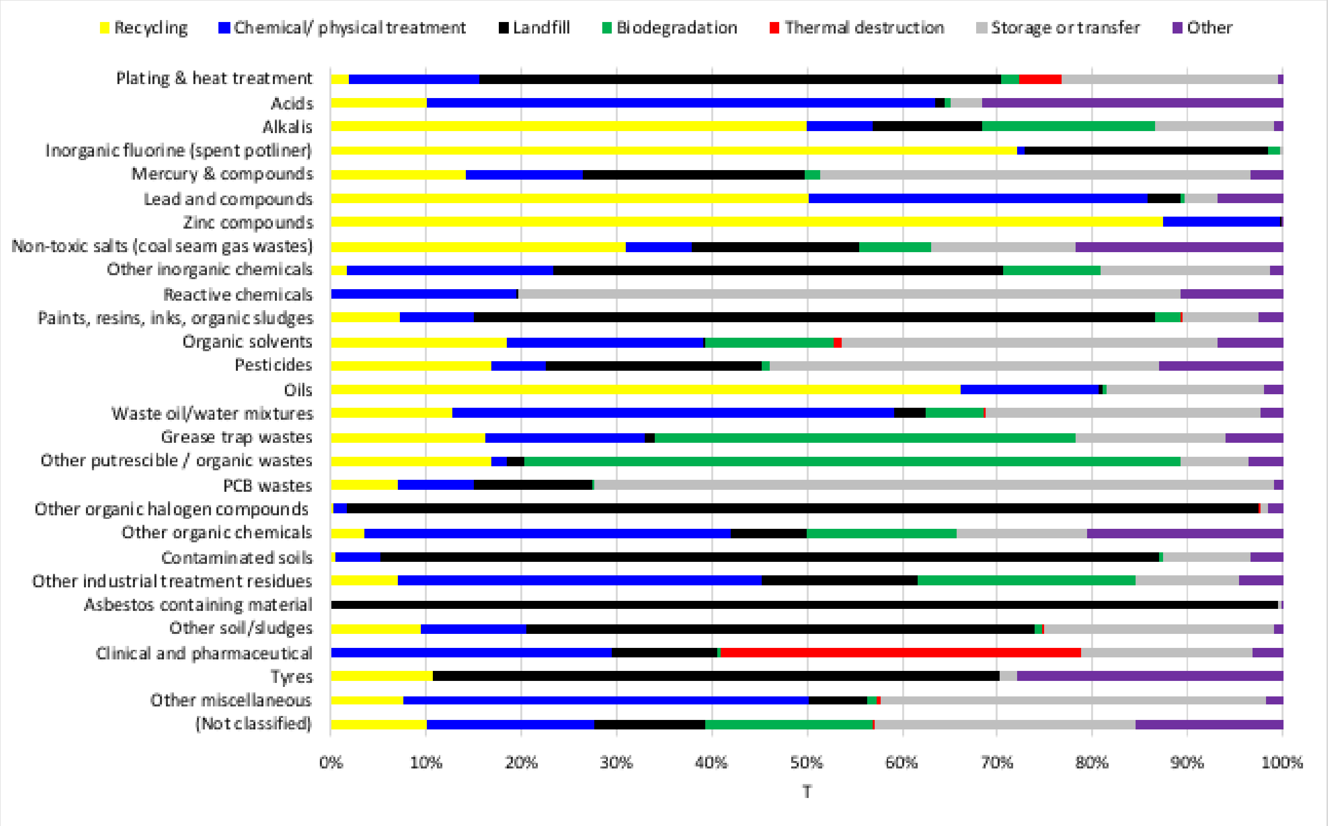


Figure 14 The management of tracked hazardous waste in NSW, 2017-18 (tonnes)

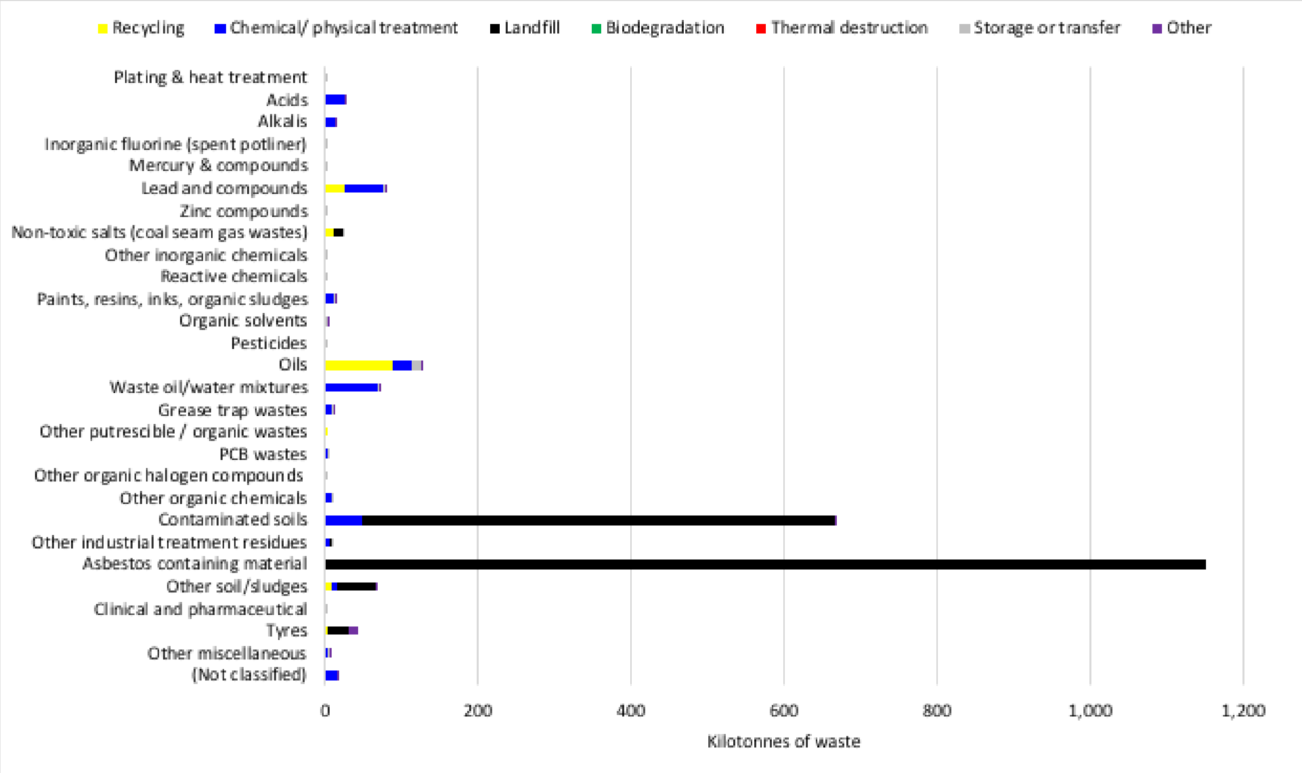


Figure 15 The management of tracked hazardous waste in Qld, 2017-18 (tonnes)

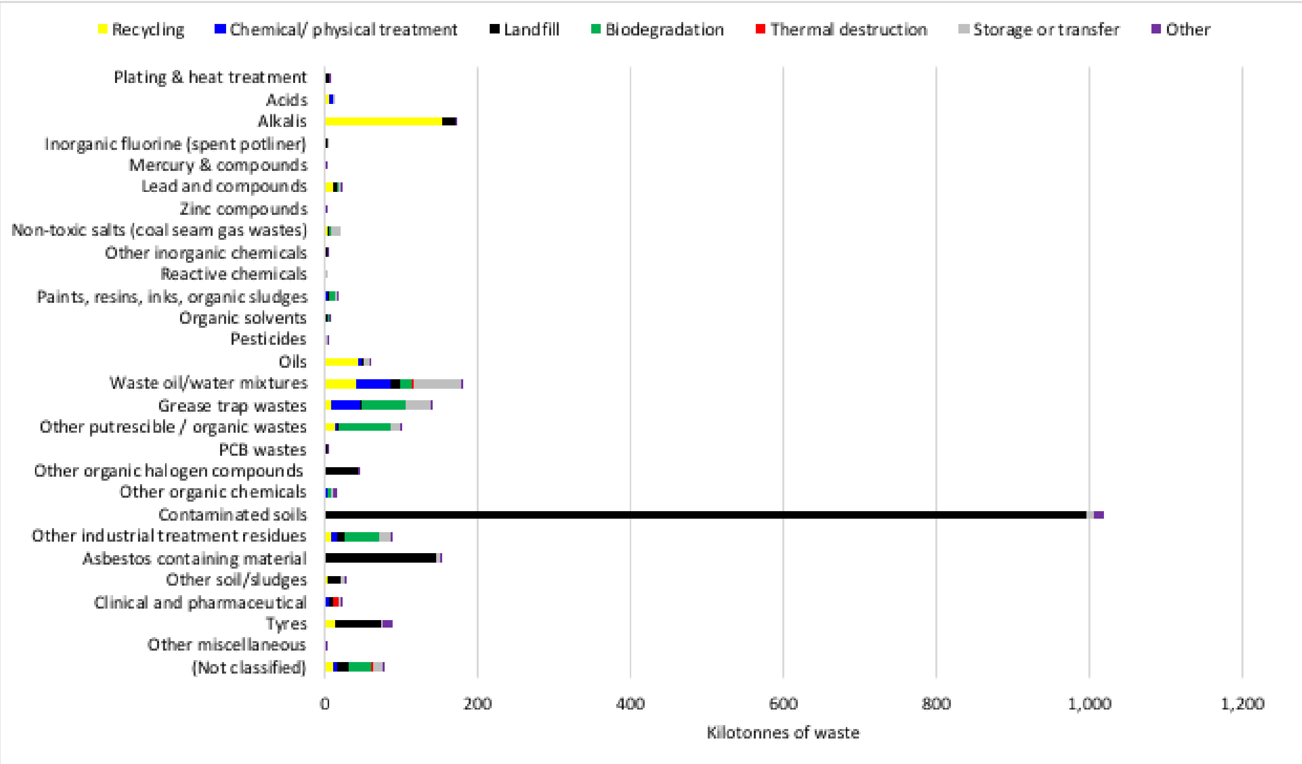


Figure 16 The management of tracked hazardous waste in SA, 2017-18 (tonnes)

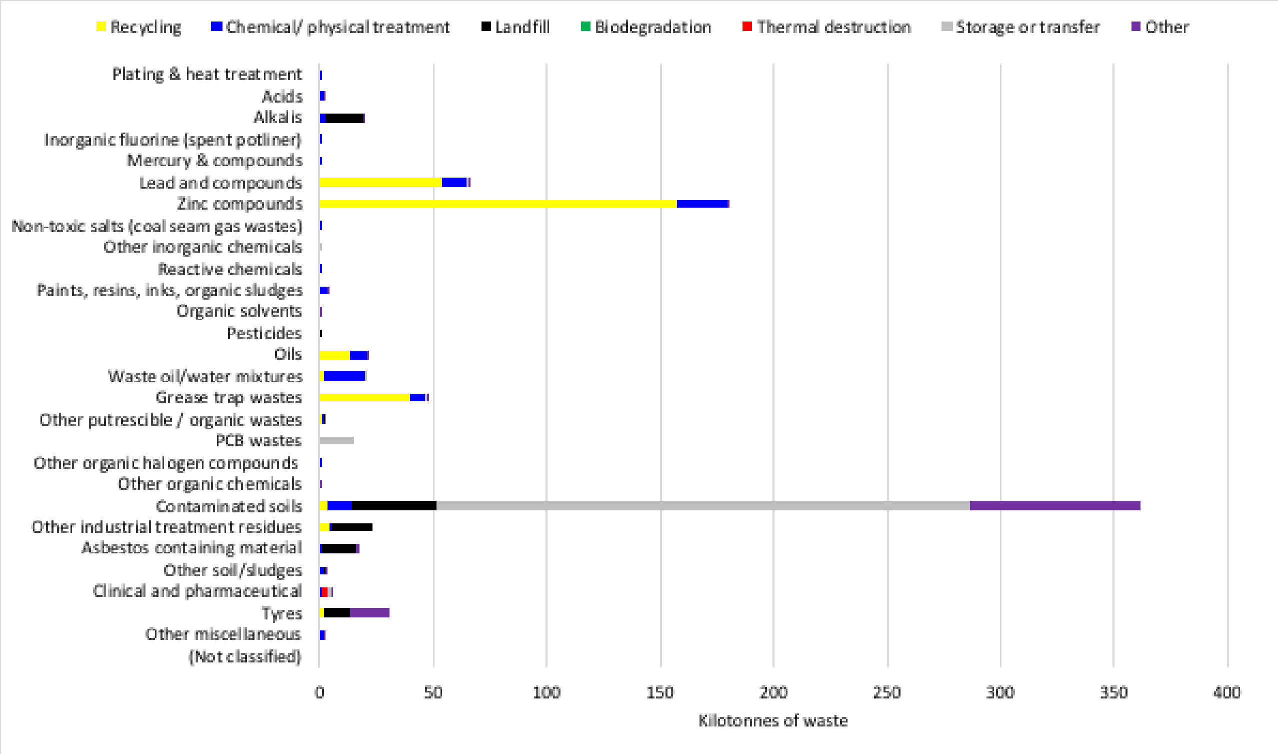


Figure 17 The management of tracked hazardous waste in Vic, 2017-18 (tonnes)

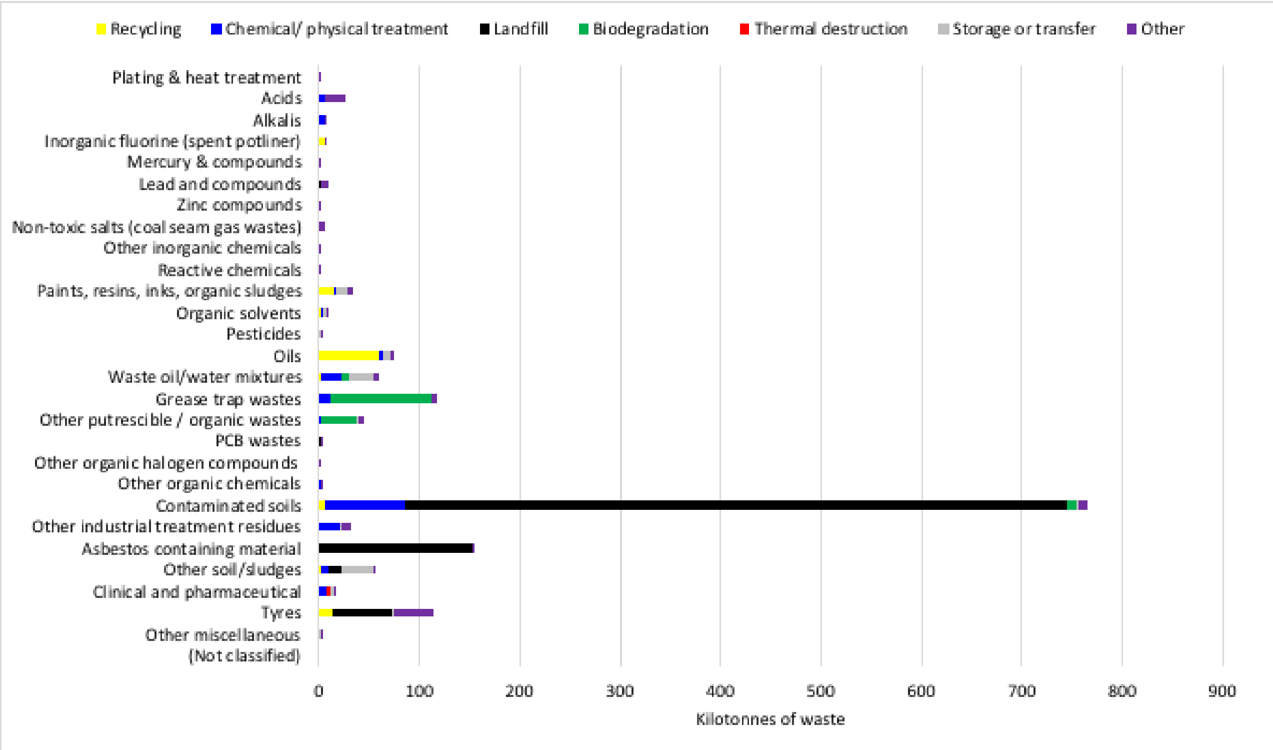
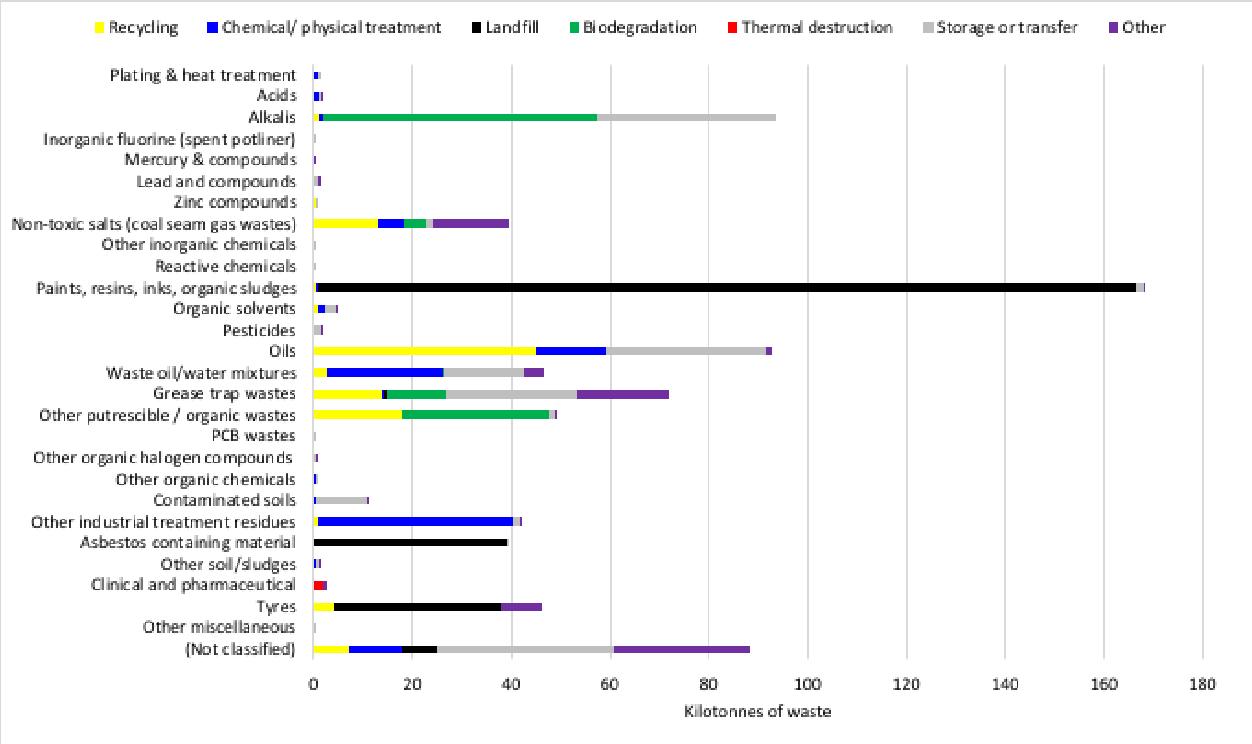


Figure 18 The management of tracked hazardous waste in WA, 2017-18 (tonnes)



4. Current and emerging challenges

This section considers some of the challenges currently facing the hazardous waste management system. It addresses PFAS, other POPs, the increasing quantities of contaminated soil and asbestos, problems with hazardous waste infrastructure, contaminated biosolids, fly ash and oil and gas industry wastes.

4.1 PFAS waste

PFAS describes a range of per- and polyfluoroalkyl substances, which includes perfluorooctane sulfonic acid (PFOS), its salts (perfluorooctane sulfonates) and perfluorooctane sulfonyl fluoride (PFOSF). These chemicals were listed on the *Stockholm Convention on Persistent Organic Pollutants (POPs)* in 2009, as part of a suite of 'new' POP listings. PFOS is likely to arise in waste with other PFAS chemicals, such as perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS), the former very recently listed on the Convention (May 2019) and the latter currently under review for potential listing.

The environmental and potential human health impacts from exposure to PFAS are of increasing concern worldwide. The Heads of EPAs Australia and New Zealand (HEPA) collaborated to develop the *PFAS National Environmental Management Plan* (PFAS NEMP[16]), which is designed to achieve a nationally consistent approach to the environmental regulation of PFAS.

PFAS has been widely used for many decades in household products such as non-stick cookware, stain protection and food packaging as well as industrial and commercial applications, such as firefighting foams, mist suppressants and coatings. PFAS is persistent and highly resistant to degradation. PFOS, the PFAS compound of most concern, was the key ingredient in Scotchgard, a fabric protector made by 3M, and numerous stain repellents. Under the Stockholm Convention domestic treaty-making process, Australia must determine whether to ratify the listing of PFOS after considering the costs and benefits of ratification. This decision has not yet been made.

PFAS-containing wastes, particularly (but not exclusively) from the use of PFOS-containing aqueous film-forming foam (AFFF, or firefighting foam), have been isolated for specific analysis in Section 4.1.1. This is because PFAS is a pressing regulatory issue, as evidenced by the development of the PFAS NEMP, regardless of the status of Stockholm ratification, ahead of the other recent POP listings. Similarly, PFAS-contaminated soils are large focus of Section 4, as they could arise in extremely large quantities.

PFAS has historically not been present in tracking systems because it has not been recognised as hazardous. From 2016-17 onwards, POPs contaminated waste has been appearing in the waste tracking data, often under M160 *Organohalogen compounds—other than substances referred to…*, which has typically been PFAS-contaminated waste. In future years, as implementation systems respond to the PFAS NEMP, it is intended that these volumes are tracked under the PFAS-specific

[16] PFAS NEMP January 2018, available at https://www.epa.vic.gov.au/your-environment/land-and-groundwater/pfas-in-victoria/pfas-national-environmental-management-plan. The NEMP was undergoing revision at the time of writing. The consultation draft, known as NEMP 2.0, is available at: https://www.epa.vic.gov.au/your-environment/land-and-groundwater/pfas-in-victoria/pfas-nemp-2-0 .

code M270 *Per- and poly-fluoroalkyl substances (PFAS) contaminated materials, including waste PFAS- containing products and contaminated containers*.

4.1.1 Aqueous film-forming foams (AFFF)

AFFFs containing very high levels (parts per hundred) of PFOS were used extensively in fire training and actual firefighting situations until relatively recently. Training drills conducted on concrete fire pads (and in some cases bare soil) are routine at fire-risk sites such as defence facilities, airports, fire training facilities, fuel storage facilities and major hazard facilities. AFFFs containing PFOS have been typically withdrawn from use but there are significant quantities of the original foam concentrates still present at these sites. These are expected to arise in more significant quantities as a waste for disposal, now that the NEMP has been implemented and the prospect of Stockholm ratification looms.

AFFFs containing PFOS have generally been phased out and replaced with other, shorter chain length PFASs. These replacement foams containing other PFASs, as active ingredients and as impurities, continue to be used in commissioning and testing, routine trainings drills, and for firefighting at these primary fire-risk sites. Consequently, significant quantities of PFAS-contaminated AFFF waste are anticipated to arise now and in the future, and require disposal as per the guidance set out in the PFAS NEMP.

Tracking data from 2017-18 marks the first year that significant quantities of PFAS containing AFFF foams can be identified in the data, albeit only through careful examination. (Broader PFAS rather than the narrower PFOS is described hereafter for these foams, since tracking data does not provide enough information for a distinction to be made.) PFAS wastes can be seen in all tracking system states in 2017-18 (Vic, NSW, Qld, SA and WA), with significant quantities arising in Vic, NSW and Qld, particularly under the M160 (other organohalogens) NEPM code. NSW AFFF volumes are reported under several NEPM codes. This variability of classification is because the M270 classification was only adopted in early 2018.

Close examination of waste transport certificates in Vic and NSW reveals AFFF foams in liquid wastes from Defence, fire protection, airport and related facilities. These are listed under the expected codes of M160 and M250 (and others in NSW), with some specific clues under the contaminants field (where they have been recorded). Table 7 outlines AFFF PFAS waste identified from tracking records in NSW, Vic and Qld, with the former two states having better supporting information in their tracking systems to deduce this information. Table 7 also includes estimates of other jurisdictions' AFFF volumes.

Table 7 estimates 2017-18 AFFF (containing PFAS) arisings to be approximately ***8,300 tonnes***. This is substantially higher than earlier estimates. BE *et al.* 2017 estimated annual arisings of AFFF (as PFOS in the concentrate, which is approx. 3% PFOS) as 38 tonnes in 2014, corresponding to 1,267 tonnes of AFFF waste. This earlier estimate assumed an annual decline, as these stocks presented for destruction, at around 8%per year, which would forecast 908 tonnes in 2017-18. The tracking data therefore suggests that AFFF stocks are presenting into the hazardous waste management system at around 10-fold higher than was previously thought.

Table 7 Estimated arisings of AFFF (containing PFAS) in Australia 2017-18

NEPM code	Description	Est. arisings (tonnes)	Estimation data source/ reasoning
NSW			
M250	Surface active agents (surfactants), containing principally organic constituents and which may contain metals and inorganic materials	3,066	*1. All from NSW tracking data 2. Liquid wastes classified as J120, G150, M250 & M160 with PFAS (or AFFF) explicitly identified as contaminants are assumed to be AFFF 3. Liquid wastes classified as J120 (without contaminants identified), that were sent to the main location where a significant numnber of other J120 records had AFFF contaminants identified, from Defence, airport and fire services sources, are assumed to be AFFF 4 Liquid wastes classified as M250 and M160 (without contaminants identified) from Defence, airport and fire services sources are assumed to be AFFF*
J120	Waste oil/water mixtures	1,250	
G150	Halogenated organic solvents	25	
M160	Organohalogen compounds—other than substances referred to in this Table or Table 2	24	
	NSW total	4,365	
Vic			
M250	Surface active agents (surfactants), containing principally organic constituents and which may contain metals and inorganic materials	1,341	*1. All from Vic tracking data 2. Liquid wastes classified as M160 from Defence, airport and fire services sources are assumed to be AFFF 3. Liquid wastes classified as M160 sent from Vic to Qld (cement kiln destruction) are assumed to be AFFF 4. Liquid wastes classified as M250 from Defence, airport and fire services sources and sent to a known PFAS liquid treatment facility are assumed to be AFFF*
M160	Organohalogen compounds—other than substances referred to in this Table or Table 2	977	
	Vic total	2,318	
Qld			
M250	Surface active agents (surfactants), containing principally organic constituents and which may contain metals and inorganic materials	93	*1. All from Qld tracking data 2. Liquid wastes classified as M160 from Defence, airport, fire services and waste industry sources & sent for thermal destruction are assumed to be AFFF 3. Liquid wastes classified as M250 from Defence, airport and fire services and waste industry sources are assumed to be AFFF*
M160	Organohalogen compounds—other than substances referred to in this Table or Table 2	257	
	Qld total	350	
WA			
M160	Organohalogen compounds—other than substances referred to in this Table or Table 2	357	*1. From WA tracking data, which is not supplied with sufficient disaggregation to identify sources or waste form 2. All wastes classified as M160 are assumed to be AFFF*
	WA total	357	
Other jurisdictions combined			
N/A	N/A	869	*1. Calculated on a per capita basis from all AFFF identified in NSW, Vic, Qld & WA above*
Total AFFF estimated arising in Australia, 2017-18 (tonnes)		8,259	

4.1.2 PFAS-contaminated soils

As discussed in Section 4.1.1, AFFF has been widely used at sites such as airports, oil refineries, military bases and other major hazard facilities (as defined in Workplace Health and Safety legislation) for emergency and training purposes. Training exercises may occur weekly or even several times per week depending on the site. Fire training drills are usually conducted on concrete slab training pads. Hydrocarbon-fuel (e.g., kerosene) is ignited and firefighters are employed to extinguish the fire. The resultant exposure has contaminated training ground infrastructure with residual chemicals from the fuels used and, more significantly, from the firefighting foams.

At these fire training grounds, PFASs have bled into surrounding soils with run-off to surface waters and seepage to groundwaters causing some large plumes of contamination. These contaminated soils have gained increased regulatory attention in the last 2-3 years, as media reports of environmental and potential human health impacts from PFAS use have increased, starting with Oakey Army facility in Queensland in 2010 and the Williamtown RAAF Base near Newcastle, NSW in 2012.

Robust publicly available estimates of the total quantity of PFAS-contaminated soil present in Australia have not yet been made. However, given the extensive use of these foams and the large number of sites under investigation, PFAS-contaminated soil is likely to arise in large quantities over the next decade. PFAS-contaminated soils are now appearing in tracking data, recorded under codes like N120 *contaminated soil* and M160 *Organohalogen compounds—other than substances referred to…* They are not sufficiently or comprehensively identified, but 2017-18 data, in particular, contains clear evidence of PFAS-soil.

A ‘top-down’ method could be used to estimate PFAS-contaminated soil quantities, albeit with very large uncertainties and wide-ranging assumptions. To do so requires an estimate of the total number of facilities that may keep PFOS AFFF concentrates for fire training or emergency purposes, followed by an estimate of the likely quantity of contaminated land on each facility. Table 8 summarises information gathered about possible PFAS-contaminated soil sites that could help in deducing top-down estimates.

Note that for the purpose of this estimation exercise, PFAS contaminated soil is taken to include other PFAS-containing solid wastes that would be expected to be excavated alongside soil, such as concrete rubble, asphalt and even dredging spoil.

Table 8 Key PFAS-contaminated soil sites – raw data and information

State/ Territory	Information item	Information detail	Source
National	Number of Defence 'major bases and dispositions'	44	Australian Defence Force Major Bases and Disposition in Australia, ADF 2019
	Number of major airports with dedicated aviation fire stations	26	Airservices Australia - aviation rescue firefighting stations, 2019
	Number of smaller airports/ aerodromes	606	Airservices Australia, En Route Supplement Australia (ERSA) 2019
	Total number of Fire & Rescue facilities (approx.)	1,000	Estimated from Vic and NSW fire brigade listings, which number ~200 per state
	Number of major hazard facilities (approx.)	210	Estimated from Vic and NSW data below, using population proportions
NSW	No. major hazard facilities	39	SafeWork NSW 2017
	No. Fire & Rescue facilities (known to have PFAS issues)	25	NSW EPA 2019
VIC	Number of major hazard facilities	38	Worksafe Victoria 2017
WA	Single large stockpile of PFAS-contaminated soil excavated as part of Perth airport rail link project	900,000m^3 of PFAS-contaminated soil stockpiled on a Forrestfield industrial site, awaiting a long-term solution.	City of Kalamunda documents (via various media reports, including ABC News 19 October 2017
NT	No. stockpiles	Four at 100,000m^3 in total Upwards of 100 sites in (jurisdiction) known to be contaminated with PFAS (airports, industry, emergency services and Defence)	Confidential information provided to REC/ Ascend 2017

Note: m^3 has been assumed as the same as tonnes (density of 1t/m^3) for the purpose of this analysis

The 'major' airports with dedicated aviation fire stations' identified in Table 8 are shown geographically in Figure 19.

Tonnages of PFAS-contaminated soil likely to be present per contaminated site is difficult to estimate. The following has been identified through careful analysis of tracking data:

- A single Defence site in Qld was responsible for 35kt of PFAS-contaminated soil in 2017-18 data, under the M160 code.
- A single contaminated land project in Vic was responsible for 18kt of PFAS-contaminated soil in 2017-18 data, under the Vic N119 code (Category A contaminated soil, the highest level of soil contamination).

In addition, Table 8 indicates that one small jurisdiction had four known PFAS contaminated sites/ stockpiles at an average of 25kt each (assuming a soil density of approximately 1t/m^3 [17]). At the other end of the scale, a single WA stockpile is known to be contaminated in PFAS (likely to be at low levels) and is estimated to comprise 900kt of soil.

Figure 19 Locations of the 26 nominated major airports in Australia with aviation fire stations

Source: Airservices Australia - aviation rescue firefighting stations, 2019

Assuming the WA stockpile is unusually high, the average of the other three site tonnages is 26 kt per contaminated site. This is assumed to correlate to a 'high' volume site corresponding to significant historical usage of AFFF in regular fire training exercises.

Using this 26 kt per contaminated site figure as a guide, low and medium tonnages per site have been deduced as <u>2 kt</u> and <u>10 kt</u> respectively, the former by assuming low historical AFFF activity would yield 10-fold less contaminated material and the latter as an intermediate value between the two.

Table 9 applies the estimates of PFAS-contaminated sites in Table 8 to the 'quantity per site estimates', by consigning each site to high, medium and low PFAS-contaminated soil AFFF usage categories.

[17] https://www.epa.vic.gov.au/business-and-industry/lower-your-impact/~/media/Files/bus/EREP/docs/wastematerials-densities-data.pdf

Table 9 National estimates of PFAS-contaminated soil (kilotonnes, kt)

Type of likely PFAS soil site	No. of sites	Amount of PFAS soil likely per site	Estimates kilotonnes (kt) of PFAS soil
Defence 'major bases and dispositions'	44	High = 26 kt/ site	1,144
Major airports with dedicated aviation fire stations	26	High = 26 kt/ site	676
Smaller airports/ aerodromes	606	Low = 2 kt/site	1,212
Fire & Rescue facilities (approx.)	1,000	Low = 2 kt/site	2,000
NSW Fire & Rescue facilities under investigation for PFAS contamination	25	High = 26 kt/ site	650
Major hazard facilities (approx.)	210	Med = 10 kt/ site	2,100
Total	**1,911**	**2 – 26 kt/ site**	**7,782**

In total, this 'top-down' method estimates a total of ***7,782 kt*** (7,782,000 t) of PFAS-contaminated soil in Australia. This figure is likely to be an underestimate, because it is conservative in the following aspects:

- the number of fire and rescue facilities nationally is likely to be underestimated, and only NSW has published a list of facilities currently under investigation for PFAS contamination
- there are more Defence sites than those identified as 'major'
- tonnage per site estimates are based on known information about three sites only; major AFFF use sites with high lateral transport of PFAS-containing surface water and/ or groundwater, quantities of PFAS contaminated soils requiring management may well be one or more orders of magnitude higher than 26 kt/ site
- no account is taken of sources other than from AFFF usage, such as industrial mist uses or ubiquitous domestic use of PFAS in water-proofing and food packaging applications
- no account is taken of areas potentially impacted from contamination from diffuse PFAS sources, such as landfill leachate, waste water treatment plant outlets and sites where biosolids have been stored or applied to land
- no account is taken of land that is likely to have been contaminated beyond the identified PFAS use sites, due to run-off, seepage or other transport into adjacent sites
- no attempt has been made to identify levels of PFAS contamination in the soil.

The quantum of PFAS-contaminated soil that actually enters the hazardous waste stream will depend on the management approach chosen at each site in light of broader regulatory, economic, environmental, and social considerations. Consequently, a significant proportion of the PFAS-containing soil currently in the environment at contaminated sites is unlikely to enter the hazardous waste stream. For example, one estimate in the public domain for the volume of potentially contaminated soil at Williamtown alone is 6 million tonnes.

The estimated quantity of almost eight million tonnes PFAS-contaminated soil could be expected to enter the waste stream over some timeframe determined by a regulatory implementation period, involving site identification, investigation, assessment, clean-up, management and ongoing monitoring. We nominally estimate this timeframe as 10 years, to reflect possible changes in knowledge, hazard and risk science and regulatory approaches.

Applying this nominal 10 year clean up period indicates an annual arising estimate for PFAS-contaminated soil in Australia of ***approximately 800,000 tonnes per year***. This estimate is highly uncertain, and is potentially at the low end of a plausible range of estimates.

4.1.3 Other PFAS-containing wastes

PFOS (and the broader suite of PFASs) have relatively high water-solubility compared with other POPs. This means every PFAS-contaminated site could contain both soil and water that require treatment. The levels of PFOS (And other PFAS) contamination accepted in water environments in global guideline values for PFAS in water, including the interim values in the PFAS NEMP, are very low (compared to other pollutants), which means that even minor levels of water contamination may require remediation, removal and treatment.

Contaminated waters would likely be remediated on-site using granular activated carbon or similar media 'pump and filter' interventions, creating waste absorbent media. This waste absorbent, a relatively concentrated PFAS waste, is likely to have similar management requirements to AFFF concentrates.

Other PFAS-containing wastes could include N160 *Encapsulated, chemically-fixed, solidified or polymerised wastes referred to in this list*, given the NEMP's indication that pre-disposal immobilisation may be required for some PFAS wastes. There are indications of PFAS wastes immobilised in this way in 2017-18 data, although it is difficult to be certain since contaminant recording in the data is poor.

4.1.4 PFAS waste management

Management of PFAS contaminated waste in Australia is guided by the PFAS NEMP, which draws acceptable management methods from the Stockholm Convention, its stated contaminant limits (low POP content limits) and specific technical guidance documents published by the United Nations Environment Program. The most pertinent guidance for PFOS management is UNEP/CHW.12/5/Add.3/Rev.1, *Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride*[18], while other PFAS chemicals management guidance is expected to follow as other PFASs become listed under the Convention.

Broadly speaking, management of POPs waste under the Stockholm Convention generally needs to either destroy or irreversibly transform the chemical. The Convention allows for POPs wastes to be "... otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option..." (Article 6 1. (d) (ii)).

Further delineation of 'environmentally sound' management is given in the UNEP guidelines mentioned above. No recycling, recovery or reuse options are allowed for these wastes unless there is a specific exemption, and landfill is not acceptable for wastes above the low POP content limit of 50 mg/kg of PFOS. The PFAS NEMP adopts landfill acceptance criteria of up to 20 mg/kg for unlined

[18] Available from: *http://www.basel.int/TheConvention/ConferenceoftheParties/Meetings/COP12/tabid/4248/mctl/ViewD%20etails/EventModID/8051/EventID/542/xmid/13027/Default.aspx*

landfills and up to 50 mg/kg for higher landfill designs, both for the sum of PFOS and PFHxS . Landfill may be acceptable for wastes below these limits, but immobilisation or similar treatment may first be required.

The NEMP landfill acceptance criteria for PFAS wastes appears somewhat inconsistent with existing jurisdictional classification approaches, although it is noted that the NEMP provides a minimum national standard agreed by all jurisdictions, and so allows for higher standards to be applied by some jurisdictions. Table 10 outlines landfill acceptance criteria for the sum of PFOS and PFHxS from the NEMP, and is compared with appropriate waste and landfill classifications in those jurisdictions where they exist.

A notable observation from Table 10 is that NSW regulation is significantly stricter than the NEMP with what PFAS wastes it accepts into landfill, even for the Elizabeth Drive restricted solid waste landfill, which is the most highly engineered form of landfill containment in NSW. From a WA perspective, Class IV landfills are effectively on-par with the NEMP, but there is only one of these in the state (EMRC Red Hill). For the remainder of the state's landfills, WA's requirements for total contaminant testing-based waste acceptance are 10-fold more stringent than the NEMP, both for lined Class II/III and unlined (L=Class I and II) landfills.

The question raised by this comparison is whether the NEMP's landfill acceptance criteria are too lenient for the acceptance of PFAS contaminated waste into the majority of landfills in Australia.

Table 10 Australian landfill acceptance criteria/ waste classification for PFAS wastes

		Landfill acceptance criteria/ waste classification equivalent for sum of PFOS + PFHxS			
Landfill type	**Criteria type**	**NEMP**	**NSW[19]**	**WA[20]**	**Qld[21]**
Unlined	ASLP leachable concentration (µg/L)	0.07		0.001	-
	Total concentration (mg/kg)	20		0.02	0[21]
Clay/ single composite lined	ASLP leachable concentration (µg/L)	0.7	0.05	1.3	-
	Total concentration (mg/kg)	50	1.8	5	0[21]
Double composite lined	ASLP leachable concentration (µg/L)	7	0.2	13	-
	Total concentration (mg/kg)	50	7.2	50	0[21]

[19] NSW EPA 2016, Addendum to the Waste Classification Guidelines (2014) – Part 1: classifying waste, available at: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/wasteregulation/addendum-1-to-the-waste-classification-guidelines.pdf

[20] WA DER 2017, Government of Western Australia Department of Environment Regulation, *Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), Contaminated Sites Guidelines*, Version 2.1 January 2017, available at: https://www.der.wa.gov.au/images/documents/your-environment/contaminated-sites/guidelines/Guideline_on_Assessment_and_Management_of_PFAS_v2.1.pdf

[21] Thresholds for Regulated Waste in Qld for PFAS are 0mg/kg. This is assumed to mean any detectable concentration of PFAS deems a waste to be Regulated Waste. These thresholds do not directly relate to specifications of landfill.

Beyond the question of what levels PFAS landfill acceptance limits should be, there is an issue regarding the extent to which landfills are already 'sinks' for PFAS contamination, due to PFAS-containing wastes historically deposited there. Box 1 investigates this.

Managing POP wastes according to Stockholm requirements is problematic in Australia because the capacity to do so is very limited. However, new facilities are being developed that are likely to offer Stockholm-compliant management of POP wastes such as PFAS. Several soil remediation facilities, which use thermal technologies such as thermal desorption followed by off-gas destruction, are either operational, trial-scale operational or under development in Victoria. In addition, a geological repository facility is in the construction phase in WA which, according to Section IV.G.3 (b) of the UNEP guidelines, would appear likely to meet *environmentally sound disposal* requirements for POPs. All of these potential future POPs-managing facilities require an operating licence from their respective state or territory regulators to enable the acceptance of such wastes.

Box 1 Landfill acceptance criteria and the 'PFAS soup' effect

The PFAS NEMP outlines landfill acceptance criteria for PFAS contaminated wastes which range from 20 mg/kg to 50 mg/kg, on a total concentration basis, and 0.07 μg/L to 7 μg/L on a leachable concentration basis (sum of PFOS and PFHxS for both), depending on the engineering rigour of the landfill design. It is noted, however, that these values are prefaced by the regulator's right to take site-specific factors into account, and set lower limits.

Landfills are still plentiful in Australia, although those engineered to accept significantly-hazardous wastes can be counted on one hand. Jurisdictions may require a form of immobilisation to be applied to some PFAS wastes, prior to landfill. This decision is based on evaluation of immobilised PFAS contaminant's leachability against landfill acceptance criteria. But should a landfill be allowed to accept PFAS based simply on contaminant levels and the landfill's basic design?

Landfills are a potential 'PFAS soup' – they have accepted this waste for decades and its water mobility means it is present in landfill leachate. An alternative method for deciding if a landfill can accept PFAS would be to reference the pre-existing levels in the landfill leachate. Assuming other characteristics were equal, a landfill with higher PFAS contamination levels measured in its leachate would be held to more stringent acceptance criteria.

A precedent is Qld's regulatory approach for biosolids[22] contaminants, which follows this approach for land application by requiring maximum limits in both the biosolids (0.4 mg/kg for total organic fluorine, a catch all that includes PFAS) and the receiving soil (0.005 mg/kg for total organic fluorine).

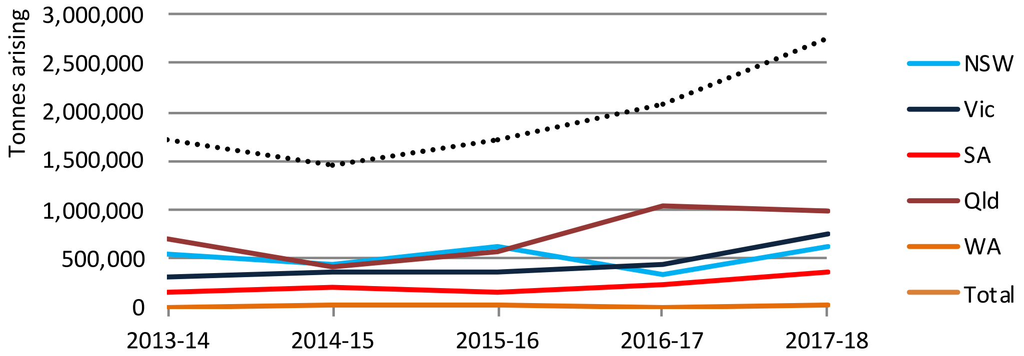
As the manager of a prominent landfill recently noted in discussions about PFAS wastes with the author, "It's probably not a question of 'could we' accept it but, given our long-term responsibility post-closure and the PFAS concentrations we see in our leachate now, the real question is 'should we?'"

[22] Qld DES, *End of Waste Code Biosolids (ENEW07359617)*, January 2019, available at: https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-biosolids.pdf

4.2 The rise of contaminated soils and asbestos

National contaminated soil (N120) tonnages have almost doubled in the three years since numbers were collated for HWiA 2017 (2014-15 data), making this waste the most dominant influence (in tonnage terms) on total arisings trends. Eighty percent of the increase occurred over the last two years. This national rise in shown in Figure 20.

Figure 20 National contaminated soil arisings trends in the years NSW data is available



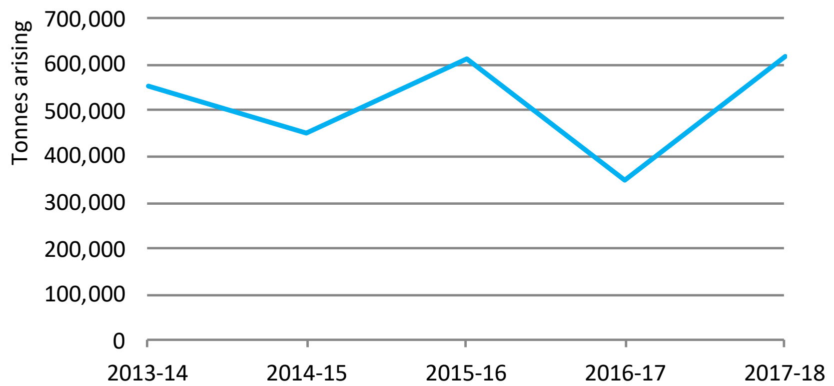
Asbestos waste (N220) is also tracking upwards at a rapid rate (see Figure 54), building on a historical trend of strong growth with a further 52% jump in 2017-18 on 2016-17 figures nationally.

Contaminated soil and asbestos are almost totally responsible for a significant rising trend in total national hazardous waste volumes over this period (see Figure 7). The question, on both counts, is 'why?'

NSW

NSW contaminated soils have increased to their highest level in the five years of recorded soils data, although 2017-18 is only marginally higher than its largest recorded year, 2015-16. The NSW trend is provided in Figure 21. Contaminated soils are not fully tracked in NSW so the data is obtained from landfills, and we consequently have little insight into the nature of their contaminants.

Figure 21 NSW historical arisings of contaminated soil



NSW soils data is difficult to decipher, because the EPA appears to take a stricter view on including asbestos-contaminated soils in the regulatory net, even at low levels of contamination. Complicating the matter further is whether these asbestos-contaminated wastes are recorded in landfill records as N120 contaminated soils or N220 asbestos. From January 2017, NSW EPA required asbestos-contaminated soil to be separated out from other asbestos waste for reporting purposes, which resulted in an approximate split of 50:50 of each in 2017-18 data. Since the first half of 2017-18 collected only undifferentiated data, it is possible that asbestos contaminated soil could have been taking up more like three-quarters of the asbestos soil:asbestos estimate, both in the full 2017-18 year and historically.

NSW dominates asbestos generation in Australia, at around 72% in 2017-18, and has shown dramatic growth since HWiA 2017 reported 2014-15 data, as shown by Figure 22, with 70% of that coming between 2016-17 and 2017-18.

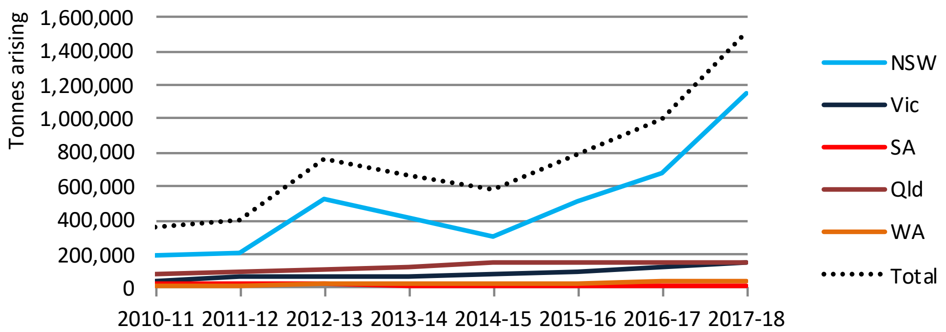
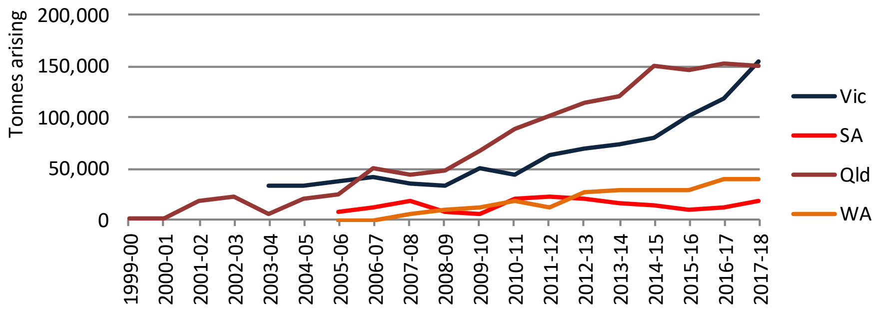


Figure 22 National asbestos waste arisings trends in the years NSW data is available

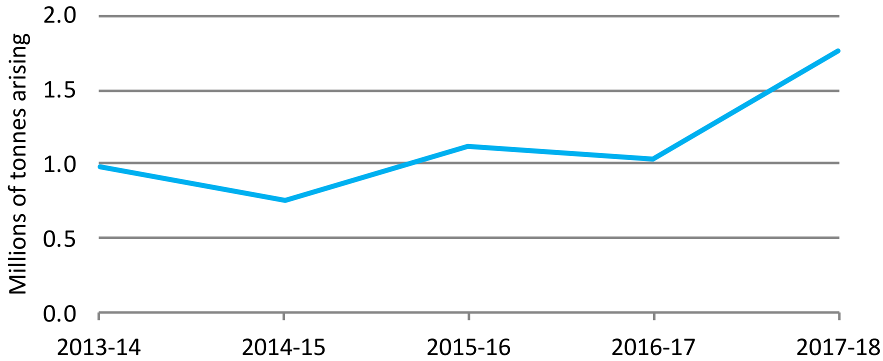
Figure 22 also shows that NSW arisings are the dominant driver of national growth and arisings, over the eight-year period where data is available for all jurisdictions. Separating out the arisings of other states for reference (Figure 23) shows that Vic and Qld have followed a similar pattern of rapid growth to NSW, but on a more consistent basis over time, while SA and WA show more modest rates of increase.

Figure 23 Qld, SA, Vic & WA historical arisings of asbestos waste



It is not clear why NSW asbestos tonnages would accelerate so much in 2017-18 but it is likely that asbestos contaminated soils are a large contributor. It cannot be simply a classification issue, with asbestos contaminated soil migrating (in a classification sense) from N120 to N220, because otherwise the sum of the two wastes would be relatively constant. Figure 24 shows that even when combined, the 2017-18 increase remains sharp. So, a significant change has certainly occurred in 2017-18, that is related to asbestos waste, asbestos contaminated soil, non-asbestos contaminated soil, or combinations thereof.

Figure 24 NSW historical arisings of contaminated soils and asbestos



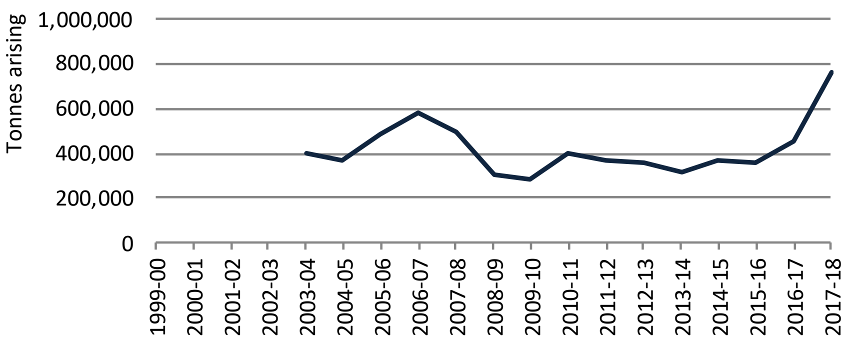
The possible scenarios are:

- N220 asbestos (including asbestos contaminated soil) increased dramatically in 2017-18, over arisings of the previous seven years, or
- asbestos contaminated soil in 2017-18 has 'migrated' from N120 (contaminated soil) to N220 (asbestos), significantly loading up the N220 figure, and simultaneously there was a large increase in other types of contaminated soils to make up this difference and give rise to a slight increase on the previous year, or
- The NSW policy shift to require asbestos contaminated soil reporting as a standalone item in 2017-18 has exposed previous under-reporting of this waste.

Vic

Vic contaminated soils also increased dramatically in 2017-18, rising 69% on 2016-17 levels. Compared to just two years previous, they show by far the largest growth (in volume) of all jurisdictions, at 116% from 2015-16 levels. This sudden change in trend is shown in Figure 25.

Figure 25 Vic historical arisings of contaminated soil



Vic uses a contamination-level coding system for contaminated soils where the highest level is coded as N119 (known as Category A soils), the intermediate level is N120 (known as Category B soils) and the low level is N121 (known as Category C soils). To better understand this recent trend, further analysis was segmented by these three soil classifications, and focused on the waste's producers, receivers and what sort of contaminants were recorded as present. In addition, key players identified from this analysis, plus two major national (contaminated soil) commercial laboratory managers, were consulted as to their opinions on the contributing factors to the contaminated soil quantity rise, both in Vic and elsewhere.

Vic is the best-placed jurisdiction for recording contaminants within a waste, as part of the tracking process. Their system allows for up to four contaminants to be recorded in a waste transport certificate, chosen from a set 'pick-list' of choices. Contaminants were recorded for 92% of the 37,431 contaminated soil waste transport certificates present in Vic data in 2017-18. An indicative review of contaminants reveals some clues, although critical information is sometimes missing from the dataset, such as producer addresses and postcodes.

Tracking data and industry opinion concur that the driving force on Vic's doubling of soil volumes has been unprecedented infrastructure project activity, such as rail, road, level crossing removals and commercial development, which produces predominantly low level (Category C) contaminated soil. Other contributions to the rise come from a number of major industrial closures over recent years, which are being remediated and contribute significant volumes of contaminated soil.

Major projects identified include the Metro Tunnel project, level crossing removal projects, commercial and residential urban construction projects and remediation of closed industrial sites, of which one inner suburban site is prominent. The 300kt+ increases seen in Category C soil in 2017-18 (since 2015-16) could very foreseeably come from these types of projects. A partial producer-level analysis of 2017-18 tracking data revealed project volumes (in the types of projects mentioned above) of between 30kt and 60kt per project, with an average of around 40kt.

This demonstrates that it doesn't take too many major infrastructure projects to account for the increase seen in Vic Category C soils.

Another important consideration is that projects like Metro Tunnel and level crossing removals cannot use 'cut and fill' techniques to manage significant excavated volumes onsite – all contaminated soil from these specific projects must be exported offsite, which results in high project volumes compared to projects that are less physically constrained, such as non-inner city road projects. Industry sources also contended that "we have only seen 10-15% of the contaminated soil that will come out of these major projects," predicting that 2018-19 and beyond will likely see even greater increases in contaminated soil volumes coming out of Vic major infrastructure projects.

Vic Category B soils in 2017-18 followed a similar doubling trend (from 2015-16) to Category C, which reflects the same sorts of major project drivers as Category C.

Category A contaminated soils showed the biggest rise, in percentage terms from its 2015-16 volumes, of the three categories, although they make up the smallest volume. Close inspection of tracking data shows almost two-thirds of the 2017-18 tonnage came from one company, and presumably one project. All of this was soil contaminated with two codes that suggest PFAS contamination: code 53 *Hydrocarbons and its oxygen nitrogen or sulfur compounds NOS* and code 17 *Fluoride compounds NOS*; despite the latter not being a sound choice to describe PFAS, it has been used in previously observed tracking datasets.

Of critical importance for the PFAS line of enquiry is that the EPA Vic contaminants list used for populating the contaminants field in waste transport certificates does not include a dedicated PFAS contaminant code. This makes identifying PFAS-contaminated soils in tracking data difficult.

All Category A soil from this company/ project was sent to thermal soil remediation/ contaminant destruction, another strong indicator that the contaminant was PFAS. These probable-PFAS contaminant codes were not present to any significant extent in Category B or C data.

Qld

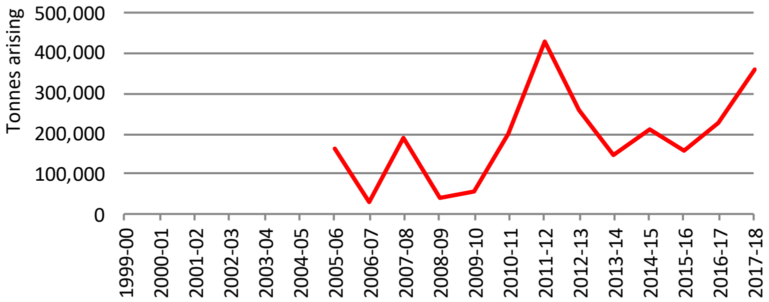
Queensland does not track contaminated soils but provides data from landfill records similar to NSW. Consequently no information is recorded about contaminants, but the clear identification of a single Defence site contributing 35kt of PFAS-contaminated soil in 2017-18 data, under the M160 code (Organohalogen compounds—other than substances referred to..), is evidence that PFAS soils are beginning to appear, if outside the N120 contaminated soil code in this case. This example implies PFAS may be a factor in the rise of Qld contaminated soils of 73% in 2017-18, on 2015-16 levels.

Assuming there are other similar PFAS-soil producing projects Australia-wide (such as the suspected one in Vic discussed above), just a handful or so projects of this scale would account for a noticeable increase in contaminated soil volume in Qld, and nationally.

SA

SA has also seen a dramatic increase in contaminated soil volume in 2017-18, up 128% in the two years from 2015-16, with most of that in 2017-18, as shown in Figure 26. Unlike Vic, this level is not unprecedented, with higher tonnages recorded in 2011-12 (likely to have been related to major projects like the Adelaide hospital and the Adelaide Oval redevelopment).

Figure 26 SA historical arisings of contaminated soil



Apart from the 2017-18 rate of increase, a feature of SA contaminated soil data in 2017-18 is the unusually high rate of storage – 65% of all management. There is limited additional information available through contaminants information, which is largely unfilled in the data.

SA's rising numbers could be supporting PFAS contaminated soils on the basis of the contaminants most predominant in SA data ("99 Other", which means it is not one of the other 98 choices) and their significant proportion of storage (65% of all management), which is unusual for contaminated soils.

WA

WA contaminated soils contributed only 4% of national contaminated soils volume in 2017-18, and its data reveals nothing about why contaminated soils are increasing. A notable feature of WA soils data is its very high rate of storage. In 2014-15 just 11% of N120 went to storage but this increased to 97% in 2017-18. Similar to SA, storage of contaminated soils could indicate that an acceptable management fate is not readily available, such as could be the case with either very high levels of a contaminant or an unusual contaminant with non-routine management needs.

Summary - asbestos

It is not clear why asbestos waste has increased so fast, but the answer lies in NSW, the source of most of volume and growth. There are two possible scenarios at play in NSW. Either N220 asbestos (including asbestos contaminated soil) has increased dramatically in 2017-18, or it is a data issue, caused by re-allocation of asbestos contaminated soil from (historically) N120 to N220 in 2017-18. However, if this is the case, something else (non-asbestos related) grew significantly to take its place in the N120 category.

Outside of NSW of the quantities of asbestos waste rose at a rate more easily explained by increased asbestos removal programs.

Summary – contaminated soil

Vic was the biggest influence on the national rise in contaminated soils seen in 2017-18, and the driving force behind this appears to be their program of unprecedented infrastructure project activity, such as rail, road, level crossing removals and commercial development, complemented by remediation activity emanating from a number of major industrial closures over recent years. PFAS contaminated soil appears to also be playing a part, although this appears to be restricted to high-level contaminated soils going to thermal treatment.

Qld soils grew rapidly in 2016-17, and maintained that level again in 2017-18, but the reasons why are not transparent in data alone. Discussions with commercial laboratories, a key gatekeeper in the process of waste/ soil analysis for classification purposes, suggested that PFAS in soil testing demands had grown markedly in the last two years, with one of those comments specifically about Qld. Given that one very large project of PFAS contaminated soil is apparent in Qld tracking data, (despite their tracking limitations for contaminated soil), it seems possible that PFAS contaminated soil may be contributing to the rise there.

SA has an equivalent dramatic 2017-18 rise pattern to the aforementioned states, and a previously unseen reliance on storage of contaminated soils in 2017-18. WA is not a significant player in this issue, but curiously storage of contaminated soils in that state has risen from 11% to 97% between 2015-16 and 2017-18. Both of these states may be seeing an influence from PFAS contaminated soils, given their known emergence elsewhere, but evidence for this is indirect only.

NSW is unable to be reliably described due to the 2017-18 practice of reporting asbestos contaminated soil within contaminated soil, without clearly understanding how that distinction operated historically. In any case (excluding the asbestos issue) NSW doesn't show the same clear growth trends of Vic and Qld.

The very recent, rapid rise, seen across all of the states that record contaminated soil volumes in their entirety, suggest a national phenomenon. While there is enough evidence to suggest that PFAS contaminated soils are starting to enter the waste stream in significant quantities, state tracking systems are not as helpful as they could be in confirming this. However, in Vic at least, 'conventional' contaminants from unprecedented infrastructure development contribute most of the increase in quantities, albeit at the lower end of the contaminant-risk scale.

An ominous sign for PFAS contaminated soils is that the PFAS NEMP was only released in early 2018, two-thirds of the way through this report's 2017-18 data period, so it follows that its full implementation would be expected to be seen in PFAS contaminated soil volumes more in 2018-19 data and beyond.

4.3 Hazardous waste infrastructure issues and risks

The draft *Assessment of hazardous waste infrastructure needs and capacities in Australia* report[23] proposes that a number of infrastructure types in Australia could be constrained in future unless there is additional development. Some key risks are touched on below, which are drawn from the infrastructure assessment.

4.3.1 Solvents management in Vic

Melbourne has had the following recent issues with hazardous (flammable) chemicals management:

- 30 August 2018: A major fire at a West Footscray warehouse, which took approximately 140 firefighters several days to fully control. The warehouse stored large quantities of flammable chemicals (which it was not registered to do under dangerous goods legislation). Within hours of the fire, authorities issued a warning to a wide range of nearby suburbs to close windows and doors, and fish, eels, birds and other wildlife were washing up dead on the banks of Stony Creek.
- 29 December 2018: In response to the West Footscray fire, authorities uncovered about 19,000 tonnes[24] of hazardous (flammable) chemicals illegally stockpiled in eight warehouses in Epping and Campbellfield, both northern Melbourne suburbs. According to press reports at the time[25], the same tenant is linked to both incidents.
- 5 April 2019: A major industrial fire broke out at Bradbury Industrial Services in Campbellfield, a waste solvents recycler, affecting neighbouring communities similarly to the West Footscray fire.

These are in addition to two very large fires at SKM Recycling Coolaroo, a non-hazardous waste facility, on 7 July 2018 and 13 July 2017, which burnt for 11 days.

While the illegal warehousing issue before it was worrying enough, the Bradbury Industrial Services fire in Campbellfield, Melbourne, on 5 April 2019, is disturbing because:

- The facility was not an illegal warehouse but a known EPA licensed site operating for over 10 years as a major player in the solvents waste market in Australia, taking hazardous wastes (mostly waste groups F *Paints, resins, inks, organic sludges* and G *Organic solvents*) and

[23] Blue Environment, Randell Environmental Consulting and Ascend Waste and Environment (2018), *Assessment of hazardous waste infrastructure needs and capacities in Australia* – draft, prepared for the Department of the Environment and Energy.

[24] https://www.theage.com.au/national/victoria/up-to-19-million-litres-of-toxic-waste-dumped-in-eight-suburban-warehouses-20190315-p514lm.html

[25] https://www.theage.com.au/national/victoria/complex-chemical-stockpile-clean-up-20190206-p50vye.html

recycling them through solvent distillation followed by blending to specification and packing for sale.

- The facility was audited by EPA Vic and found to be storing three times its licensed limit, resulting in suspension of its licence to receive further waste. The licence had allowed 154 kL of liquid wastes to be stored on the premises at any time.
- The fire EPA's licence withdrawal has effectively closed Bradbury at the time of writing. This facility is an example of a 'single point dependency' for F and G wastes in Vic – Bradbury was/is the only licensed facility able to recycle solvents in Vic.
- Loss of this facility removes a major portion of market supply while national demand for F (paint wastes) and G (organic solvent) waste recycling, in recent years at least, appears to be growing. This could create more opportunities for illegal management of these wastes.

Turning to the illegal warehousing issue, the chemicals stored were quoted in the media as being "solvents, paints, detergents, aerosols and cleaning chemicals." If this material was wholly in waste groups F *Paints, resins, inks, organic sludges* and G *Organic solvents*, the stored volume would correspond to an additional 85% of the 2017-18 Vic arisings of these two waste groups (22,416 tonnes combined).

This incident was stated in the media to be "undoubtedly the biggest illicit dumping operation in the city's history."[26] By comparison, Bradbury's storage allowance was about 154 tonnes at a single point in time, which makes the northern suburbs' warehouse find equivalent to over 100 Bradbury-like facilities. The scale of this illegal warehousing begs the question: how much waste is missing from national data collations due to illegal activity outside tracking systems? And how would this affect assessments of the adequacy of infrastructure planning?

4.3.2 Hazardous waste storage practices

The Vic solvents experience raises the possibility that storage above licensed limits is not uncommon. Tracking data records storage of some wastes at surprisingly high levels, which equates to many risks of individual sites exceeding their licensed storage limits. Storage occurs for logical and lawful reasons, such as: economies of scale (accumulation for later transport in bulk to a processing facility), high throughput rates keeping processing infrastructure busy (resulting in storage at the processing facility) and, perhaps most commonly, shortages in infrastructure capacity or capability. In all of these cases storage is supposed to be short term, but what 'short-term' means is not specifically defined or regulated.

An analysis of 2015-16 and 2016-17 waste tracking data from Qld and NSW was conducted by the author, focused on a selection of wastes with high storage proportions, as part of investigating possible improvements to the multiple-counting adjustment method used. This is discussed further in ***Appendix C.***

The analysis centred on F (paint wastes) and G (organic solvent) group wastes (those discussed in Section 4.3.2 and 4.3.1), D300 (salt wastes), Other T (various miscellaneous wastes), D120 (mercury wastes), K110 (grease trap), Other N (various soils/ sludges) and H (pesticide) wastes. This

[26] https://www.theage.com.au/national/victoria/up-to-19-million-litres-of-toxic-waste-dumped-in-eight-suburban-warehouses-20190315-p514lm.html

investigation indicated that wastes going into storage were not re-emerging in significant amounts within the 12-month tracking data covered.

This analysis is by no means definitive about whether storage limits are being exceeded, but the observed rates of retention over a 12-month period suggests the risk is there.

4.3.3 Ageing infrastructure

Some of Australia's key infrastructure is ageing, which presents challenges into the medium-term. This is particularly true of landfills, which have a constrained operational lifespan, and CPT plants, because reports from industry are that CPT inflows (historically manufacturing wastes) have been in decline for some time and are placing operational pressure on some of these facilities.

In the case of soon-to-close landfills (that are reaching their end of life), there are direct policy commitments, such as those in the Victorian Government's *Resource Recovery Infrastructure Investment Prospectus*[27], to reduce the number of landfills. This puts pressure the disposal options of hazardous wastes that currently go to regional landfills in particular, such as asbestos.

CPT infrastructure represents a variety of technologies, chemistries and novel approaches to rendering a waste less hazardous. If the viability of such operations is reduced, reinvestment in ageing facilities may not occur, leaving niche wastes without reasonable access to options for their sound environmental management.

A case in point is NSW's Homebush Bay liquid waste facility, a key and longstanding piece of NSW infrastructure, the lease for which expires in 2025. This facility is facing increasing pressure from nearby residential development, in addition to questions about costs of infrastructure upgrades, or even outright relocation, against a backdrop of the reportedly challenging economics of CPT.

4.3.4 Insurance

The waste management industry is reportedly finding insurance harder to get due to recent incidents such as those discussed above, and media attention on unscrupulous activity regarding waste more broadly. This could create barriers for new market entrants into the industry, and increase management and disposal costs. The industry is already somewhat marginal, as evidenced by single point dependencies like Bradbury. Further barriers such as a difficulty purchasing insurance are unhelpful to system that is already exposed to its many operational, market and regulatory risks.

4.4 Contaminated biosolids – possible regulatory directions

HWiA 2017 introduced a range of emerging contaminants of concern that are likely to be present in Australian biosolids. These included various POPs formally identified by the Stockholm Convention and other similar chemicals, with POP-like properties of persistence, bioaccumulation and toxicity, as well as chemicals with other damaging properties. Non POP chemicals include cleaning and personal care ingredients such as triclosan and triclocarban, perfumed substances such as 'polycyclic musks' (galaxolide), plasticisers such as phthalates and a long list of pharmaceuticals and steroid hormones.

[27] Sustainability Victoria 2015, *Victoria's Waste & Resource Recovery Infrastructure Investment Prospectus*, available at: https://www.sustainability.vic.gov.au/About-us/Publications/Victorias-Waste-and-Resource-Recovery-Infrastructure-Investment-Prospectus

HWiA 2017 also included an extensive analysis of the shortcomings of the current contaminants in biosolids regulatory framework (jurisdictional biosolids guidelines) when compared to Australian jurisdictional hazardous waste contaminant frameworks. It found that biosolids guidelines were too narrow in focus (inadequate coverage of contaminants), and recommended they be modernised to reflect the breadth of relevant hazards known to be present in biosolids today.

With the exception of total organic fluorine compounds in Qld's biosolids End of Waste Code[28], which includes chemicals from the PFAS group, none of these emerging chemical contaminants in biosolids are currently managed in jurisdictional biosolids guidelines. Table 14 from HWiA 2017 has been reproduced as Table 11 below, updated to include the Qld addition.

Table 11 Summary of contaminants listed in Australian biosolids guidelines

Contaminant	NSW, Qld, Tas, Vic	WA	SA	EU	USA
Arsenic	Y	-	-	-	Y
Cadmium	Y	Y	Y	Y	Y
Chromium	Y	Y	Y	-	Y
Copper	Y	Y	Y	Y	Y
Lead	Y	-	-	Y	Y
Mercury	Y	-	-	Y	Y
Nickel	Y	-	-	Y	Y
Selenium	Y	-	-	-	Y
Zinc	Y	Y	Y	Y	Y
Organochlorine pesticides	Y	Y	Y	Y	-
PCB Total	Y	-	-	Y	-
Total Organic Fluorine	Qld only[28]	-	-	Y[29]	-

Of most immediate concern is the PFAS group, which is also discussed at length in other waste contexts in Section 4.1.

4.4.1 PFAS in biosolids

One of the key issues analysed was the risk posed by POPs in biosolids, particularly PFOS (and the broader PFAS group), due to:

- their unusual leachability chemistry, which tends toward higher levels of transport in the environment
- their potential to result in significant ecological impacts (to fish and other aquatic species, plus birds and mammals that feed on them), even at lower exposure concentrations than other POPs
- the high prevalence of biosolids application to agricultural land in Australia
- the potential for stringent biosolids-specific PFOS/ PFAS guidelines, orders of magnitude lower than limits in other waste media, in light of what has been already adopted (in Qld[30], Germany

[28] Qld Government Department of Environment and Science, *End of Waste Code Biosolids (ENEW07359617)*, available at: https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-biosolids.pdf

[29] Germany and the UK regulate for Total Organic Fluorine in biosolids for application to land, as described in Section 4.4.1.

[30] Qld Government Department of Environment and Science, *End of Waste Code Biosolids (ENEW07359617)*, available at: https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-biosolids.pdf

and the UK), and what has been documented in the Stockholm Convention's technical guidelines for PFOS[31].

A number of developments have occurred in this space since HWiA 2017, including:

- An extensive analytical study of PFAS concentrations in biosolids from 13 Australian wastewater treatment plants was carried out by the Australian and New Zealand Biosolids Partnership (ANZBP), and reported on in December 2017[32].
- The finalisation of the PFAS NEMP (February 2018).
- A revised draft PFAS NEMP 2.0 released for public comment (March 2019), including tighter soil criteria for ecological protection.
- The Qld Beneficial Use Approval for land application of biosolids expired and was replaced with an 'End of Waste Code', which has a low contaminant limit for PFAS in biosolids (0.39 mg/kg) and the soil to which it is intended to be applied.
- On 25 October 2018 NSW EPA banned the use of mixed waste organic material on agricultural land, and is ceasing use on plantation forests and mining rehabilitation land until further controls can be considered. The product is predominantly organic material from household general waste processed into a soil amendment. The main contaminant identified as posing a potential risk to health was equivalent to POP-BDEs.
  - While NSW EPA's website notes that the change "does not apply to compost or biosolids", and the risk identified was not from PFAS, this action sets a precedent that the issue of contaminants in agricultural beneficiation is under the regulatory microscope.

These issues are analysed below.

PFAS in Australian biosolids

As described in HWiA 2017, Gallen *et al.* 2016[33] analysed biosolids from 16 wastewater treatment plants for various persistent bioaccumulative and toxic chemicals, including 10 types of PFAS chemicals.

While only a single study at a particular time, Gallen's 16 chosen facilities serviced a population of 2.8 million people (over 10% of the population of Australia). This was followed by the ANZBP study of 2017, which analysed samples from 13 treatment plants. The results of the two studies, with respect to PFAS compounds, are shown in Table 12. These results include extrapolated estimates of PFAS, calculated from the 10-compound PFAS analysis carried out by Gallen, as described in the footnote to the table.

[31] UNEP (2015b), *UNEP/CHW.12/INF/10 (2015) Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)*, available from: *http://www.basel.int/TheConvention/ConferenceoftheParties/Meetings/COP12/tabid/4248/ctl/Download/mid/13277/Default.aspx?id=13&ObjID=12379*

[32] ANZBP 2017 (Hopewell, Darvodelsky), *Assessment of Emergent Contaminants in Biosolids*, available at: *https://www.biosolids.com.au/wp-content/uploads/Emerging-Contaminants-in-Biosolids-Research-report.pdf*

[33] Gallen, C, Drage, D, Kaserzon, S, Baduel, C, Gallen, M, Banks, A, Broomhall, S, Mueller, J.F, *Occurrence and distribution of brominated flame retardants and perfluoroalkyl substances in Australian landfill leachate and biosolids*. Journal of Hazardous Materials 312 (2016) pp.55–64.

Table 12 PFAS in Australian biosolids results from Gallen et al. 2016 and ANZBP 2017 (µg/kg)

	PFOS		PFOA		PFAS	
Source	Gallen	ANZBP	Gallen	ANZBP	Gallen[3]	ANZBP[2]
Mean	67	21 ± 62	11	2 ± 7	138	*43*
Maximum	370	386	30	50	*759*	*791*
Minimum	11	1	0.26	1	*23*	*2*

Notes:

1. *Gallen analysed for 10 PFAS compounds: PFOS, PFOA, PFHxA, PFNA, PFDA, PFBS, PFUnDA, PFDoDA, PFTrDA and PFTeDA*
2. *ANZBP analysed for PFOS and PFOA only, so PFAS could not be directly determined, but has been estimated by multiplying by the ratio (from Gallen) of: total PFAS compounds mean concentrations/PFOS mean concentration, or 138/67 = 2.05.*
3. *Gallen's paper does not include results data beyond PFOS, PFOA and PFHxA, but does include all ten PFAS compounds' mean results. These have been used (as in "2") to calculate estimated maximum and minimum concentrations of PFAS.*
4. *All extrapolated estimates are provided in the table in italics.*

The exact number of samples taken across each of the sites in both studies is unclear, although it appears that greater than 50 samples (from 16 sites) made up the Gallen study, and 109 samples were taken in the ANZBP study. A true weighted average across the two studies is not possible without access to all raw data, per sample. However, taking a simple mean of the results between the two studies, including those extrapolated PFAS results, provides estimated mean results and ranges for biosolids in Australia, drawn only from these two studies. These are shown in Table 13.

Table 13 Estimated mean PFAS in Australian biosolids, pooled from Gallen et al. 2016 and ANZBP 2017 (µg/kg)

	PFOS	PFOA	PFAS
Mean	44	7	91
Maximum (of both studies)	386	50	791
Minimum (of both studies)	1	0.26	2

Germany regulates a PFOS limit of 100 µg/kg in biosolids, and Gallen reports that the UK's limit is 46 µg/kg, both of which are specific to biosolids' use in land application. Closer to home, Qld has regulated a limit of 390 µg/kg for total organic fluorine[34], previously in their Beneficial Use Approval for biosolids land application and, superseding that in January 2019, via their End of Waste Code for biosolids land application.

Comparison of the PFAS estimates of Table 13 with these regulatory limit suggests that biosolids contaminated to the level of the mean of these two studies would be suitable for land application in Qld, extremely close (but under) the German limit and over the UK limit. Maximum estimates from the two studies, on the other hand, would exceed all three regimes' limits by a significant margin. It

[34] Total Organic Fluorine includes any organic fluorine compound, which inclusive of PFAS compounds plus PFAS precursors, determined by the Total oxidisable precursor assay, or TOPA.

is noted that the ANZBP study indicates that results are much higher from biosolids drawn from "sites with known local PFOS contamination issues."

These estimates suggest some Australian biosolids will be contaminated with PFAS above the Qld limit and, if such sites were located in Qld, they cannot be applied to land there. If the Qld limit sets a precedent that other jurisdictions follow, these studies suggest that some Australian biosolids, in future, will be contaminated in PFAS to the extent that they cannot be applied to land.

Even reported mean concentration estimates are borderline (if the German limit was adopted) and within the same order of magnitude as the Qld limit. The estimates in Table 13 do not include the full range of PFAS precursors, as the Qld End of Waste Code limit requires, which means the assessment of mean biosolids concentrations, with respect to the Qld limit, could underestimate total organic fluorine.

The ANZBP study was undertaken prior to the release of the PFAS NEMP, essentially Australia's first step towards consistent PFAS regulation. As part of the study, ANZBP recommended that PFOS and PFOA in biosolids would be "suitable and safe for restricted use such as application to agricultural land" at levels of 4,200 µg/kg for PFOS and 300 µg/kg for PFOA. This range exceeds Qld's regulated limit of 390 µg/kg for all forms of PFAS and its precursors.

This apparent inconsistency is strengthened by reference to the updated NEMP 2.0 figures for soil investigation ecological values (released as draft in March 2019). The draft interim soil investigation level for ecological indirect exposure is 10 µg/kg for PFOS. Taking ANZBP's assumed post-application dilution ratio of one part biosolids for 70 parts soil, a contamination concentration at ANZBP's proposed limit of 4,200 µg/kg would result in subsequent soil levels of 60 µg/kg PFAS (assuming no pre-existing contamination). Based on this scenario, application of biosolids considered safe under the ANZBP guideline could contaminate soil to a level that warrants investigation for PFOS contamination under the draft NEMP.

It is important to note that the ANZBP study was undertaken prior to both the original NEMP and the release of the draft PFAS NEMP 2.0. In addition, the ANZBP study considered human health protection, and did not include any quantitative analysis based on guideline values for ecological protection. This helps to explain the difference between the values mentioned from the ANZBP study as compared to the values mentioned from the NEMP.

The water industry has shown leadership in conducting the ANZBP study, as they have done in the past on other emerging pollutant issues. As stated in the study findings, understanding of risks from PFAS contamination can only be furthered through an increased focus on gathering more data about contaminants in Australian biosolids.

4.5 Other persistent organic pollutants waste

4.5.1 PentaBDE, octaBDE and HBCD wastes

Pentabromodiphenyl ether (pentaBDE), octabromodiphenyl ether (octaBDE) and hexabromocyclododecane (HBCD) are brominated flame retardant chemicals, with the first two known colloquially as POP-BDEs, along with decaBDE (see below). PentaBDE was used in high concentrations in cushioning polyurethane foams in car upholstery and furniture, and was phased out of use in new products around the late 1990s. OctaBDE, phased out around the same time (or slightly later) was used for flame retardancy in hard Acrylonitrile Butadiene Styrene (ABS) plastics, particularly computer cases, TVs and other IT and home entertainment equipment. HBCD was used in foam building insulation and, although alternatives are now used, it has been in widespread use as a flame retardant up until very recently.

Under the domestic treaty-making process, Australia must determine whether to ratify listing of the POP-BDEs (on the Stockholm Convention) after having considered the costs and benefits of the feasible technical options needed to satisfy ratification. This decision has not yet been made. Consequently, these wastes have not materially appeared in tracking system data up to this point. If and when they do, they would be seen under NEPM code M160.

4.5.2 DecaBDE wastes

Decabromodiphenyl ether (decaBDE), another POP-BDE more recently added to the Stockholm Convention, was also used extensively in flame retardancy of hard e-waste plastics (typically ABS plastics). Australia has not yet ratified its listing on the Convention, so wastes containing decaBDE are not treated as hazardous at present. Should that become the case in future, wastes contaminated with decaBDE would also be captured within NEPM code M160.

DecaBDE, although nominally lower in hazard than 'lower' brominated BDEs like penta and octa, could provide greater management complexities in future, as discussed in the breakout box below.

Box 2 Example emerging issue – decaBDE contaminated waste

PFAS-contaminated soils are possibly the best example of an emerging waste problem: a POP-contaminated waste stream of high scale, hazard and community concern. However, one lesser-known but problematic issue for the near-term future is *decaBDE*.

While the production of its cousins pentaBDE and octaBDE has long stopped, the production of decaBDE continues, as it has lower toxicity than the 'lower' brominated BDEs. OctaBDE was almost totally phased out of use as a flame retardant in Australian hard plastics in electrical and electronic equipment by the year 2000. It was replaced by others like decaBDE, tetrabromobisphenol A (TBBPA) and decabromodiphenyl ethane (DBDPE).

The potential environmental impact of decaBDE has been under review over the last few years due to evidence that it can degrade in thermal processes, environmental processes and in biota to more dangerous lower brominated PBDEs, including POP-BDEs such as octaBDE and pentaBDE. In 2013, Norway drafted a proposal to list commercial decaBDE on the Stockholm Convention. After consideration at various stages of the Convention listing process, decaBDE was formally listed on the Stockholm Convention at the eighth meeting of the Conference of the Parties to the Stockholm Convention, held in Brussels in May 2017.

While there is likely to be a significant time-lag between this decision and an Australian regulatory response, the decision has far greater implications for the e-waste recycling industry in Australia than the listing of octaBDE. DecaBDE's use in electronics to the present day, as opposed to the other POP-BDEs' withdrawal from use 15 plus years ago, has the potential to force the withdrawal of large tonnages of decaBDE-containing e-waste plastics out of the dismantling and recycling industry and into the hazardous waste market. The in-use lifetime of items such as TVs could ensure a steady and increasing stream of end of life e-waste contaminated in decaBDE – a new source of hazardous waste – for years to come.

Will e-waste become hazardous waste, because of decaBDE?

Historically, Australia has not deemed e-waste items destined for reuse, or repair and refurbishment with the intention of reuse overseas, to be hazardous waste. Therefore these materials did not require an export or import permit. E-waste in its intact form has either been expressly regulated as non-hazardous (such as in Qld regulations) or has not triggered contaminant thresholds due to the overall weight of the item and the low concentrations of contaminants such as heavy metals. Dismantled e-waste components such as printed circuit boards, disk drives, or cathode ray tube glass, on the other hand, are commonly determined to be hazardous waste on account of the higher concentration of these contaminants in the dismantled material. Domestically as well, e-waste in its various intact end of life item form has not been subject to tracking as hazardous waste.

However, brominated flame retardants (such as decaBDE) have typically been used in large concentrations in e-waste plastics. As regulatory requirements around flame retardants in particular strengthen, some intact e-waste items may be contaminated beyond future POP-contaminant limits, and will be regarded as hazardous waste in their own right. This will cause regulatory conflict, particularly with Qld's *Environmental Protection Regulation 2008* where, in Schedule 7 Part 2, 'intact or partly disassembled' specific types of e-waste are deemed to be 'not regulated waste', and therefore not subject to tracking and other control.

As an aside, one of Australia's major export destinations, Hong Kong, has not previously required Basel export permits for the import of e-waste for recycling of components, but as recently as 31 December 2018 deemed large item e-waste (TVs, computers, copiers etc., but not mobile phones) to be hazardous waste, legally subject to permitting.

4.6 Fly ash – old and new issues

Fly ash is a residue generated from combustion. It comprises fine particles that mix and rise with combustion flue gases in chimneys and post-combustion chambers of thermal plants, and are captured by particle filtration equipment such as electrostatic precipitators or fabric baghouse filters. Fly ash usually refers to ash produced during combustion of coal, the bulk of which arises in power stations. However, this is specifically excluded from the relevant NEPM hazardous waste classification N150 '*fly ash, excluding fly ash generated from Australian coal fired power stations*'.

Fly ash (from coal fired power generation) arises in exceptionally large quantities, but is typically discussed and quantified outside of the hazardous waste framework (see the National Waste Report[35], Figure 45 p. 105). However, it contains hazardous materials such as heavy metals at concentrations that, without the exemption, could be sufficient to classify it as hazardous waste. The heavy metals derive from the input fuel and arrive in fly ash either as constituent of fine combustion particles or in gaseous combustion products that condense in the cooling process. The mass of Australian black coal ash is close to 20% of the original coal tonnes consumed, whereas Victorian brown coal is much lower, at around 2% (ADAA 2016).

[35] Blue Environment and Randell Environmental Consulting (2018), *National Waste Report 2018*, available at: http://www.environment.gov.au/system/files/resources/7381c1de-31d0-429b-912c-91a6dbc83af7/files/national-waste-report-2018.pdf

The Ash Development Association of Australia (ADAA) conducts and publishes annual surveys on fly ash volumes produced from coal fired power stations, but the issue of how best to manage these large-volume industrial wastes tends to sit 'under the radar', since compilations like the numbers supporting this report[36] do not include them, because they don't 'arise' into the hazardous waste market.

Coal fired power generation is slowly declining in Australia. This will create a legacy of large onsite storages of fly ash. The extent to which these storages will be remediated and made safe for the long-term is unclear.

With the impending development of significant energy from waste infrastructure in Australia[37], the future of fly ash will turn to that produced from waste feedstock, which will be classified, tracked and managed as a hazardous waste, due to levels of heavy metals. These levels could be higher than in coal, depending on the make-up of the feedstock waste. Fly ash volumes will grow with the energy from waste industry, as volumes decline from fossil-fuel derived power. However, energy from waste fly ash would be a new waste volume for the hazardous waste management industry, as these residues would likely be managed in landfill, or require immobilisation before receival in landfill.

There is a strong case for diverting currently landfilled waste to energy recovery, particularly where landfill is scarce, and resultant fly ash is only around 2% by mass of the input feedstock[38].

4.6.1 End of life lithium ion batteries and solar panels

Lithium-ion batteries are the most prevalent rechargeable battery technology used today in applications ranging from handheld batteries (typically 5kg or less), such as those used in home electronics and power tools, to electric vehicle automotive batteries through to domestic and industrial application of large batteries for grid storage. Although lithium ion batteries are not regulated as hazardous waste for transport within Australia, they have significant hazardous potential, particularly because they can cause explosions and fires when improperly handled, which can be a major problem within waste infrastructure such as a landfills. Use of lithium ion batteries has been increasing strongly.

Disused photovoltaic solar panels are another emerging e-waste category deserving of some attention going forward. Their consumption in Australia grew very strongly from around 2010, reflecting rapid uptake of rooftop solar systems due to various government subsidies and rising electricity prices.

Different panel technologies have been employed historically, but some solar cells contain small amounts of heavy metals such as cadmium, selenium, copper or tellurium. Like other e-waste, intact panels are unlikely to contain these substances in high enough concentrations to render them hazardous waste, based on current contaminant concentration thresholds. However, if broken into

---

[36] Historical annual hazardous waste data reports such as NEPM annual reports, Basel Convention reports, OECD reports, previous editions of *Hazardous Waste in Australia* and internal jurisdictional tracking reports do not include coal-derived fly ash in annual compilation tonnages.

[37] ABC News 27 April 2018 (*https://www.abc.net.au/news/science/2018-04-27/waste-incineration-last-resort-experts-warn-frydenberg/9702490*) quoted then Minister for Energy and Environment Josh Frydenberg as saying "We've already got more than 30 [waste-to-energy] projects underway in Australia…"

[38] *https://www.iswa.org/uploads/tx_iswaknowledgebase/Kalogirou.pdf*

sub-components as part of disposal or recovery at end of life, some of these could contain heavy metals in sufficient concentrations to be deemed hazardous waste.

Reflecting the timing of some of the earlier systems reaching end of life (15-30 years), photovoltaic panels are likely to grow as a component of the e-waste stream from around 2025, creating a new management challenge. Sustainability Victoria has provided impetus for a national solar panel product stewardship scheme, conducting a research project in 2018 that analysed potential options for a national scheme to help manage these end of life products[39].

4.6.2 Stockpiling hazardous waste

Problems can arise in hazardous waste management markets due to infrastructure shortages, changing economics or logistical impediments. One of the possible consequences of these failures is that short-term solutions to waste problems become long-term ones, and stockpiling can occur. States and territories do not publicly report on amounts of hazardous waste put into onsite stockpiles, nor their locations, because no offsite movement, and therefore tracking obligation, occurs. Stockpiling could in some circumstances be used as a method to avoid waste levy liability, although requirements around this have tightened in recent years in some jurisdictions.

Stockpiling has occurred at reasonable scale in Australia in relation to a range of wastes, including, for example, spent pot liner from aluminium smelting, salt cake from aluminium smelting and contaminated biosolids.

A history of unresolved management suggests a problem that has long been difficult to deal with. Wastes retained onsite are not recorded on state-based hazardous waste tracking systems and have also been historically absent from annual reports to the Basel Secretariat on Australian generation of hazardous wastes. This has kept them somewhat under the public and regulatory ‘radar’. Stockpiled or legacy wastes are important in assessing future infrastructure needs because they represent potential volumes additional to those recorded on tracking systems. They can be present in much larger volumes than annual arisings, and could potentially be ‘unlocked’ due to regulatory change or a decreased corporate appetite for contingent liability.

REC 2018a[40] defines a deposit of solid or liquid hazardous waste as a stockpile where all of the following apply:

- it has not been treated or processed
- a significant proportion (i.e. 75%) has been stored for more than one year
- it requires ongoing management or monitoring to prevent impacts to human health or the environment
- it is subject to ‘clearance’ requirements set out by relevant environmental legislation.

For clarity, REC 2018a also defines ‘approved long-term on-site storage’ as waste storage that is:

- on-site (or near site)

[39] Waste Management Review, August 16 2018, *Planning for national solar panel product stewardship underway*, available at: http://wastemanagementreview.com.au/planning-for-national-solar-panel-product-stewardship-underway/

[40] REC 2018a (Randell Environmental Consulting (2018a)) *Hazardous waste stockpiles and approved long-term storages in Australia*, produced for the Department of Environment and Energy, December 2018, not yet published.

- in designated area/s
- pre-approved[41] for long-term storage (i.e. greater than 10 years) by state or territory regulator and has pre-approved management processes in place
- typically, not required to meet stockpiled waste 'clearance' requirements
- still under management by waste generator (i.e. liability has not been transferred to a third party/facility such as a hazardous waste landfill or isolation facility).

Some examples of particularly significant hazardous waste stockpiles were discussed in HWiA 2017. REC 2018a (as yet unpublished) expands on this by reporting the existence of a number of significant hazardous waste stockpiles in Australia.

4.7 Oil and gas industry wastes

Several types of geological formations trap naturally occurring gas. They are categorised as either 'conventional' or 'unconventional' gas reserves.

A NSW EPA fact sheet on sources of petroleum gas[42] differentiates these as follows:

> *"Conventional gas is trapped in naturally porous reservoir formations that are capped with impermeable rock strata. When intercepted by a well, gas is able to move to the surface without the need to pump.*
>
> *Unconventional gas is formed in more complex geological formations which limit the ability of gas to migrate and therefore different methods are required to extract the gas.*
>
> *There are several types of unconventional gas, including shale gas and tight gas, which occur in reservoirs with very low permeability compared to conventional reservoirs. In these geological formations, horizontal drilling and hydraulic fracturing are often necessary for economic gas extraction.*
>
> *The other form of unconventional gas is coal seam gas, where methane gas is trapped within the coal seam under pressure by overlying formations. To extract the gas, a steel-encased well is drilled vertically into the coal seam at which point the well may also be hydraulically fracture stimulated or drilled horizontally along the coal seam to increase access to the gas reserves."*

Both methods of gas extraction and downstream processing create hazardous wastes. The industry overall is classified in the ANZSIC system under *Oil and Gas Extraction [0700]*.

4.7.1 Coal seam gas industry wastes

Coal seam gas (CSG) extracted from south-west Qld (mainly the Surat Basin), and its subsequent volumes of salty wastes, were discussed at length in HWiA 2017, which was based on historical data up to and including 2014-15. From around 2015, the industry has undergone some changes with respect to its waste management:

---

[41] The storage of the waste was planned and approved by environment regulators prior to placement including management requirements to protect human health and the environment.

[42] NSW EPA fact sheet: *Sources of petroleum gas, Conventional and unconventional gas*, December 2015, available at: *https://www.epa.nsw.gov.au/-/media/40B251DEC4B44D378CC4EC56B7116602.ashx?la=en*

- Qld's Beneficial Use Approval system for regulating CSG drilling muds and extraction waters (sometimes known as 'associated water') is being progressively replaced by a regime of 'End of Waste Codes', of which one exists for drilling mud that facilitates processing through composting. The Beneficial Use Approval for CSG waters remains in effect until May 2019. Drilling muds managed according to the End of Use Code appear to fall out of the regulated waste framework (See Section 7.3). Whether this will remove the tracking requirement for drilling muds (which are typically coded as C100) is unclear, but if it is no longer classified as regulated waste, it would appear so.
- Regulation of extraction waters is shifting management practices away from the historical storage in large scale evaporation ponds, but these still exist. The modern alternative is to maximise recovery and treatment of these waters for various reuse purposes. The first of a number of large-scale reverse osmosis desalination plants in region came online from late 2014.

Desalination plants do an excellent job of lowering salts in the water to a level enabling a range of uses such as irrigation, stock drinking water and dust suppression. While it lowers the volume, this comes at the cost of concentrating the original problem – salt, or brine. An earlier Qld approval document[43] described this as "a small remaining concentrated brine stream", but it is only 'small' compared with the vast volumes of CSG waters treated by desalination.

The industry has been helpful in quantifying levels of these leftover brines as part of another project involving the author, but this work has not yet reached publication stage. Suffice to say, the volumes of brines currently stored in regulated dams by the major operators in Qld is extremely large, particularly since inputs to these facilities have only started to occur at scale from late 2014.

Dam aggregation is not sustainable, so the industry is currently working on longer term solutions to brine management. These could involve purification and resale (as salt), solidification and crystallisation of salts for long-term storage in dedicated facilities (onsite), or geological repository, a form of permanent isolation of waste that is soon to be operational in Australia.

4.7.2 Mercury from oil and gas processing

In addition to the CSG industry in Qld, there is a much longer-standing 'conventional' oil and gas exploration and extraction industry in Australia, with large operators offshore from the north-west coast of WA in particular.

Mercury is present in all hydrocarbon reservoirs at trace levels, and is concentrated in waste from mercury removal units (MRUs) in the form of spent mercury adsorbents (usually activated carbon) or contaminated hydrocarbon sludges. Other mercury wastes from the oil and gas sector include process waters, contaminated soils and contaminated worker personal protective equipment. In the absence of a pressing need for processing, these wastes have traditionally been held in onsite stockpiles.

---

[43] QGC, Brine and salt management, available at: *https://www.shell.com.au/about-us/projects-and-locations/qgc/environment/water-management/reports/_jcr_content/par/expandablelist_48b1/expandablesection_ea.stream/1498083766935/69ace52f1a08b0264db8548364c587a2530faf143488edd9de362c98a7050388/qgc-stage-3-wmmp-dec-13-15.pdf*

Apart from environmental and worker health and safety concerns about mercury, there is a risk that mercury-entrained petroleum feedstock can damage aluminium and other metal components of processing plant equipment through a form of corrosion, which can lead to catastrophic equipment failure. This explains the long-term use of MRUs.

The Minamata Convention on Mercury came into force in August 2017 and Australia is very close to ratification of it. The Department of the Environment and Energy is in the process of finalising the documentation for the Australian Government to consider ratifying the Convention. Consequently, MRU residues that have historically been stored or otherwise managed will come under increased regulatory scrutiny, and requirements for more environmentally sound management.

It is difficult to quantify the extent of mercury waste that could become available to the hazardous waste market from the oil and gas sector, either in annual arisings or releases from longer-term stored or stockpiled material. Recorded volumes in tracking systems are very small but they appear to exclude these oil and gas quantities wastes because they have traditionally not been moved offsite. Stockpiled MRU wastes could be contaminated to levels of between 2% and 10% mercury.

Industry discussions suggest the oil and gas industry could be stockpiling hundreds or perhaps thousands of tonnes of mercury wastes, with the potential for hundreds of tonnes of annual arisings in addition to current D120 volumes.

There are also likely to be other mercury wastes from the handling of the highly contaminated spent MRUs, such as equipment wash-down wastes, surrounding soils, sludge residues, personal protective equipment etc. Once they become waste, these would be deemed hazardous if they contain more than 0.0075% mercury (using the Victorian framework as a guide). It is highly likely that the volumes of wastes so contaminated will exceed the quantities of MRU adsorbents.

5. Key messages

Section 2 introduces the hazardous waste market in Australian and Section 3 takes a 'helicopter view' of hazardous waste data, providing a high-level picture of where hazardous waste is coming from, where it is going and how this has changed in recent history. Section 4 examines those wastes, issues and challenges, both current and emerging, that provide the most pressing concerns for policymakers and those in the industry. Section 7 backs up these preceding sections by providing more detailed data analysis and commentary on each of the 28 waste groups.

The section examines these aspects of the report to draw out the following key messages.

5.1 The quantities of hazardous waste are increasing

The quantities of hazardous wastes in Australia are increasing. Between 2013-14 and 2017-18, quantities increased at a compound annual growth rate (CAGR) of 9.1% per year. Across the last two data years, national tracked arisings grew at a CAGR of 21%.

Contaminated soils and asbestos have driven this trend, with unprecendented national increases. When they are excluded, the CAGR between 2013-14 and 2017-18) is only 2.2% per year.

5.2 The quantities of contaminated soil have increased markedly in recent years

National contaminated soil (N120) tonnages have almost doubled in the three years since numbers were collated for HWiA 2017 (2014-15 data), making this waste the dominant influence over tonnage trends.

Vic experienced the largest rise in 2017-18, and there are plausible explanations that relate to the scale of current development projects, including the level crossing removal program. PFAS-contaminated soils are also apparent in the data but do not conclusively explain the increases. It is unfortunate that the contaminants list for users to select from does not contain a PFAS contaminant code.

The pattern of very recent, very rapid rise, seen across all of the states that record contaminated soil volumes in their entirety, suggest a national phenomenon. PFAS-contaminated soils could explain it. Very large volumes of soil recorded as going to storage in SA, and very large rates of soil storage in WA, suggest an unusual and difficult to manage contaminant, indicative of something like PFAS. A single Defence site in Qld contributing 35kt in 2017-18 is indicative of the potential scale of PFAS-contaminated soil.

There is not enough hard evidence from tracking data alone to explain the sudden rise in contaminated soil quantities. We may be seeing PFAS-contaminated soils starting to enter the waste stream in significant quantities. The tracking systems are not as helpful as they could be in identifying if this is so. Although the PFAS NEMP was released in early 2018, it has not been fully implemented in tracking systems in usage of either the PFAS waste code (M270) or and PFAS-specific contaminants/ codes.

5.3 PFAS-contaminated soils have started to arise, are projected to become very large and have restricted management options

Robust publicly available estimates of PFAS-contaminated soil present in Australia have not yet been made, but 2017-18 marks the first time they have been identifiable in tracking data, in significant volumes.

An estimate is derived in Section 4.1.2 of ***approximately 800,000 tonnes per year*** over a nominal 10-year period. This estimate is highly uncertain, and is potentially at the low end of a plausible range of estimates, but provides a sense of the scale of the future problem.

PFAS contaminated wastes above the 50 mg/kg low POP concentration limit set in the Stockholm Convention must be destroyed, irreversibly transformed, or otherwise managed in an 'environmentally sound manner'. Direct landfill or recycling are precluded. Landfill acceptance criteria established by the PFAS NEMP may (and in the view of the author should) be lower than this, in line with acceptance criteria already regulated in NSW and WA, and in recognition of:

a) the very low limits imposed (by the draft NEMP 2.0) on soil and water criteria for ecological protection and
b) the fact that landfill leachate is likely to leak into the environment and already contains significant levels PFAS.

5.4 PFAS firefighting foams (AFFF) have emerged in tracking data in 2017-18 (for disposal), in quantities much higher than previously thought

Tracking data from 2017-18 marks the first year that significant quantities of PFAS containing AFFF foams can be identified in the data. Close examination of waste transport certificates in Vic and NSW reveals clear signs of AFFF foams in liquid wastes from Defence, fire protection, airport and related facilities. These are listed under the expected codes of M160 and M250 (and others in NSW).

Based on tracking data from NSW, Qld, Vic and WA, we estimate 2017-18 Australian arisings of **8,259 tonnes**. This suggests that AFFF stocks are presenting into the hazardous waste management system in quantities around 10-fold higher than was previously thought.

5.5 The environmental risk of PFAS contamination, through the pathway of biosolids applied to land, is real and unmitigated by current and proposed Australian regulatory tools

Recent data published by the ANZBP of PFAS measurements in Australian wastewater treatment plants was pooled with previous data and extrapolated to represent a 10-analyte estimate of PFAS compounds, rather than the two the key PFAS chemicals (PFOS and PFOA) measured by ANZBP. Comparison of pooled results finds that:

- Biosolids contaminated to the level of the mean of these two studies would be suitable for land application in Qld (the only Australian jurisdiction that regulates PFAS in biosolids), extremely close (but under) the German limit and over the UK limit.
- Maximum estimates from the two studies would exceed all three regimes' limits by a significant margin.

- These estimates suggest some Australian biosolids will be contaminated with PFAS above the Qld limit and, if such sites were located in Qld, they cannot be applied to land there. If the Qld limit sets a precedent that other jurisdictions follow, these studies suggest that some Australian biosolids, in future, will be contaminated in PFAS to the extent that they cannot be applied to land.
- These extrapolations do not include the full range of PFAS precursors, as the Qld limit requires, which means the assessment of mean biosolids concentrations, with respect to the Qld limit, could underestimate of total organic fluorine.

Comparison of the ANZBP's recommended upper limit for PFOS in biosolids to enable safe land application appears to be inconsistent with the Qld limit and ecological values in the draft PFAS NEMP 2.0. Biosolids considered safe under the ANZBP guideline could contaminate soil to a level that warrants investigation for PFOS contamination under the draft NEMP.

It is important to note that the ANZBP study was undertaken prior to both the original NEMP and the release of the draft PFAS NEMP 2.0, that it considered human health protection, not ecological protection, and that the industry has shown leadership in conducting their study. It is also important to note that the issue has been identified as important in future work under the PFAS NEMP.

5.6 The risks of non-compliance by hazardous waste managers are high

Vic has had a recent history of significant incidents related to inappropriate or illegal storage of hazardous wastes, particularly those with flammability hazards, such as solvent and paint wastes. These suggest non-compliance with legislation governing hazardous waste management is potentially a high risk:

- A network of illegal hazardous waste/ chemical storage warehouses was found in Melbourne in December 2018, highlighting the high risk of illegal and criminal activity in hazardous waste management. The chemicals stored were quoted in the media as being "solvents, paints, detergents, aerosols and cleaning chemicals." If this material was wholly in waste groups F *Paints, resins, inks, organic sludges* and G *Organic solvents*, the stored volume would correspond to an additional 85% of the 2017-18 Vic arisings of these two waste groups (22,416 tonnes combined). This suggests an alarming level of illegal 'leakage' from the Vic hazardous waste regulatory system.
- The Bradbury Industrial Services fire in Campbellfield, Melbourne was disturbing because the facility was a licensed and leading solvent recycling facility, but was storing flammable liquid wastes at three times the level their licence allowed. Bradbury was/is essentially a 'single point dependency' for F and G wastes in Vic –the only licensed facility of this type in Vic. Loss of this facility could create more opportunities for illegal management of these wastes.
- Storage rates in Vic and NSW are reasonably low across all hazardous wastes, which suggests a well-functioning market. Yet 19,000 tonnes of predominately solvent wastes were found in illegal warehouses in Vic. Storage rates in Qld are twice as high, WA three times as high and SA, unusually, were almost five times as high. Noting that both Vic and NSW EPAs have carried out compliance campaigns in this area during the last six months, storage demand (or lack of appropriate infrastructure capability) suggests a high risk of sites exceeding their licensed storage limits.

5.7 Market failure risks are high

The Bradbury case highlights what is quite typical in the hazardous waste market: companies operate in national markets and there are often only one or two facilities that can satisfactorily handle a particular waste, within a jurisdiction or sometimes in the whole country. The market is mature but sub-markets have limited competition, particularly where the management requirement is somewhat exotic or unique. This creates a reliance on 'single point dependency' facilities either absolutely, in the case of landfills that accept wastes at the higher hazard end of the range, or in relation to preferred recycling fates within the waste hierarchy.

In the event of a Bradbury-like fire, an EPA 'shutdown' or a corporate decision to close a key business, this represents a risk of market disruption.

According to the latest national hazardous waste infrastructure assessment[44], some infrastructure types are either close to the limits of their capacity or likely to exceed it in the near future. PFAS and other POPs management facilities are a primary example. Inadequate infrastructure capacity and absent capability in the market leads to storage and other imperfect behaviours that ultimately increase the possibility of illegal activity, as also indicated in key message 5.6.

5.8 Weaknesses in data quality are preventable obstacles to understanding

In the main, 2017-18 data quality was a significant improvement on the 2014-15 dataset used for developing HWiA 2017. But there remain data-related issues – gaps, limitations and quality problems – that create obstacles to understanding real hazardous waste problems and their solutions. Some of these issues are preventable with limited effort. These issues are explored in Appendix C and include:

- Paper based certificates create ongoing data quality headaches and resourcing bottlenecks in data entry and quality assurance. This resulted in an incomplete 2017-18 Qld dataset that precluded conclusive assessment of key wastes such as those from the CSG industry.
- Reporting of industry sources of waste and contaminants within waste, remains poor, although SA provided rich source information in 2017-18.
- Difficulties identifying PFAS wastes caused by lack of data clarity.
- Limitations caused by the six-category system of classifying management methods.
- Data shortcomings caused by regulatory exemptions in NSW.

[44] BE *et al. 2018a* (Blue Environment, Randell Environmental Consulting and Ascend Waste and Environment 2018), *Assessment of hazardous waste infrastructure needs and capacities in Australia* – draft, prepared for the Department of the Environment and Energy.

6. Recommendations

Below are recommendations that may help to address some of the key issues identified in Section 5.

6.1 Increase understanding of potential problems

Recommendation 1: Promptly analyse 2018-19 contaminated soils data

States should prioritise tracking system data entry and quality assurance tasks to enable prompt analysis of 2018-19 data, as soon after the end of the period as possible. This should focus on contaminated soils in particular, to see if the historically high quantities have continued from 2017-18, and to try to understand the large recent increases.

Recommendation 2: Develop jurisdictional inventories of PFAS waste

Following on from recommendation 1, jurisdictions should prioritise (if they have not already done so) the development of inventories of PFAS-contaminated soil and other PFAS waste, using, amongst other things, tracking data.

Recommendation 3: Develop an agreed sampling and testing protocol for contaminants in biosolids

Biosolids may contain a range of chemical contaminants, particularly persistent bioaccumulative and toxic chemicals, at levels of potential environmental concern. Jurisdictions should agree on a sampling and testing protocol that extends the range of parameters to be tested beyond the restrictive list in current biosolids guidelines and also covers frequency of testing/ sampling, test/ sampling methods, methods of data sharing and flexibility in how requirements are to be applied across different scales of waste water treatment plants, including consideration of both contaminant concentrations and loads. A starting point could be the *National contaminant sampling and testing protocol* AWE (2017).

6.2 Plan for and respond to emerging risks

Recommendation 4: Develop contingency plans for sites that represent a single point dependency

State and territory regulators should consider developing contingency plans for sites located within their jurisdiction that may be 'single point dependencies' – facilities that, within that jurisdiction at least, are the only viable licensed means of managing a particular waste to a particular environmental standard. These plans should consider alternative management options available in the event that such facilities stop operating, temporarily or permanently, and the pathways and likelihood of that occurring.

6.3 Increase regulation and compliance activity

Recommendation 5: Increase scrutiny of licensed storage

Environmental licenses in many jurisdictions set specific limits on the quantity of wastes that can be stored on the site of generation at any point in time. Illegal and unlicensed incidents, high rates of storage for some wastes, low rates of competition in niches of the hazardous waste industry, single point facility dependencies in some jurisdictions and an observation from tracking data that short-term storage is not necessarily short term, all create a 'perfect storm' of conditions for storage of hazardous waste beyond licensed allowances. Regulators should consider tighter monitoring of such licence conditions through:

- establishing regular (perhaps monthly) company reporting requirements of their stored quantities, referenced against licence allowances, that could be built into tracking system usage
- increased compliance checks, as have been undertaken recently in Vic and NSW, targeting high-risk wastes and those identified as subject to high levels of storage.

Recommendation 6: The PFAS NEMP should include a biosolids-specific limit for PFAS compounds and landfill acceptance criteria with existing contamination in mind

The PFAS NEMP should set a maximum concentration for PFAS in biosolids, above which land application is prohibited. This should be chosen in recognition of the soil and water criteria already established, and through consideration of other precedents in Europe and, particularly, in Australia, such as the Biosolids End of Waste Code in Qld. For land application, such criteria could consider whether there are different concerns associated with one-off vs repeated biosolids applications.

The landfill acceptance criteria under the PFAS NEMP should be reassessed, in light of lower regulatory levels applied to landfills in NSW and Qld, and recognising pre-existing concentrations of PFAS within landfills (and their leachate), so that a total PFAS load is considered.

Recommendation 7: Consider the merits of 'community right to know' public disclosure of hazardous waste tonnages and information

Hazardous waste data, prior to recent years' publication of national collation datasets and reports, was rarely made available to the public. Company-specific information about the hazardous waste they produce is not publicly disclosed. In light of media reports about fraudulent activity in the waste sector, the question should be asked – why not? Are perceived risks of exposure of commercially sensitive information through publication of company-specific waste volumes justified, in light of the experience of the National Pollutant Inventory (NPI), which has disclosed very similar information without confidentiality issues for more than 15 years?

For waste management operators (as opposed to waste producers), data on the types and quantities of waste they receive is more likely to be commercially sensitive. But should these concerns outweigh the public benefit in making available transparent information about which wastes go to which locations for which management methods?

Waste management operators are on the public record, in terms of who they are, where they are and what they are licensed to carry out; waste producers are not. Disclosing waste producers, their tonnages and the management methods that they are sent to would be a major improvement on current arrangements, even if specific tonnages received by waste management operators was not disclosed.

6.4 Improve administrative systems and data

Recommendation 8: Agree on clear and distinguishable PFAS waste and contaminant codes

Clear and distinguishable waste and contaminant codes should be agreed for wastes containing PFAS, and should be implemented as a priority in tracking systems. If based on the M270 code in the PFAS NEMP, consideration should be given to splitting this into sub-codes, such as M271, M272, M273 etc to allow PFAS waste matrices to be clearly identified.

An alternative could be to use the contaminants system, beneath the M270 code, with identifications such as 'Soil contaminated with PFAS', 'AFFF', 'absorbents containing PFAS' etc.

Recommendation 9: Integrate waste classification and tracking data in the future

Hazardous wastes are identified through reference to jurisdictional contaminant frameworks, which requires laboratory testing. These test results are typically provided to EPAs as part of the classification decision. Since this information already exists, it is inefficient not to couple it with tracking system data. The means to do so is the contaminants field, which is present in some form in most jurisdictional tracking systems. Online systems should be designed so that wastes (for a particular company) are characterised once, in terms of contaminants, linked and reused each time a certificate is raised.

The goal should be to have a fully integrated system that combines and links tracking data with a waste's contaminants by retaining and entering data originally provided to EPAs as part of the classification decision.

6.5 Enhance levels of collaboration across governments

Recommendation 10: Establish a jurisdictional data sharing agreement

At present, each state's tracking data is maintained as confidential and not shared with other jurisdictions other than the Commonwealth. This represents an unnecessary obstacle to good policy analysis and should be addressed through a data sharing agreement that facilitates full access to other jurisdictions' data. Such an agreement would enable state environmental agencies to share data from their tracking systems in real time, which could provide intelligence for immediate and strategic regulatory purposes. Such agreements would be tightly bound in regulator-in-confidence principles.

Recommendation 11: Move towards a detailed national system for categorising hazardous waste management

States and territories should migrate their regulatory and administrative systems towards a national taxonomy of hazardous waste management methods that is consistent with the level of detail used currently in Vic and Qld, which are based on the Basel Convention's 'D' and 'R' codes. This would enable a far greater understanding of the processes applied at waste management facilities, beyond the restrictive and 'blunt' six-category system currently used in national data collations. This important need is already established in the Standard (Item 21).

Recommendation 12: Agree to a national tracking system for cross-border transport of hazardous waste

A national hazardous waste tracking system, for the movement of controlled wastes across borders, should be developed to improve the patchwork of approaches to data management across Australian jurisdictions. This would markedly streamline government administration of the system, industry's use of it and provide a broader understanding of the national market.

7. Data analysis – by waste group

The section analyses and comments on the data presented in Section 3 and detailed in ***Appendix B (Section B.1)*** *National hazardous waste data 2017-18 and 2018 – by NEPM code*, for each of the waste groups.

The summary source analysis tables listed for each waste group (for each state) show contributing industry sectors in approximate order of highest to lowest contributing tonnages. More detailed analysis has been undertaken for NSW and Vic data, to determine percentage breakdowns of their source industries, which have also been listed in square brackets by Australian and New Zealand Standard Industrial Classification (ANZSIC code), the definitive 4-digit industrial categorisation system. A qualitative analysis was provided on Qld and SA source data, while WA is not listed at all, as no level of source identification in provided in its data. For other jurisdictions (ACT, NT and Tas), no breakdown by source is possible because they do not maintain electronic tracking systems.

Similarly, management data is collated and discussed below for NSW, Qld, SA, Vic and WA. The ACT, NT and Tas do not record management data due to the absence of electronic tracking systems in these jurisdictions.

Where 2017-18 analysis figures are quoted, such as percentage contributions by jurisdiction or waste type, waste generation figures have been used. When discussing trends, arisings data is typically used – unadjusted to *generation* because the information required to make such 'multiple-count' adjustments is not always available for the historical record. This approach allows trends to be viewed consistently over time.

Although biosolids are presented in the waste group analysis below (Section 7.22), national percentages (waste group to total waste) quoted in the respective discussions of each waste group exclude biosolids; due to the swamping effect of their size and the fact that biosolids are not expressly captured by jurisdictional hazardous waste regulations (although they may exhibit hazardous characteristics).

7.1 A. Plating and heat treatment

This group includes:

- A100 Waste resulting from surface treatment of metals and plastics: Overspray of coating materials together with excess material removed in cleaning of equipment – the latter includes sandblast cleaning and surface protection of metal surfaces, including shipping hulls.
- A110 Waste from heat treatment and tempering operations containing cyanides: Molten inorganic salts used to 'case harden' or 'face harden' iron or low-carbon steel or to control temperature in the tempering process.
- A130 Cyanides (inorganic): Solutions of sodium and potassium cyanides are used in processes that do not result in their complete transformation or destruction and they are present in wastes from such processes.

Sources

Table 14 provides a summary of the main sources of waste in each jurisdiction.

Table 14 Plating and heat treatment summary source analysis 2017-18

NSW (A130 only)	Vic	Qld (A100 only)	SA (A100 only)	National summary
2% of national total for waste group	*N/A – Vic does not track A group wastes*	• Shipyards & Slipways • Metal Coating and Finishing • Waste Collection, Treatment and Disposal Services • Coal mining	• Metal Coating and Finishing • Oil & Gas Extraction	• Shipyards & Slipways • Metal Coating and Finishing • Waste Collection, Treatment and Disposal Services • Coal mining

Virtually all the source data presented in Table 14 is generated in Qld as A100 from the following sources:

- shipyards and slipways (from ship hull cleaning and protective coating)
- metal coating, finishing and surface blasting; such as electroplaters, galvanisers and metal cleaning via sandblasting

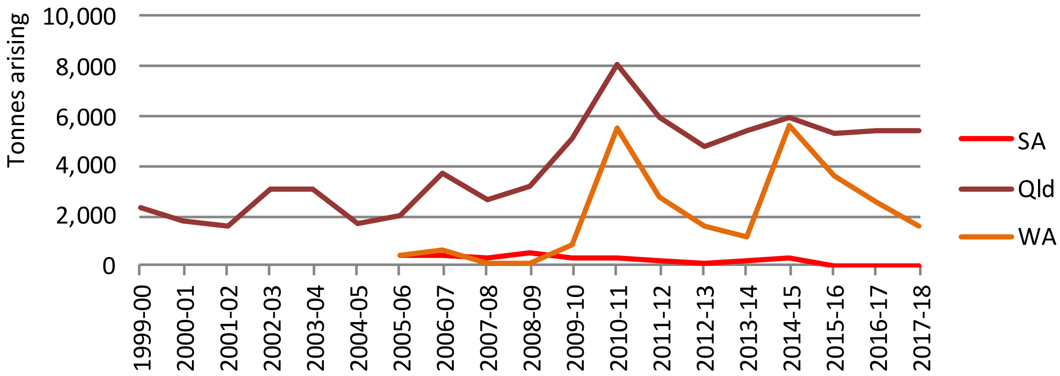
The other notable feature of 2017-18 data for this waste group is that WA contributed 14% of the national total, along with Qld's 83%, leaving only 3% coming from all other jurisdictions combined. No source data is available for WA. Vic does not recognise this waste group, incorporating the relevant wastes within the 'D' group codes (inorganic chemicals).

Analysis

This waste group is small by volume in Australia, making up only 0.07% of the national total in 2017-18. It is dominated by *A100 Waste resulting from surface treatment of metals and plastics* and derives from overspray of coating materials together with excess material removed in cleaning of equipment. This waste is generated from either metal surface cleaning and protection, such as barnacle removal from ship hulls, cleaning, blasting and other surface finishing techniques in metal manufacturing/ finishing industries and industrial cleaning and protection of heavy equipment, such as is used for mining applications.

Historical trends in arisings for this waste group, predominantly for Qld and WA, are shown in Figure 27. Viewed from around 2008-09 onwards, Qld and WA data indicate an inclining trend.

Figure 27 Historical arisings of plating and heat treatment waste



Management

Management approaches for this waste group differ between Qld and WA. In Qld, 71% goes to landfill and 15% to storage while in WA 45% is recorded as going to chemical/ physical treatment, with 50% to storage. This difference is likely to be attributable to the different types of materials used in these differing surface treatment processes. Marine anti-fouling technologies are likely to use quite different approaches and materials to land steel applications. The 'peak and trough' pattern of generation volume in WA is consistent with the state's high rate of storage of this waste – it could be indicative of short-medium term storage and release spike activity, as wastes are accumulated for later on-sending to other management.

The Qld historical data record has been updated for this waste since its supply for HWiA 2017. This has resulted in changes to the Qld trend in Figure 27, most notably in 2014-15, where recently supplied data is much lower than was the case previously. This is consistent with Qld data anomalies noted in HWiA 2017, which were annotated as potentially (erroneously) high.

7.2 B. Acids

This group comprises the single NEPM code *B100 Acidic solutions or acids in solid form*. It can take a large variety of forms including, but not limited to: sulfuric acid, hydrochloric acid, nitric acid, phosphoric acid, chromic acid, hydrofluoric acid, mixed inorganic and organic acids.

Sources

Table 15 provides a summary of the main sources of waste in each jurisdiction.

Table 15 Acids summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 47% Iron Smelting and Steel Manufacturing [2110] • 40% Petroleum Refining & Petroleum Fuel Man. [1701] • 2% Cu, Ag, Pb & Zn Smelting & Refining [2133]	• 41% Other Structural Metal Product Manufacturing [2229] • 35% Petroleum Refining and Petroleum Fuel Man. [1701] • 3% Petroleum Product Wholesaling [3321] • 1% Other Motor Vehicle Parts Manufacturing [2319]	• Copper Refining • Metal Coating and Finishing • Coal Mining • Alumina Refining • Waste Collection, Treatment and Disposal Services	• Metal Coating and Finishing • Fabricated Metal Product Manufacturing • Electrical Equipment Manufacturing *<2% of national total for waste group*	• Other Structural Metal Product Manufacturing • Petroleum Refining • Copper Refining • Iron Smelting and Steel Manufacturing • Petroleum Product Wholesaling • Metal Coating and Finishing • Coal Mining • Alumina Refining

Vic produced the largest quantities of acid wastes in 2017-18 (71%) followed by Qld with 17%. Their main sources were steel and metal related industries such as metal product manufacturers, foundries, metal refiners, electroplaters, galvanisers, and other metal product manufacturing industries, as well as petroleum refineries.

Analysis

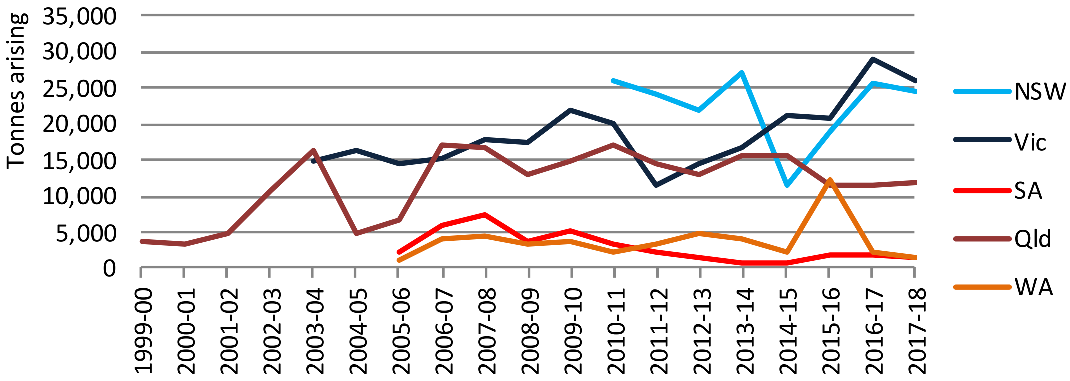
This waste group is relatively small by volume in Australia, making up 0.85% of the national total in 2017-18. Liquid is the dominant waste form.

Historical trends in arisings for this waste group are shown in Figure 28. While there is some historical fluctuation over the last decade, Vic and NSW arisings (the main contributing jurisdictions) have climbed since HWiA 2017 (2014-15 data). This is probably due to a renaissance in the steel (and supporting) industries' in recent years, as export markets have strengthened for this sector, since (acidic) spent pickle liquor is a key component of this waste stream.

NSW operates a system of regulatory exemptions from waste tracking requirements. Spent pickle liquor wastes from NSW destined for reuse in NSW are underestimated in the data of this report because this activity is one of these exemptions.

Another important aspect of acids waste is that a large proportion of the waste stream appears as exports from Vic to NSW.

Figure 28 Historical arisings of acids waste



Management

The management of this waste group is listed as:

- 97% chemical/ physical treatment in NSW
- 20% chemical/ physical treatment and 78% 'Other' in Vic
- 55% recycling and 29% chemical/ physical treatment in Qld
- 99% chemical/ physical treatment in SA
- 64% chemical/ physical treatment and 33% storage or transfer in WA.

While neutralisation via chemical/ physical treatment is an historically typical pathway, analysis of NSW tracking data shows that Vic companies send their B100 waste to spent-acid regeneration infrastructure in NSW. These waste transport certificates record the management as 'chemical/ physical treatment' although it would appear to more accurately be recorded as (the Basel disposal operation) *R6 Regeneration of acids or bases*, which would best be described as a form of recycling. This highlights a broader issue (discussed in Appendix C, where NSW's (and by default SA's) restrictive system of only six management type headings can result in blurred distinction between recycling and chemical/ physical treatment, the latter often used as a broad catch-all category.

The 78% 'Other' management category in Vic is most likely capturing export to NSW recycling, with a lack of clear management categorisation. This demonstrates a weakness in 'closing the loop' of the interstate transport system, where such a transaction is not being fully reflected back in the tracking system of the state of origin of the waste (Vic in this case). This type of issue appears throughout the report in discussions of wastes that are commonly moved across borders under the Controlled Waste NEPM.

7.3 C. Alkalis

This group comprises the single NEPM code *C100 Basic solutions or bases in solid form*.

Sources

Table 16 provides a summary of the main sources of waste in each jurisdiction.

Table 16 Alkalis summary source analysis 2017-18

NSW	Vic	Qld	SA	National Summary
• 78% Industrial Gas Manufacturing [1811] • 10% Iron Smelting and Steel Manufacturing [2110] • 3% Petroleum Refining & Petroleum Fuel Man. [1701]	• Petroleum Refining and Petroleum Fuel Man. [1701] • Metal Coating and Finishing [2293] • Other Motor Vehicle Parts Manufacturing [2319] • Waste Collection, Treatment and Disposal Services	• Ready-Mixed Concrete Manufacturing • Asphalt manufacturing • Oil & Gas Extraction (CSG/ LNG) • Aluminium refining	• Cement and Lime Man.	• Ready-Mixed Concrete Manufacturing • Asphalt manufacturing • Oil & Gas Extraction (CSG/ LNG) • Aluminium refining[45] • Cement and Lime Manufacturing • Industrial Gas Manufacturing • Petroleum Refining & Petroleum Fuel Man.

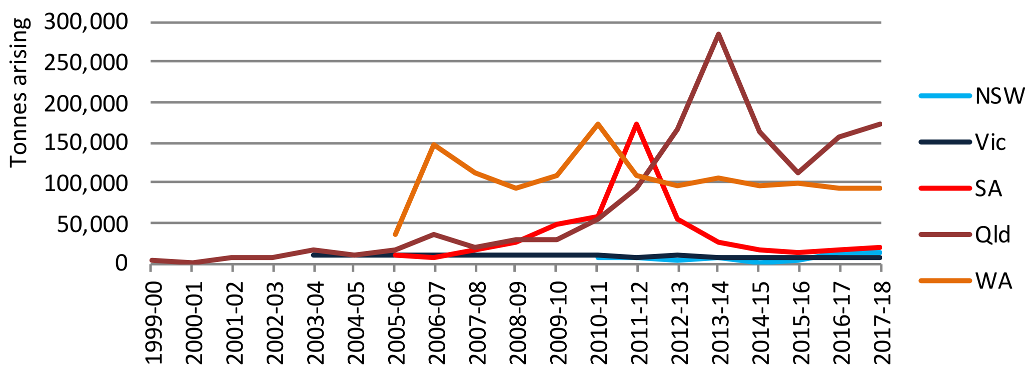
Qld produced the largest quantities by far of alkali wastes in 2017-18 (63%) followed by WA with 22%. Historically the main Qld source was coal seam gas (CSG) extraction (79% in 2014-15) but this has changed markedly in 2017-18, as discussed in 'Analysis' below, to be dominated by concrete manufacturing. WA C100 is entirely red mud from the aluminium refining industry, which is a contributor to Qld tonnages as well. Red mud is produced in exceptionally large quantities in aluminium refining, but the WA volumes are the only ones significantly captured in tracking data, because they represent the waste's movement from production sites to dedicated 'residue storage areas'.

C100 is also produced in small quantities across Australia as waste from surface cleaning/ degreasing in a range of industries as diverse as metal coating and finishing to fast food.

Analysis

Historical trends in arisings for this waste group are shown in Figure 29 below. This waste is moderately significant nationally, at 3.6% of all hazardous waste arising in 2017-18.

Figure 29 Historical arisings of alkalis waste



[45] Although not reflected in WA tracking data, C100 alkali waste in WA is 'red mud', a high-volume waste from aluminium refining in the state

Qld arisings from the CSG industry

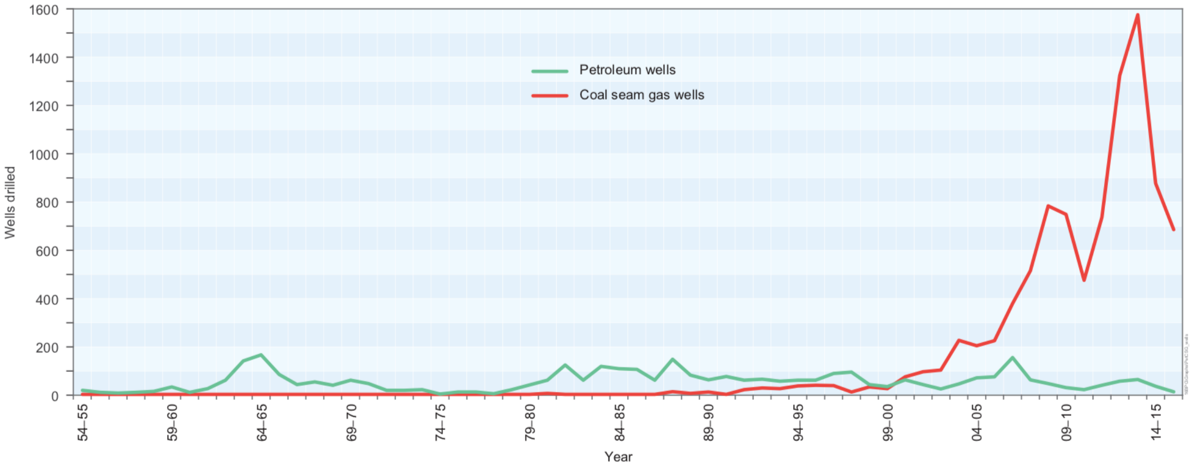
Qld C100 waste that is produced by the CSG industry is mostly drilling mud (in liquid form), the waste output of the use of drilling fluids to access the coal seams, described in HWiA 2017 as containing mostly brine/ water (76%), barium sulphate (14%) and bentonite clay/ polymer (6%). This has dropped as a proportion of total Qld C100 quite dramatically in recent years – 79% of Qld C100 in 2014-15 down to just 20% in 2017-18.

From about 2009 to 2014 there was strong growth in Qld C100 arisings which, given a similar trend for non-toxic salts (the other classification for CSG industry 'salty' wastes), was likely to be reflective of the rise of the CSG extraction industry in Qld. Similarly, the substantial drop in waste volumes since then also appear to reflect industry drilling rates, which peaked at 1,634 wells in 2014-15 then fell to 700 wells in 2015-16[46], as shown by Figure 30, which mirrors the Qld chart of C100 waste in Figure 29.

It is noted however that drilling is the development phase of gas extraction, so while drilling rates have gone down, gas production rates are increasing exponentially, as discussed in Section 4.7.1, which still brings production-related waste issues to manage.

In terms of the industry's contribution going forward, C100 waste may fall to negligible levels, as the new 'End of Waste Code' for Coal Seam Gas Drilling Mud[47] became effective in January 2019, which appears to enable drilling mud to fall out of the waste classification system and into the lexicon of a 'resource', as long as it is managed according to this code. This management is essentially composting, to produce compost, mulch, soil conditioner or 'general purpose soil'. Although the End of Waste Code is silent on the issue, it is likely that this change in classification will see drilling muds no longer tracked in Qld.

Figure 30 Annual Queensland conventional petroleum and CSG wells drilled, to 30 June 2016



Source: QDNRM 2017[46]

[46] QDNRM 2017: Queensland Government Department of Natural Resources and Mines, *Queensland's petroleum and coal seam gas 2015-16*, available at: *http://www.australiaminerals.gov.au/__data/assets/pdf_file/0003/47622/Queenslands-petroleum-and-coal-seam-gas-2017.pdf*

[47] QDSE 2019: Queensland Government Department of Environment and Science, *End of waste code Coal Seam Gas Drilling Mud (ENEW07543018),* 01 January 2019, available at *https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-drilling-mud.pdf*

In reality, if Figure 29 was simply about CSG drilling mud it would have fallen off sharply after 2015-16, as the CSG industry accounted for just 35 kt (approximately) in 2017-18. Another industry has taken its place.

Qld arisings from the pre-mix concrete industry

2016-17 and 2017-18 tracking data includes large representation from the concrete production (and aligned asphalt production) industries, sectors that were essentially absent from 2014-15 data. Approximately 67%[48] of all Qld C100 waste in 2017-18 was from these sectors. There appears to have been some form of regulatory or industry policy change post 2015 that has captured waste concrete materials (presumably with high pH) to be C100 regulated waste, and subject to tracking in Qld. These industry sectors are not represented at all as C100 sources in NSW or Vic.

The waste is likely to be dried out solid alkaline materials from concrete washout areas, "used to contain concrete slurry and liquids when the chutes of concrete mixers and hoppers of concrete pumps are rinsed out after delivery to a site. The washout facilities are used to consolidate solids for easier disposal or reuse and to prevent runoff of contaminated liquids."[49]

Management

Qld data indicates that 88% of alkali waste is recycled, 10% is landfilled and 1% is sent to Chemical/ physical treatment. C100 from concrete production and asphalt production was solid waste sent to Qld management codes R5 (recycling/ reclamation of inorganic substances) or R6 (recycling/ reclamation of acids or bases), with receival facilities typically quarries. Quarries are not generally licensed as hazardous waste management facilities in other jurisdictions but are in Qld, and may have only become so due to recent changes to environmentally relevant (activities ERAs) legislation.

Drilling muds from the CSG industry are sent to composting facilities, as the End of Waste Code (and previous Beneficial Use Application) allow for. WA red mud is sent to specific residue storage areas, which are a form of regulator approved storage, that is essentially long-term or indefinite.

7.4 D110. Inorganic fluorine (spent potliner)

This group comprises the single NEPM code *D110 Inorganic fluorine compounds excluding calcium fluoride*, previously not provided as its own waste group in *HWiA 2015*, but presented within the broader catch-all group 'Other D – Other inorganic compounds'. This NEPM code is used in the Australian dataset virtually exclusively to describe spent pot liner (SPL), a waste material generated from aluminium smelters, of which there are four in current operation (in Vic, NSW, Qld and Tas) and two recently closed (in Vic and NSW).

SPL can exhibit the following hazards:

- toxicity – leachable fluoride and cyanide compounds, with fluoride levels often around 10%
- corrosiveness – high pH due to the presence of alkali metals and oxides

[48] On a gross mass basis, unadjusted for density.

[49] NSW Government Transport for NSW 2015, Concrete Washout Guideline 3TP-SD-112/2.0, available at: https://www.transport.nsw.gov.au/sites/default/files/media/documents/2017/concrete-washout-guideline%20-3tp-sd-112.pdf

- reactivity with water – producing toxic, explosive, and inflammable gases.

SPL is sometimes heat-treated prior to transport to recycling/ re-processing fates to remove cyanides and flammability risk, but not fluorides, hence the convention to record it in tracking systems as *D110 Inorganic fluorine compounds excluding calcium fluoride*.

Sources

Table 17 provides a summary of the main sources of waste in each jurisdiction.

Table 17 Inorganic fluorine (SPL) summary source analysis 2017-18

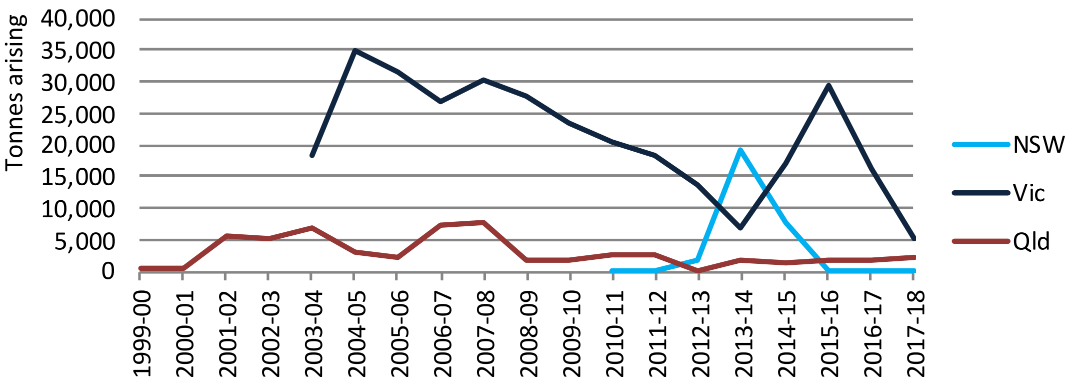
National summary (in Vic, NSW, Qld & Tas only)
100% Aluminium Smelting, ANZSIC code 2132

Analysis

This waste group is relatively small by volume in Australia, making up 0.5% of the national total in 2017-18. However it is a good example of why volume (tonnage) is not an accurate indicator of the significance of a waste, particularly based on annual arisings. SPL is problematic because it contains a number of different (and significant) hazards, is produced from a potentially declining industry sector in Australia (which increases the risk of stranded infrastructure with legacy environmental liabilities), has a long history of intractable environmental management (with some specific successes) and, most of all, is currently stored in large stockpiles around Australia. Since management solutions have proved difficult for decades, there are approximately 700,000t of SPL held in either above-ground (shed) or below-ground (landfill) storages around Australia (REC *et al*. 2016), which dwarfs the 34,413t annual arisings estimates in Table 17.

Historical trends in arisings for this waste group are shown in Figure 31 which provides some value from an indicative trend perspective, but is limited by two issues:

Figure 31 Historical arisings of inorganic fluorine (SPL) waste



1. Aluminium industry annual (aluminium) production figures are used to derive 'generation' figures instead of tracking system data, on the basis that it is a better estimate of tonnages produced, due to the prevalence of onsite storage (that is not visible in tracking systems) and spike-like intermittent releases of SPL that may be included in tracking systems sporadically. The arisings trends in Figure 31 are based on tracking systems.

2. The other state with an operational aluminium smelter (Tas) is not represented because it does not have a tracking system.

However, Figure 31 does indicate that:

- Vic's SPL arisings have been declining over the last decade, culminating in a low when Alcoa Point Henry closed down in February 2014 and rebounding up the year after that (due to some movements of previously stored material).
- NSW shows a spike of SPL was taken out of onsite storage in 2013-14 and, although aluminium (and SPL) production has continued since then, virtually none has move offsite for treatment/ disposal.

Management

Tracking data shows that SPL in Vic was exclusively recycled when it arose in 2017-18, noting that onsite storages, or historically in Alcoa Point Henry's case, onsite recycling, are not captured in tracking data. SPL-specific management infrastructure in Vic closed down in 2018, so it is likely that new Vic arisings in 2018-19 have remained in onsite storage.

Actual NSW arisings (of SPL specifically) in tracking data are negligible, which also indicates onsite storage in 2017-18.

Qld data appears to suggest that, for a small number of movements in 2016-17 and 2017-18, some SPL was accepted into landfill, a form of management that is not typically suitable for SPL. SPL generated in Qld has historically been managed in cement kiln infrastructure, as a form of industrial ecology.

7.5 D120. Mercury & compounds

This group comprises the single NEPM code *D120 Mercury; mercury compounds*. While volumes are small, this waste has been singled out due to its inherent hazard, as evidenced by the *Minamata Convention on Mercury*.

Sources

Table 18 provides a summary of the main sources of waste in each jurisdiction.

Table 18 Mercury & compounds summary source analysis 2017-18

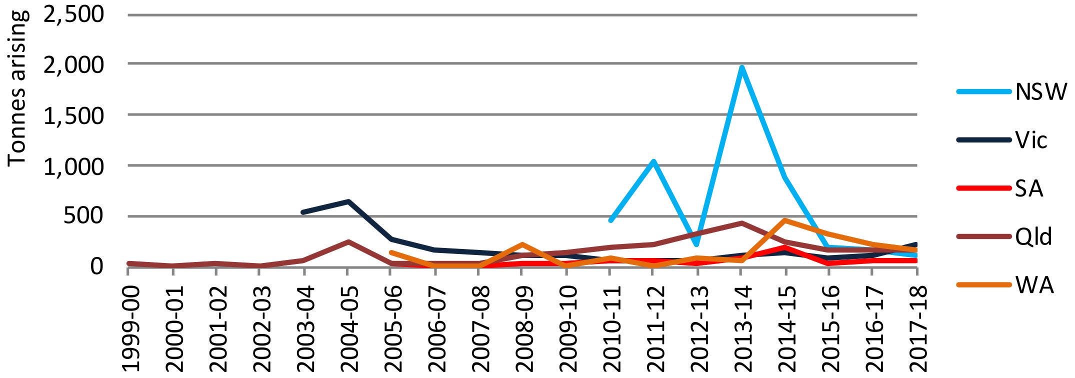
NSW	Vic	Qld	SA	National summary
• Waste Treatment and Disposal Services [2921] • Various Manufacturing • Lighting (retail)	• 53% Waste Treatment and Disposal Services [2921] • 18% Non-Residential Building Construction [3020] • 11% Aluminium Smelting [2132]	• Disparate sources	• Waste Collection, Treatment and Disposal Services • Electricity Supply • Medical, dentistry, universities	• Waste Collection, Treatment and Disposal Services • Lighting (retail) • Electricity Supply • Medical and Dentistry

Mercury volumes are small and, in SA and NSW in particular, seem to reflect fluorescent lamp collection programs, both industrial and through retailers. Often the waste industry is listed as the producer, given their role in such programs.

Analysis

Historical trends in arisings for this waste group are shown in Figure 32 below. While extremely small by tonnage (0.005% of all hazardous waste arising in 2017-18), this waste is another example of a very high hazard waste with limited long-term management options.

Figure 32 Historical arisings of mercury waste



Major spikes such as the one in NSW in 2013-14 are likely to be from mis-coded soil whose contaminant was mercury, and should have been coded as N120 contaminated soil (not D120 mercury). This could also be a simple typographical error, given the commonality of the '120' part of the code. This has also been observed in Qld data previously, and the Vic source 'Non-Residential Building Construction' is evidence of such a mistake in 2017-18 data.

Management

Other than miscoded contaminated soil, mercury waste tends to be sent either to storage/ accumulation (due to its small volumes and difficulty of management) and/or recycling, which is sometimes identified as CPT.

7.6 D220. Lead & compounds

This group comprises the single NEPM code *D220 Lead; lead compounds*. Australia has the world's largest deposits of both lead and zinc and as a result, both are mined and used locally and exported (Geoscience Australia 2015). Table 19 provides a summary of the main sources of waste in each jurisdiction.

Sources

Table 19 provides a summary of the main sources of waste in each jurisdiction.

Table 19 Lead & compounds summary source analysis 2017-18

NSW	Vic 2012-13	Qld	SA	National summary
• 72% Motor Vehicle Parts Retailing [3921] • 12% Metal and Mineral Wholesaling [3322] • 8% Motor Vehicle Dismantling & Used Parts Wholesale [3505] • 2% Copper, Silver, Lead and Zinc Smelting and Refining [2133]	• 61% Motor Vehicle Dismantling & Used Parts Wholesale [3505] • 19% Motor Vehicle Parts Retailing [3921] • 13% Copper, Silver, Lead and Zinc Smelting and Refining [2133]	• Lead Acid Battery Collection • Scrap Metal Collectors and Recyclers • Iron and Steel Manufacturing • Waste Collection, Treatment and Disposal Services	• Iron Smelting and Steel Manufacturing • Lead Acid Battery Collection	• Zinc smelting & refining (Tas only) • Motor Vehicle Parts Retailing and Dismantling & Used Parts Wholesale • Lead Acid Battery Collection • Scrap Metal Collectors and Recyclers • Iron and Steel Manufacturing • e-waste Recycling • Glass and Glass Product Manufacturing

Lead waste arisings in Australia can be essentially viewed two ways – that emanating from Tas and everything else, the latter being mostly used lead-acid batteries (ULABs).

The Tas-produced lead waste comes exclusively from zinc refining.

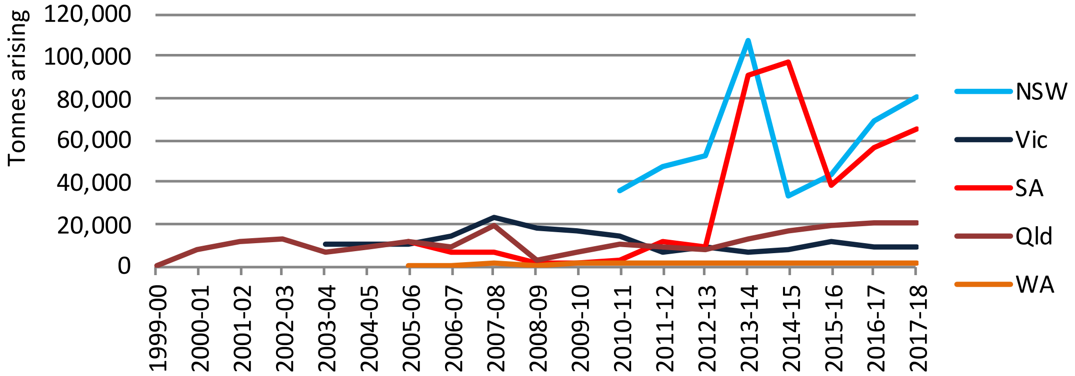
The 'everything else' case heavily reflects end-of-life lead acid batteries typically bound for recycling/ recovery and (to a lesser extent) glass from e-waste recycling of Cathode ray tube (CRT) screens that contains high concentrations of lead (CRT glass). The former originally comes from a broad range of industries, including vehicle intensive ones such as mining and transport-related businesses, but usually via collection programs facilitated by metal and other resource recovery companies. The latter comes from e-waste dismantlers/ recyclers, and may arise through intermediate storage facilities. There are also smaller, more specific arisings of lead waste from smelting and refining of metals, mining and scrap metal recyclers.

Analysis

This waste was quite significant nationally by tonnage in 2017-18, coming in 11th highest at 2.4% of all hazardous waste generated, according to data evident in tracking systems. The majority of this was generated in Tas (35%), with 31%, 17% and 6% generated in Vic, Qld, and SA respectively, while only 8% was generated in NSW and about half as much again from WA.

Historical trends in arisings for this waste group are shown in Figure 33

Figure 33 Historical arisings of lead waste



Tas D220 lead generation

While not directly present[50] in the data of Figure 33 due to its lack of a tracking system, Tas generated the largest tonnage of lead waste in Australia from the zinc refining industry in that state. A total of 61,048 tonnes was generated from Tas in 2017-18, which is down on the very large volume reported in HWiA 2017 (144,149 tonnes in 2014-15). Although Tas production of lead waste has been reliably large over recent years, such large fluctuations, against a back drop of much steadier zinc production, suggests there may be some drawing down of historical stockpiles.

While there were extremely high levels of generation in 2013-14 and 2014-15, they dropped back in 2015-16 to a level that appears to be rising at a more measured rate.

SA D220 lead generation

SA does generate a relatively modest amount of its own D220 lead waste, through ULABs as well as the lead smelting industry, the latter acting more as receival/ processing infrastructure for the re-smelting of Tas lead waste than a net source of lead itself.

NSW D220 lead generation

Like the remainder of Australia, ULABs are produced in NSW from batteries disposed by motor vehicle parts retailers, car wreckers and other collection centres, often run by third parties. But, as highlighted in earlier editions of HWiA, NSW generation of lead waste in the tracking system-generated data set is an underestimate, due to the NSW waste tracking regulatory exemption, for *spent lead acid batteries destined for reuse*[51].

But Figure 33 shows NSW arisings to be higher than other states, other than Tas, so how can this be? The answer lies in the fact that trends are reflections of 'arisings' not generation, so the blue NSW trend line is in fact a sum of all other jurisdictions exports to NSW, since it houses the hub of ULAB recycling capability in Australia (predominately through secondary lead smelting infrastructure). Conversely this is also why the other jurisdictions' arisings are so low.

[50] Tas tonnages are actually contained within the SA red chart line, because their generation tonnage is sent to SA (via ship), so it is said to 'arise' in SA.

[51] See *http://www.epa.nsw.gov.au/wasteregulation/lead-acid-battery.htm*

Further complicating NSW arisings observations is a major historical glitch: two obvious certificate mistakes from an interstate import into NSW, amounting to a 45,000-tonne over-estimation (shown as the 2013-14 spike in Figure 33 above).

The only way to obtain reliable NSW-specific generation of D220 lead is to source data from the major battery recyclers and add that to other (non-battery) generation of lead waste recorded in the NSW tracking system. This would not be difficult, as there are only licensed battery recyclers in NSW, with the suggestion there may be further consolidation in future.

Discussion with the largest of these recyclers suggests that NSW is their largest market in Australia, as might be expected. Using Vic ULAB exports to NSW (44 kt) as a guide, assuming that there is no ULAB processing occurring in Vic, it would be reasonable to assume a similar amount for NSW (also assuming that tracked D220 lead in NSW is lead waste from sources other than ULABs destined for recycling). On that basis a more correct estimate for NSW generation could be approximated as 14 kt (current NSW generation) plus 44 kt (equivalent to Vic) = 58 kt.

NSW lead waste currently sits third by tonnes in NSW arisings for 2017-18, behind only the massive contributors of contaminated soils and asbestos, and 11th nationally. If the 44 kt adjustment was made (which it hasn't for the tabulated numbers in this report), national D220 lead arisings would move up to be eighth highest by tonnes.

Management

As expected, recycling dominates the management of arisings of lead waste in Australia, particularly for used lead acid batteries within infrastructure located in NSW. There is also a significant lead recycler in Qld. A misleadingly high proportion of batteries imported into NSW through the interstate consignment process nominate CPT as the management infrastructure, when they are clearly received within secondary lead smelting (recycling). Adjusting for anomalies such as this suggests around 85% of all D220 (lead) waste in Australia is recycled.

7.7 D230. Zinc compounds

This group comprises the single NEPM code *D230 zinc compounds* and is analysed separately because of the significant tonnage generated.

Sources

Table 20 provides a summary of the main sources of waste in each jurisdiction.

Table 20 Zinc & compounds summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 100% Metal and Mineral Wholesaling [3322] – *exported to SA*	• *100% Metal and Mineral Wholesaling [3322] – exported to SA*	*<0.5% of national total for waste group*	• Iron Smelting and Steel Manufacturing	• Zinc smelting & refining (Tas only) • Metal and Mineral Wholesaling • Iron Smelting and Steel Manufacturing

This waste was quite significant nationally by tonnage in 2017-18, at 2% of all hazardous waste generated. The vast majority of this was generated in Tas (84%), with the only other significant generation from Vic at 10% and NSW 5%.

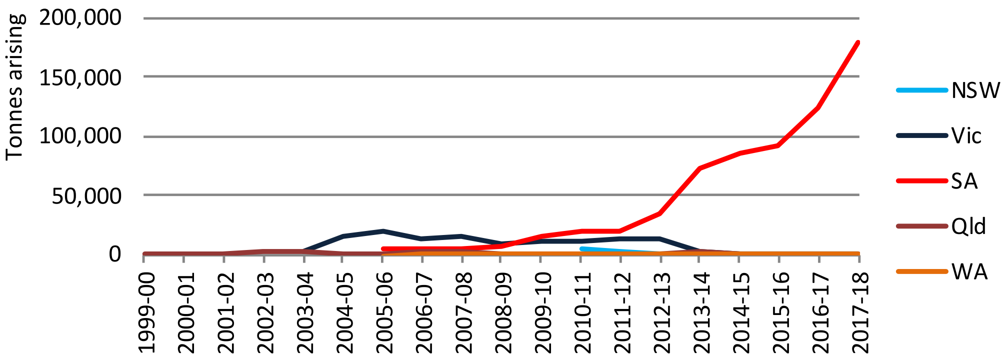
Analysis

The Tas-produced zinc waste, like its lead waste, comes exclusively from zinc refining. Historical trends in arisings for this waste group are shown in Figure 34.

The most notable aspect of Figure 34 is the SA (red) line, which shows large growth from 2010-11 onwards. Like lead waste this is not about SA at all but entirely about Tas. That state's zinc refining industry has been sending large shipments of zinc waste (like lead waste) to smelting infrastructure in SA for recycling over the last 5 years. These show up as SA arisings in raw SA tracking system numbers, because they have arisen in the SA waste management system. Because Tas has no tracking system, it is not obvious that this comes from Tas exports, but this fact is borne out in SA tracking data which, unlike previous years before their adoption of a new online tracking system, makes imported waste transactions clearly visible. Similarly, Vic and NSW export reasonable quantities of zinc waste, slag, dust and sludges from steel mills in each state.

The rate of zinc arisings into SA appears to have been increasing more rapidly since 2015-16. This is likely to be due to major upgrades of the Port Pirie lead smelter, which was commissioned in late 2017, increasing throughput by 70% and enabling the treatment of internal residues across their smelter network[52].

Figure 34 Historical arisings of zinc waste



Management

As described above, all of the zinc waste is received into metal smelting infrastructure in SA for recycling.

[52] Nyrstar Investor Presentation, January 2018. Available at: https://www.nyrstar.com/~/media/Files/N/Nyrstar/investor-toolkit/talkbook-january-2018-12.pdf

7.8 D300. Non-toxic salts (including coal seam gas wastes)

This group comprises the single NEPM code *D300 Non-toxic salts*. In Qld, in particular, this equates to highly saline solids, liquids and sludges that are by-products of coal seam gas (CSG) extraction, but these are not the main types of D300 appearing in tracking systems in 2017-18.

Significant non-CSG related sources of this waste are dominated by liquid wastes from WA, followed by salty slags leftover from the smelting or refining of aluminium, steel, lead and other metals.

Sources

Table 21 provides a summary of the main sources of D300 non-toxic salts in each jurisdiction.

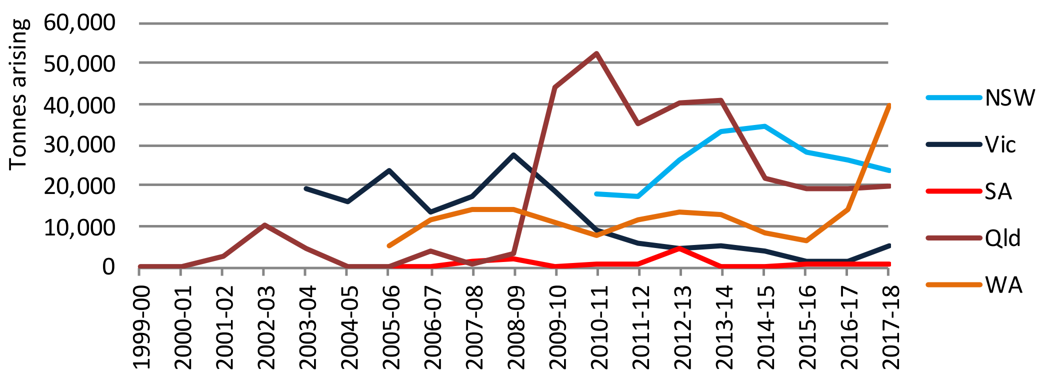
Table 21 Non-toxic salts summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 51% Copper, Silver, Lead and Zinc Smelting and Refining [2133] • 41% Aluminium Smelting [2132] • 6% Metal and Mineral Wholesaling	• 72% Aluminium Smelting [2132] • 13% Metal and Mineral Wholesaling [3322]	• Oil & gas extraction (CSG/ LNG) • Salt product manufacturing *(Limited 2017-18 data available for analysis – relies on previous years source data)*	*1% of national total for waste group*	• Oil & gas extraction (CSG/ LNG) • Aluminium smelting • Copper, Silver, Lead and Zinc Smelting and Refining • Metal and Mineral Wholesaling

Analysis

Historical trends in arisings for this waste group are shown in Figure 35.

Figure 35 Historical arisings of non-toxic salts waste



In total this waste makes up 1% of all hazardous waste generated nationally by tonnage in 2017-18, with WA generating 50%, NSW 26%, Vic 12% and Qld 11%.

Qld CSG-produced non-toxic salts waste

Arisings are perhaps a better reflection of generation for this waste, because it shows very high storage behaviour in Qld (56%). The double-counting adjustment (for generation) assumes that short-term storage is just that – short term – but Qld arisings of this waste appear not to significantly re-emerge into the market (within a 12-month period at least), as investigated in Appendix C.2 ‘Adjusting for ‘multiple counting’ of wastes generated’. This creates a false discounting effect on tonnages. On an arisings basis, Qld’s share doubles to 22% at the expense of Vic (6%), other jurisdictions’’ D300 shares remain unchanged.

It is hard to determine what is happening with D300 from CSG activities in Qld, because 2017-18 tracking data is particularly incomplete for this waste. The Qld trend in Figure 35 appears flat but this is simply a reflection that population adjusted past data has had to be used. Section 4.7.1 steps back from tracking data and discusses the current state of waste management in the Surat Basin, where the industry is both making good progress and throwing up new challenges in managing its waste.

WA-produced non-toxic salts waste

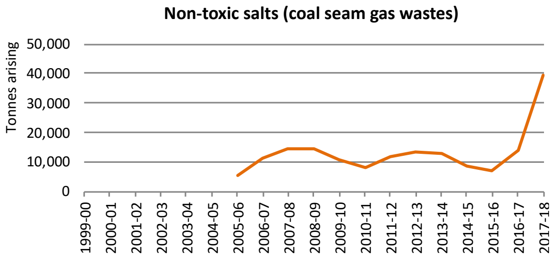
Given the lack of access to source information in all WA data, analysis of the largest D300 non-toxic salts contribution in national data in 2017-18 is speculative. What is known is that this waste is liquid and it has risen very sharply this year, on the back of a smaller rise in 2016-17. Transaction numbers have gone up for each year but proportionally not as much as the tonnage, which suggests a new source with much larger waste loads per truck.

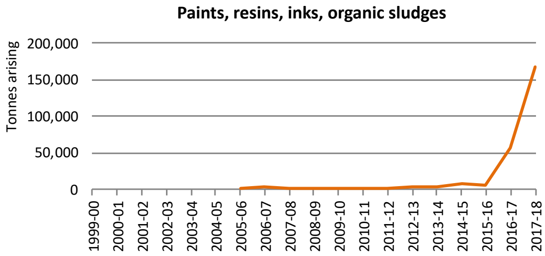
One possible source is the desalination plant in Binningup, 150 km south of Perth, but his reached full capacity in January 2013, so would have been expected to have its full brine waste effect by the 2014-15 year, which is not supported by the WA trend line. The other requires a speculative triangulation process.

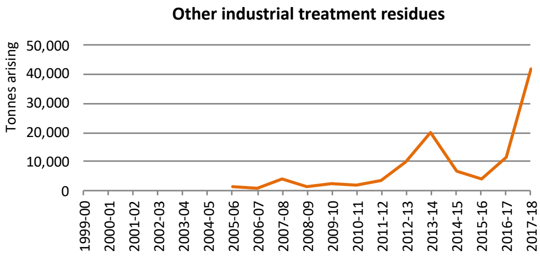
Figure 36 lays out three historical waste arisings charts, from WA data only, which all show a very similar profile of growth, starting slowly in 2016-17 and rising rapidly in 2017-18. Section 7.11 discusses the rapid rise of F wastes, as F100, as a single established industry player newly introduced to the tracking system, with very large volumes of slurried ‘treatment solid residues’ from the process’ neutralisation plant. The company’s licence suggests that landfill leachate from the cell containing this waste is re-carted back to the original site, where it re-treated in the neutralisation plant and flushed to sea. Since this waste or its leachate has properties of acidity and high salts (mostly chlorides), it is feasible that either the original movement of post-neutralised waste (to the landfill) could alternatively be coded as D300 (based on different decisions by certificate users), or similarly the returning leachate.

The similar pattern in N205 *Other industrial treatment residues* suggests this code may have also been interchangeably used. In this case the waste is well described, since it is either “slurried treatment solid residues” from the company’s neutralisation plant, or landfill leachate, a waste commonly reported under N205b.

Figure 36 WA historical arisings of three wastes, D300, F and N205b, respectively







Non-toxic salts waste from metal manufacturing

These are made up of:

- aluminium smelting industry wastes, mostly aluminium dross but also other salty wastes (often called salt cake) from ingot rolling in the final production process
- other metal smelting and refining industry slags, mostly furnace slags from lead acid battery recycling processes.

Management

Aluminium dross is recycled in specific aluminium recovery/ recycling infrastructure, with subsequent low value (secondary) dross material sent to hazardous waste landfill. Furnace slag from lead acid battery reprocessing and related metal smelting operations is also sent to hazardous waste landfill. Qld CSG waste D300 appears to be predominantly sent to storage, although 2017-18 Qld management data is significantly incomplete.

7.9 Other D. Other inorganic chemicals

This group includes waste and wastes contaminated with metal carbonyls; inorganic sulphides; perchlorates; chlorates; arsenic, cadmium, beryllium, antimony, thallium, selenium and tellurium; compounds of copper, cobalt, nickel, vanadium, boron, barium (excl. barium sulphate), chromium (hexavalent & trivalent) and phosphorus (excl. mineral phosphates)[53].

Other D wastes are small nationally by tonnage, at around 0.07% of all hazardous waste generated in 2017-18. Table 22 provides a summary of the main sources of waste in each jurisdiction.

Sources

Table 22 Other inorganic chemicals summary source analysis 2017-18

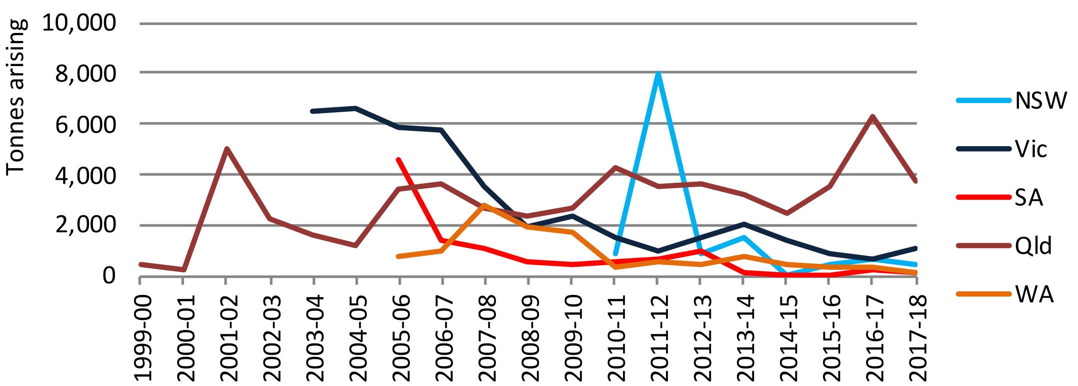
NSW	Vic 2012-13	Qld	SA	National summary
Not determined	• Fossil Fuel Electricity Generation • Motor Vehicle Parts Manufacturing • Petroleum Refining • Leather Tanning, Fur Dressing and Leather Product Manufacturing	• Foundries and steel product manufacturing • Rail transport • Metal Coating and Finishing • Fossil Fuel Electricity Generation	*Not determined*	• Foundries and steel product manufacturing • Rail transport • Metal Coating and Finishing • Fossil Fuel Electricity Generation

Qld generated 66% of this waste and Vic 18% in 2017-18. Steel and foundry related industries in Qld were the main source industries for chromium and nickel wastes (D140 and D210 respectively), while rail transport was identified for arsenic waste (D130) in Qld.

Analysis

This group of wastes made up only 0.07%% of all hazardous waste generated nationally by tonnage in 2017-18. Historical trends in arisings are shown in .

Figure 37 Historical arisings of other inorganic chemical waste



53 Also including compounds containing these elements.

Trends are difficult to decipher in the arisings data, which appears to show what may be a storage release spikes for NSW in 2011-12 or, perhaps more likely, a mis-coded contaminated soil, contaminated in one of the metals in this group.

Qld arisings appear to be trending up in the long term, with lumps and bumps possibly indicative of storage/ release behaviour. This could be linked to the strength of the steel and related industries, as noted for waste B100 (Section 7.2). The spike in 2016-17 Qld data is from tellurium waste and is from a number of waste movements from single earth moving/ demolition/ civil contracting company, sending solid waste to landfill. This is probably an example of mis-coded contaminated soil, although it is unusual to have tellurium as the contaminant of concern, so the tellurium contaminant may be an additional certificate user mistake. A less likely explanation could be that the waste resulted from broken or disused solar panels, some of which are known to use tellurium in their photovoltaic chemistries.

Management

Management data are as varied as the wastes themselves with the majority in Qld listed as going to hazardous waste landfill. The major management is listed as chemical/ physical treatment in Vic.

7.10 E. Reactive chemicals

This waste group comprises the single NEPM code: *E100 Waste containing peroxides other than hydrogen peroxide*, although it shares similar strong oxidising properties to *D340 Perchlorates* and *D350 Chlorates*, which were not grouped together in this category to preserve NEPM E reporting alignment and because the contributions from D340 and D350 are similarly small.

Sources

Table 23 provides a summary of the main sources of waste in each jurisdiction.

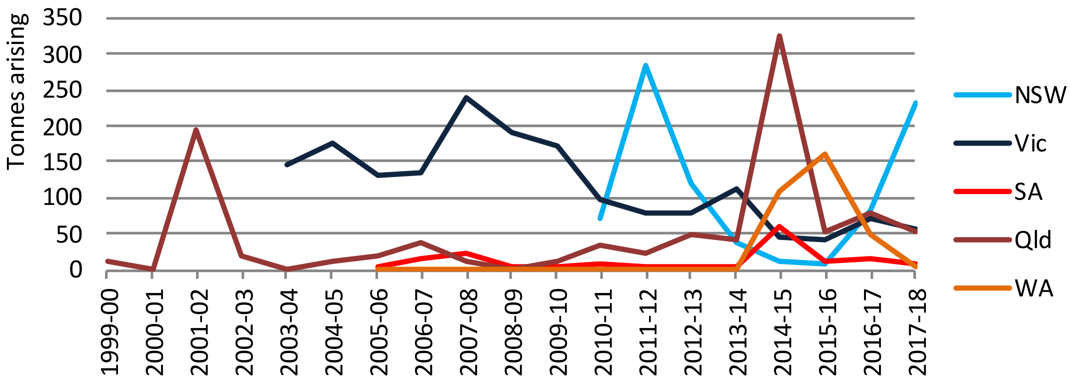
Table 23 Reactive chemicals summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
Not Determined	• 43% Waste Treatment and Disposal Services [2921] • Other Basic Non-Ferrous Metal Manufacturing [2139]	• Aluminium Smelting	*Insufficient source information available*	• Waste Treatment and Disposal Services • Aluminium Smelting • Other Basic Non-Ferrous Metal Manufacturing

Analysis, including management

This waste was extremely small nationally by tonnage in 2017-18, at 0.002% of all hazardous waste generated. The majority of this was generated in NSW (42%), Qld (27%) and Vic (23%). Historical trends in arisings for this waste group are shown in Figure 38.

Figure 38 Historical arisings of reactive chemicals waste



This waste is very small and difficult to characterise, because much of it is listed as being from the waste industry. This is typical of difficult to manage high hazard wastes that often default to storage, as is the case here, with 70% of all E waste going to storage in 2017-18. One significant source is specifically identified as a specialist metals manufacturing company. The waste in this case may be a type of spent catalyst which may still pose reactivity risks.

7.11 F. Paints, resins, inks, organic sludges

This group includes:

- F100 Waste from the production and use of inks, dyes, pigments, paints, lacquers & varnish
- F110 Waste from the production & use of resins, latex, plasticisers, glues and adhesives.

The former includes polymeric material such as polyacrylates and methacrylates, together with pigments and small quantities of substances like plasticizers and anti-oxidants. The latter includes monomers used in production of polymers, waste products from the production site, or waste generated in or after use of the products.

Sources

Table 24 provides a summary of the main sources of this waste in each jurisdiction.

Table 24 Paint, ink, resin and organic sludge summary source analysis 2017-18

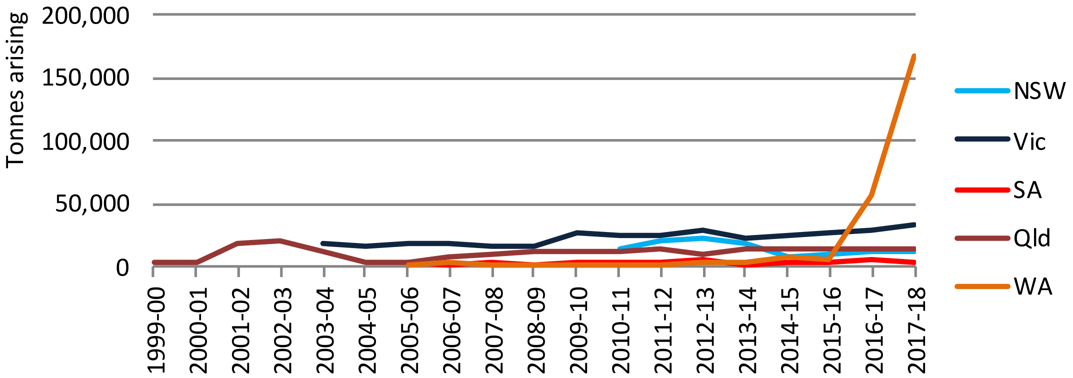
NSW	Vic	Qld	SA	National summary
• 40% Waste Treatment and Disposal Services [2921] • 14% Paint and Coatings Manufacturing [1916] • 11% Basic Organic Chemical Manufacturing [1812] • Printing, other 35%	• 40% Waste Treatment and Disposal Services [2921] • 14% Paint and Coatings Manufacturing [1916] • 2% Motor Vehicle Manufacturing [2311]	• Paint and Coatings Manufacturing • Chemical and chemical product manufacturing • Printing • Metal product manufacturing • Pulp and paper manufacturing • Aircraft manufacturing	• Motor Vehicle Manufacturing • Waste Treatment and Disposal Services • Pulp and paper manufacturing	• Paint and Coatings Manufacturing • Waste Treatment and Disposal Services • Chemical and chemical product manufacturing • Printing • Motor vehicle manufacturing

Although not included quantitatively in the source summary of Table 24, WA generated 77% of this waste, followed by Vic at 9% and NSW and Qld 6% each, in 2017-18. Paint and coating manufacturing was responsible for the large WA arising, as the industry is in other states, albeit at times via the waste industry.

Analysis

In total this waste makes up 2.9% of all hazardous waste generated nationally by tonnage in 2017-18, which ranks it surprisingly highly as the 7th highest. Historical trends in arisings for this waste group are shown in Figure 39. WA arisings swamps all other jurisdictions combined. The WA waste in question is F100 *Waste from the production, formulation and use of inks, dyes, pigments, paints, lacquers and varnish*.

Figure 39   Historical arisings of paint, ink, resin and organic sludge wastes



The WA tonnage suggests a rapid increase has recently occurred, but the source is a single company that has been in existence for some time, and has only begun using the controlled waste tracking system in WA since 2016, probably as a result of this anomaly being identified via a licence amendment process.

Management

Potentially more concerning than the large quantity of F100 waste arising in WA is its fate – landfill, not an expected management for liquid wastes that might potentially include solvents, a range of organic chemicals in paint/lacquer/varnish and even metals acting as colourants in pigments and dyes. F100 is an example of a waste that describes the industry that it comes from rather than the waste's properties itself, which is not particularly helpful in this case. According to the company's licence the waste is slurried 'treatment solid residues' from the process' neutralisation plant, so it is likely to contain inorganic salts and solids. The industrial process in this case has more in common with basic inorganic chemical manufacturing than paint manufacturing, as it makes a precursor to for such downstream applications, and the waste itself is essentially a slurry of neutralised acids (and therefore salts, particularly chlorides) and unreacted solids. This bears little resemblance to other wastes in the F description, such as solvents, resins, adhesives and paint sludges.

The landfill that is licensed to receive this waste does so in a specific cell, with the resulting leachate returned back to the original facility's neutralisation plant (by road tanker again) for further treatment and subsequent discharge via ocean outfall (see Section 7.8).

While technically correct, it would seem that the choice of waste code in the WA example, F100, is probably not what was intended of the category. Perhaps D300 (salts), B100 (acids) or N205b (industrial treatment residues) might be better classification choices.

7.12 G. Organic solvents

This waste group includes:

- G100 ethers
- G110 organic solvents excluding halogenated solvents
- G150 halogenated organic solvents
- G160 waste from the production, formulation and use of organic solvents.

Solvents have three principal areas of use; as cleaning agents, as a raw material or feedstock in the production and manufacture of other substances, and as a carrying and/or dispersion medium in chemical synthetic processes. They are often distinguished on the basis of halogenation in their chemical structure, with halogenated organic solvents more of a health and environmental concern than non-halogenated organic solvents. As a result, both usage and waste from halogenated organic solvents tend to be declining in favour of non-halogenated alternatives.

Sources

Table 25 provides a summary of the main sources of this waste in each jurisdiction.

Table 25 Organic solvents summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 25% Waste Treatment and Disposal Services [2921] • 11% Printing & packaging Remainder made up of: • Dry cleaning, Chemical and chemical product manufacturing, Automotive and other machinery servicing, laboratory services, other manufacturing	• 35% Waste Treatment and Disposal Services [2921] Remainder made up of: • Pharmaceutical manufacturing [1841]; Printing [1611]; Oil & gas extraction [0700]; Motor Vehicle Manufacturing [2311]; Organic Chemical Manufacturing [1812]	• Automotive and other machinery servicing • Waste Collection, Treatment and Disposal Services • Dry cleaning • Oil refining • Asphalt production • Motor vehicle manufacturing • Defence • Paint manufacturing	• Dry cleaning • Waste Collection, Treatment and Disposal Services • Motor Vehicle Manufacturing • Printing	• Waste Treatment and Disposal Services • Printing & packaging • Pharmaceutical • Dry cleaning • Chemical and chemical product manufacturing • Motor vehicle manufacturing • Paint manufacturing

NSW, Vic, Qld and WA generated this waste in roughly equivalent quantities each, in 2017-18. The waste industry is one of a number of major contributors to arisings, most likely through chemical/ physical treatment or solvent recovery processes.

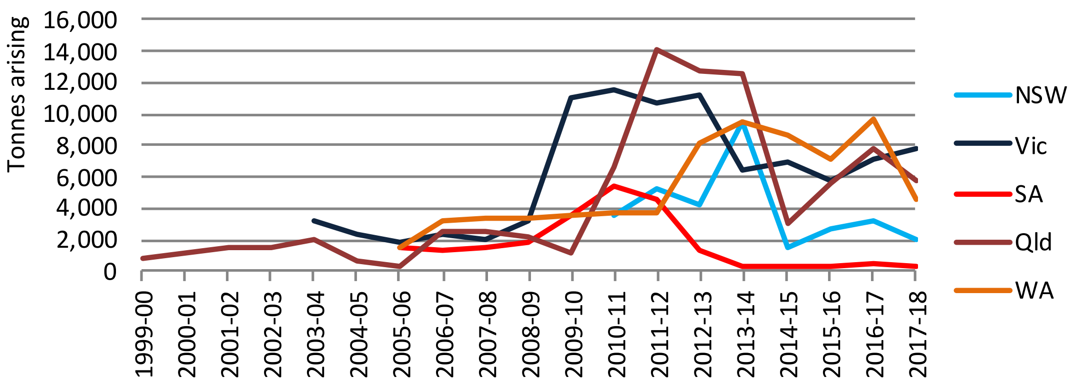
Analysis and management

This waste group is small by volume in Australia, making up 0.2% of the national generation total in 2017-18. However, it accounts for more than 50% of this volume again in total arisings, because almost 40% of all G waste management, nationwide, is recorded as 'stored'. This puts solvent wastes in the top five wastes (for storage as a percentage of total management) in Australia, and of these five it is the largest tonnage.

Storage can dominate as a form of management for a number of reasons: difficulty of treatment due to limited infrastructure, complex management requirements due to high-hazard, small volumes per transaction (leading to accumulation and later release) or storage awaiting an interstate consignment authorisation (since 88% of this waste is ultimately managed in Qld and Vic).

Historical trends in arisings for this waste group are shown in Figure 40.

Figure 40 Historical arisings of organic solvents wastes



7.13 H. Pesticides

This group includes three potentially diverse types of waste:

- *H100: waste from the production, formulation and use of biocides and phytopharmaceuticals*
- *H110: organic phosphorous compounds*
- *H170: waste from manufacture, formulation and use of wood-preserving chemicals*.

H100 is the major pesticide heading (biocide means pesticide) although it also includes the relatively unrelated phytopharmaceuticals, which are plant derived pharmaceutical products such as alkaloids.

H110 includes wastes from organic phosphorus compounds used as lubricants, plasticisers, flame retardants and, most notably, organophosphate pesticides.

H170 is different again in that it covers wastes from timber preservation which in Australia has historically been dominated by chromated copper arsenate treatment. Its overlap in this NEPM category is presumably due to the function of this timber preservation process, where the copper acts as a fungicide, the arsenic an insecticide (both types of biocide) and the chromium chemically fixes these to the wood to stabilise them.

Over 8,000 pesticide and veterinary products have been registered for use in Australian agriculture, horticulture, livestock, forestry, commercial premises, parks, homes and gardens (Immig 2010). Pesticide wastes can arise due to historical activities where the active ingredients may be mixed or perhaps unknown, due to weathered container labelling. It also arises from manufacturing and formulating of these chemicals, such as agricultural chemical suppliers, wood preserving chemical supply and chemical manufacturing.

Sources

Table 26 provides a summary of the main sources of this waste in each jurisdiction.

Table 26 Pesticides summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 53% Waste Treatment and Disposal Services [2921] • 17% Pesticide Manufacturing [1832] • 2% Basic Organic Chemical Manufacturing [1812] • Shipyards & Slipways	• 72% Waste Treatment and Disposal Services [2921]	• Wood product manufacturing • Electricity Supply • Waste Treatment and Disposal Services • Shipyards & Slipways	• Waste Treatment and Disposal Services • Agriculture, forestry & fishing industries	• Waste Treatment and Disposal Services • Pesticide Manufacturing • Wood product manufacturing • Shipyards & Slipways

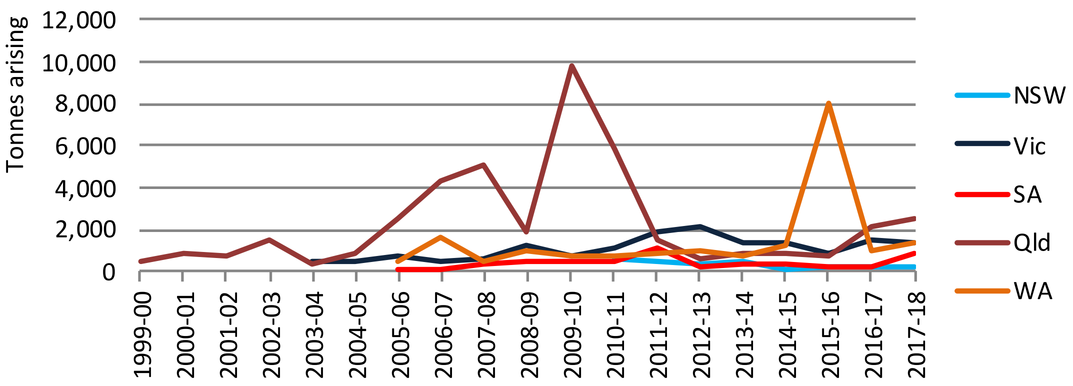
NSW generated 38% of pesticide wastes nationally in 2017-18, followed by SA (23%) and the remainder spread relatively evenly between Vic, WA and Qld. The waste sector is regularly mentioned as a source, possibly due to their role in household or farm collection program wastes. The waste sector in this case is the collector rather than the true 'generator'.

Sources of this waste are quite specific in the case of H170, which arises from the wood preservation chemicals used by the wood product manufacturing industry. For H100 and H110 sources are more variable.

Analysis

This waste group was very small nationally by tonnage in 2017-18, at 0.05% of all hazardous waste generated. Historical trends in arisings for this waste group are shown in Figure 41.

Figure 41 Historical arisings of pesticide wastes



Management

A proportion of pesticide wastes are managed via cross border flows, with 96% of those ending up in infrastructure in Qld and Vic. Like G solvent wastes, it is also subject to high levels of storage, with 41% of all H waste management recorded as storage in 2017-18. Pesticide wastes fit a similar high hazard profile as G wastes as well, which means management is expensive, and could originate from disparate sources which may contribute to accumulation behaviour.

However, on the surface at least, tracking data is not always what it seems. The major management types for H wastes are mixed: storage in NSW; storage, landfill and some CPT in Qld; recycling in Vic and landfill in SA. Despite thermal destruction being the main Stockholm Convention-sanctioned treatment for POPs like pesticides, it is the only one of the six-category national management categories that records nothing at all in 2017-18. So, what is going on?

Various explanations may apply. Firstly, the six-category system is to blame, because recycling (in Vic) is loosely correct - the waste is blended into a fuel and subsequently burnt for energy recovery in industrial processes, hence the use of the recycling-based (Victorian) management code R1 *Use as a fuel (other than in direct incineration) or other means to generate energy*. The waste component of concern – pesticides – is thermally destroyed (not recycled), even if it is a (very small) part of a fuel blend. In Qld, CPT tends to be used to describe a thermal destruction facility (for reasons that are not clear) and storage is not necessarily storage because, in Qld at least, landfill infrastructure is receiving pesticide waste but some of these transactions are recorded as 'storage'.

Finally, in discussing these seemingly anomalous management type choices, there is the most concerning observation: why is 23% of all Australia's pesticide waste going to landfill? Some of it not only goes to landfill, but actually crosses the border to go to Qld landfill. While this is not ideal environmental outcome, closer inspection of these waste transport certificates reveals that they are either soils contaminated in tri-butyl tin (and so should have been classified as N120), or soils/ solids contaminated in creosote.

Lastly for pesticide wastes in 2017-18 there are two concerning observations in the data:

1. SA is a major contributor of pesticide waste and virtually all of it is identified as 'copper-chrome-arsenic' in liquid form, being sent from a Council to an SA landfill. Waste liquids from this treatment would not typically be accepted at landfill, but it is noted that waste transport certificates do not reveal all of the information about a waste.

2. Similar to that reported in HWiA 2017, there was a small amount of pesticide waste in 2017-18 sent to what appear to be composting facilities in Qld: creosote contaminated material and solid waste from wood preserving chemicals, the latter recorded as "blending or mixing before disposal…"

7.14 J100 & J160. Oils

This waste group comprises two NEPM codes:

- J100 Waste mineral oils unfit for their original intended use
- J160 Waste tarry residues arising from refining, distillation and any pyrolytic treatment.

J100 is dominated by used oil from transport vehicles and off-the-road machinery, while a small proportion of (mostly Vic) data also includes the used oil filters themselves. J160 is a much smaller contributor, produced in the refining of petroleum, re-refining of lubricating oils, production of metallurgical coke or town gas by pyrolysis of coal.

Sources

Table 27 provides a summary of the main sources of this waste in each jurisdiction.

Table 27 J100 & J160 (oils) summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 19% Basic Organic Chemical Manufacturing [1812] • 19% Water Passenger Transport [4820] • 12% Coal Mining [0600] • 9% Waste Treatment and Disposal Services [2921] • 6% Petroleum Refining & Petroleum Fuel Man. [1701] • 2% Fossil Fuel Electricity Generation [2611] • Others including: Other Automotive Repair and Maintenance [9419]; metal ore mining [080]; Road Freight Transport [4610]	• 80% Waste Treatment and Disposal Services [2921]	• Mining • Manufacturing (various, including food, petroleum & metal coating) • Transport • Automotive Repair and Maintenance • Waste sector	• Mining • Manufacturing (various, including food, petroleum & metal coating) • Transport • Automotive Repair and Maintenance Waste sector	• Waste Treatment and Disposal Services • Basic Organic Chemical Manufacturing • Mining • Petroleum Refining & Petroleum Fuel Man. • Other Automotive Repair and Maintenance • Transport

Oily wastes arisings are distributed across industries in jurisdictions quite similarly, with differences being more to do with jurisdictional industrial mix variations, such as the prevalence of mining in WA and Qld.

The Product Stewardship for Oil Program (PSO) was introduced by the Australian Government in 2001 to provide incentives to increase used oil recycling. The program aims to encourage the environmentally sustainable management and re-refining of used oil and its reuse. The arrangements comprise a levy-benefit system, where an 8.5 cents per litre levy on new oil, helps fund benefit payments to used oil recyclers. These arrangements provide incentives to increase used oil recycling.

Analysis and management

This waste was quite significant nationally by tonnage in 2017-18, at 4% of all hazardous waste generated. NSW generated 39% of oily wastes nationally in 2017-18, followed by Vic (21%), WA (20%), Qld (12%) and SA (6%).

Historical trends in arisings for this waste group are shown in Figure 42. WA and Qld have historically trended much higher in arisings than other states, although both have flattened since about 2013-14. This could be due in both cases to slow down in mining activity. NSW, Vic and SA have followed more sedate growth, as would be expected from population-style growth in motor vehicle ownership.

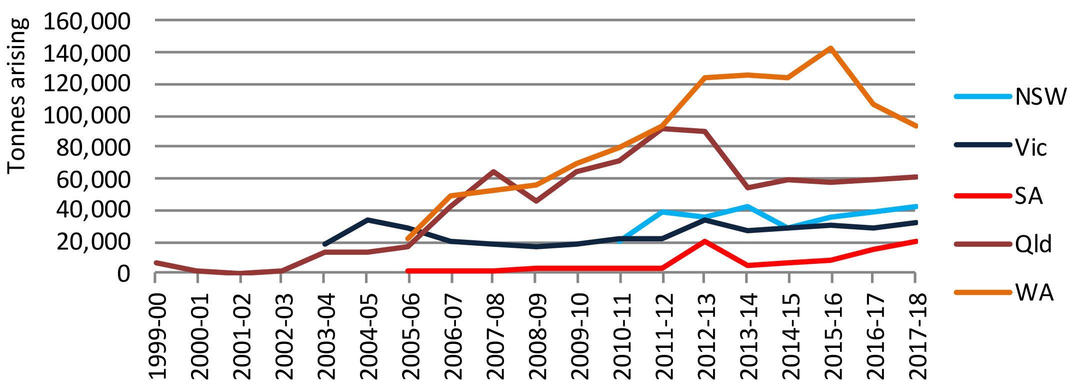
Oils, regulatory exemptions and the PSO

HWiA 2015 provided a lengthy discussion about J100 Oils, on the basis that, as Figure 42 seems to suggest, WA and Qld could be over-reported (perhaps through multiple-counting) given how much higher their arisings were compared to other jurisdictions. It concluded that WA and Qld were not necessarily over-reported as the trend graph suggests. Rather:

- J100 oils were significantly under-reported in NSW, on account of their waste tracking exemption for used oil going to re-refining (recycling)
- J100 oils were probably under-reported in Vic as well, although perhaps to a lesser extent, due to tracking exemptions for so-called Accredited Agents, the name given to licensed transporters who use a 'milk run' style approach to large numbers of small (same waste) pick-ups, such as occurs with motor repair shop used oils/ filters.

Since then, PSO annual reports have proven the above to be the case, so we have updated our method of data collation for J100, for NSW and for Vic, by taking the annually reported total recycled oil figure (for Australia) and working backwards to allocate additional recycling component tonnages for NSW and Vic that result in total (recycled) arisings matching reported PSO numbers. This changes estimated NSW generation markedly from 41kt (tracking data) to 125 kt (using PSO data), and Vic data by about 40 kt extra.

Figure 42 Historical arisings of waste oils



While the PSO results in large volumes of recycled oil, there are still significant quantities going to more rudimentary oil treatment facilities or energy recovery, options lower on the waste hierarchy. Anecdotally at least, at the lowest of end of the management scale, it has been suggested from within the industry that there are operators using waste oil directly in ammonium nitrate/ fuel oil (ANFO) explosives on mine sites, with centrifugal phase separation the only pre-treatment.

7.15 J120. Waste oil/water mixtures

This waste group comprises the NEPM code *J120 Hydrocarbons/water mixtures or emulsions* and, like its 'oilier' counterpart waste J100, is dominated by used oil/ water mixtures from vehicles or, more specifically, vehicle washwater pump-out liquids.

Sources

Table 28 provides a national summary of the main sources of waste.

Table 28 Oil/water mixtures summary source analysis 2017-18

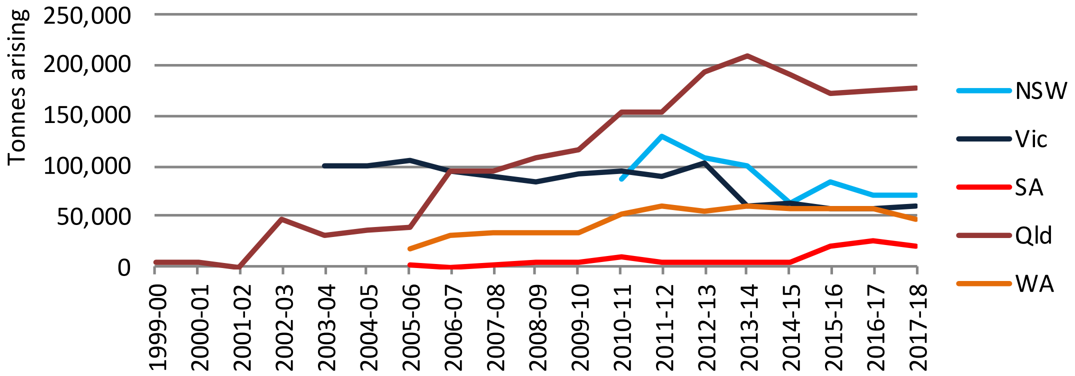
NSW	Vic	Qld	SA	National summary
• 10% Waste Treatment and Disposal Services [2921] • 8% Motor Vehicle Parts Retailing [3921] • 2% Copper, Silver, Lead, Zinc Smelting & Refin. [2133] • 2% Iron Smelting and Steel Manufacturing [2110] • Highly varied sources Repair and Maintenance [9419]; metal ore mining [080]; Road Freight Transport [4610]	• 72% Waste Treatment and Disposal Services [2921]	• Mining • Manufacturing • Automotive Repair and Maintenance • Waste Treatment and Disposal Services	Various	• Waste Treatment and Disposal Services • Motor Vehicle Parts Retailing • Mining • Various manufacturing • Copper, Silver, Lead, Zinc Smelting & Refining • Iron Smelting and Steel Manufacturing

Sources for this waste are similar to J100 – places that handle lubricating oils through vehicle and other machinery servicing and cleaning. The difference between J120 and J100 is that the former also has large contributions from dedicated vehicle washing facilities, such as commercial car washes and truck bays, as well as similar forecourt wash-down collection systems found on retail vehicle refuelling stations, and industrial process waters where oil/ water mixtures are collected

Analysis

This waste was significant nationally by tonnage in 2014-15, at 4% of all hazardous waste generated. The majority of this was generated in Qld (45%), followed by NSW at 25%, WA 12% and Vic 11%. Historical trends in arisings for this waste group are shown in Figure 43.

Figure 43 Historical arisings of waste oil/ water mixtures



HWiA 2017 featured a massive jump in Qld J120 from around 200 kt in 2013-14 to over 500 kt in 2014-15. This was pointed out as part of that work to be due to limitations in quality assurance of the data before its provision, resulting in a large number of unit errors recording individual data points 1,000-fold too high. Since that time the project team has implemented simple checks for all waste from all jurisdictions, which has resulted in the disappearance of this spike from the historical record.

All states show reasonably flat trends, with Vic and NSW possibly in slight decline and the other states flat to inclining.

Management

CPT dominates management of J120 at 47% nationally, while storage is also quite prominent at 29%. The prevalence of CPT correlates with the large numbers of simple oil/ water separation and storage facilities, known as Oil Water Treatment, identified in the *Hazardous Waste Infrastructure Needs and Capacity Assessment*, carried out in 2016 and updated again in 2018[54].

According to HWiA 2017, storage of J120 in Vic was just 10% of all management in 2014-15, but that has grown to 44% (the highest of all states). Perusal of tracking data suggests it could simply be the double-counting from the accredited agents system, where multiple pick-ups are tracked individually and brought back to central facilities and accumulated, then on-sent to further management. If this is the case, it is not clear why this proportion would have gone up so much (four-fold increase) in that time.

7.16 K110. Grease trap wastes

K110 Grease trap waste, or grease interceptor trap waste, is waste from a grease interceptor used for the capture of food, grease and solids before entry to the sewer. These wastes include any solids that are derived from the treatment of this waste. It is primarily sourced from retail food business, such as restaurants and fast food outlets.

As well as the potential odour amenity issues and sewer system blockages, grease trap waste can be a significant pollutant if discharged to water (such as into the stormwater system), and can turn

[54] BE et al

acidic if left standing in the tank too long (due to the presence of food scraps, which produces sulfides that combine with water to produce sulfuric acid).

Sources

Table 29 provides a summary of the main sources of this waste in each jurisdiction.

Table 29 Grease trap waste summary source analysis 2017-18

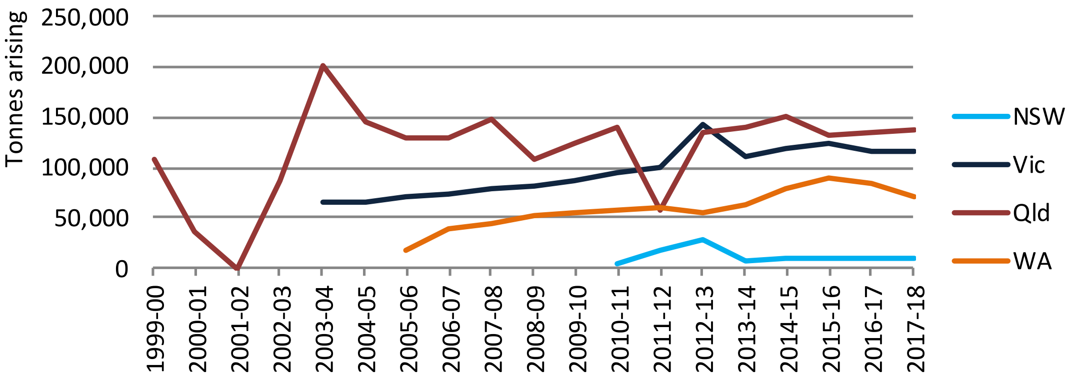
National summary
• Cafes, Restaurants and Takeaway Food Services • Supermarkets and grocery stores • Waste sector (as collectors and aggregators from cafes and restaurants)

Like other K wastes, grease trap is not tracked in NSW or SA.

Analysis

Historical trends in arisings for this waste group are shown in Figure 44.

Figure 44 Historical arisings of grease trap waste



This waste was the third highest national contributor of hazardous waste by tonnage in 2017-18, when biosolids are not included, at 5% of all hazardous waste generated. However, from a hazard perspective, it poses risks at the lower end of the scale. Impacts could include odour and environmental impacts similar to the more viscous and solid petroleum fractions, such as waste mineral oils and waste tarry residues. Primarily though, large amounts of oil and grease create congealment on the surface of tanks and clog pipes, due to their insolubility in water, as well as hampering effective treatment at wastewater treatment plants. These indirect potential 'environmental' impacts, in a related vein to tyres, are the reason some jurisdictions do not view them as 'hazardous' waste.

Generation follows population-style proportions per jurisdiction, as can be seen from the generally even inclining trends over the last 5-10 years in Figure 44.

Management

Management data for grease trap waste shows biodegradation to be the highest form of management nationally, at around 44% in 2017-18, which is not surprising given its applicability for biological breakdown in processes like composting or digestion technologies. Sometimes the terminologies of biodegradation, recycling and even CPT are used differently across jurisdictions, even when composting type operations are involved.

Vic has a regulatory 'classification for reuse' in place[55] (like used oil filters) which essentially requires grease trap not to be mixed with other similar wastes to ensure recycling and reuse outcomes, which are mandatory. Consequently, either composting or oil/ grease recovery make up 85% of all management in Vic, small amounts listed as 'recycling' (likely to be the same), some storage and around 10% listed as CPT. The latter may be unsuitable for recovery due to contamination, or it might represent the more solid fractions of the waste stream that go for "solidification" or other physical treatment to perhaps be further reused.

7.17 Other K. Other putrescible/ organic wastes

This waste group aggregates together the non-grease trap K wastes:

- *K100 Animal effluent and residues (abattoir effluent, poultry and fish processing wastes)*
- *K140 Tannery wastes (including leather dust, ash, sludges and flours)*
- *K190 Wool scouring wastes*

Sources

Table 30 provides a summary of the main sources of this waste in each jurisdiction.

Table 30 Other putrescible/ organic waste summary source analysis 2017-18

National summary
• Meat and meat product manufacturing • Leather and leather product manufacturing • Textile product manufacturing

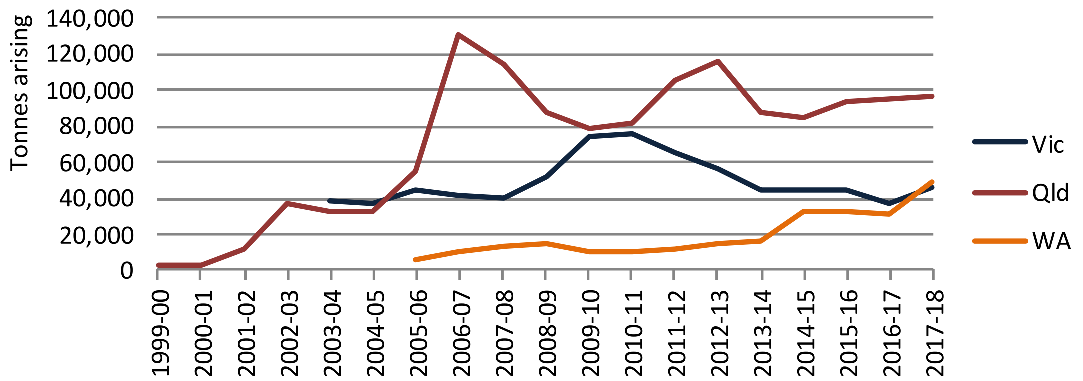
Analysis

This waste group is almost completely dominated by K100, comprising wastes from the meat and seafood processing industries, which are typically high in organic material content. It is significant by tonnage at 3% of all hazardous waste generated in Australia in 2017-18.

NSW and SA arisings are derived from national per capita average arisings, since their respective tracking systems do not track these wastes. Of the remaining jurisdictions, Vic, Qld and WA track K100 while K140 and K190 require supplementation by the same national averaging technique in some cases. Historical trends in arisings for this waste group are shown in Figure 45.

[55] See http://www.epa.vic.gov.au/~/media/Publications/IWRG421.pdf

Figure 45 Historical arisings of other putrescible/ organic wastes



Trends have remained relatively flat over recent years. Qld are significantly higher in arisings than Vic, the other significant jurisdiction within those that track this waste. This may be due in part at least to classification definition, as to what is deemed regulated waste (in this category) compared to Vic, or vice versa what Vic expressly exclude as not prescribed industrial waste (in this category).

Management

Management of Other K wastes in Vic, Qld and WA is dominated by recycling and biodegradation as you would expect given the nutrient organic nature of the wastes, with composting the major activity.

7.18 M100. PCB wastes

This group comprises the single NEPM code M100 *Waste substances and articles containing or contaminated with polychlorinated biphenyls, polychlorinated naphthalenes, polychlorinated terphenyls and/or polybrominated biphenyls* and is considered on its own due to the hazard interest and specific regulatory management requirements for PCBs. It consists of any materials contaminated with PCBs and is dominated by waste oils.

PCBs were removed from service in the 1980s and 1990s, but there remained paraffin oil contaminated with commercial PCB mixtures. Polychlorinated terphenyls (PCTs) and polybrominated biphenyls (PBBs) are not known to have been used in Australia.

Sources

Table 31 provides a summary of the main sources of this waste in each jurisdiction.

Table 31 PCB waste summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 62% Fossil Fuel Electricity Generation [2611] • 14% Waste Treatment and Disposal Services [2921] • 4% Other Heavy and Civil Engineering Construction [3109]	• Fossil fuel electricity generation [2611] • Waste Treatment and Disposal Services [2921]	• Fossil fuel electricity generation • Waste Treatment and Disposal Services	Construction services	• Fossil fuel electricity generation • Waste Treatment and Disposal Services • Construction services

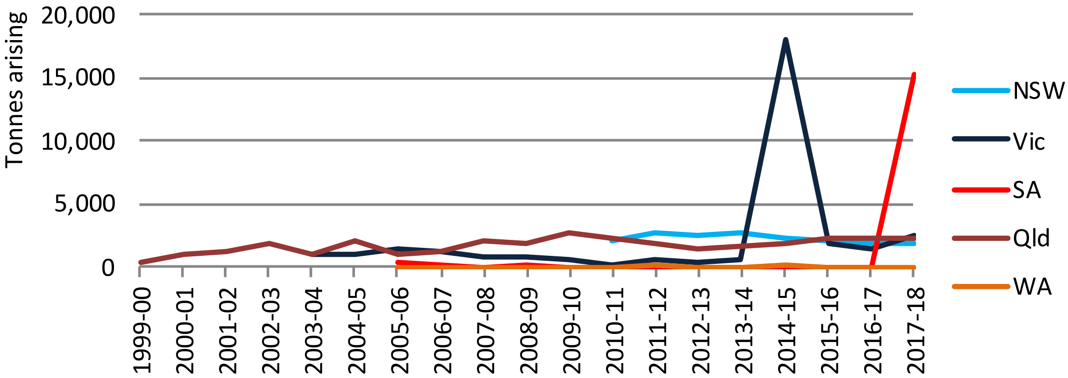
PCB-containing wastes are typically used transformer oils from the electricity supply industry, or waste industry collection of same.

Analysis

This waste was small nationally by tonnage in 2017-18, at 0.2% of all hazardous waste generated. The majority of this (58%) was generated SA, followed by Qld, Vic and NSW in similar amounts.

Historical trends in arisings for this waste group are shown in Figure 46.

Figure 46 Historical arisings of PCB waste



SA's large share – and it's spectacular 2017-18 rise (shown in Figure 46) – suggest suspicious data quality. Analysis of SA source data shows it all to be a single waste transport certificate, of "PCB-contaminated solid waste", which is described as "16 x IBC s". A standard IBC is approximately 1m^3 or 1 tonne, so the recorded quantity of 15,200 tonnes should have been 15,200 L or kg, which is 15 tonnes. This error should be corrected for data analysis purposes in future.

The Vic 2014-15 spike was soil contaminated with PCBs, that would have been more accurately coded as N120.

Management

PCBs in oils, at significant concentrations, are managed in Australia through a couple of types of technologies:

- destruction technologies, such as plasma arc furnace, incineration, cement kilns or related thermal treatment
- solvated electron chemistry technology[56], which uses a solution of ammonia and an alkali metal (such as metallic sodium) to create a powerful reducing agent that chemically transforms PCBs (and potentially other POPs like pesticides) into relatively benign substances.

However, management data does not appear to reflect this very well. This is another example of the problems with the restrictive six national management type headings (as mentioned elsewhere in this report) and inconsistent or incorrect interpretation of which management code to use by tracking system users.

[56] http://www.cpeo.org/techtree/ttdescript/solvelectr.htm

In NSW data, CPT and recycling management types are used interchangeably, despite the receiver being the same facility that performs the solvated electron process. This is probably best described as chemical treatment (therefore CPT) although it is quite unlike traditional CPT. Recycling is understandably chosen because the oil component is recycled (after separation of PCBs), but the PCB components is destroyed, which is not recycling. Even the longer form Basel based D and R type management codes do not provide an ideal fit – a process of irreversible chemical transformation probably can only be coded as D9B *Chemical treatment and solidification or solidification* only, which is still a poor fit.

Vic data also confuses M100 management in a similar way, because of similar issues where a fuel is blended for energy recovery (hence the coding choice of recycling), but in doing so the hazard of interest PCB is destroyed (hence the coding choice of CPT – in this case probably neither are correct and 'thermal destruction' would be a better choice.

Qld data takes a thermal destruction process (plasma arc) and calls it CPT, which is not an accurate reflection of what occurs.

Lastly, Vic includes 1,515 tonnes of M100 sent to landfill in 2017-18. Like the 2014-15 Vic example above, this is actually low-level contaminated soil (with PCB as the primary contaminant, plus secondary contamination in asbestos, copper and mercury) from a single company, which should have been recorded as N120.

When these adjustments are made, including netting out Vic and SA PCB-contaminated soils (and excluding storage), management data shows that almost 100% of PCB oils in Australia are destroyed by either of these two means (thermal and chemical). Adjusted data for national PCB arisings and management for 2017-18 is estimated by Table 32, which is more accurate than raw tracking numbers.

Table 32 Adjusted M100 (PCB waste) arisings and management in Australia, 2017-18

Arisings 2017-18 (tonnes)	Management 2017-18, tonnes and (%)			
	Thermal destruction	Irreversible chemical transformation	Storage	Other
3,849	1,582 (41%)	1,663 (43%)	322 (8%)	283 (7%)

7.19 M160. Other organohalogen compounds

M160 Organohalogen compounds—other than substances referred to in this Table or Table 2, is waste that contains some form of organohalogen compound not elsewhere mentioned on the NEPM list.

The common property of this waste type is that it contains organic chemicals that contain halogen elements (usually fluorine, chlorine, bromine) as significant components in their structure. This waste type shares commonality with other waste types such as chlorophenols (M150), halogenated solvents (G150), dioxins and furans (M170 and M180), PCB-like compounds (M100) and organochlorine pesticides (within H100).

The presence of the halogen species is usually the reason for the property of interest – and the reason for the toxicity. Examples of organohalogen active ingredients are the Stockholm Convention listed pollutants; the brominated flame retardants (BFR) polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD), and PFOS and related chemicals (collectively known as PFAS (per- and polyfluoroalkyl substances)).

PFAS waste issues are significant in Australia at present, largely because of historical use of firefighting foams. A dedicated discussion of the various PFAS wastes and issues is discussed in Section 4.1.

Sources

Table 33 provides a summary of the main sources of this waste in each jurisdiction.

Table 33 Other organohalogen compound wastes summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• 63% Waste Treatment and Disposal Services [2921] • 36% Fire Protection and Other Emergency Services [7713]	• 51% Defence [7600] • 18% Waste Treatment and Disposal Services [2921] • 11% Fire Protection [7713] • 7% Oil & gas extraction [0700]	• Defence • Construction, demolition and related development activity • Waste Treatment and Disposal Services	• *< 0.5% of national total for waste group*	• Defence • Construction, demolition and related development activity • Waste Treatment and Disposal Services • Fire Protection and Other Emergency Services • Oil & gas extraction

This waste has changed markedly in 2017-18, compared to HWiA 2017 (2014-15 data). There has been a significant emergence of PFAS related wastes, as discussed in Section 4.1, the likes of which (by tonnage) have not previously been seen. These wastes have overtaken other wastes than could be present in the M160 category, such as POP-BDEs, which are insignificant presently (in tracking data), by comparison. Much of the 'movement' in the PFAS waste landscape has been driven by the finalisation of the PFAS National Environmental Management Plan (PFAS NEMP) in February 2018.

PFAS waste sources are either directly AFFF firefighting foams (being removed for destruction), or wastes contaminated from the use of these foams, such as contaminated soils, biosolids, groundwaters or media used in their clean-up, such as contaminated granular activated carbon.

These foams have been heavily used by Defence bases, major hazard facilities, airports and fire protection, all locations where fire training procedures (using AFFF) have historically taken place.

The PFAS NEMP has introduced a PFAS-specific NEPM waste code: M270 *Per- and poly-fluoroalkyl substances (PFAS) contaminated materials, including waste PFAS- containing products and contaminated containers*. This new classification had not made its way into most tracking systems at the time that the data was collected, so PFAS wastes are typically found under M160 or M250 (surfactants), as well as contaminated soil (N120) where appropriate.

Analysis

Estimates of major PFAS arisings have been attempted in Section 4.1.

M160 waste was small nationally by tonnage in 2017-18, at 0.6% of all hazardous waste generated, but this is up enormously from 2014-15 figures, where it accounted for just 0.001%. 97% of this is from Qld data, the swamping due to almost totally to PFAS-contaminated soils. More remarkable Is the fact that Qld data is incomplete across the board for 2017-18, so this figure may well have been higher in a full dataset.

M160 hasn't typically been used for PFAS soils outside of Qld, at least to the extent that it can be identified in tracking data. There is also PFAS containing AFFF foams reported in the figure, but these make up just 0.8% of the 43,707 tonne Qld total. The most striking aspect of Qld M160 is that 35 kt, or 83% of the total Qld generation tonnage, is PFAS-contaminated soil from a single Defence site.

But there is more than a Qld story in the national M160 data. Figure 47 shows historical trends in arisings but overleaf in Figure 48 are breakdowns that remove the high tonnes of dominant state data (such as Qld's) to allow NSW, WA and Vic data trends to be seen, respectively down the page in that order. This reveals a remarkable and virtually identical pattern of explosive growth in arisings in 2017-18, on differing scales per state but dramatic in each case nonetheless.

Outside of Qld, these M160 tonnages are not PFAS-contaminated soil but AFFF foams, hence the difference of tonnage scales. Waste code M270 (under Other M) also features AFFF arisings.

It is clear that 2017-18 has heralded the arrival of PFAS waste quantities into tracking systems, in a big way. Given the timing of the NEMP was only February 2018, 2018-19 data still to come could be expected to be higher again in PFAS wastes like this one.

Figure 47 Historical arisings of other organic halogen compound wastes

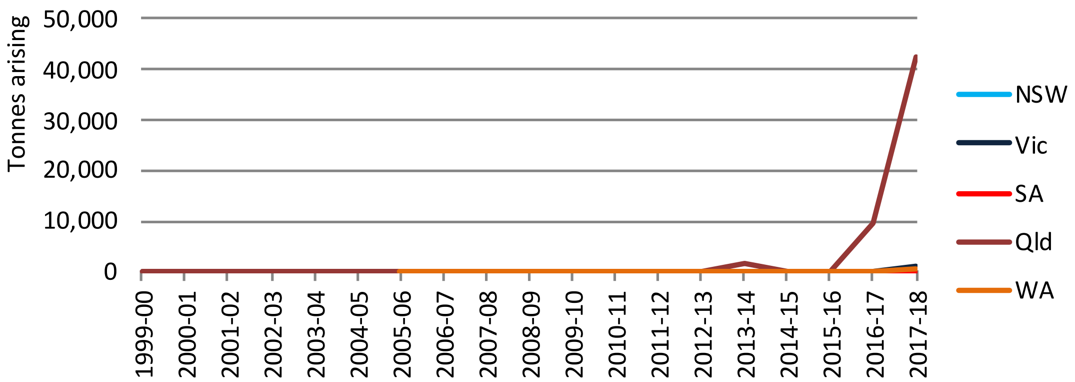
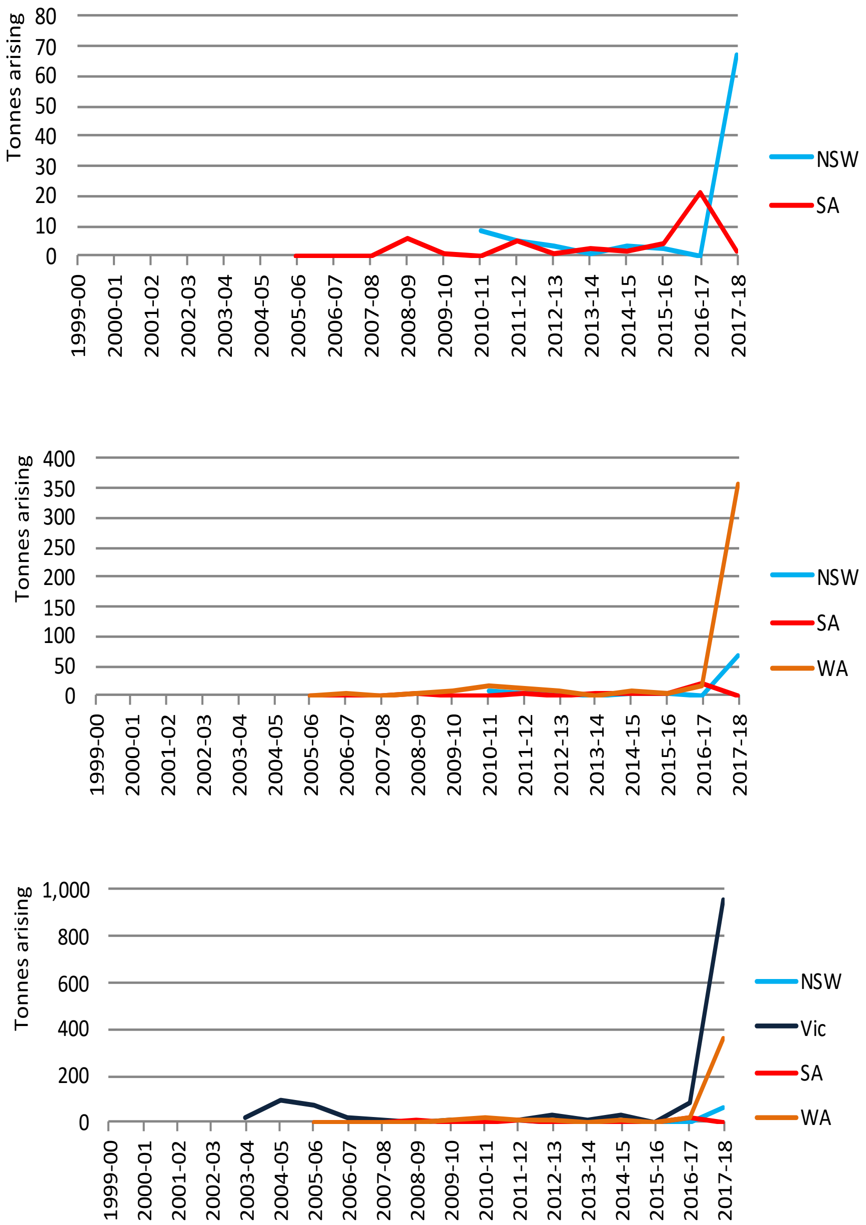


Figure 48 Historical arisings of other organic halogen compound wastes in NSW, WA and Vic (respectively beneath each other)



Management

PFAS-contaminated soil in Qld was sent to landfill, which would suggest that contaminant levels were low, based on that landfill's licensed PFAS acceptance criteria.

Like PCBs (M100), AFFF foams (nationally) were sent to thermal destruction infrastructure often identified as CPT, with a significant amount stored.

7.20 Other M. Other organic chemicals

This waste group includes the broad catch-all of:

- *M150 phenols, phenol compounds including chlorophenols*
- *M170 & M180 polychlorinated dibenzo-furan and polychlorinated dibenzo-p-dioxin, respectively*
- *M210 cyanides (organic)*
- *M220 isocyanate compounds*
- *M230 triethylamine catalysts for setting foundry sands*
- *M250 surface active agents (surfactants) containing principally organic constituents*
- *M260 highly odorous organic chemicals (including mercaptans and acrylates).*

Sources

Table 34 provides a summary of the main sources of this waste in each jurisdiction.

Table 34 Other organic chemical wastes summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• ~ 42% Defence, Fire Protection Services, Airport operations • Waste Treatment and Disposal Services [2921] • Human Pharmaceutical & Medicinal Product Manufacturing [1841] • Cosmetic & Toiletry Preparation Manufacturing [1852] • Cleaning Compound Manufacturing [1851]	• Aircraft Manufacturing and Repair Services [2394] • Organic Chemical Manufacturing [1812] • Oil & gas extraction [0700]	• Waste Treatment and Disposal Services • Various other manufacturing	Fabricated metal product manufacturing	• Soap and detergent manufacturing • Airline industry • Iron and steel manufacturing • Chemical manufacturing

This waste was almost exclusively M250 *surface active agents (surfactants) containing principally organic constituents*, in all states. The majority of this was generated in NSW and on-sent to Qld (76%), followed by Vic (11%) and Qld (10%). While soap and detergent manufacturing and the pharmaceutical industry have traditionally been the dominant sources for this waste, 2017-18 has seen the addition of PFAS wastes in the form of AFFF foams, from Defence in particular.

PFAS wastes are discussed in detail and Section 4.1 and similar observations about their emergence in tracking data are made in Section 7.19, the analysis for M160.

Analysis

This waste was small nationally by tonnage in 2017-18 at 0.3% of all hazardous waste generated. Historical trends in arisings for this waste group are shown in Figure 49.

One feature of this graph is the sharp rise in apparently Qld arisings in 2016-17, but this is in fact a NSW waste management facility sending large amounts of liquid M250 into Qld infrastructure. While it looks like these arisings have dropped back in 2017-18, this may only be a function of Qld's incomplete data.

In terms of AFFF containing PFAS, these are mostly visible in NSW and Vic data, but proper NSW trend data (for AFFF related M250 from Defence) is masked by the recent emergence of exports to Qld. Figure 50 isolates Vic (and WA) M250 trends so the trendline can more easily be seen. 2016-17 shows a major turning point from long-term decline to a sharp increase, similar to that observed for M160 (Section 7.19), then remained at similar levels in 2017-18. Defence and fire protection facilities are identifiable in both 2016-17 and 2017-18 data. WA shows more modest growth, which began a couple of years earlier and may be unrelated to AFFF.

Figure 49 Historical arisings of other organic chemicals waste

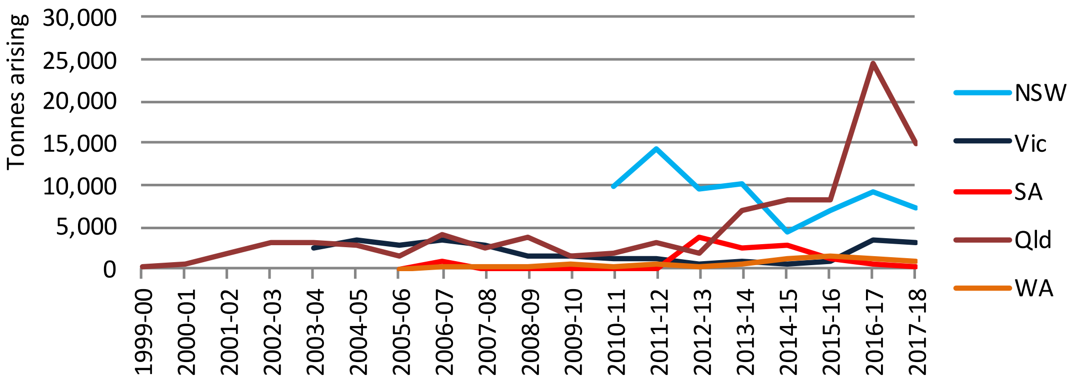
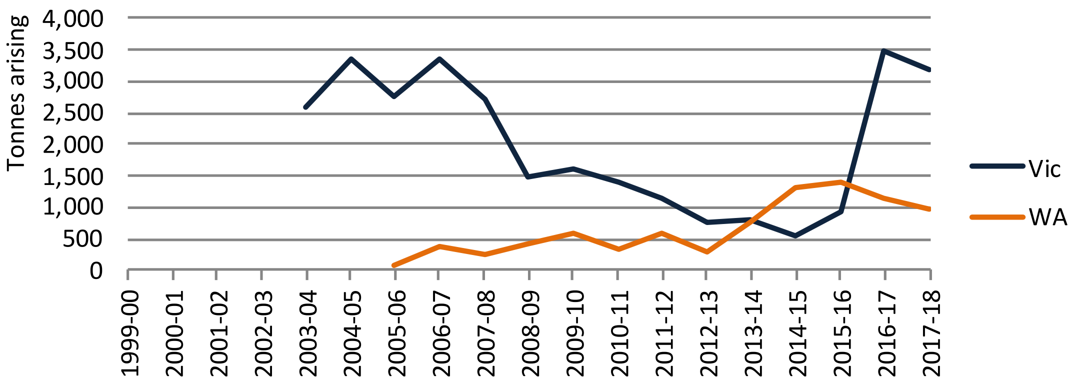


Figure 50 Historical arisings of other organic chemicals waste in Vic and WA only



Management

Of some concern is that several thousand tonnes of M250 surfactant liquids were sent to Qld in 2017-18, for management that is mostly not adequately recorded; but where the field is entered it identifies recycling, via Qld code R3 *Recycling or reclaiming an organic substance not used as a solvent*. This practice was also identified from 2016-17 data. The receiving facility undertakes composting, and R3 is typically used in Qld to denote composting.

This specific case is a concern because M250 is a commonly used NEPM code for PFAS AFFF foams (though not exclusively so), as described above. It is noted that in this case the NSW M250 export to Qld may not be PFAS related, but there are questions about the composting value and validity of accepting M250 surfactant liquids unrelated to PFAS anyway. HWiA 2017 reported concerning behaviour about the composting of a number of hazardous wastes in Qld, where the potential to add value to the process or end product may have been outweighed by the potential for environmental impacts.

7.21 N120. Contaminated soils

This group comprises *N120 Soils contaminated with a controlled waste*. NSW and Qld do not specifically track contaminated soils in their tracking systems, although both collect and supply this data from landfill records.

Sources

Table 35 provides a summary of the main sources of this waste in each jurisdiction.

Table 35 Contaminated soil wastes summary source analysis 2017-18

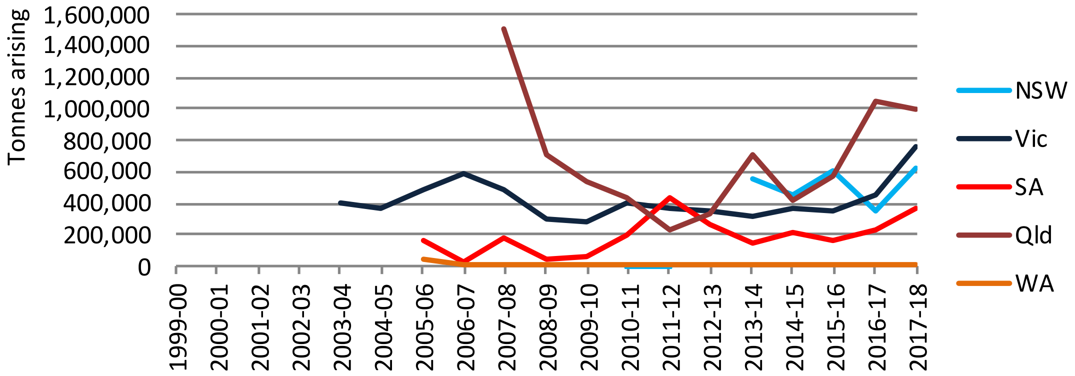
NSW	Vic	Qld	SA	National summary
• Construction, demolition and related development activity [E] • Waste Treatment and Disposal Services [2921]	• Construction, demolition and related development activity • Waste Treatment and Disposal Services [2921] • Asbestos removal contractors	• Construction, demolition and related development activity • Waste Treatment and Disposal Services	• Construction, demolition and related development activity • Waste Treatment and Disposal Services	• Construction, demolition and related development activity • Waste Treatment and Disposal Services [2921] • Asbestos removal contractors

Contaminated soils arise exclusively from construction and development (including demolition) activities that require the excavation of contaminated material. The level of contamination is almost wholly an historical legacy issue, whereas the quantity produced in any given year fluctuates with the level of development activity in contaminant-prone geographical areas.

Analysis

Contaminated soils are the largest hazardous waste in national data, making up 35% of the tonnages in 2017-18. Qld was the highest contributor of arisings at 37%, followed closely by Vic at 29% and NSW at 25%. WA appears unusually low at only 0.2%, but they only track high level contaminated soil. Historical trends in arisings for this waste group are shown in Figure 51.

Figure 51 Historical arisings of contaminated soils



The most striking feature of contaminated soils in 2017-18 is their sharp rise, even in the context of a history of high tonnages. HWiA 2017 reported 2014-15 levels of contaminated soil arisings at 1.48 Mt – in 2017-18 this has grown to 2.77 Mt, which is close to double. Virtually all of this rise has occurred in the two years from 2015-16 to 2017-18. An analysis of this phenomena of rapid rising soils is provided in Section 0.

Management

Landfill is the dominant fate recorded for contaminated soil throughout Australia, at 60%, which is substantially down from 93% in 2014-15. Storage is also a surprise, up from 7% in 2014-15 to 22% in 2017-18. The latter is almost all SA, which stored 65% of its contaminated soil in 2017-18. These issues are further explored in Section 0.

7.22 N205a. Biosolids

Biosolids are only currently considered hazardous waste in annual data reported to Basel, as a precautionary approach, and coded to N205. Consequently, there is a split in this code:

- N205a: Biosolids
- N205b: Other industrial treatment residues.

This NEPM group considers N205a biosolids in totals that are produced in Australia. A detailed discussion from a hazard classification perspective is provided in Section 4.4.

Sources

Wastewater treatment plants around Australia are the sole source of biosolids. Biosolids generation is not collated from tracking systems but provided from a biennial survey of wastewater treatment plants conducted by the ANZBP.

Analysis and management

Biosolids are third largest hazardous waste behind contaminated soils and asbestos in national data, making up 17% of the tonnages in 2017-18, when biosolids are included in the total. Arisings roughly follow population, with Vic the highest contributor at 31%, followed by NSW at 20% and Qld at 22%.

Historical trends in arisings for this waste group are not available as they are not taken from tracking records. However, when adjusted for an assumed national average solids content of 21% for 'dewatered' biosolids (their equilibrium state of water retention), national figures can be estimated in line with how other water-containing wastes are reported. Total figures from the last three ANZBP national surveys, adjusted to a 'dewatered' (not dry) basis, are shown in Table 36. The latest survey data pertains to the 2016-17 financial year, and has been adjusted up to 2017-18 using population growth.

Table 36 Dewatered' biosolids produced in Australia over the last 4 survey collection periods

Year	2010	2013	2015	2017-18
Total biosolids (t)	1,350,246	1,409,565	1,476,190	1,581,328

Source: Darvodelsky P, Pollution Solutions and Designs (2017), Biosolids Production in Australia 2017, ANZBP 2017 biosolids survey, prepared for the ANZBP, based on an average of 21% water in 'dewatered' biosolids.

Management categories collected in detail by the ANZBP survey are provided in Table 37.

Table 37 N205a arisings going to biosolids-specific management categories, 2017-18 (percent)

Management options	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	National
Stockpile	2%	2%	18%				1%	18%	2%
Agriculture	61%	61%	66%	99%	100%	100%	65%	66%	61%
Land rehabilitation	5%	5%		1%			31%		5%
Landfill	2%	2%	10%					10%	2%
Landscaping (compost)	26%	26%	6%				3%	6%	26%
Ocean discharge	4%	4%							4%
Other	0%	0%							0%

Table 37 indicates that the majority (61%) of biosolids are managed through application to agricultural land in Australia, with 66% directly applied to land (when land rehabilitation is also included). A key difference from the previous survey, quoted in Table 41 of HWiA 2017 (for 2014-15), is that biosolids in compost has grown from 7% to 26%, reflecting a burgeoning composting market, at least with respect to biosolids as a feedstock.

7.23 N205b. Other industrial treatment residues

This category covers the single NEPM code *N205 Residues from industrial waste treatment/disposal operations*. For this project, we rebadge this material as *N205b. Other industrial treatment residues* to distinguish it from biosolids, which are not typically reported in jurisdictional tracking systems, and which we characterise as N205a. Therefore, this NEPM group considers N205b, industrial treatment residues, not including biosolids.

Sources

Table 38 provides a summary of the main sources of this waste in each jurisdiction.

Table 38 Other industrial treatment residues waste summary source analysis 2017-18

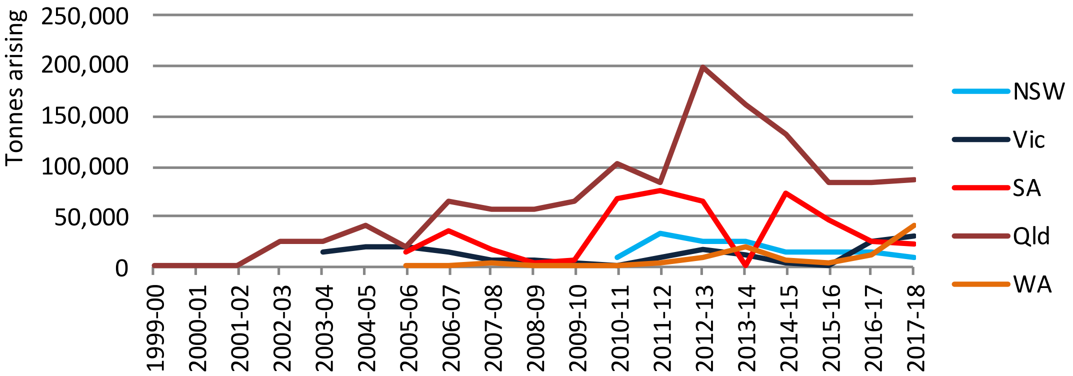
NSW	Vic	Qld	SA	National summary
• 60% Waste Treatment and Disposal Services [2921] • 9% Veterinary Pharmaceutical and Medicinal Product Manufacturing [1842] • 7% Coal Mining [0600] • 3% Explosive Manufacturing [1892)]	• 82% Waste Treatment and Disposal Services [2921]	• Waste treatment and disposal services • Wastewater treatment plants • Petroleum refining (LNG)	• Waste Treatment and Disposal Services • Beverage manufacturing	• Waste treatment and disposal services • Wastewater treatment plants • Petroleum refining (LNG) • Beverage manufacturing

Analysis and management

This waste was significant nationally by tonnage in 2014-15, at 2.3% of all hazardous waste generated. Qld is the largest contributor to national generation with 40% of industrial treatment residues in 2017-18, followed by WA with 23%, Vic with 19% and SA with 13%.

Historical trends in arisings for this waste group are shown in Figure 52.

Figure 52 Historical arisings of other industrial treatment residues



N205b is catch-all in nature, and seems to include a variety of industrial residues. Several quite different wastes seem to be tracked under the N205 banner, such as the following in Qld:

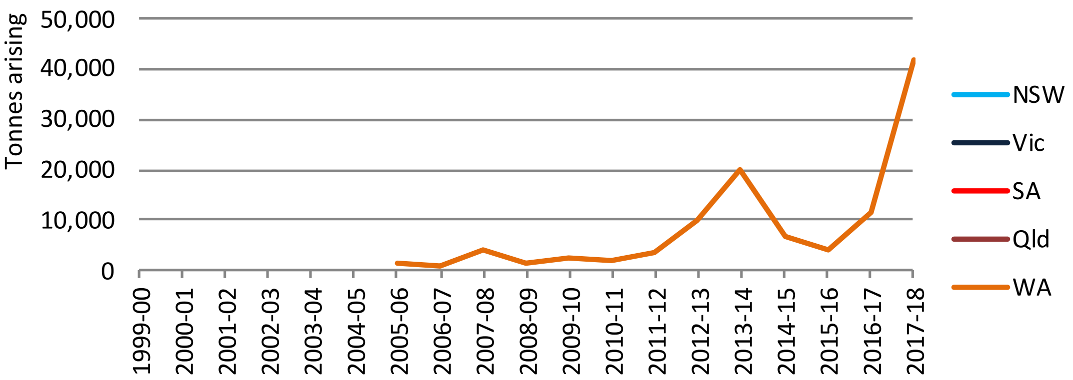
- N205b from the waste industry, made up of:
  - mostly solids going to landfill
  - liquids going to composting
  - liquids and sludges, which are probably septic pump-outs, going to sewage treatment plants
- Qld LNG processing wastes:
  - mostly liquids going to composting
  - solids and sludges going to composting
- Council facility liquid wastes (probably sewage sludge) going to composting
- the rest: various industrial sources.

Qld is the only state that composts N205b. It is also likely that sewage sludge included in N205 may result in some multiple counting with biosolids. This may be a contributing factor to explaining why Qld is the largest jurisdictional arising.

An interesting issue concerns a tie-back to discussions about WA production of F waste (Section 7.11) and D300 waste (Section 0). F waste in WA shows a massive increase in 2017-18 (beginning in 2016-17) to the point that it dominates Australian arisings of this waste. This waste is from a single established industry player newly introduced to the tracking system, with very large volumes of slurried 'treatment solid residues' from the process' neutralisation plant. The company's licence also suggests that leachate (from the landfill cell where this waste is sent) is re-carted back to the original site, where it re-treated in the neutralisation plant and flushed to sea. Since this waste or its leachate is a residue from industrial treatment (either neutralisation or leaching from landfill) it may at times be coded as F110, D300 or even N205.

This theory is supported by the nature of the large rise in Figure 53, which matches very closely the 2017-18 rises in F waste and D300.

Figure 53 Historical arisings of WA 'other industrial treatment residues'



In other words, WA's F, D300 and N205 profiles of a massive rise in 2017-18 could be directly related, and may be one and the same, either of two wastes (neutralisation residues and landfill leachate from a waste-specific cell), both involving one company.

7.24 N220. Asbestos containing material

This waste group captures the single NEPM code of *N220 Asbestos*, including products that contain asbestos and wastes contaminated with them. Asbestos is the name given to a group of naturally occurring minerals found in rock formations. Inhalation of asbestos fibres can cause respiratory problems that can be fatal. Asbestos-containing building products are classified as either 'friable' (soft, crumbly) or 'bonded' (solid, rigid, non-friable). Friable asbestos products may be as much as 100% asbestos fibres and can become airborne and inhalable very easily. Bonded products such as asbestos cement sheet (otherwise known as 'fibro') contain approximately 15% asbestos fibres, bonded with cement and do not normally release fibres into the air when in good condition.

Houses built before the mid-1980s are highly likely to have asbestos-containing products, between mid-1980s and 1990 likely, and after 1990 unlikely.

Asbestos is one of the largest flows of hazardous waste in Australia and poses significant health risks. Asbestos waste includes both end-of-life asbestos-containing building materials as well as soil that has been tested to demonstrate asbestos contamination. Since the latter may involve very low asbestos fibre concentrations and very high soil volumes, this greatly contributes to reported asbestos waste volumes.

Sources

Table 39 provides a summary of the main sources of this waste in each jurisdiction.

Table 39 Asbestos containing material waste summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• Asbestos removal contractors • Construction, demolition and related development activity	• 33% Waste Treatment and Disposal Services [2921] • 19% Pulp, Paper and Paperboard Manufacturing [1510] • Remainder (48%) – unidentified asbestos removal & construction	• Asbestos removal contractors • Construction, demolition and related development activity	• Asbestos removal contractors • Construction, demolition and related development activity	• Waste treatment and disposal services • (specifically) Asbestos removal contractors • Construction, demolition and related development activity • Pulp, Paper and Paperboard Manufacturing

Sources of asbestos are construction/ demolition related as well as any residential, commercial or industrial buildings that are involved in removal of asbestos containing material.

Jurisdictional tracking systems in the main do not differentiate between asbestos-containing building materials and asbestos-contaminated soils. However, from January 2018, NSW EPA splits asbestos containing material from asbestos contaminated soil, although both are combined for the purpose of the tonnages and categories of this report. For 2017-18, this resulted in NSW data (by far the largest in Australia) to be split roughly half and half between these two categories.

Analysis

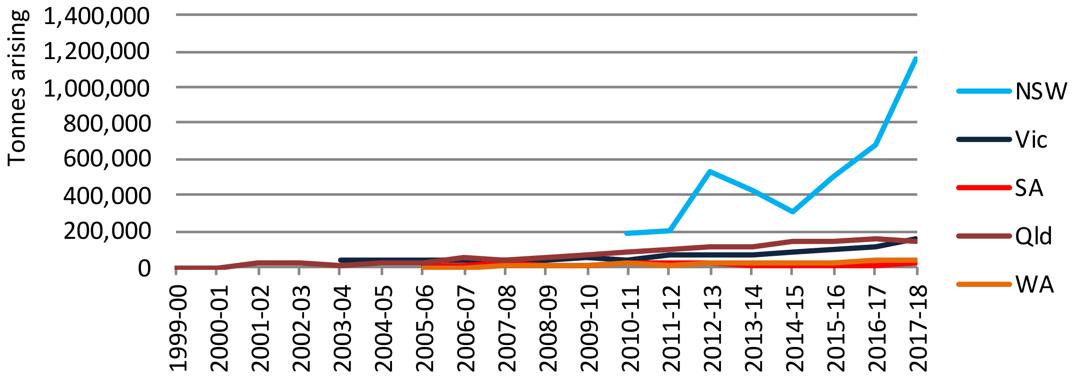
Asbestos is a large contributor to national hazardous waste volumes, making up 21% of generation tonnages in Australia in 2017-18. NSW reported by far the highest quantity in 2017-18, with 72% of national volumes, followed by Vic with 10% and Qld with 9%.

Surprisingly, ACT is not far behind with 6%, well above its per capita expectation. This is due to continued asbestos clean-up work from residential housing effected by the Mr Fluffy roofing insulation asbestos contamination disaster, loose fill asbestos fibres (of the most harmful type – (brown) amosite and (blue) crocidolite. After receiving a $1 billion loan from the Australian Government, the ACT Government responded in October 2014 with a plan to remove the Mr Fluffy legacy from the Canberra community through the Loose Fill Asbestos Insulation Eradication Scheme (the Scheme)[57]. This continues to provide large (relative to population) quantities of asbestos for the ACT in national collations.

Historical trends in arisings for this waste group are shown in Figure 54.

[57] http://www.asbestostaskforce.act.gov.au/buyback

Figure 54 Historical arisings of asbestos containing material



Due to the very large volumes in 2017-18, particularly in NSW, further discussion of asbestos is provided in Section 0.

Management

97% of asbestos waste is disposed of at landfills licensed by environmental regulators to receive asbestos waste. The remainder is stored.

7.25 Other N. Other soils/ sludges

This waste group collects those remaining N group codes including:

- *N100 containers & drums contaminated with residues of substances referred to in the NEPM 15 list*
- *N140 fire debris and fire wash waters*
- *N150 fly ash, excluding fly ash generated from Australian coal fired power stations*
- *N160 encapsulated, chemically-fixed, solidified or polymerised wastes in the NEPM 15 list*
- *N190 filter cake contaminated with residues of substances referred to in the NEPM 15 list*
- *N230 ceramic-based fibres with physico-chemical characteristics similar to those of asbestos.*

Sources

Table 40 provides a summary of the main sources of this waste in each jurisdiction.

Table 40 Other soils/ sludges waste summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
Not determined	• Waste Treatment and Disposal Services [2921] • Chemical product manufacturing [18] • Pulp, Paper and Paperboard Manufacturing [1510] • Machinery & equipment manufacturing [24]	• Waste Treatment and Disposal Services • Metals manufacturing • Petroleum refining • Meat industry • Water supply & sewerage	• Waste Treatment and Disposal Services • Motor vehicle manufacturing	• Waste Treatment and Disposal Services • Chemical product manufacturing • Metals manufacturing • Petroleum refining • Paper & paper product manufacturing

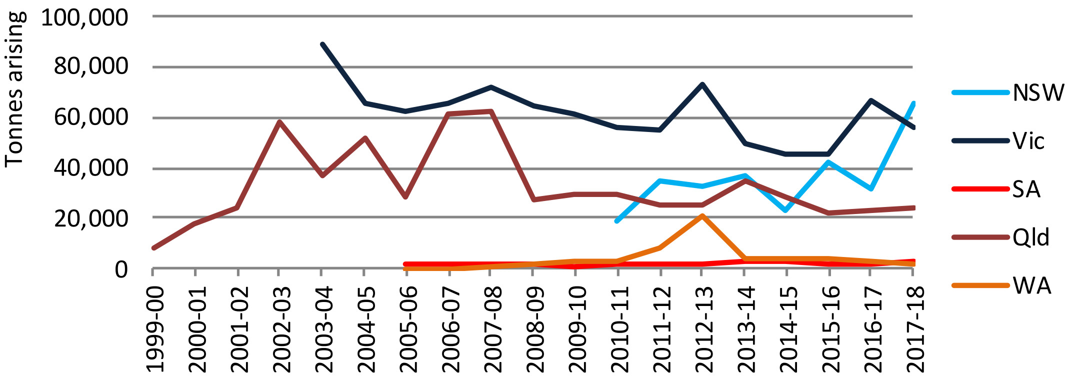
N160 Encapsulated waste is waste that has been treated to reduce its hazard by various chemical/ physical treatment facilities in the waste industry. Chemical product and related manufacturing and petroleum refining contribute to drums arisings (N100) and N190 filter cake is a waste from a variety of industrial processes, including chemical product manufacturing, metals manufacturing, paper and paper product manufacturing and machinery and equipment manufacturing.

N150 fly ash in contributed from various forms of thermal processing, including from incineration, alumina refining, meat processing, cement kilns, coal-fired power stations (despite the waste classification name), non-coal derived power plants, asphalt plants, iron and steel manufacturing and petroleum refining.

Analysis

On a national basis, *N160 encapsulated waste* is the primary contributor of arisings, followed by *N100 containers and drums*, then *N190 filter cake*, with the remainder in much lower proportions. The whole group makes a small contribution to national figures at 0.7% combined. Historical trends in arisings for this waste group are shown in Figure 55.

Figure 55 Historical arisings of other soil / sludge's waste



This waste group is significant in that it includes N160, which is expressly removed from 'adjusted generation' tonnages, in an attempt to reduce double-counting (since the original waste volume goes into an encapsulation process, and the hazardous component may return back out again, in a more secure and fixated form). N160 arisings volumes in NSW in particular have jumped quite sharply in 2017-18., which is due to soils that required immobilisation from a single large foreshore development project in NSW.

Management

The dominant management in 2017-18 tracking data for this whole waste group is landfill (53%), which, for N160 waste, logically follows on as the fate subsequent to treatment to ameliorate hazard. Storage follows at 24% then chemical physical treatment at 11%. And recycling at 9%.

7.26 R. Clinical and pharmaceutical waste

This waste group is made up of:

- *R100 Clinical and related wastes*
- *R120 Waste pharmaceuticals, drugs and medicines*
- *R140 Waste from the production and preparation of pharmaceutical products.*

Clinical and related wastes are wastes arising from medical, nursing, dental, veterinary, laboratory, pharmaceutical, podiatry, tattooing, body piercing, brothels, emergency services, blood banks, mortuary practices and other similar practices, and wastes generated in healthcare facilities or other facilities during the investigation or treatment of patients or research projects, which have the potential to cause disease, injury, or public offence, and includes: sharps and non-sharps clinical waste.

Other wastes are also generated within health care settings. Waste pharmaceuticals, drugs and medicines are waste pharmaceutical products that have: passed their recommended shelf life; been discarded as off-specification batches; been returned by patients or been discarded. These wastes are often generated directly from pharmacies, hospitals, medical centres and hospital dispensaries.

A particularly notable pharmaceutical waste is waste cytotoxic drugs, or waste (including sharps) contaminated by cytotoxic drugs. A cytotoxic drug has carcinogenic (cancer-causing), mutagenic (increase mutations of genetic material) or teratogenic (birth defect) potential, and is commonly used in the treatment of cancer.

Lastly, waste from the production and preparation of pharmaceutical products is similar to R120, the key difference is the setting that it is generated – at the pharmaceutical product manufacturing stage rather than the point in the lifecycle where the product is sold, administered or used (pharmacy or health care facility). Another difference is that as a manufacturing waste, there will be process wastes that may be raw materials-based rather than wastes of final manufactured products.

Sources

Table 41 provides a summary of the main sources of this waste in each jurisdiction.

Table 41 Clinical and pharmaceutical waste summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
Not determined (waste exempt from tracking)	• 78% Waste Treatment and Disposal Services [2921] • 6% Human Pharmaceutical and Medicinal Product Manufacturing [1841]	• Waste Treatment and Disposal Services • Health care sector • Human Pharmaceutical and Medicinal Product Manufacturing	• 80% healthcare sector • 7% Waste Treatment and Disposal Services • 4% Professional, scientific & technical services • 4% Education & training	• Waste Treatment and Disposal Services • Health care sector • Human Pharmaceutical and Medicinal Product Manufacturing

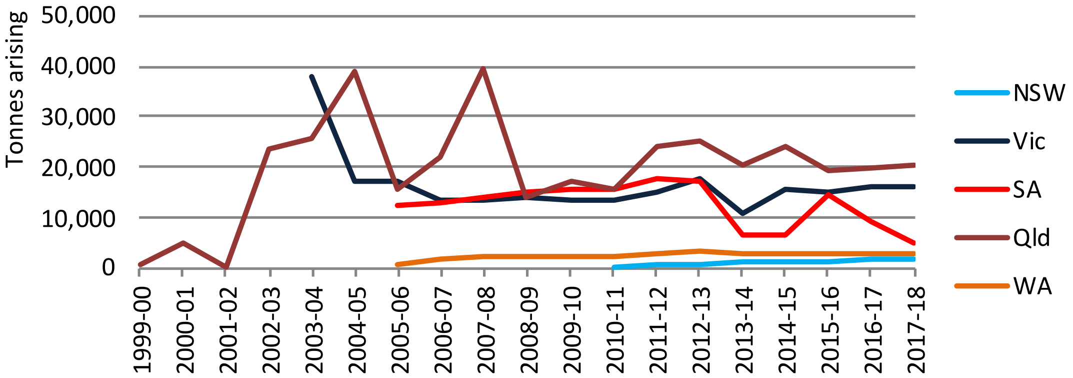
NSW does not track any of the R group wastes. National data includes estimates of NSW arisings derived from per capita comparison with other jurisdictional arisings.

Sources of R100 are health care and allied sectors at the core, with the waste industry heavily identified because of their role as waste collection agents from these facilities. R120 is quite specific to hospitals and pharmacies, while R140 is specific to pharmaceutical manufacturing.

Analysis

The R waste group made up 0.7% of Australia's hazardous waste in 2017-18, with R100 clinical and related waste making up almost all of it. Historical trends in arisings for this waste group are shown in Figure 56.

Figure 56 Historical arisings of clinical and pharmaceutical wastes



Trends in arisings over the last five to ten years are quite flat, even though one would expect incremental growth in hospital bed days as the population ages. Historical arisings for WA appear lower than their population would indicate, and NSW is very low on account of its tracking exemption for this waste.

Management

For this type of waste, the following management techniques are routinely carried out in Australia:

- Incineration
- Autoclaving and shredding
- Chemical disinfection and shredding.

Management data gathered for 2017-18 shows thermal destruction to be the highest management proportion nationally, with 38% of all waste going there, followed by CPT at 29% and storage at 18%. In reality, the thermal destruction proportion will be higher than that, due to some incompleteness in Qld data falsely inflating the landfill figure. Landfill of clinical waste does occur (in Qld and WA) in very small amounts, as re-arisen clinical waste after treatment by a clinical waste company, such as by autoclave and shredding. In this case landfill is a safe and acceptable final management.

Levels of storage of clinical waste reported in HWiA 2017 (2014-15 data) were surprisingly high at 32% nationally, but have reduced to 18% in 2017-18. Victoria has the highest levels of storage of clinical waste at 25%, but this can be explained through their accredited agents system, where large volumes are collected from multiple pick-up points by the medical waste industry collectors, who often accumulate at their depots and on-send (quite quickly thereafter) to fates such as incineration (thermal destruction). This double-count is evident due to the much higher arisings tonnages in Vic (compared to generation), noting that management analysis is done on arisings tonnages.

7.27 T140. Tyres

This group is the sole NEPM category *T140 Tyres*. Tyres or 'waste tyres' are used, discarded or rejected tyres that have reached the end of their useful life, i.e., when they can no longer be used for their original purpose, and are subsequently removed from a vehicle.

Tyres are tracked in Qld and WA only (although NSW does track tyres in their WasteLocate system) and the recorded arisings indicate that they are significantly under-reported in tracking data, when compared with credible recent estimates of arisings (REC 2016)[58]. Consequently, in reporting to Basel and the 2017-18 dataset for this report, data from the REC report was used to estimate arisings.

Sources

The bulk of this waste nationally is produced from tyre and motor vehicle retailing and motor vehicle servicing industries.

Analysis

Using REC data, tyres are a large national waste, making up 6% of national hazardous waste generation. While NSW and Vic have not historically controlled tyres in their 'hazardous' waste regimes, they have both taken significant steps over the last 5 years to more closely regulate them, due to the prevalence of tyre stockpiles and the risks, particularly from uncontrollable fires, associated with these storages.

Both Vic and NSW export large volumes of shredded tyres for recycling in overseas markets, and these appear to be growing. This export data is not included in this report's exports (Table 1), because tyres are not deemed hazardous waste under the Basel Convention, so do not trigger export permitting requirements. Nonetheless, given the experience with the China National Sword with respect to plastics, paper and other recyclables, the large-scale reliance on exports for tyre recycling carries similar risks.

Management

REC data shows that just 10% of tyres are recycled through domestic material recycling, into high-value commodities such as crumb rubber and granules. A further 27% is exported as low-value materials and the majority, 63%, extracts effectively no value, through landfill, on-site disposal, or illegal activities like dumping and stockpiling.

[58] Randell Environmental Consulting (2016) National market development strategy for used tyres, produced for Tyre Stewardship Australia and various others, November.

7.28 Other T. Other miscellaneous

This waste group includes:

- *T100 waste chemicals from research and development or teaching activities*
- *T120 waste from the production & use of photographic chemicals and processing materials*
- *T200 waste of an explosive nature not subject to other legislation.*

This waste group is a collection of relatively unrelated wastes that are produced in small quantities and are made up of mostly T100, with smaller quantities of T200 and T120.

Sources

Table 42 provides a summary of the main sources of this waste in each jurisdiction.

Table 42 Other miscellaneous waste summary source analysis 2017-18

NSW	Vic	Qld	SA	National summary
• Public administration & other education • Domestic chemical collections	• Waste Treatment and Disposal Services • Public administration & other education • Domestic chemical collections	• Public administration & other education • Domestic chemical collections	• Public administration & other education • Domestic chemical collections	• Waste Treatment and Disposal Services • Public administration & other education • Domestic chemical collections

NSW generated 45% of this waste nationally in 2017-18, followed by SA (32%) and the remainder spread evenly between Vic and Qld.

This waste was primarily T100 from R&D, university or teaching institutions, as well as from domestic chemical collections. This may explain the surprising prominence of SA's T100 waste, which could be due to a more active household collection program than some other jurisdictions. The waste industry often acts as the 'producer' through collection of these wastes.

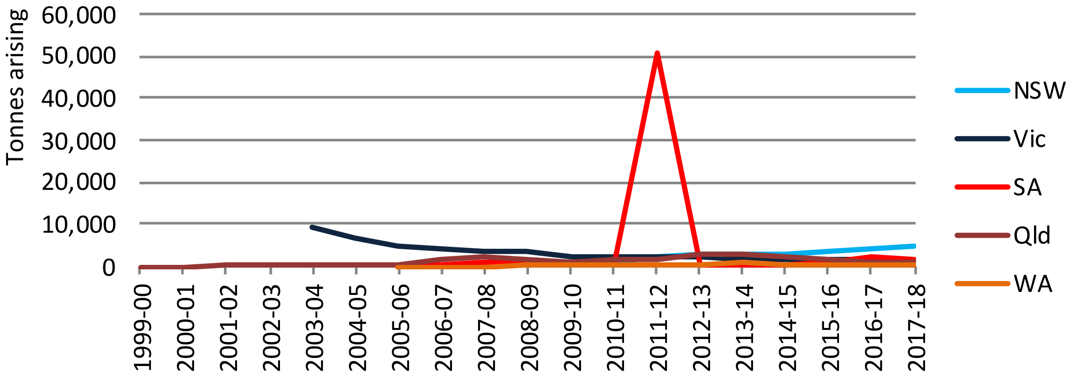
T120 is a specialty waste from the printing industry, but also includes x-ray photography activities such as dentists and other health practitioners, that would fit into the 'public administration' heading above. Curiously, NSW records cruise ships as a regulator contributor of this waste.

T200 is produced by the mining industry from the use of mine explosives, but also from manufacturers and suppliers of these explosives. Only WA records this waste as present in 2017-18 data, in very small quantities.

Analysis

Other T miscellaneous wastes made up just 0.08% of all hazardous waste generation nationally in 2017-18. Historical trends in arisings for this waste group are shown in Figure 57.

Figure 57 Historical arisings other miscellaneous waste



The most striking trend is the massive spike in SA data in 2011-12, which is due to T100. This could be a storage release but, given how large and conspicuous it is, it is very likely that it is a unit error (recorded as m^3 instead of kg), although the lack of transparency in certificate level detail (with the systems in use at that time) does not allow confirmation of this suspicion. However, the last 3 years of data show an average of 798 individual certificate movements occurred, at an average of 0.3 tonnes per movement. This suggest that an error is the likely explanation.

Management

CPT is the largest management type nationally (43%), although storage is not far behind at 41% of all arisings of this group. Storage is typical of a waste group collation of small quantities of 'rats and mice', some of it of potentially unknown origin.

References

ABC News 27 April 2018 (https://www.abc.net.au/news/science/2018-04-27/waste-incineration-last-resort-experts-warn-frydenberg/9702490)

ABC News, 19 October 2017: *Forrestfield Airport Link toxic soil dump creates headache for WA Government*, available at: http://www.abc.net.au/news/2017-10-19/forrestfield-tunnel-toxic-pfas-soil-dump-future-uncertain/9066212

ADF 2019, Australian Defence Force, Australian Defence Force Major Bases and Disposition in Australia, available at: http://www.defence.gov.au/review/docs/disposition.pdf

The Age 5 April 2019: *Burning factory had three times as many chemicals as allowed*, EPA says, available at: https://www.theage.com.au/national/victoria/burning-factory-had-three-times-as-many-chemicals-as-allowed-epa-says-20190405-p51b9g.html

The Age 18 March 2019: *Up to 19 million litres of toxic waste dumped in eight suburban warehouses*, available at: https://www.theage.com.au/national/victoria/up-to-19-million-litres-of-toxic-waste-dumped-in-eight-suburban-warehouses-20190315-p514lm.html

The Age 5 April 2019: *'Like Jenga': Complex, toxic chemical clean-up begins in Melbourne warehouses*, available at: https://www.theage.com.au/national/victoria/complex-chemical-stockpile-clean-up-20190206-p50vye.html

Airservices Australia 2019, Aviation rescue firefighting stations, available at: http://www.airservicesaustralia.com/about/our-facilities/aviation-rescue-fire-fighting/

ANZBP 2017 (Hopewell, Darvodelsky), *Assessment of Emergent Contaminants in Biosolids*, available at: https://www.biosolids.com.au/wp-content/uploads/Emerging-Contaminants-in-Biosolids-Research-report.pdf

BE *et al. 2018* (Blue Environment and Randell Environmental Consulting 2018), *National Waste Report 2018,* prepared for the Department of Environment and Energy, available at: https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018

BE *et al. 2018a* (Blue Environment, Randell Environmental Consulting and Ascend Waste and Environment 2018), *Assessment of hazardous waste infrastructure needs and capacities in Australia* – draft, prepared for the Department of the Environment and Energy.

BE *et al.* 2017a (Blue Environment, Randell Environmental Consulting and Ascend Waste and Environment 2017) *Hazardous waste in Australia 2017*, prepared for the Department of the Environment and Energy, available at: http://www.environment.gov.au/protection/hazardous-waste

BE *et al. 2017b* (Blue Environment, Ascend Waste and Environment and Randell Environmental Consulting 2017), *Australian hazardous waste data and reporting standard – 2017 revision,* prepared for the Department of Environment and Energy, available at:

http://www.environment.gov.au/protection/waste-resource-recovery/publications/australian-hazardous-waste-data-reporting-standard

BE *et al. 2015* (Blue Environment, Randell Environmental Consulting and Ascend Waste and Environment 2015) *Hazardous waste in Australia*, prepared for the Department of the Environment, available at: http://www.environment.gov.au/protection/publications/hazardous-waste-australia

CSIRO (2018) *Lithium battery recycling in Australia Current status and opportunities for developing a new industry*, available at https://www.csiro.au/en/Research/EF/Areas/Energy-storage/Battery-recycling

DiGangi J, IPEN, and Strakova J, ARNIKA (2015), *Toxic toy or toxic waste: recycling POPs into new products, Summary for Decision-Makers*, available from: https://ipen.org/sites/default/files/documents/toxic_toy_or_toxic_waste_2015_10-en.pdf

DoEE (Department of the Environment and Energy 2017) *Annual Report 2016-17* (Appendix: Operation of the Product Stewardship (Oil) Act 2000), available at: http://www.environment.gov.au/system/files/resources/00a9e787-a1a6-4d80-9ab7-f44e6896110c/files/annual-report-2016-17-appendices.pdf

Gallen (2016): Gallen, C, Drage, D, Kaserzon, S, Baduel, C, Gallen, M, Banks, A, Broomhall, S, Mueller, J.F, *Occurrence and distribution of brominated flame retardants and perfluoroalkyl substances in Australian landfill leachate and biosolids*. Journal of Hazardous Materials 312 (2016) pp.55–64.

Heads of EPAs (2018) *PFAS National Environmental Management Plan*, available at: http://www.epa.vic.gov.au/~/media/Files/Your%20environment/Land%20and%20groundwater/PFAS%20in%20Victoria/PFAS%20NEMP/FINAL_PFAS-NEMP-20180110.pdf

Heads of EPAs (2019) *PFAS National Environmental Management Plan*, version 2.0 Consultation Draft, available at: https://www.epa.vic.gov.au/your-environment/land-and-groundwater/pfas-in-victoria/pfas-nemp-2-0

Luo, Y., Guo, W., Ngo, H. Hao., Nghiem, L. Duc., Hai, F. Ibney., Zhang, J. & Liang, S. (2014). A review on the occurrence of micropollutants in the aquatic environment and their fate and removal during wastewater treatment. Science of the Total Environment, 473-474 (March), 619-641, available from: http://ro.uow.edu.au/cgi/viewcontent.cgi?article=2861&context=eispapers

Minamata Convention on Mercury, available from: http://www.mercuryconvention.org/Convention

National Environment Protection Council (2017), *National Environment Protection Council annual report, 2016-17*, available from: http://www.nepc.gov.au/system/files/resources/afef0a22-b780-41ed-ab10-416162bb201e/files/nepc-annual-report-2016-17.pdf

NSW EPA 2019, NSW EPA PFAS investigation program, available at: http://epa.nsw.gov.au/MediaInformation/pfasinvestigation.htm

NSW EPA 2016a, *Environmental Guidelines Solid waste landfills*, second edition, 2016, available at: https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/waste/solid-waste-landfill-guidelines-160259.ashx

NSW EPA 2016b, *Addendum to the Waste Classification Guidelines (2014) – Part 1: classifying waste*, available at: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/wasteregulation/addendum-1-to-the-waste-classification-guidelines.pdf

NSW EPA 2016c, Addendum to the Waste Classification Guidelines (2014) – Part 1: classifying waste, available at: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/wasteregulation/addendum-1-to-the-waste-classification-guidelines.pdf

NSW EPA fact sheet: *Sources of petroleum gas, Conventional and unconventional gas*, December 2015, available at: https://www.epa.nsw.gov.au/-/media/40B251DEC4B44D378CC4EC56B7116602.ashx?la=en

NSW Government Transport for NSW 2015, Concrete Washout Guideline 3TP-SD-112/2.0, available at: https://www.transport.nsw.gov.au/sites/default/files/media/documents/2017/concrete-washout-guideline%20-3tp-sd-112.pdf

Nyrstar Investor Presentation, January 2018. Available at: https://www.nyrstar.com/~/media/Files/N/Nyrstar/investor-toolkit/talkbook-january-2018-12.pdf

The Parliament of the Commonwealth of Australia, *The Global Financial Crisis and regional Australia*, available at: https://www.aph.gov.au/binaries/house/committee/itrdlg/financialcrisis/report/gfc%20final%20report.pdf

QDNRM 2017: Queensland Government Department of Natural Resources and Mines, *Queensland's petroleum and coal seam gas 2015-16*, available at: http://www.australiaminerals.gov.au/__data/assets/pdf_file/0003/47622/Queenslands-petroleum-and-coal-seam-gas-2017.pdf

QDSE 2019a: Queensland Government Department of Environment and Science, *End of waste code Coal Seam Gas Drilling Mud (ENEW07543018),* 01 January 2019, available at https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-drilling-mud.pdf

QDSE 2019b: Qld Department of Environment and Science, *End of Waste Code Biosolids (ENEW07359617)*, January 2019, available at: https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-biosolids.pdf

QGC (Queensland Gas Company), *Brine and salt management*, available at: https://www.shell.com.au/about-us/projects-and-locations/qgc/environment/water-management/reports/_jcr_content/par/expandablelist_48b1/expandablesection_ea.stream/1498083766935/69ace52f1a08b0264db8548364c587a2530faf143488edd9de362c98a7050388/qgc-stage-3-wmmp-dec-13-15.pdf

REC 2018 (Randell Environmental Consulting (2018)) *Waste lithium ion battery projections*, produced for the Department of Environment and Energy, June, available at: https://www.environment.gov.au/system/files/resources/dd827a0f-f9fa-4024-b1e0-5b11c2c43748/files/waste-lithium-battery-projections.pdf

REC 2018a (Randell Environmental Consulting (2018a)) *Hazardous waste stockpiles and approved long-term storages in Australia*, produced for the Department of Environment and Energy, December 2018, not yet published.

REC 2016 (Randell Environmental Consulting (2016)) National market development strategy for used tyres, produced for Tyre Stewardship Australia and various others, November.

REC 2016a (Randell Environmental Consulting 2016a) *Spent pot lining project (feasibility of an agreement based approach to clear stockpiles),* available at: http://www.environment.gov.au/protection/publications/spent-pot-lining-project-feasibility-agreement-based-approach-clear-stockpiles-final

SafeWork NSW (2017) Major hazard facilities, available at: http://www.safework.nsw.gov.au/health-and-safety/safety-topics-a-z/hazardous-chemical/major-hazard-facilities

UNEP (2009*), The Stockholm Convention on Persistent Organic Pollutants (POPs)*, available from: http://chm.pops.int/TheConvention/Overview/TextoftheConvention/tabid/2232/

UNEP (2015a), *UNEP/CHW.12/5/Add.2, Technical guidelines: updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*, available from: http://www.basel.int/TheConvention/ConferenceoftheParties/Meetings/COP12/tabid/4248/mctl/ViewDetails/EventModID/8051/EventID/542/xmid/13027/Default.aspx

UNEP (2015b), *UNEP/CHW.12/INF/10 (2015) Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)*, available from: http://www.basel.int/TheConvention/ConferenceoftheParties/Meetings/COP12/tabid/4248/ctl/Download/mid/13277/Default.aspx?id=13&ObjID=12379

WA DER 2017, Government of Western Australia Department of Environment Regulation, *Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), Contaminated Sites Guidelines*, Version 2.1 January 2017, available at: https://www.der.wa.gov.au/images/documents/your-environment/contaminated-sites/guidelines/Guideline_on_Assessment_and_Management_of_PFAS_v2.1.pdf

WA DWER 2018, Government of Western Australia Department of Water and Environmental Regulation, *Landfill Waste Classification and Waste Definitions 1996 (as amended 2018), Environmental Protection Act 1986*, April 2018, available at: https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/WasteDefinitions-revised.pdf

Appendix A: Key terms and definitions

A.1 Key terms and definitions

The primary source of information about hazardous waste terms and definitions in Australia is the *Australian hazardous waste data and reporting standard*[59] (referred to in this and subsequent appendices as 'the Standard'). Some of the most pertinent terms to this report are defined below.

Hazardous waste

Hazardous waste is waste that, by its characteristics, poses a threat or risk to public health, safety or to the environment. In national reporting this term is taken to correspond with:

- wastes that cannot be imported or exported from Australia without a permit under the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*
- wastes that any jurisdiction regulates as requiring particularly high levels of management and control, namely: regulated waste (Qld); trackable waste (NSW); prescribed waste (Vic); listed waste (SA and NT); or controlled waste (ACT, Tas and WA)
- additional wastes nominated as hazardous by the Australian Government[60].

NSW (along with the ACT[61], due to their adoption of NSW classification procedures) uses the term 'hazardous waste' in a specific regulatory sense. The NSW *Protection of the Environment Operations (Waste) Regulation 2005* and associated guidance defines 'hazardous waste' as one of six classes of waste – and it typically cannot be disposed at landfill without hazard reduction treatment such as immobilisation. 'Hazardous waste' in this strict NSW (and ACT) regulatory interpretation is equivalent only to those *hazardous* wastes (in national reporting terminology) that would be categorised at the higher hazard end of the range.

Regulating and tracking hazardous waste in Australia

Whereas the Australian Government has responsibilities in relation to hazardous waste under the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* (the Act) and the *National Waste Policy,* regulation of hazardous waste management is mainly the responsibility of the states and territories (the jurisdictions). In order to ensure appropriate management of these wastes, the five largest jurisdictions (NSW, Qld, SA, Vic and WA) operate systems for 'cradle to grave' tracking of the movement of each consignment of hazardous waste from point of generation to treatment or disposal. Tracking certificates include the type and quantity of waste, the dates, and the producer, transporter and details of the receiving facility. A copy is sent to the government. The jurisdictions agreed to allow the use of the large data sets generated by their tracking systems in this study, under confidentiality agreements. ACT, NT and Tas do not have intrastate tracking systems per se in place, although much of their waste is sent to infrastructure across borders, which is tracked under Controlled Waste NEPM requirements. In addition, the NT require reporting of amounts of controlled waste handled by producers, transporters and receivers, for the operating year of their licence.

---

[59] Available at: https://www.environment.gov.au/protection/waste-resource-recovery/publications/australian-hazardous-waste-data-reporting-standard

[60] For example, the Australian Government has considered waste lithium ion batteries as hazardous in assessing the adequacy of hazardous waste infrastructure.

[61] Environment ACT (2000) *ACT Environmental Standards: Assessment and Classification of Liquid & Non-liquid Wastes,* June, available from: http://www.environment.act.gov.au/__data/assets/pdf_file/0005/585500/wastestandards.pdf

The reporting year used for data in this report

The Standard identifies five purposes for reporting quantities of hazardous waste at a national level in Australia. These are reproduced in Table 43. Basel and OECD reporting use calendar year format while the *National Waste Report* (which incorporates hazardous waste), reporting under the *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure* (hereafter referred to as the NEPM) and HWiA all use financial year format.

The reporting year used in this report is the ***2017-18 financial year***, the most recent financial year for which data was provided or available for all jurisdictions.

Table 43 National reporting of hazardous waste data

Report	Rationale	Period	Frequency	State & territory data needed by	Content
Report to the Basel Secretariat	Requirement of the Basel Convention	Calendar year	Annually	By end of previous calendar year	Quantities generated nationally by waste type
Hazardous Waste in Australia	Government commitment	Financial year	Every two years	Not yet fixed	Quantities, trends in quantities, sources, pathways and fates, potentially with sub-analyses by jurisdiction
National waste reports	Government commitment	Financial year	Not yet fixed	Not yet fixed	Quantities, pathways and fates by jurisdiction
OECD reports	Requirement of OECD membership	Calendar year	Various	Varied	Various
NEPM reports	Requirement of under the NEPM and its implementation agreement	Financial year	Annual	Not fixed	Collated summary information on the: (i) movement of controlled waste into each jurisdiction, indicating jurisdiction of origin, waste code and quantity of waste; (ii) level of discrepancies (e.g. non-arrival of a consignment) as a percentage of total authorised controlled waste movements; and (iii) benefits arising from the implementation of the Measure.

Source: Blue Environment, Ascend Waste and Environment & Randell Environmental Consulting (2016). Australian hazardous waste data and reporting standard, prepared for the Australian Government Department of the Environment and Energy for distribution to the Australian states and territories, Appendix H Table 6.

Appendix B (B.1) includes hazardous waste generation data at the 'NEPM 75' level, presented to enable either financial year or calendar year viewing. ***Appendix B (B.2)*** includes hazardous waste generation data in Y code format (as required by Basel) submitted for the Basel report for calendar year 2017, alongside the two six-monthly blocks it was collected in.

The meaning of waste 'arising'

The term 'arise' is used in relation to hazardous waste data derived from tracking systems. Waste 'arises' when it is delivered to hazardous waste processing, storage, treatment, or disposal infrastructure. This is distinct from 'generation', a term commonly used in waste reporting, in that if waste is transported to more than one site it may 'arise' more than once in the tracking system data.

Some of the data presented in this report is waste arising, which is consistent with data from the jurisdictional tracking systems. This differs for the Basel report (***Appendix B***), which specifically requires waste 'generation' as defined below.

It should be noted that until a waste is moved offsite, it does not arise. Waste that is created on a site and remains stored there has not arisen.

The meaning of waste 'generation'

Waste generation is the process of creating a waste. For data purposes, generation of non-hazardous waste is normally taken as the sum of waste disposed of, recycled or sent for energy recovery. Generation of hazardous waste is more difficult to estimate because data on the tonnages to each of these fate types is not always readily available, and additional pathways, such as storage or treatment, may be taken by hazardous waste on route to its final fate. Inclusion of tonnages to these additional pathways would result in multiple counting of the same waste, which was generated only once.

In using arisings data to estimate hazardous waste generated for the purpose of this report (and related work such as Basel reporting), the following is subtracted (to the extent the relevant tonnes can be identified):

1. hazardous waste sent to facilities for short-term storage or transfer
2. hazardous waste outputs of hazardous waste infrastructure – only inputs are counted.

This method seeks to avoid multiple counting in waste generation. Conversely, waste arisings have no adjustments applied for multiple counting.

The meaning of waste 'source'

The source of waste is where it is generated, which could be the location (geographical source) or the company or industry sector that produced it. This report, like others, describes geographical source at the jurisdictional level. However, to provide a greater level of understanding of the data, this report focuses on the industry source sector where possible. Reporting industry source is not always possible due to the need to protect the commercial confidentiality of individual waste-producing companies and due to limitations in the level of detail recorded in jurisdictional tracking systems.

Industry sectors are shown in this report using the Australian and New Zealand Standard Industrial Classification (ANZSIC code) system where quantitative data exists. Jurisdictional tracking systems typically allow for inclusion of 'waste origin' in transport certificates, which is generally equivalent to ANZSIC code, but both provision of this information and its accuracy is typically limited.

The meaning of waste 'fate'

Waste fate refers to the ultimate destination of the waste within the management system. Types of fate may include recycling, energy recovery, long-term storage and disposal, each of which categories can be divided into more specific fates. Treatment, transfer and short-term storage are not fates, but are rather part of the *pathway* leading to a fate.

The meaning of waste 'pathway'

The pathway of hazardous waste covers the various steps in the route between hazardous waste generation and fate, potentially including transfer, storage and/or treatment.

The meaning of waste 'management'

For the purposes of this report, *management* of hazardous waste comprises the activities through which it is dealt with in infrastructure approved to receive it. The types of management are recycling, energy recovery, long-term storage, disposal, treatment and short-term storage. The first four of these are a type of *fate*; the last two are a type of *pathway*.

Therefore, for hazardous waste, tonnes 'managed' = tonnes sent to pathway infrastructure + tonnes sent to fate infrastructure.

In this report, management data was available from states (NSW, Qld, SA, Vic and WA), but the categories of management used were not entirely consistent. Consequently, a lowest common denominator approach was taken to categorise management methods, to allow comparative analysis between these states. The categories applied to enable all three states' data to be used were:

- recycling
- chemical/ physical treatment
- landfill
- biodegradation
- incineration
- storage or transfer.

This approach, and the way primary data is recorded in these tracking systems, introduces a level of ambiguity that limits the value of the management/ fate assessment. For example:

- Recycling includes resource recovery, reclamation and energy recovery, since there is no 'energy recovery' category. This can lead to mapping of an incineration process, for example, not to incineration but to recycling, because the thermal treatment process may either recover energy or use the waste (in some small or large part) as recovered fuel.

- Biodegradation is a category on its own, but composting of organic material could be coded as either biodegradation or recycling, because the biodegradative process produces another beneficial use for the waste.
- Chemical/ physical treatment processes typically describe chemical processes (e.g. oxidation, reduction, precipitation, neutralisation, etc.) and physical treatments (e.g. sedimentation, filtration, adsorption, immobilisation, etc.). If the outputs from simple chemical/ physical treatment find a further use, the management/ fate could also be described as recycling.
- Incineration is an unnecessarily narrow categorisation – thermal destruction would have been more useful – because POPs destruction facilities such as those that use plasma arc are left without an accurate fate category – under the current headings they could be deemed to reside in chemical/ physical treatment, which is not the purpose of that category.

These are limitations of the tracking system data and its interpretation. The Standard seeks to address and unify these different jurisdictional approaches to recording management types, over time as systems are reviewed and updated.

International imports and exports of waste

Waste arisings/ generation data should include:

1. waste that is generated within a jurisdiction and destined for management infrastructure located within that jurisdiction
2. waste that is generated within a jurisdiction and destined for management infrastructure located outside that jurisdiction, in another Australian state or territory
3. waste that is generated within a jurisdiction and destined for management infrastructure located out of the country, via international export under the permit system of the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* (the Hazardous Waste Act).

The first two types of arisings are intended to be captured by this project. Internationally exported/ imported wastes, via the Hazardous Waste Act's permitting system, are not included in this project explicitly as part of generation and arisings, because they are generally not captured in underlying jurisdictional tracking data. However, they are provided in waste 'flows' (Table 1) to provide context to the hazardous waste market in Australia. The relative contributions of imports and exports to Australia's hazardous waste tonnages are very small.

The NEPM and its waste classification systems

Hazardous waste produced in a particular jurisdiction may move to another for storage, treatment or disposal. The *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998* (the NEPM) was established to ensure that hazardous wastes transported between jurisdictions are properly identified, transported, and otherwise handled. Among other things, the NEPM established a coding system to be used for these wastes. Many of the jurisdictions' own waste classification systems have been subsequently updated to fully or mostly mirror the NEPM list. The NEPM classification system has two levels:

- the 'NEPM 75[62] list contained in Schedule A, List 1 of the NEPM

[62] There are 75 'waste categories' listed in Schedule A List 1 of the NEPM. The alpha-numeric codes (A100 for example) do not actually exist in the NEPM but have been adopted to represent the NEPM's Schedule A in practical terms, and do not include "oxidising agents", "reducing agents" and "reactive chemicals" (presumably because these descriptions are generic

- the 'NEPM 15' list, which aggregates the NEPM 75 and is used for reporting purposes.

The NEPM 15 and 75 lists provide the foundation for the waste groups used in this project.

Basel Convention Y-codes

Basel Y-codes (see ***Appendix B.2***) are a pre-determined waste classification system for reporting under the Basel Convention. For Australian data, which is collected by states and territories first using their own classification systems, this must undergo a two-stage translation: to NEPM codes (common Australian system) and then further to Basel Y-codes. This translation process was established by the authors in a 2012 project for the Department and is further described in jurisdictional guidance developed as part of that work (BE *et al*., 2014).

After the 'translation' process outlined in this guidance was applied, a number of NEPM codes remained that were suitable for reporting but could not be readily mapped to Basel Y-codes. The answer was to create eight new descriptions for reporting to the Basel Secretariat, referred to as 'Y+8' codes (Y+1 through to Y+8), made up from groupings of the outstanding NEPM codes as described in ***Appendix B.3***.

Two Basel Y-codes stand out as different from the rest, in the context of Australia's report:

- Y46 Wastes collected from households is not considered in this report's analysis, although it has been estimated by the authors of this report and is included at ***Appendix B.2*** for completeness.
- Y47 Residues arising from the incineration of household wastes has not been either estimated or included in any part of this report. 'Energy-from-waste' based incineration technologies (of mixed waste) are only in their infancy in Australia, and while they should generate volumes for Y47, this data is likely to be captured amongst NEPM codes such as N205 (residues arising from industrial waste treatment/disposal operations) and N150 (fly ash, excluding fly ash generated from Australian coal fired power stations) which makes it difficult to isolate.

Classifications of waste applied in this project

Hazardous waste data could be grouped or codified for analysis purposes in a number of ways. Fundamental is the most detailed level of disaggregation, such as the 'NEPM 75' levels or the 'Y codes' adopted by the Basel Convention. Since Australian data is routinely captured in NEPM-like codes and descriptions, this is used by data underlying this report.

However, in compiling the original version of this report (*HWiA 2015)* it became apparent that the NEPM 75 approach was too detailed for useful analysis. Consequently, *HWiA 2017 and 2019* use a more condensed classification system, defining 28 'waste groups' that are mostly consistent with the 'NEPM 15' heading level list, but with some categories disaggregated where a component waste was likely to arise in large or highly uncertain amounts, had particular management requirements, or was of particular interest for some other reason.

These waste groups are shown in Table 44.

---

and better covered by existing more specific categories, such as perchlorates or peroxides, for example). Also, oxidising and reducing agents could be grouped as types of reactive chemicals, which introduces another level of overlap. Therefore, in reality, there are only 72 coded wastes used in NEPM tracking, and therefore in this and other reports, but 'NEPM 75' language has been chosen to describe the longer list (of 72 wastes), since it reflects what the NEPM actually prescribes.

Data presentation and analysis for this project follows the structure of these waste groups, with underlying NEPM 75 detail in ***Appendix B.1***. These groups are expounded in ***Appendix B.4*** to show their connection to relevant NEPM 75 codes that they collapse to.

Table 44 Waste groups used for Hazardous Waste in Australia 2019

Waste groups summarised	
A	Plating & heat treatment
B	Acids
C	Alkalis
D110	Inorganic fluorine (spent potliner)
D120	Mercury & compounds
D220	Lead and compounds
D230	Zinc compounds
D300	Non-toxic salts (including coal seam gas wastes)
Other D	Other inorganic chemicals
E	Reactive chemicals
F	Paints, resins, inks, organic sludges
G	Organic solvents
H	Pesticides
J100 & J160	Oils
J120	Waste oil/water mixtures
K110	Grease trap wastes
Other K	Other putrescible / organic wastes
M100	PCB wastes
M160	Other organohalogen compounds
Other M	Other organic chemicals
N120	Contaminated soils
N205a	Contaminated biosolids
N205b	Other industrial treatment residues
N220	Asbestos containing material
Other N	Other soil/sludges
R	Clinical and pharmaceutical
T140	Tyres
Other T	Other miscellaneous
Other	(Not classified)

Data analysis in HWiA follows both the detailed (NEPM 75) and condensed (waste groups) categorisations, as follows:

- **Waste arisings and generation**
  - -Sections 3 and 7 of this report list waste arisings (or generation) by the waste groups of Table 44.
  - -Appendix B.1 provides 2017-18 national hazardous waste data, broken down in a detailed NEPM 75 level of collation. All data analysis is carried out is on foundation NEPM code data, with aggregation to the 'condensed' waste groups as described above for management (fate and pathway) analysis and waste trends.
  - -Appendix B.2 provides the 2017 Basel report data, in Basel Y-codes. This report does not conduct further analysis of this data in the Basel Y-code format.
- **Waste sources**
  - Where source data is available, this is described for each waste at the waste group level.
- **Fate and pathway (management) of wastes**

  - Management is presented in this report based under the six fate and pathway headings described in 'The meaning of waste 'management'' above, and by the waste group.
- **Waste trends**
  - Where data exists, historical trends are provided in this report based on the waste group level by jurisdiction.

Waste groups strike a sensible balance for this analysis between complexity (the 75 NEPM classifications) and overly aggregated simplicity (the 15 NEPM headings).

Biosolids in a hazardous waste context

Biosolids are a product of sewage sludge (the sludge collected from wastewater treatment) once it has undergone further treatment to reduce disease causing pathogens and volatile organic matter, producing a stabilised product. Biosolids may be contaminated above guideline levels or recovered as a resource for various beneficial uses.

The concepts of 'biosolids' and 'contaminated biosolids', and how they fit into the context of hazardous waste have the potential to be confusing. The following describes how biosolids have been differently interpreted and applied in related DoEE projects:

- **Basel Reporting** (see ***Appendix B.2***): All biosolids are reported as a hazardous waste (as a subsection of 'Y+4 Putrescible/ organic waste'), as a conservative measure in line with reporting of other wastes not typically deemed 'hazardous' in Australia, such as (Basel code) *Y46 Wastes collected from households*. This is because we do not have comprehensive testing and quality data to confirm an exact amount of biosolids that is hazardous (due to contaminants), from the total, therefore we report the total amount.
- **National Waste Report**: Biosolids are nearly all assumed to be uncontaminated, following the reporting for the Biosolids Partnership.
- **HWiA 2017 and 2019**: Typically includes biosolids in hazardous waste arisings and generation, using the N205a 'biosolids' waste group, other than for:
  - Historical trends of arisings: which does not include biosolids, as they are not regulated as hazardous in jurisdictional tracking systems.
  - Management: Actual fate and pathway data (from Vic, NSW and Qld) did not include biosolids, therefore attributions of arisings to fate do not include biosolids.

Section 0 of this report explores potential resource and hazard aspects of biosolids from the perspective of emerging contaminants, due to some uncertainties and complexities that need to be considered in its environmental management from both operational and regulatory perspectives.

Confidential and commercial-in-confidence information

The tracking system data used in this project was submitted to the jurisdictions under legal commitments to protect confidentiality. The jurisdictions, in turn, agreed to provide tracking system data for this project under agreements that required the project team to maintain commercial confidences. Tracking system data was analysed to examine tonnages of waste arisings by waste code, year and jurisdiction – if this was made publicly available, in some cases companies might be able to work out the scale of rival's operations.

Strategies used to prevent this were:

- The presentation of arisings, historical trends, sources and fates at the waste group level, which is definitionally aggregated more broadly than what has been published in past years' Basel reporting and related data projects.
- This report breaks down national hazardous waste tracking data to a level of source information that identifies industry sectors, although in most cases data quality limits quantitative assessment at this level. This largely qualitative approach further protects confidentiality (it is noted that the Standard states that "state and territory data collated by NEPM or Basel Y-code is not considered confidential" (p.21)).

Appendix B: Underlying data to this report

B.1 National hazardous waste data 2017-18 and 2017 – by NEPM code

Adjusted generation by NEPM code					
NEPM group	Waste group	NEPM code	NEPM code description	2017-18	2017
A	Plating and heat treatment	A100	Waste resulting from surface treatment of metals & plastics	5,375	6,354
		A110	Waste from heat treatment & tempering operations containing cyanides	12	12
		A130	Cyanides (inorganic)	77	87
B	Acids	B100	Acidic solutions or acids in solid form	63,664	69,450
C	Alkalis	C100	Basic solutions or bases in solid form	268,698	303,137
D	Inorganic chemicals	D100	Metal carbonyls	146	159
		D110	Inorganic fluorine compounds excluding calcium fluoride	34,413	34,461
		D120	Mercury; mercury compounds	404	515
		D130	Arsenic; arsenic compounds	332	412
		D140	Chromium compounds (hexavalent & trivalent)	1,567	1,499
		D150	Cadmium; cadmium compounds	82	75
		D160	Beryllium; beryllium compounds	25	24
		D170	Antimony; antimony compounds	0	104
		D180	Thallium; thallium compounds	0	0
		D190	Copper compounds	641	696
		D200	Cobalt compounds	0	20
		D210	Nickel compounds	1,046	963
		D220	Lead; lead compounds	175,926	162,914
		D230	Zinc compounds	180,398	131,044
		D240	Selenium; selenium compounds	2	64
		D250	Tellurium; tellurium compounds	3	3
		D270	Vanadium compounds	64	11
		D290	Barium compounds (excluding barium sulphate)	0	38
		D300	Non-toxic salts	75,258	32,880
		D310	Boron compounds	1	2
		D330	Inorganic sulfides	590	468
		D340	Perchlorates	3	3
		D350	Chlorates	25	25
		D360	Phosphorus compounds excluding mineral phosphates	467	468
E	Reactive chemicals	E100	Waste containing peroxides other than hydrogen peroxide	168	264

F	Paints, resins, inks, organic sludges	F100	Waste from production, formulation & use of inks, dyes, pigments, paints, lacquers & varnish	210,432	136,152
		F110	Waste from the production, formulation & use of resins, latex, plasticisers, glues & adhesives	4,850	6,398
G	Organic solvents	G100	Ethers	698	822
		G110	Organic solvents excluding halogenated solvents	9,397	13,551
		G150	Halogenated organic solvents	450	398
		G160	Waste from the production, formulation & use of organic solvents	2,502	2,600
H	Pesticides	H100	Waste from the production, formulation & use of biocides & phytopharmaceuticals	2,024	3,207
		H110	Organic phosphorous compounds	114	132
		H170	Waste from manufacture, formulation & use of wood-preserving chemicals	1,855	1,219
J	Oils	J100	Waste mineral oils unfit for their original intended use	318,907	344,096
		J120	Waste oil/water, hydrocarbons/water mixtures or emulsions	283,573	259,367
		J160	Waste tarry residues arising from refining, distillation, & any pyrolytic treatment	1,571	1,206
K	Putrescible/ organic waste	K100	Animal effluent & residues (abattoir effluent, poultry & fish processing wastes)	236,801	226,288
		K110	Grease trap waste	427,553	479,565
		K140	Tannery wastes (incl. leather dust, ash, sludges & flours)	7,358	6,879
		K190	Wool scouring wastes	32	705
M	Organic chemicals	M100	Waste substances & articles containing or contaminated with polychlorinated biphenyls, polychlorinated napthalenes, polychlorinated terphenyls and/or polybrominated biphenyls	14,525	6,267
		M150	Phenols, phenol compounds including chlorophenols	1,030	2,105
		M160	Organo halogen compounds—other than substances referred to in this Table or Table 2	43,707	42,831
		M170	Polychlorinated dibenzo-furan (any congener)	4	4
		M180	Polychlorinated dibenzo-p-dioxin (any congener)	0	1
		M210	Cyanides (organic)	5	1
		M220	Isocyanate compounds	181	219
		M230	Triethylamine catalysts for setting foundry sands	1,491	1,511
		M250	Surface active agents (surfactants), containing principally organic constituents &	20,358	21,372

			which may contain metals & inorganic materials		
		M260	Highly odorous organic chemicals (including mercaptans & acrylates)	2	5
N	Soil/ sludge	N100	Containers & drums that are contaminated with residues of substances referred to in this list	28,700	18,332
		N120	Soils contaminated with a controlled waste	2,656,884	2,475,086
		N140	Fire debris & fire wash waters	1,068	1,745
		N150	Fly ash, excluding fly ash generated from Australian coal fired power stations	7,036	7,260
		N160	Encapsulated, chemically-fixed, solidified or polymerised wastes referred to in this list	0	0
		N190	Filter cake contaminated with residues of substances referred to in this list	14,645	13,790
		N205b	Other industrial treatment residues (excludes biosolids)	172,596	245,407
		N220	Asbestos	1,612,041	1,294,202
		N230	Ceramic-based fibres with physico-chemical characteristics similar to those of asbestos	131	254
R	Clinical and pharmaceutical	R100	Clinical & related wastes	45,343	47,346
		R120	Waste pharmaceuticals, drugs & medicines	1,777	1,998
		R140	Waste from the production & preparation of pharmaceutical products	1,442	1,616
T	Miscellaneous	T100	Waste chemical substances arising from research & development or teaching activities, including those which are not identified and/or are new & whose effects on human health and/or the environment are not known	3,729	2,976
		T120	Waste from the production, formulation & use of photographic chemicals & processing materials	1,853	1,831
		T140	Tyres	442,426	442,426
		T200	Waste of an explosive nature not subject to other legislation	395	68
Other		Other		166,625	167,160
Totals				**7,555,498**	**7,024,549**
Notes					
1	The 2017 data set does not subtract or add inter-jurisdictional transfers. The total tonnes in 2017-18 when inter-jurisdictional transfers are excluded is 7,675,089: i.e., 1.6% higher than when jurisdictional data transfers are included.				
2	The Basel data ignores 'other'. The 2017 data set presented includes 'other'.				

B.2 2017 Basel data (in Y codes)

(See 'Basel Convention Y-codes' definition in Appendix A)

Basel Convention		Tonnes generated		National totals, 2017
Code	Waste description (Annex 1)	Jan-Jun	Jul-Dec	
Total amount of hazardous wastes under Art. 1 (1)a (Annex I: Y1-Y45) generated				**4,557,812**
Total amount of hazardous wastes under Art. 1 (1)b generated				**8,280,583**
Total amount of other wastes (Annex II: Y46 - Y47)				**12,587,557**
Y1	Clinical wastes from medical care in hospitals, medical centres and clinics	24,821	22,525	47,346
Y2	Wastes from the production and preparation of pharmaceutical products	836	780	1,616
Y3	Waste pharmaceuticals, drugs and medicines	1,032	967	1,998
Y4	Wastes from the production...... of biocides and phytopharmaceuticals	1,544	1,663	3,207
Y5	Wastes from the manufacture...... of wood preserving chemicals	616	603	1,219
Y6	Wastes from the production, formulation and use of organic solvent	1,325	1,276	2,600
Y7	Wastes from heat treatment and tempering operations containing cyanides	6	6	12
Y8	Waste mineral oils unfit for their originally intended use	173,449	170,647	344,096
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsion	130,039	129,329	259,367
Y10	Waste substances .... containing or contaminated with PCBs, PCTs, PBBs	2,557	3,710	6,267
Y11	Waste tarry residues ... from refining, distillation and any pyrolytic treatment	648	558	1,206
Y12	Wastes from production...... of inks, dyes, pigments, paints, etc	56,561	79,592	136,152
Y13	Wastes from production......resins, latex, plasticizers, glues, etc	3,336	3,061	6,398
Y14	Waste chemical substances arising ..... environment are not known	1,291	1,685	2,976
Y15	Wastes of an explosive nature not subject to other legislation	178	181	359
Y16	Wastes from production, formulation and use of photographic chemicals...	1,138	693	1,831
Y17	Wastes resulting from surface treatment of metals and plastics	3,408	2,946	6,354
Y18	Residues arising from industrial waste disposal operations	832,570	843,545	1,676,115
Wastes having as constituents ...				
Y19	Metal carbonyls	86	73	159
Y20	Beryllium; beryllium compounds	12	12	24
Y21	Hexavalent chromium compounds	701	798	1,499
Y22	Copper compounds	326	369	696
Y23	Zinc compounds	47,954	83,090	131,044

Y24	Arsenic; arsenic compounds	241	172	412
Y25	Selenium; selenium compounds	62	2	64
Y26	Cadmium; cadmium compounds	37	38	75
Y27	Antimony; antimony compounds	104	0	104
Y28	Tellurium; tellurium compounds	1	1	3
Y29	Mercury; mercury compounds	241	274	515
Y30	Thallium; thallium compounds	0	0	0
Y31	Lead; lead compounds	69,712	93,201	162,914
Y32	Inorganic fluorine compounds excluding calcium fluoride	17,250	17,211	34,461
Y33	Inorganic cyanides	24	63	87
Y34	Acidic solutions or acids in solid form	36,037	33,414	69,450
Y35	Basic solutions or bases in solid form	151,932	151,205	303,137
Y36	Asbestos (dust and fibres)	591,537	702,664	1,294,202
Y37	Organic phosphorus compounds	72	61	132
Y38	Organic cyanides	1	0	1
Y39	Phenols; phenol compounds including chlorophenols	1,565	541	2,105
Y40	Ethers	403	419	822
Y41	Halogenated organic solvents	194	205	398
Y42	Organic solvents excluding halogenated solvents	7,594	5,957	13,551
Y43	Any congenor of polychlorinated dibenzo-furan	2	2	4
Y44	Any congenor of polychlorinated dibenzo-p-dioxin	0	0	0
Y45	Organohalogen compounds other than …(e.g. Y39, Y41, Y42, Y43, Y44)	21,295	21,536	42,831
Categories of wastes requiring special consideration (Annex II)				
Y46	Wastes collected from households	6,269,464	6,318,092	12,587,557
Y47	Residues arising from the incineration of household wastes	0	0	0
	Additional waste categories not included in Y-Codes			
1	Other metal compounds	492	539	1,031
2	Other inorganic chemicals	15,597	18,221	33,818
3	Other organic chemicals	11,796	11,311	23,106
4	Putrescible/ organic waste	364,483	348,954	713,437
5	Waste packages and containers containing Annex 1 substances in concentrations sufficient to exhibit Annex III hazard characteristics	9,138	9,194	18,332
6	Soils contaminated with residues of substances in Basel Y-codes 19-45	1,039,812	1,435,274	2,475,086
7	Sludges contaminated with residues of substances in Basel Y-codes 19-45	8,357	7,178	15,535
8	Tyres	221,213	221,213	442,426

B.3 Adopted Y-code translations from additional NEPM codes (Basel 'Y+8')

Additional waste categories not included in Y-Codes (Y+8 codes)		NEPM code	
Y+1	Other metal compounds	D200	Cobalt compounds
		D210	Nickel compounds
		D270	Vanadium compounds
		D290	Barium compounds (excluding barium sulphate)
Y+2	Other inorganic chemicals	D300	Non-toxic salts
		D310	Boron compounds
		D330	Inorganic sulfides
		D360	Phosphorus compounds excluding mineral phosphates
Y+3	Other organic chemicals	M220	Isocyanate compounds
		M230	Triethylamine catalysts for setting foundry sands
		M250	Surface active agents (surfactants), containing principally organic constituents and which may contain metals and inorganic materials
		M260	Highly odorous organic chemicals (including mercaptans and acrylates)
Y+4	Controlled putrescible/ organic wastes	K100	Animal effluent and residues (abattoir effluent, poultry and fish processing wastes)
		K110	Grease trap waste
		K140	Tannery wastes (including leather dust, ash, sludges and flours)
		K190	Wool scouring wastes
Y+5	Waste packages and containers containing Annex 1 substances in concentrations sufficient to exhibit Annex III hazard characteristics	N100	Containers and drums that are contaminated with residues of substances referred to in this list
Y+6	Soils contaminated with residues of substances in Basel Y-codes 19-45	N120	Soils contaminated with a controlled waste
Y+7	Sludges contaminated with residues of substances in Basel Y-codes 19-45	N140	Fire debris and fire wash waters
		N190	Filter cake contaminated with residues of substances referred to in this list
Y+8	Tyres	T140	Tyres

B.4 Waste groups map

NEPM code	Waste group	Waste group description
A100	A	Plating & heat treatment
A110	A	
A130	A	
B100	B	Acids
C100	C	Alkalis
D100	Other D	Other inorganic chemicals
D110	D110	Inorganic fluorine (spent potliner)
D120	D120	Mercury & compounds
D130	Other D	Other inorganic chemicals
D140	Other D	
D150	Other D	
D160	Other D	
D170	Other D	
D180	Other D	
D190	Other D	
D200	Other D	
D210	Other D	
D220	D220	Lead and compounds
D230	D230	Zinc compounds
D240	Other D	Other inorganic chemicals
D250	Other D	
D270	Other D	
D290	Other D	
D300	D300	Non-toxic salts (including coal seam gas wastes)
D310	Other D	Other inorganic chemicals
D330	Other D	
D340	Other D	
D350	Other D	
D360	Other D	
E100	E	Reactive chemicals
F100	F	Paints, resins, inks, organic sludges
F110	F	
G100	G	Organic solvents
G110	G	
G150	G	
G160	G	
H100	H	Pesticides
H110	H	
H170	H	
J100	J100 & J160	Oils
J120	J120	Waste oil/water mixtures
J160	J100 & J160	Oils
K100	Other K*	Other putrescible / organic wastes
K110	K110	Grease trap wastes
K140	Other K*	Other putrescible / organic wastes

NEPM code	Waste group	Waste group description
K190	Other K*	
M100	M100	PCB wastes
M150	Other M	Other organic chemicals
M160	M160	Other organohalogen compounds
M170	Other M	Other organic chemicals
M180	Other M	
M210	Other M	
M220	Other M	
M230	Other M	
M250	Other M	
M260	Other M	
N100	Other N	Other soil/sludges
N120	N120	Contaminated soils
N140	Other N	Other soil/sludges
N150	Other N	
N160	Other N	
N190	Other N	
N205	N205b	Other industrial treatment residues
N220	N220	Asbestos containing material
N230	Other N	Other soil/sludges
R100	R	Clinical and pharmaceutical
R120	R	
R140	R	
T100	Other T	Other miscellaneous
T120	Other T	
T140	T140	Tyres
T200	Other T	Other miscellaneous
Other	*Other*	(Not classified)

* Although recognised in five jurisdictions (WA, Qld, SA, Tas and NT) code K130 (often used for sewage or sewage sludge) is not recognised under the Controlled Waste NEPM, and so was not analysed in this project.

Appendix C: Data sources, limitations and quality issues

C.1 Data sources

This report is supported by current and historical data, predominantly sourced from confidential hazardous waste tracking data (waste transport certificates). This data covers the 2017-18 financial year, the focus of this report, but also includes tracking data reaching as far back as 1999-2000 (in the case of Qld) to provide trends and historical context.

Data was supplied by the states as comprehensive tracking system 'data dumps', encompassing hundreds of thousands of individual transactions per year. Additional data from landfill reports was provided in some cases where a hazardous waste is not tracked, such as for contaminated soil and asbestos in NSW. Additional data from other studies was also applied in some cases where a hazardous waste is not tracked, nor recorded in landfill data, to fill obvious gaps. The ACT, NT and Tas provided completed Basel data workbooks.

The data supporting this report is housed in the *National hazwaste data collation 2017-18 – HWiA* workbook. The *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998* (NEPM) data from the National Environment Protection Council Annual Report 2016-17, was also reviewed, to inform data and discussion involving interstate management of waste.

The data collection method

Methods of data collation used for this work follow the *Australian hazardous waste data and reporting standard*[63], in particular Section 4 of this standard.

A 'waste receival end' approach, instead of a 'waste arising end' approach to collating waste data was used in this project (and HWiA 2017), because it offers potential data quality improvements over the first HWiA approach (HWiA 2015) such as:

- more reliable capture of interstate movement data, which could subsequently be apportioned back to the jurisdiction that generated it
- easier elimination of double-counting, through subtraction of tonnages going into short-term storage or transfer management infrastructure
- better alignment with NEPM implementation reporting, which also reports hazardous waste received into its borders from other jurisdictions, on a calendar year basis
- a theoretically easier compilation task for jurisdictions.

This approach has several jurisdiction-specific limitations, which involves a 'patchwork' of data collection methods to arrive at the highest data quality outcome. The approach taken in each jurisdiction and relevant characteristics of the data provided in each case are analysed in Table 45.

[63] Blue Environment, Randell Environmental Consulting and Ascend Waste and Environment 2017, *Australian hazardous waste data and reporting standard – 2017 revision*, prepared for the Australian Department of the Environment and Energy (and available at: http://www.environment.gov.au/protection/waste-resource-recovery/publications/australian-hazardous-waste-data-reporting-standard

Table 45 Data collection approach for HWiA 2019

	Expected data status in relation to inter-jurisdictional transfers	Main receiving jurisdiction(s) based on NEPC 14-15 ann. rpt.	Comments on the corresponding data in jurisdictions receiving or exporting waste	Conclusions and adjustments to data received from this jurisdiction	Change in approach from 14-15?
ACT	Assumed to receive no waste from outside ACT. ACT data except asbestos is from NEPM transport certificates and so should be represented in the receiving jurisdiction's data.	NSW (based on NEPC data and ACT staff advice)	Transformed NSW data (9,551 t) is greater than quantities reported by ACT (8,441 t) for 2017-18.	ACT data to be used. Subtract ACT waste recorded in other jurisdictions' data.	As per the information to the left
NSW	Data identifies jurisdiction where waste is produced	Qld, Vic, SA		Subtract waste recorded in NSW data as produced elsewhere. Add data from other states recorded as produced in NSW.	As per the information to the left
NT	Assumed to receive no waste from outside NT. NT data except asbestos is from NEPM transport certificates and should therefore be represented in the data of the receiving jurisdiction.	NSW, Qld, SA, WA		NT data to be used. Subtract NT waste recorded in other jurisdictions' data.	As per the information to the left
Qld	Data identifies jurisdiction where waste is produced	NSW, NT, SA, Vic		Subtract waste recorded in Qld data as produced elsewhere. Add data from other states recorded as produced in Qld.	As per the information to the left
SA	Data identifies jurisdiction where waste is produced	NSW, NT, Vic		Subtract waste recorded in SA data as produced elsewhere. Add data from other states recorded as produced in SA.	
Tas	Assumed to receive no waste from outside Tas. All Tas data except asbestos is from NEPM transport certificates and so should be represented in the receiving jurisdiction's data.			Tas data to be used. Subtract Tas waste recorded in other jurisdictions' data.	Tas data to be used. Subtract Tas waste recorded in other jurisdictions' data. Estimate this amount for SA as shown above.
Vic	Data identifies jurisdiction where waste is produced	NSW, SA, Qld, WA		Subtract waste recorded in Vic data as produced elsewhere. Add data from other states recorded as produced in Vic.	As per the information to the left
WA	Data identifies jurisdiction where waste is produced			Subtract waste recorded in WA data as produced elsewhere. Add data from other states recorded as produced in WA.	Add data from other states recorded as produced in WA.

C.2 Data limitations

All of the tracking data and other arisings estimates used in this report are subject to limitations. Ultimately, waste transport certificates capture only those hazardous waste movements that legally occur. If a transport movement occurs without an accompanying waste transport certificate, such activity is illegal and would not be captured as part of the waste arisings assessed in this report.

Waste transport certificates suffer from the vagaries of choices made by the certificate users, such as choice of waste and code, or choice of management code, as two examples, which can result in mis-coded data. There may also be more than one code (for wastes or management types) that could be justified as appropriate, which could result in wastes allocated across different categories. It is noted however that online tracking systems go some way to controlling many of these potential user errors.

Data gaps

Although generically similar, there is some variation in hazardous waste classification, tracking and data collection throughout the states and territories. This leads to significant gaps in hazardous waste data, particularly where tracking systems alone are used for input data, that need to be filled in collating a credible national dataset. In accordance with the Standard, the project's team's approach in this, and previous annual data collations, has been to fill these gaps where possible, using alternative data sources and estimation methods. Expertise, judgement and potentially consultation are needed to determine whether a jurisdictional datum or an empty cell should be adjusted with data from an alternative source. In undertaking the assessment, the following principles were considered:

1. Is a waste for which no data is provided likely to have been generated in significant quantities?
2. Are there other reasons, such as policy priorities, existing programs or particular hazards posed, that justify seeking data that a jurisdiction was not able to provide?
3. Is a reasonable data source or estimation method available (such as a nationally consistent data set or average quantity per capita) that is likely to produce a more accurate or more consistent national figure than the data (or blank entry) collected from a jurisdiction?

Various adjustments are provided for in the *National hazwaste data collation workbook*, in the 'Gap data' worksheet based on:

- Using figures from various sources and reports to estimate waste quantities (tyres, biosolids and wastes collected from households [Basel code Y46])
- Calculating the average quantity of the waste generated per capita in jurisdictions providing the data. This figure is applied to population data to estimate the quantity generated in a jurisdiction that did not provide data for that waste type.

Various adjustments have been applied by the project team to 2017-18 (and 2017) data, while other gaps are left uncorrected, due to a lack of reasonable estimation method. Table 46 compiles these along with some suggested reasons as to why the data gaps and weaknesses still prevail.

Table 46 Gaps and weaknesses in jurisdictional tracking system data and methods for adjusting them

Waste	Adjusted?	Adjustment method	Possible reason for gap
All jurisdictions			
Biosolids (N205a)	Yes	Remove tracking data where reported and replace with estimations from biosolids data (latest ANZBP survey) reported on a 'wet' basis	The state-based K130 is unreliably tracked in WA, Qld, SA, NT and Tas and not at all in the remaining jurisdictions. This is not an official NEPM code – biosolids are not uniformly recognised across jurisdictions as hazardous (or trackable) waste.
Tyres (T140)	Yes	Remove tracking data where reported and replace with estimates from REC 2016	Unreliably tracked since tyres are not uniformly recognised across jurisdictions as hazardous (or trackable) waste.
Several jurisdictions: NSW, Vic, Qld, Tas			
Spent pot lining (D110)	Yes	Derived as a proportion of aluminium produced in NSW, Qld, Tas and Vic (22kg/t Al produced based on Holywell et al 2013)	Onsite stockpiling is commonplace, so tracking only shows sporadic releases from these stockpiles, which is a poor guide to annual generation. Estimation method is more reliable.
Several jurisdictions: NSW, SA, NT			
Animal effluent and residues (K100)	Yes	Use average of data reported by other states to obtain a t/capita figure. Multiply t/capita by population in NSW, SA and NT respectively	Wastes not tracked in these jurisdictions – probably due to perception that hazard is not as acute as other tracked wastes
Grease trap waste (K110)	Yes	Use average of data reported by other states to obtain a t/capita figure. Multiply t/capita by population in NSW, SA and NT respectively	Wastes not tracked in these jurisdictions – probably due to perception that hazard is not as acute as other tracked wastes
Tannery wastes (K140)	No	No estimates made - no defensible principle-based method available	Limited tannery and wool scouring operations in Australia – largely historical industry so waste not as relevant today.
Wool scouring wastes (K190)	No	No estimates made - no defensible principle-based method available	Limited tannery and wool scouring operations in Australia – largely historical industry so waste not as relevant today.
NSW			
Acids (B100)	No	No defensible principle-based method to estimate so data reporting in tracking is used.	This waste (in the specific form of spent pickle liquor that is destined for reuse) is not tracked in NSW, on account of a regulatory exemption (from tracking).
Lead and compounds (D220)	No	No defensible principle-based method to estimate so data reporting in tracking is used. It is suggested that NSW examine non-tracking approaches to data gathering as this waste is large and important.	This waste (only in the specific form of lead acid batteries that are destined for reuse) is not tracked in NSW, on account of a regulatory exemption (from tracking).
Zinc compounds (D230)	No	No defensible principle-based method to estimate so data reporting in tracking is used.	This waste (only in the specific form of zinc wastes destined for reuse) is not tracked in NSW, on account of a regulatory exemption (from tracking).

Waste	Adjusted?	Adjustment method	Possible reason for gap
Waste oils (J100)	Yes	Uses data from the Product Stewardship for Oil (PSO) program to estimate NSW (and some Vic) data missing from tracking systems due to tracking exemptions	This waste (only in the specific form of non-hazardous waste hydrocarbon oil destined for reuse) is not tracked in NSW, on account of a regulatory exemption (from tracking). Vic, through their Accredited Agents program, appear to also be missing significant tonnages in tracking data.
Clinical and related wastes (R100)	Yes	Use average of data reported by other states to obtain a t/capita figure. Multiply t/capita by population in NSW	This waste is not tracked in NSW, on account of a regulatory exemption (from tracking).
Waste pharms., drugs and medicines (R120)	Yes	Use average of data reported by other states to obtain a t/capita figure. Multiply t/capita by population in NSW	This waste is not tracked in NSW, on account of a regulatory exemption (from tracking).
Qld			
Cobalt compounds (D200)	No	No defensible method to estimate.	No information to suggest this waste is generated in Qld
Ceramic-based fibres (N230)	No	No defensible method to estimate.	No information to suggest this waste is generated in Qld
Tas and WA			
Asbestos (N220)	N220	Use average of data reported by other states to obtain a t/capita figure. Multiply t/capita by population in Tas and WA respectively.	Tas and WA do not track or otherwise record asbestos waste generation.

Note: 1. No data gaps specific to the ACT and Victoria were identified so they are not included in Table 46

Limitations caused by the six-category national management system

NSW and SA use a six-category system of allocating waste tonnages to fate and pathway types (management types), while WA use a different categorisation again, covering 11 management types. These limited choices for describing what is happening at receival infrastructure are quite blunt when compared to Qld and Vic, which categorise hazardous waste management activities in over 30 categories, in line with the Basel Convention. This simplicity leads to other complications in national data, from a market understanding perspective.

The situation is made worse by the fact that even within these six categories there is major ambiguity for certificate users, who frequently choose the wrong management types. For example, using NSW categories, a cement kiln POPs destruction facility could be classified as incineration (which it technically isn't), recycling (since the waste matrix such as the solvent carrying pesticide waste will displace fuel in the kiln, resulting in energy recovery), chemical/ physical treatment (since the solvent containing pesticide waste will be blended with other wastes of calorific value first, before entry into the kiln) or 'other' since it is neither of these things. Underwhelmingly, 'other' is probably the most accurate choice in this example.

These limitations skew interpretation of what is happening to hazardous waste. NSW data has many instances where legitimate recycling activities (like lead acid battery recycling) are recorded under the chemical/ physical treatment heading, causing misunderstanding an under-representation of recycling activity.

Data shortcomings caused by regulatory exemptions in NSW

Major volumes that go to recycling as a form of management are 'invisible' to the NSW tracking system, due to regulatory exemptions and other reasons for not tracking wastes included in the scope of national hazardous waste collations.

Grease trap waste arises at over 100kt each in Qld and Vic, but without a requirement for tracking it appears as 9kt in NSW. The Commonwealth Product Stewardship for Oil (PSO) program data indicates as much as 80kt of J100 is probably generated beyond that tracked in NSW. Lead is likely to be a very similar story – 14kt is recorded as generated in NSW but Vic (for example) sends 44kt to NSW alone. The same under-tracked scenario applies to spent pickle liquor (B100) and zinc waste (D230), which are also both recycled.

Not only does this add up to large volumes of hazardous waste unrecorded (in the NSW tracking system) and potentially unaccounted for in collations like the one for this project, it underplays the significant role that recycling plays in hazardous waste management in NSW.

Although these exemptions are typically for a recovery/ recycling management purpose, the reason why such an exemption is applied and how it might better facilitate such recovery (if that is indeed the exemption's purpose) is not clear or publicly accessible.

Interstate transport data

It appears that once a waste shipment leaves the sending jurisdiction, with consignment authorisation in place, the information of its arrival in the receipt jurisdiction is regularly either not forwarded (by the receiving jurisdiction) or not recorded (by the sending jurisdiction). This results in patchwork information that makes identifying cross-border movements and collating national data about them 'hit and miss'.

This could lead to large quantities of exported wastes unaccounted for if a sending jurisdiction's system was relied upon for the data – this is borne out through comparison of certificate records in sender/ receiver jurisdictional databases; the latter typically shows much larger volumes.

Paper based certificates

This issue leads to major data quality issues (Section C.3) but it is discussed here because it is a systemic limitation rather than a direct quality issue.

Jurisdictions have poor control over data integrity when paper certificates are used instead of electronic certificates. Two issues define this inadequacy:

- the certificate-user is much more likely to make significant data recording errors and leave data gaps, given the lack of controls and restrictions that come with an open access paper form
- Paper certificates bring problems with subsequent data entry:
  - cost, time-lag, loss of records
  - legibility, resulting in mis-entered information
  - data entry mistakes.

This is the single biggest factor in tracking system data quality. Vic, Qld and WA still rely heavily in paper-based certificates, while the ACT, NT and Tas use only paper based certificates for interstate movements.

A fully electronic system, or as close as is practical to one, could vastly improve the quality of data within it, as well as provide real-time potential.

Long-term onsite stockpiles and storages are not captured in tracking systems

Wastes are significant in hazard and are generated in significant quantities but a high proportion remains in storage onsite. Consequently, limited volumes are captured by tracking systems. Spent pot liner (SPL) waste from the aluminium industry is a rare example where quantities that arise each year are included in this data compiled for this report. However, historical amounts remaining in onsite storages/ stockpiles are not reported.

Interjurisdictional data sharing

Information from other jurisdictions' tracking systems, which is not routinely made available to cross-border state and territory government agencies, would enable a clearer picture of the waste management system in any particular jurisdiction, through a clearer understanding of interstate waste movements and comparison with like activities for benchmarking purposes. This lack of data sharing is an unnecessary disconnect for good policy analysis.

Adjusting for 'multiple counting' of wastes generated

The Standard's item 14 describes how to convert 'waste arisings' data to 'waste generation' data. The method attempts to adjust for 'multiple counts' by removing:

a) wastes recorded as going to short-term storage (or, in the absence of data, the average proportion of wastes sent to these management types in jurisdictions where it is recorded) – the idea is that these wastes will be captured when they leave their short-term storage for their final management

b) outputs of treatment – the idea is that these wastes are already counted on their way into the treatment facility.

In practice, this has not worked out well because:

- the accuracy of management reporting in this category is poor – some large quantities of waste are missing from 'generation' data because they are classified as going into short-term storage from which they may never be removed. A review of Qld and NSW data found that of selected wastes going to 'short-term storage', the proportion coming back out (in a 12-month period) was less than 10% for D120, D300, F100, F110, G110 and N150, and less than 25% for J120 and K110.
- The proportional management of wastes in states lacking the ability to differentiate 'short-term' from 'long-term' storage data (NSW, SA, WA) is not necessarily the same, or even similar, to those states that have this data (Qld and Vic).
- There is user demand for data on treatment outputs and surprise that it is eliminated from the data set.

- The difference between the two methods is small. In 2017-18, 'generation' of tracked codes is 1% less than 'arisings' – is this difference worth the additional complexity and potential confusion?

While multiple counting certainly occurs in the hazardous waste management system, there is probably too much uncertainty in the current approach to warrant its continued use. Should it be dropped, arisings and generation would still be distinguished by:

- arisings would describe all wastes under movement in the hazardous waste management system, that were managed within a particular jurisdiction
- generation would account for wastes generated that were sent interstate for management, by removing them from the receiving jurisdiction's generation numbers and placed them against generation numbers for the jurisdiction they emanated from.

The latter method is currently applied, as a means of eliminating interstate transport double-counts (or non-counts).

C.3 The quality of jurisdiction-provided data

Item 25 of the Standard states (with respect to jurisdictional validation of the quality of hazardous waste data it submits to the Australian Government for various reporting purposes):

> "*Prior to provision to the Australian Government, states and territories should ensure hazardous waste data is validated through data quality checks and cleaning. The checks should consider completeness, accuracy, consistency and reasonableness. In particular, checks should be made to look for:*
> - *unit errors (such as mistaking kilograms for tonnes)*
> - *inconsistent coding of wastes from the same company or of the same type*
> - *major gaps (for example, hazardous wastes that are not included in tracking systems)*
> - *major differences from previous years (e.g. in the quantity of a particular waste type*
> - *use of historical reporting codes (these should be converted to modern codes).*
>
> *Significant errors should be identified and removed, and significant gaps should be filled to the extent practicable. Suspect data should be identified in the submission.*"

Overall jurisdictional data quality

The reliability of the data presented varies by jurisdiction. An assessment of data quality by jurisdiction, sorted as both strengths and weaknesses in different data categories, is summarised in Table 47.

In the main, 2017-18 data quality was a significant improvement on the 2014-15 dataset used for HWiA 2017. Historical Qld data quality was notably better than in HWiA 2017, because the historical record has now been cleansed of some major errors that were previously present. However, 2017-18 Qld data was largely unusable, not because of errors but incompleteness – departmental resourcing was not sufficient to have all of the data quality assured in time for release, so only a partial dataset was provided. This resulted in the need to use population-based adjustment from past years' data, for many wastes, which led to difficulty in drawing conclusions.

Table 47 Quality characteristics of jurisdictionally-supplied data

Data type	Strengths	Weaknesses
General	Qld, NSW, Vic, SA and WA have tracking systems which provides exceptionally rich detail of data. Tas, ACT and NT use data from interstate transport certificates, which is quite accurate given the lack of hazardous waste facilities in these jurisdictions. Qld, NSW, Vic, SA: Complete dataset supplied – allows 'full window' for interpretation, finding anomalies. ACT and NT data supplied in full from collated interstate paper tracking dockets. SA 2017-18 data improved significantly from that provided in HWiA 2017, due to the use of their new online tracking system, which is based NSW online waste tracking (OWT) system. Vic 2017-18 data improved dramatically on previous years – not because quality assurance was better but because all previous years' releases have been of a dataset that has been aggregated to exclude source company detail, due to confidentiality concerns. 2017-18 was the first time a full data set was provided. The NSW and SA datasets are well-organised and complete <u>for core data</u>, due to their use of an essentially the same online tracking system (OWT).	Tas, ACT and NT do not have tracking systems, making compilation labour-intensive. WA deny access to key data details. Vic & Qld have poor control of data integrity when paper certificates are used. Qld, NSW, SA do not use pre-set user fields as routinely as it could, which allows for inconsistency and errors.
Waste arisings	Vic provide the most sophisticated data on contaminants by virtue of their system of collecting up to 4 contaminants per certificate, and enforcing that (for contaminated soils at least). NSW data sometimes contains descriptive fields which helps in assessing the waste type, and includes contaminants as a summarised free text field. All 'receiving jurisdictions'' data contains reliable records of wastes imported from other jurisdictions. ACT supplied accurate asbestos data. SA supplied interstate imports into SA for the first time.	All data contains a number of waste coding errors. WA did not supply asbestos data (asbestos is not tracked in WA and landfill data was not supplied due to confidentiality concerns). WA does not supply contaminants data and SA has limited information in the contaminants fields. NSW regulatory exemptions results in under-reporting of D220, J100, B100, D230 and R wastes, and do not track others, such as grease trap and other K wastes.
Source data	SA source data recording was excellent in 2017-18, with 82% of all tonnes recorded against an ANZSIC code.	Vic source data coverage has dropped from 80% to 14% of all tonnes making it unusable. Qld source data coverage in 2017-18 was unusable. NSW source data continues to be unusable (2% of all tonnes). WA source data is absent.

Management data	Qld and Vic management codes are based on Basel so are more detailed than NSW and WA, allowing clearer identification of management types Reliable and comprehensive SA management data was provided for the first time in 2017-18 data.	NSW, SA and WA management codes are too narrow which leads to confusing allocations and limits the value of the entire national management analysis.
Historical arisings trends		NSW data only goes back 8 years and for contaminated soils, which is typically in the top two largest wastes generated, it only goes back five years.

Reporting of meta-data

The purpose of tracking waste movements is mostly about core information: what was it, when did it leave, where was it sent to, how much was there and did it all end up there safely? When it comes to using tracking data for more long-term strategic analysis purposes, some of what might be called 'meta-data' (in the core waste tracking sense) becomes very important. Key meta-data is source data (the industry that is producing the waste) and chemical contaminants information (what causes the waste to be hazardous). Reporting of these two fields (or in the case of contaminants in the Vic system, four) is typically poor in Australian tracking systems, but need not be. The fields in the waste transport certificate are already there, but no attention is paid by either certificate users or regulators to ensure they are filled out.

This is particularly confounding in the case of contaminants, since laboratory testing of waste for contaminants and subsequent EPA approval of the classification outcome happens as a matter of course, yet this information is not being connected into tracking systems to the extent that it could.

Difficulties identifying POP (PFAS) wastes caused by lack of data clarity

Contaminants is also an issue for PFAS, which has made direct identification of PFAS wastes in 2017-18 difficult. Notes in the 'waste description' field in Qld data have helped identify PFAS wastes, although contaminated soils in Qld and NSW are not part of the regular tracking system but provided as a simple annual tonnage figure. NSW's 'contaminants' field (and sometimes other descriptive text fields) have also helped identify PFAS wastes. Vic has an extensive system of contaminants, with pre-set codes applied to 90 different contaminant chemicals. However, PFAS chemicals are not yet included in this list. So even though Vic contaminant information is well populated (at least for contaminated soils), PFAS identification becomes a guessing game between some commonly chosen contaminants, namely:

- Contaminant no. 53: *Hydrocarbons and its oxygen nitrogen or sulfur compounds NOS*
- Contaminant no. 17: *Fluoride compounds NOS* (an incorrect choice).

If a contaminant code was available for PFAS, Vic data would be a rich opportunity to identify PFA contaminated soils.

Jurisdictional tracking systems, have not yet responded to the requirements of the PFAS NEMP (which was only published in February 2018), so the NEMP's mandated new NEPM code M270 *Per- and poly-fluoroalkyl substances (PFAS) contaminated materials*, including waste PFAS- containing products and contaminated containers has not yet been implemented in tracking data seen to date.

Even if it was, on the surface at least, it seems like it would not be very helpful, because it does not distinguish between the different waste matrices that PFAS can contaminate. For example, without further alterations, M270 would appear to lump together AFFF, PFAS soils, PFAS waters, PFAS absorbent media, PFAS end of life products and PFAS-contaminated biosolids. Unless some sub-heading codes are introduced, this looks like a lost opportunity for better understanding PFAS waste volumes.