Report on the NICNAS Voluntary Call for Information on Chemicals of Security Concern

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Introduction

Chemicals available in Australia are legitimately used by industry and in the community on a regular basis. However some of these chemicals could be diverted from their lawful use for other purposes including terrorist related activities.

A key challenge for the government is to minimize the risks associated with misuse of these chemicals to ensure public safety and national security while allowing these chemicals to remain available for their legitimate use by consumers and industry.

The Attorney-General's Department (AGD) is responsible for the implementation of the Council of Australian Governments (COAG) *Agreement on Australia's National Arrangements for the Management of Security Risks Associated with Chemicals.* In 2008, the COAG *Report on the Control of Chemicals of Security Concern* named 96 chemicals of concern and tasked AGD with preparing risk assessments on each chemical so that they could be given a security risk rating based on the consequence and likelihood of their illegitimate use.

NICNAS was contracted by AGD to collect wide-ranging information on industrial chemicals to help inform these risk assessments. Over a three year period NICNAS has obtained and collated information on the use of 67 of the 96 chemicals that were defined under the *Industrial Chemicals (Notification and Assessment) Act 1989* (the Act) as 'industrial chemicals' (Table 1). The remaining chemicals were considered to be used exclusively in agricultural/veterinary applications.

NICNAS did not collect information from introducers and downstream users of one of the 67 chemicals, ammonium nitrate. However the industrial (non-agricultural) uses of ammonium nitrate were identified by a comprehensive search and review of international and NICNAS databases. Apart from common major usage in explosives and fertilisers, other uses identified were in chemical manufacture and as an oxidizing agent. The international sources also referenced minor usage in hair dyes, electroplating baths, freezing mixtures and as a desiccant for cotton.

Table 1. Chemicals of Security Concern

Chemical Name	CAS No.	Chemical Name	CAS No.
Ammonium nitrate *	6484-52-2	**Industrial reactives**	
Explosive precursors		Cyanogen bromide	506-68-3
Hydrogen peroxide	7722-84-1	Cyanogen chloride	506-77-4
Nitric acid	7697-37-2	Osmium tetroxide	20816-12-0
Sodium chlorate	7775-09-9	Phosphorous	7723-14-0
Potassium chlorate	3811-04-9	Phosphorous oxychloride	10025-87-3
Ammonium perchlorate	7790-98-9	Phosphorous pentachloride	10026-13-8
Sodium perchlorate	7601-89-0	Phosphorous trichloride	7719-12-2
Potassium perchlorate	7778-74-7	Sulfur dichloride	10545-99-0
Perchloric acid	7601-90-3	Sulfur monochloride	10025-67-9
Potassium nitrate	7757-79-1	Thionyl chloride	7719-09-7
Sodium nitrate	7631-99-4	Thiophosphoryl chloride	3982-91-0
Nitromethane	75-52-5	**Industrial inorganics**	
Sodium azide	26628-22-8	Arsenic pentoxide	1303-28-2
Bulk acids and gases		Arsenic trioxide	1327-53-3
Ammonia, anhydrous	7664-41-7	Beryllium sulfate	13510-49-1
Hydrochloric acid	7647-01-0	Ethyl mercury chloride	107-27-7
Hydrogen chloride	7647-01-0	Mercuric chloride	7487-94-7
Sulfuric acid	7664-93-9	Mercuric nitrate	10045-94-0
Chlorine gas	7782-50-5	Mercuric oxide	21908-53-2
Bromine	7726-95-6	Mercurous nitrate	10415-75-5
Fluorine gas	7782-41-4	Dimethyl mercury	593-74-8
Carbon monoxide	630-08-0	Thallium sulfate	7446-18-6
Hydrogen cyanide	74-90-8	**Industrial organics**	
Hydrogen sulfide	7783-06-4	Carbon disulfide	75-15-0
Nitric oxide	10102-43-9	Chloropicrin	76-06-2
Phosgene	75-44-5	Diethyl phosphite	762-04-9
Phosphine	7803-51-2	Dimethyl phosphite	868-85-9
Arsine	7784-42-1	Dimethyl sulfate	77-78-1
Inorganic cyanides		Ethyldiethanolamine	139-87-7
Calcium cyanide	592-01-8	Fluoroacetic acid	144-49-0
Mercury cyanide	592-04-1	Fluoroethyl alcohol	371-62-0
Potassium cyanide	151-50-8	Fluoroethyl fluoroacetate	459-99-4
Sodium cyanide	143-33-9	Methyldiethanolamine	105-59-9
Zinc cyanide	557-21-1	Methyl fluoroacetate	453-18-9
		Triethanolamine	102-71-6
		Triethyl phosphite	122-52-1
		Trimethyl phosphite	121-45-9

* security-sensitive ammonium nitrate (SSAN) [ammonium nitrate, ammonium nitrate emulsions and ammonium nitrate mixtures containing greater than 45 per cent ammonium nitrate, excluding solutions.]

Information Collection

Grouping of Chemicals

Apart from ammonium nitrate and a high priority subset of 12 explosive precursor chemicals, the remaining 54 chemicals were split into groups (Table 2) based on similar use profiles in order to avoid having to survey the same groups of downstream users multiple times. Collection of information on the chemical groups was staggered for ease of data provision and analysis.

Table 2. Grouping of Chemicals

Chemical Groups	Basis for Grouping	Comments
Bulk acids & gases (14)	Shared uses and diversion scenarios	Includes corrosive and high acute toxicity chemicals
Inorganic cyanides (5)	Likelihood of overlapping uses	High acute toxicity
Industrial reactives (11)	Corrosive and often asphixiant due to release of other chemicals through rapid reactions in contact with water, air and tissue	Exert local effects at the point of contact (e.g. hydrogen chloride)
Industrial inorganics (10)	Toxicity intrinsic to one of the components of the chemical.	Mercury and arsenic compounds are examples
Industrial organics (14)	Non-reactive organic chemicals	Includes phosphites and ethanolamine compounds which are precursors to chemical warfare agents

Voluntary Call for Information for Introducers

The Voluntary Call for Information was conducted in three stages over a three year period. A notice calling for information directed to all companies and individuals who manufactured or imported any of the 12 explosive precursors, 14 bulk acids and gases and remaining 40 industrial chemicals was published in the *Chemical Gazette* of 7 April 2009, 6 July 2010 and 2 August 2011 respectively.

The specific information sought on the chemicals included:

- quantities of each chemical imported into and/or manufactured in Australia over a specified 15-18 month period;
- for products containing the chemicals, the concentration of the chemicals in these products and the total volume of the chemicals imported;
- uses of the chemicals;
- container sizes used for these chemicals or products containing the chemicals;
- address(es) of major sites where the chemical is handled or stored (including waste storage) and availability at the sites;
- transport company name(s), and
- company names and contact details of downstream users of these chemicals or products containing these chemicals.

Introducers were given six weeks to submit the information. A survey template was linked to the notices to assist the provision of the required information.

Peak industry bodies

Peak industry bodies were notified of the Voluntary Call for Information and agreed to assist in publicising and disseminating the Call for Information to their respective industry members through their website and newsletters.

Australian Customs and Border Protection Service data

NICNAS requested import information from the Australian Customs and Border Protection Service (ACBPS) on the 66 chemicals of security concern for the calendar years 2007 to 2010 and 1 January 2011 to 30 June 2011.

Goods imported into Australia require classification under the *Customs Tariff Act 1995*. A Tariff is a listing of goods together with their applicable rates of duty. Customs import entry procedures are based upon self-assessment of the correct classification of goods by importers.

The present Australian Customs Tariff is grouped into chapters containing descriptions of goods. Each chapter relates to a specific group of goods which make up the Tariff Classification Numbers. The goods description is sufficient for Customs to ascertain the correct tariff classification of the goods.

ACBPS identified the importation of 55 of the 66 chemicals using the chemical name, CAS Registry number, common names and Tariff Classification Number relevant to these chemicals. The Tariff Classification Number for each of the chemicals on the list was confirmed by the customs chemist.

The Customs data included the following information:

- Importer Australian Business Number (ABN)
- Full name and business address of importer
- Discharge port code
- Full name of supplier
- Principal origin country and Loading Port Code
- Tariff classification number
- Trade names/other names
- Goods description
- Quantity unit and value
- Details of brokers for the importing company
- Arrival date

Organisations identified in the ACBPS data as importers of the chemicals were contacted in writing and encouraged to respond to the Call for Information via submission of a completed survey form. Follow-up of the non-responders by e-mail and phone was commenced two weeks before the deadline for provision of information.

Australian High Volume Industrial Chemicals List (AHVICL)

NICNAS has compiled a list of industrial chemicals (AHVICL) that are introduced (i.e. manufactured or imported) in Australia in quantities of 1000 tonnes or more per year. The first AHVICL was published by NICNAS in July 2002 and was updated in 2006. The list contains information on the volume of the chemicals introduced at high volume in Australia, the industry sectors that introduce the chemicals and general uses

of the chemicals. The AHVICL was used to identify introducers of the chemicals of security concern not included in the ACBPS data, who were contacted in writing and encouraged to respond to the Call for Information. Follow-up activities by e-mail and phone were undertaken for all non-responders.

Other sources

A small number of manufacturers of the chemicals not listed on the AHVICL were identified by a search of the Directory of Australian and New Zealand Chemical Manufacturers 2009-2010. They were contacted and, where necessary, followed up.

Downstream user survey

The survey of introducers resulted in a list of names and contact details for downstream users of the majority of the 66 chemicals.

Where possible, NICNAS contacted each organisation to ensure that the most appropriate person in the company was sent a downstream user survey by email. Alternately, contact was made by sending a letter to the address provided by the supplier or sourced from the organisation's website, regardless of whether this was the most appropriate contact. The postal contact included hard copies of the survey form and an offer to forward electronic copies. Separate survey forms were targeted to end users and formulators/resellers, with additional questions on products and customers for the latter category.

All downstream organizations known (or strongly suspected) to be purchasing small quantities of chemicals were not routinely included in the mail-outs. The overwhelming majority of these small volume users were laboratories who use the chemicals for research or in analytical procedures. However a cross-section of these users was contacted and followed up to ensure that representative data was collected in order to characterise and validate the profile of typical end users across this sector.

The deadline for data provision was six weeks after commencement of the mail-out. Follow up activities were conducted to increase the responses in each industry sector to enable valid characterisation of the types of activities in each of the sectors.
The industry sectors were identified for each of the chemicals based on scrutiny of the lists of downstream users. The users were placed into a sector according to name and, where possible, information provided by suppliers or obtained from relevant websites describing their activities. When responses were received, the sectors were confirmed against the responses. However, it was recognised that the response rate per sector may have been distorted due to miscategorisation of non-respondents.

Types of Products of Interest

In consideration of the types of downstream products that are likely to be of interest, AGD provided advice regarding threshold minimum concentrations for each chemical based on their utility and potential impact. In general, the interest was in mainly pure or simple solutions, solids or gases from which the chemical could be readily recovered in a functional form.

On this basis, formulators who supplied products containing any of the security sensitive chemicals at a concentration of less than the specified threshold concentration were considered to convert the chemical to a non-recoverable form.

These formulators were therefore categorised as “Chemical manufacturers (end users)” rather than “Commercial suppliers”.

Data analysis

Analysis of the sectors was undertaken to determine if the types of products used and regularity of use were common across the sector, and whether the volume in use was predominantly a function of the size of each company. Where a sector had a small number of companies, and particularly where the usage rate for each company was high, the follow-up was intended to achieve a 100% response rate.

Where sectors included a large number of companies with similar use patterns, the objective of the follow-up was to achieve a minimum 25% response rate, with a range of different sized companies.

Results

Although comprehensive data were provided by introducers and downstream users of the 66 chemicals, only a subset of the collected information is presented below due to potential security concerns.

Introducers' Response to Call for Information

Letters were sent to 210 organisations identified from the AHVICL, the Directory of Australian and New Zealand Chemical Manufacturers and Wholesalers, the information provided by ACBPS and those who reported independently as manufacturers. Since 62 of the organisations contacted were responsible for introducing more than one of the chemicals on the list, the final number of organisation contacts was 486.

No introducers for 11 chemicals (calcium cyanide, mercury cyanide, cyanogen chloride, sulfur dichloride, beryllium sulfate, mercuric nitrate, mercurous nitrate, dimethyl mercury, ethyldiethanolamine, fluoroacetic acid and fluoroethyl fluoroacetate) could be identified, although six of these were reported to be in downstream use.

For the other 55 chemicals, a total of 385 responses to the Voluntary Call for Information were received. This corresponds to a response rate of 80% of all organisations contacted with only slight variation (78% minimum to 100% maximum) between the response rates for the seven chemical groups.

The results indicate that not all organisations importing the chemicals responded to the Call for Information. Reasons for non-response included:

- Denied knowledge of import. This may be due to poor record keeping or misidentification based on generic tariff codes, where the ACBPS goods description was vague or ambiguous.
- Merger or closure of organisation.
- Manufacture had been discontinued since listing in the 2006 AHVICL.
- Refusal to participate (often due to time and resource constraints).

Not all of the responders provided useful information as defined by acknowledging introduction and provision of answers to at least two questions on the survey form. Of the 486 organisation contacts, 353 (73%) provided useful data with response rates varying between 67% and 100% for the seven chemical groups. Appendix 1 presents a breakdown of Introducer response rates for each of the 66 chemicals.

Introduced Volumes

For the 55 chemicals, introduced volumes for the specified survey period were obtained from most of the organisations who responded to the Voluntary Call for Information. Where available, import volumes were reconciled with ACBPS volume data and in general found to be in reasonable agreement. Manufactured volumes for the high volume chemicals were cross referenced, where possible, against the volume data reported for the 2006 AHVICL and all were within their respective volume range.

To determine the proportion of the large volume importers that had responded, ACBPS volume data for all responders were compared with the volume data extracted from ACBPS for all importers (i.e. both responders and non-responders). This comparison showed that the largest importers had responded to the Call for Information.

The total volumes of each chemical introduced (expressed as an annual volume range), concentrations and container sizes are presented in Appendix 2.

Use data

Uses reported by Australian introducers of the 55 chemicals (Appendix 2) were common to those reported internationally. There were no domestic uses that could be considered unique.

Downstream Users

Overall, two thousand nine hundred and sixty five (2965), downstream users (nominated by introducers) of 59 chemicals were contacted and sent survey questionnaires. No downstream users were identified for seven of the chemicals. After follow up, one thousand eight hundred and ninety seven (1897) responses were received including fifty one (51) from organisations who took the opportunity to 'self-report' the use of a chemical in conjunction with at least one of the other chemicals on the list for which they had been initially contacted. This represents a response rate of 64%.

Prior to survey, downstream users of each chemical were allocated to a use sector based on their name, basic information available from websites and information provided by suppliers. This classification was subsequently verified upon receipt of survey responses and allowed the confirmation, or reclassification as necessary, of allocated industrial use sectors.

A breakdown of survey response rate by group and chemical is presented in the analysis sections below with all response rates judged as sufficient to provide representative data and allow the construction of a profile for typical users of each of the 59 chemicals across their respective use sectors.

Analysis of the sectors was undertaken to determine if the types of products used, mode of transport and features of use were common across the sector, and whether the volume in use was predominantly a function of the size of each company.

Not all industry sectors for all chemicals are described in the following text. In general, only the more complex industry sectors are described more fully in the body of the report. However a summary table of downstream industry sectors for each chemical, its reported uses, volume ranges, concentrations and response rate is presented at the end of each section.

➢ Explosive precursors

Approximately one thousand (1000) introducer-nominated downstream users of the 12 explosive precursor chemicals were sent survey questionnaires. After follow up, five hundred and forty one (541) responses were received representing an overall response rate of 54%.

Road transport was the delivery mode typically used for all chemicals across all use sectors. An exception was hydrogen peroxide and the two largest sectors (pulp & paper and mining) where a combination of road, rail and sea transport was reported.

Hydrogen peroxide

There were 14 industrial use sectors identified for hydrogen peroxide: three reseller/formulator and 11 end user categories. The overall response rate was 50% of the organisations contacted and the response rates for individual use sectors are presented in Table 3.

Environmental

Hydrogen peroxide was used in applications involving media such as air, water and related infrastructure, wastewater and soil.

Companies from a range of industrial sectors used 25%-50% hydrogen peroxide to detoxify organic and inorganic wastes, boost oxygen levels in waste streams, control odours and act as a biocide. Specific areas included food and dairy, aquaculture, textile and water/waste treatment. Another sub group used the chemical in the cleaning and biocidal treatment of water related infrastructure such as heat exchangers and boilers required for power generation.

Chemical manufacture

The chemical was used in surfactant bleaching and the synthesis of amine oxides, organic peroxides, PVC and hydrofluoric/fluorosilicic acid. This sector included resellers who were defined as end users of the hydrogen peroxide since it was entirely consumed in their own processes, rather than being on-sold in a reactive form.

Commercial supply

This sector included companies formulating products for use by:

- Food and beverage processors for hard surface disinfection;
- Laundries as a bleach, and
- Plant operators as a cooling tower biocide.

Other lower volume uses included the cleaning of beverage equipment, as an etchant additive, a wound disinfectant and in pulp and paper bleaching. Several larger distributors were non-specific in their responses and provided broad, multi-use descriptions or claimed not to know the downstream use of their products.

Both formulators and resellers largely sold into similar end user sectors to those described in Table 4. It was further noted that the volumes used by customers of the retail resellers were generally below those for customers of the wholesale sellers.

Food and beverage equipment sanitisers

Companies were identified as formulators or resellers of products used to sanitise or disinfect surfaces used in food and beverage processing. In general, either 35% or 50% hydrogen peroxide was purchased. Those identified as formulators all diluted the input product from 50% to give output product concentrations from 8% to 35%.

Other companies were identified as resellers on the basis that they resold the output product at the same concentration as input product, most commonly at 27.5% to 35%.

Laundry

All companies were identified as resellers supplying bleach for laundry use. In general, 50% hydrogen peroxide was purchased and directly on-sold.

Cooling water

All companies were identified as resellers supplying hydrogen peroxide as a biocide for use in cooling water treatment. They purchased and on-sold 50% hydrogen peroxide.

Consumer product supply

This sector included companies supplying products for use by:

- Hairdressers for hair bleaching;
- Pharmacies as bleach, mouthwash and antiseptic, and
- Retail outlets for domestic cleaning.

A common feature across all sub-sectors was the predominance of formulators.

Hairdressing

All were formulators who uniformly purchased 50% hydrogen peroxide. The input product was reformulated to give output product concentrations of 3%, 6%, 9%, 12% and 18%.

Pharmaceutical

Companies purchased 35% hydrogen peroxide before reformulation to give an output product concentration of 3%.

Domestic cleaners

All supply companies purchased 50% hydrogen peroxide to formulate products such as stain remover and dishwashing liquid at final concentrations of 3% to 6%.

Rural supply stores

These stores sold products to farms, hydroponic producers and nurseries for use in disease control and water aeration.

All rural suppliers purchased 50% hydrogen peroxide. The majority of respondents were classified as resellers who on sold to horticulturalists for use in the sanitation and oxygenation of plant roots.

A small number of formulators repackaged the input product for resale at concentrations of 3%, 6%, 10% and 50% for use as a disinfectant in dairies and veterinary practices.

Table 3: Summary of hydrogen peroxide downstream use

Industry sector	Uses	Contacted/ responded	Volume range (L/year)	Conc. (%)
Pulp & paper	Bleaching of wood pulp	6/3	>1,000,000	59.5
Mining	Destruction of residual cyanide in waste water	11/7	100,000-1,000,000	70
Environmental		43/34		50
- *water treatment*	Oxygen level booster in waste streams, deodorant	18	10,000-100,000	50
- *food & dairy*	Oxygen level booster in waste streams, deodorant	6	100-1,000	25-50
- *aquaculture*	Biocide	3	1,000-10,000	50
- *infrastructure*	Biocidal treatment of heat exchangers and boilers	4	100-1,000	25-50
Textiles	Bleaching of natural and synthetic fibres	14/12	10,000-100,000	50
Food & beverage processing	Disinfectant for preparation surfaces and food containers	54/21	variable	35, 50
Commercial supply		96/48		
- *laundry*	Wholesale supply to retailers, dry cleaners, dye works	22	100-1,000	50
- *cooling water*	Wholesale supply to power stations, plant operators	4	10,000-100,000	50
- *food & beverage*	Wholesale to food and beverage processors	14	variable	35,50
Chemical manufacture	Surfactant bleaching. Synthesis of amine oxides, organic peroxides, PVC, peracetic acid, hydrofluoric acid, inorganic persalts.	22/9	variable	50
Food modification	Bleaching of tripe. Chemical modification of cereal starch.	7/3	variable	50
Consumer product supply		15/10		
- *domestic cleaning*	Wholesale to retailers for stain removal, dishwashing liquids	5	1,000-10,000	50
- *hairdressing*	Wholesale to salons for hair bleaching	3	1,000-10,000	50
- *pharmaceutical*	Wholesale to pharmacies for dental bleaching, mouthwash, antiseptic	2	100-1,000	35
Dry cleaning	Bleach and sanitisation of clothing and linen	94/35	100-1,000	50
Other uses	Bleaching golf balls, decolourising wood, medical, disinfectant	17/8	variable	3-50
Rural Supply stores	Retail to farms and nurseries as a biocide, water aeration	24/7	100-1,000	50
Metal treatment	Passivation and pickling of metal surfaces	5/2	100-1,000	50,65
Laboratory	Reagent for analysis and research purposes	8/8	1-10	30

Nitric acid

There were 13 industrial use sectors identified for nitric acid: two reseller/formulator and 11 end user categories. The overall response rate was 55% of the organisations contacted and the response rates for individual use sectors are presented in Table 4.

Commercial Supply

Suppliers could be grouped by their marketing of products for use in:

- Metal treatment;
- Dairy cleaning;
- Laboratory based analysis and education, and
- Miscellaneous applications.

Metal treatment

This sub-sector consisted of both resellers and formulators. The majority of nitric acid used was of 68% concentration with a minority using either 60 or 65% nitric acid. Companies who were identified as formulators blended the input product from 60%-68% to give output product concentrations ranging from 3% to 20% in most cases.

Dairy cleaning

Both resellers and dedicated formulators were identified. The product end uses are described in Table 5 under the heading 'Food & beverage processing'.

The majority of suppliers purchased nitric acid at 68% while a minority used concentrations ranging from 30% to 60% nitric acid. Companies identified as formulators all reformulated the input product (60% or 68% concentrated) to give output product concentrations ranging from 27% to 52.5%.

Laboratory

This sub-sector was dominated by direct resellers. Analysis of the product end users is provided in Table 6 under 'Laboratory'. Suppliers generally purchased 65%-70% nitric acid.

Miscellaneous

Several companies either reported mixed/general usage of their products or others such as water treatment, floor treatment, agriculture or mining industry.

The most commonly purchased nitric acid was of 68% concentration with other suppliers using either 60% or 70% nitric acid. While the majority of companies were identified as resellers, among the formulators the product concentrations ranged from 17% to 34% nitric acid.

Metal treatment

This sector consisted of companies from the metal finishing industry who used nitric acid in applications including:

- Passivating stainless steel;
- Cleaning and desmutting of aluminium prior to anodising;
- Pickle cleaning and descaling of metals, and
- Etching.

Two thirds of all organisations reported using 68% nitric acid with the remainder using 60%, 65% or 70%.

Rural supply stores
Companies sold horticultural products to farms, nurseries and hydroponic producers for use in fertilising and pH control. Another sub-sector of this category covers the sale of acidic cleaners for use in the dairy industry.

Horticulture
The vast majority of rural suppliers purchased 68% nitric acid and were classified as resellers to customers for fertiliser use in horticulture and pH control in hydroponics.

Dairy cleaning
The majority of stores purchased and on-sold 30% nitric acid for the cleaning of processing equipment.

Fertiliser manufacture
The chemical was used here exclusively in the manufacture of liquid and biological fertilisers (i.e. blood & bone meal) rather than solid forms of ammonium nitrate. All companies reported that they used a product containing 60%-68% nitric acid.

Cleaning
Companies used products containing nitric acid to clean deposits from masonry, desalination membranes and chemical process equipment. All reportedly used products containing 20% to 68% nitric acid.

Table 4: Summary of nitric acid downstream use

Use sector	Uses	Contacted/ responded	Volume range (L/year)	Conc. (%)
Commercial supply		98/50		
- *dairy cleaning*	Wholesale of products to food & beverage processors	12	variable	30-68
- *miscellaneous*	Wholesale to water treatment, agriculture and mining industries	15	1,000-10,000	60-70
- *metal treatment*	Wholesale to metal finishers	18	variable	60-68
- *laboratory*	Wholesale and retail to laboratories	5	10-100	65-70
Explosives	Manufacture of explosives for the mining industry	3/2	variable	60, 68
Food & beverage processing	Cleaning of consumable product processing equipment	41/16	variable	30
Chemical manufacture	Manufacture of metal nitrate compounds	11/4	1,000-10,000	60, 68
Mining	Cleaning of ceramic filters used to separate copper concentrate; acidification of metal precipitates.	5/3	10,000-100,000	60, 68
Mine laboratory	Mineral analysis	10/10	100-1,000	62
Metal treatment	Cleaning, etching and passivation	49/27	100-1,000	68
Rural supply stores		49/23		
- *horticulture*	Retail to farmers for use in fertiliser and pH control	19	100-1,000	68
- *dairy cleaning*	Retail to dairies for food & beverage processing	4	100-1,000	30
Fertiliser manufacturer	Manufacture of liquid and biological fertilisers	11/11	100-1,000	60-68
Horticulture	pH control of irrigation water and hydroponic media	17/10	100-1,000	60,68
Cleaning	Cleaning of miscellaneous equipment	4/4	100-1,000	20-68
Other uses	General or unspecified	5/2	100-1,000	
Laboratory	Reagent for analysis and research purposes	18/13	1-10	60-70

Sodium chlorate, potassium chlorate

There were six industrial use sectors identified for the two chlorate salts: one reseller/formulator and five end user categories. The overall response rate was 68% of the organisations contacted and the rates for individual use sectors are presented in Table 5.

Pulp & paper

Paper mills reported using large volumes of sodium chlorate for the generation of chlorine dioxide employed to bleach pulp.

Mining

Sodium chlorate is used in mining operations as an oxidising agent to maximise the extraction of ore concentrates.

Chemical manufacture

This sector consisted of a small number of companies who use sodium chlorate as:

- a bleaching agent within manufacturing processes, and
- an ingredient in metal conversion coatings.

Commercial supply

One processor reported recently discontinued use of sodium chlorate for formulation and use as a liquid defoliant. Scientific supply companies supplied both sodium and potassium chlorate for sale to retailers and direct supply to laboratories.

Personal oxygen supply

A small number of airline companies reported the use of products containing sodium chlorate as chemical oxygen generators. The 'oxygen candles' contained 74%-95% sodium chlorate and were installed in older model aircraft.

Laboratory

Laboratories attached to mines, tertiary institutes and R&D facilities reported using sodium chlorate and/or potassium chlorate for analytical and research purposes.

Table 5: Summary of sodium chlorate and potassium chlorate downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Pulp & paper (Na)	Manufacture of chlorine dioxide used to bleach pulp	2/2	>1,000,000	99
Mining (Na)	Oxidant use in the extraction of metallic ores	3/2	>1,000,000	99
Chemical manufacture (Na)	Bleaching agent in manufacturing; ingredient in metal conversion coating	2/2	>1,000,000	99
Commercial supply		9/5		
- *agriculture* (Na)	Herbicide	1	1,000-10,000	99
- *scientific* (Na, K)	Wholesale and retail to laboratories	4	1-10	99
Personal oxygen supply (Na)	Oxygen generation	2/1	1-10	74-95
Laboratory (Na, K)	Reagent for analysis and research purposes	4/3	<1	99+

Ammonium perchlorate, sodium perchlorate, potassium perchlorate and perchloric acid

There were five industrial use sectors identified for perchloric acid and the three derivatives: one reseller/formulator and four end user categories. The overall response rate was 65% of the organisations contacted and the rates for individual use sectors are presented in Table 6.

Plastics

Companies used sodium perchlorate as a stabiliser in plastic products. It aids in the prevention of discolouration of certain polymers including polyvinyl chloride. Solid chemical, at concentrations of less than 20%, was used together with undisclosed volumes of the chemical supplied as a 45%-60% solution.

Explosives

Companies legitimately used potassium perchlorate and ammonium perchlorate as explosive precursors. Small amounts of the potassium salt were used as a component in an explosive device known as a 'stim gun' for the purpose of oil well stimulation. Other explosives manufacturers employed the potassium salt, at low final concentration, for supply to mining companies.

Laboratory

Laboratories associated with mines, tertiary institutes, analysts and R&D facilities predominantly used sodium perchlorate and/or potassium perchlorate and/or perchloric acid

Commercial Supply

The vast majority of responding commercial suppliers were laboratory supply companies who were retailers selling to account customers.

Sodium perchlorate was also formulated for supply to plastics manufacturers as a 'syrup' at high concentration.

Other

Ammonium perchlorate is used in the manufacture of dental products.

Table 6: Summary of ammonium perchlorate, sodium perchlorate, potassium perchlorate, perchloric acid downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Plastics (Na)	Stabiliser to prevent discolouration	2/2	10,000-100,000	45, 99
Explosives (K, NH_4)	Oxidant in fireworks and mining charges	3/2	1,000-10,000	99
Commercial supply		15/10		
- *plastics* (Na)	Supply to manufacturers	1	1,000-10,000	99
- *scientific* (acid)	Wholesale and retail to laboratories	7	10-100	70
- *scientific* (K, NH_4, Na)	Wholesale and retail to laboratories	2	1-10	99
Other (NH4)	Dental products	1/1	10-100	99
Laboratory	Reagent for analysis and research purposes	13/7	<1	70, 99

Potassium nitrate

There were seven industrial use sectors identified for potassium nitrate: two reseller/formulator and five end user categories. The overall response rate was 51% of the organisations contacted and the rates for individual use sectors are presented in Table 7.

Commercial supply

This sector included wholesalers supplying products for use in:

- Agricultural, horticultural, nursery and domestic settings, and
- Metal treatment.

Other uses included curing meat, curing rubber, as an anticorrosive in coolant, a flux for metal alloying and as a laboratory reagent.

It was noted that the volumes used by customers of the retail resellers were generally below those for customers of the wholesale sellers.

Agricultural and domestic supply

Just over half of all companies were identified as resellers of products for ultimate use as a fertiliser for use by farmers, horticulturists and domestic gardeners. The larger companies primarily serviced rural supply stores with the smaller volume wholesalers selling into the hardware and supermarket chains.

The majority of companies were identified as formulators. Of the formulators, two thirds were identified as reselling a liquid product ranging in concentration from 5.4% to 12.5% while the solid formulations were generally at a higher output concentration ranging from 20% to 80%.

Metal treatment

Companies were identified as formulators supplying potassium nitrate as a 53%-55% component of a salt mix for the heat treatment of metal.

Chemical manufacture

This sector consisted of formulator/wholesalers who all manufactured products that contained potassium nitrate as an ingredient at a concentration of 5% or less in:

- Meat preservatives
- Brake fluid
- Refractory gunning mix
- Liquid fertiliser

All companies reported use of potassium nitrate in concentrations ranging from 0.02% to 5%. The chemical was considered to be essentially non-recoverable when formulated to these final concentrations.

Laboratory

This sector consisted of laboratories attached to an oil refinery, paper mill, an optical supplier and research facilities.

Sodium nitrate

There were five industrial use sectors identified for sodium nitrate: one reseller/formulator and four end user categories. The overall response rate was 65% of the organisations contacted and the rates for individual use sectors are presented in Table 7.

Chemical manufacture

This sector consisted of formulators who used sodium nitrate as an ingredient in products including:

- Adhesives
- Corrosion inhibitors
- Printing inks
- Metal casting powders

Other uses included curing meat, in a conversion coating for mild steel, in explosive emulsions, an oxidiser in dyes and as a drilling mud additive.

The output products were not of particular interest in this analysis as the low final concentration of sodium nitrate (less than 10%), in the presence of other ingredients, would make its recovery difficult.

Commercial Supply

This sector included companies selling products for use by:

- Laboratories, and
- Metal refiners and finishers.

Several formulators used the chemical in diverse products.

Laboratory supply

Companies were resellers of greater than 98% sodium nitrate for use in the laboratory.

Metal refining and treatment

Sodium nitrate has been included as a component of an exothermic powder used in metal casting, a metal conversion coating and in heat treatment products. In all cases, 99% sodium nitrate was used with final concentrations listed as between 7% and 20%.

Other

A small number of companies were formulators and/or wholesalers who used greater than 99% sodium nitrate in various products.

Half the companies were identified as formulators who formulated their product (sewer line cleaners, fire retardants and odour control agents) to a final concentration of 33%-35% sodium nitrate. The other companies were resellers of the chemical for use in meat preservation and miscellaneous products.

Laboratory

Laboratories associated with soil analysis, metal recycling and academia typically used high purity sodium nitrate.

Table 7: Summary of potassium nitrate, sodium nitrate downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Potassium nitrate				
Commercial supply		37/24		
- *agriculture & domestic*	Wholesale to rural suppliers	14	10,000-100,000	>94
- *metal treatment*	Wholesale to engineering suppliers	3	1,000-10,000	>97.5
Rural supply stores	Retail to farms, nurseries and hydroponics for use as fertiliser	53/20	10,000-100,000	>94
Fertiliser	Commercial application by farmers and horticulturalists	20/11	1,000-10,000	>94
Chemical manufacture	Meat preservative, brake fluid, refractory gunning mix	7/4	100-1,000	>97.5
Mining	Flux for the pyro-refining of gold	2/2	100-1,000	99
Miscellaneous	chemical hardening of glass lenses; heat treatment of metals; meat cure	8/3	100-1,000	50, 100
Laboratory	Reagent for analysis and research purposes	6/3	<1	>99
Sodium nitrate				
Chemical manufacture	Adhesives, corrosion inhibitors, printing inks, metal casting powders	29/22	1,000-10,000	98-100
Commercial supply		23/13		
- *laboratory*	Wholesale, retail to laboratories	4	100-1,000	98-100
- *metal refining*	Retail to metal refiners and finishers	4	1,000-10,000	98-100
- *other*	Mixed product supply	5	100-1,000	98-100
Metal treatment	Casting, heat treatment and electro-chemical machining of metals	3/2	1,000-10,000	98-100
Other	Meat cure, growth media, deodorant	6/3	100-1,000	74-95
Laboratory	Reagent for analysis and research purposes	6/3	<1	≥99

Sodium azide

There were two industrial use sectors identified for sodium azide which were both end user categories. The overall response rate was 100% of the organisations contacted and the rates for individual use sectors are presented in Table 8.

Chemical manufacture
Formulator/wholesalers used the sodium compound to produce lead azide for the legitimate production of explosives.

Laboratory
This sector consisted of laboratories associated with in vitro diagnostics, academia and chemical synthesis. The overwhelming majority of these facilities were small volume users who use the chemical in low concentration as a biocide.

Nitromethane

There were three industrial use sectors identified for nitromethane; two reseller and one end user category. The overall response rate was 83% of the organisations contacted and the rates for individual use sectors are presented in Table 8.

Commercial supply
The chemical was supplied in bulk for use as a fuel in motor racing.

Domestic supply
Retailers sold the chemical to hobbyists as a fuel for use in radio-controlled toys.

All retailers were supplied either 100% nitromethane and/or blends of the chemical ranging from a final concentration of 5% to 25% nitromethane mixed with methanol and oils.

A few retailers were identified as formulators on the basis that they reported blending the chemical for specialised use. Two thirds of all retailers resold 100% nitromethane and most of those also sold blended products. Output products were 5%, 10%, 15%, 20%, 25% and 100% nitromethane which were on sold in small volumes.

Laboratory
This sector consisted of laboratories performing drug and chemical analysis. This profile is consistent with that of the other laboratory users that were not directly surveyed, based on data provided by two commercial suppliers to this sector.

Table 8: Summary of nitromethane, sodium azide downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Nitromethane				
Commercial supply	Wholesale, retail as a fuel for motor racing and hobbyists	2/1	1,000-10,000	100
Domestic supply	Retail to hobbyists as a fuel for radio-controlled toys	8/7	100-1,000	5-100
Laboratory	Reagent for analysis and research purposes	2/2	1-10	100
Sodium azide				
Chemical manufacture	Manufacture of lead azide for use as an explosive precursor	2/2	100-1,000	100
Laboratory	Reagent for research purposes	2/2	<1	≥99

➢ Bulk acids and gases

One thousand one hundred and sixteen (1116) introducer-nominated downstream users of the 13 bulk acids and gases were sent survey questionnaires. No users of hydrogen cyanide were identified. After follow up, six hundred and thirty six (636) responses were received representing a response rate of 57%.

For each of the 13 chemicals, road transport was the delivery mode typically used across all use sectors. Exceptions were certain sectors using anhydrous ammonia, hydrochloric acid or sulfuric acid where combinations of road, rail and sea transit were reported.

Anhydrous ammonia

There were nine industrial use sectors identified as anhydrous ammonia of greater than 99% purity; one reseller/formulator and eight end user categories. The overall response rate was 61% of the organisations contacted and the rates for individual use sectors are presented in Table 9.

Commercial Supply

This sector included wholesalers supplying products for use in:

- Agriculture, and
- Refrigeration.

Agricultural supply

A small number of companies were identified as resellers of products for ultimate use by farmers as a fertiliser. Dealers (generally larger rural supply stores) did not physically handle or store the anhydrous ammonia product as it was directly delivered by road to farms for application via specialised equipment.

Refrigeration

Several companies were identified as supplying anhydrous ammonia for use as a refrigerant.

Downstream users of these suppliers were generally not further followed up and are considered to have similar use patterns to those described herein for the same sector.

Metal treatment

Companies used ammonia gas in furnaces as a nitriding agent. Nitriding is a heat treating process that alloys nitrogen onto the surface of a metal to create a case hardened surface.

Chemical manufacture

This sector consisted of companies who use ammonia in:

- Production of aqueous ammonia for sale;
- Manufacture of ammonium salts, and
- Oil refining and production.

Anhydrous ammonia was used to produce aqueous ammonia for sale to wholesalers and the paint, coatings and sealant industry. It was also used in an undisclosed role by the petrochemical sector. A small number of companies produce ammonium salts from internal ammonia feed stocks.

Table 9: Summary of anhydrous ammonia downstream use

Industry sector	Use sector	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Metal refining	Extraction and separation of metals from ores	2/2	>1,000,000	>99.5
Commercial supply		9/7		
- *agriculture*	Wholesale as fertiliser to rural suppliers	2	>1,000,000	>99.5
- *refrigeration*	Wholesale as refrigerant to retailers	5	variable	>99.5
Chemical manufacture	Manufacture of aqueous ammonia, ammonium salts; oil refining	9/4	>1,000,000	>99.5
Food processing	Coagulant of acid extracted collagen; catalyst in caramel production	2/2	10,000-100,000	>99.5
Water treatment	pH control of boiler and process water	11/5	1,000-10,000	> 99
Waste gas scrubbing	Suppression of sulfate or nitrogen oxides in flue gas streams	3/3	variable	100
Metal treatment	Nitriding agent.	9/6	100-1,000	>99.5
Refrigeration	Refrigerant for food & industrial applications.	43/26	100-1,000	>99.5
Other	Semiconductor manufacture; security detection	9/4	1-10	>99.5

Hydrogen chloride

There were three industrial use sectors identified: one processor and two end user categories. The overall response rate was 88% of the organisations contacted and the rates for individual use sectors are presented in Table 10.

Commercial Supply
A small number of processors repackaged the gas without changing the composition from 99.9% as supplied.

Chemical manufacture
A single company used high purity grade of hydrogen chloride in the manufacture of an active pharmaceutical ingredient.

Laboratory
This sector consisted of laboratories associated with tertiary institutions and R&D facilities. All typically used high purity hydrogen chloride.

Hydrochloric acid

There were 12 industrial use sectors identified for hydrochloric acid; two reseller/formulator and ten end user categories. The overall response rate was 56% of the organisations contacted and the rates for individual use sectors are presented in Table 10.

Food processing
Processors used the acid to chemically modify plant or animal fractions to produce food ingredients.

All companies used a product ranging in concentration between 33% and 34.5%.

Some companies used the product to 'invert' sugar and produce golden syrup and glucose. The largest company was using the acid to produce glucose. As the usage was greater than 100 ML per year it is likely that the glucose was not solely destined for the food sector but was primarily used as a feedstock for ethanol production.

Several companies used the acid to digest protein derived from grain or livestock.

Rural Supply Stores
A large number of companies sold the acid to hydroponic producers, vineyards and wineries for use in descaling irrigation lines and cleaning winemaking equipment. Another sub-sector of this category covers sale for use in domestic settings such as air conditioning, pool maintenance and masonry cleaning.

Water system treatment
Companies in the food, power, cosmetics and chemicals industries often rely on an internal supply of demineralised water. Many used hydrochloric acid to maintain the associated infrastructure in:

- Regeneration of ion-exchange resins;
- Descaling of boilers and heat exchangers, and
- Membrane cleaning.

The concentration of acid used in this sector was from 28% to 36%.

Commercial Supply
Resellers and formulators marketed products for use in:

- Metal treatment;
- Mining;
- Water system treatment (i.e. descaling);
- Cleaning (domestic, brick and concrete removal);
- Water treatment (pH adjustment of swimming pool and waste water), and
- Miscellaneous applications.

The majority of purchased hydrochloric acid was of 32% or 33% concentration. Companies who were identified as formulators reformulated the input product from 33% to give output product concentrations ranging from 5% to 20% in most cases. Just over half of the companies could be classified as dedicated resellers at concentrations of 10% to 33% although the majority were at the highest concentration in this range.

Table 10: Summary of hydrogen chloride and hydrochloric acid downstream use

Industrial sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Hydrogen chloride				
Commercial supply	Unspecified use	1/1	100-1,000	99
Chemical manufacture	Pharmaceuticals	1/1	1-10	100
Laboratory	Reagent used for research purposes	6/5	<1	>99
Hydrochloric acid				
Mining	Cleaning of activated carbon filters used in gold mining	13/9	100,000-1,000,000	32
Chemical manufacture	Aluminium salts, surfactants, cosmetics, resins, fertilisers	34/17	1,000-10,000	32, 33
Swimming pools (council)	pH adjustment of swimming pool water	13/9	1,000-10,000	30-33
Rural supply stores	Retail to farms for descaling irrigation lines & cleaning winemaking equipment	61/41	100-1,000	28-33
Cleaning	Food processing vessels, moulds for wet cast limestone, masonry, bricks	21/12	100-1,000	32-34.5
Metal treatment	Electroplating, precious metal refining, pickle cleaning, etching	40/18	100-1,000	32-36
Water system treatment	Regeneration of ion-exchange resins, descaling of boilers and heat exchangers, membrane cleaning	22/14	100-1,000	28-36
Laboratory	Reagent used analytical laboratories in the chemical, mining, food and beverage sectors as well as high school laboratories and research facilities.	20/19	1-10	32-37
Commercial supply	Wholesale, retail to metalworking, mining, cleaning, water system and general	119/48	variable	32,33
Water treatment	pH adjustment of wastewater, trade waste, boiler/cooling water; generation of chlorine dioxide for wastewater sanitisation	52/34	variable	32,33
Food processing	Digestion of plant or animal fractions to produce food ingredients	10/7	variable	33-34.5
Other	pH adjustment in various processes	8/3	variable	33

Sulfuric acid

There were 14 industrial use sectors identified for sulfuric acid: two reseller/formulator and 12 end user categories. The overall response rate was 59% of the organisations contacted and the rates for individual use sectors are presented in Table 11.

Mining

Companies were involved in mineral processing activities. All used 98% acid with the majority of operations using the acid to digest gold, copper or uranium ores in combination with the neutralisation of cyanide residues. Other mineral related uses were the in the processing of glass grade sand, bauxite ore and phosphate rock.

Leather and textiles

Animal hide processors used the acid to pickle cattle hides, tan leather, carbonize wool and dye felt hats. All companies used sulfuric acid at 67% to 98%.

Rural Supply Stores

Rural stores sold the acid to hydroponic producers, vineyards and wineries for use in adjusting the pH of irrigation water, descaling irrigation lines and cleaning winemaking equipment. All could be classified as direct resellers but the majority did not hold the chemical in stock. They purchased either 33% or 98% acid.

Water system treatment

Organisations from diverse industries such as the food & beverage, power generation, metal refining, water purification and petroleum sectors (who all relied on a supply of demineralised water) used the sulfuric acid (in combination with, or in preference to, hydrochloric acid) to maintain the associated infrastructure in:

- Regeneration of ion-exchange resins;
- Descaling of boilers and heat exchangers, and
- Membrane cleaning.

The concentration of acid used in this sector was typically 98% however some users also reported using 33% and 51%.

Oil refining

Petroleum and biodiesel producers used the acid as a catalyst for the reaction of isobutane with isobutylene to form isooctane. All companies used 98% acid.

Pulp & paper

Paper mills used sulfuric acid in bleaching processes as distinct from waste treatment. All mills used 98% acid.

Chemical Manufacture

The acid was used (and consumed) in the manufacture of products including:

- Resins
- Neutralising agents
- Sulfate compounds
- Surfactants

Other uses included a component of concrete accelerator and microbiological media.

Companies overwhelmingly reported that they used a product containing 98% sulfuric acid with only occasional use of 35% and 70%. Larger users generally consumed the acid in the pH control of chemical processes, fatty acid esterification in biofuels and the manufacture of sulfate salts.

Batteries

This sector consisted of operations in the battery, automotive and recycling industries. The sulfuric acid, as used as an electrolyte in batteries, was considered to be essentially non-recoverable and therefore all companies were deemed to be end users.

There was some diversity with respect to concentration of acid purchased, as half of all users purchased either 50% or 98% acid and diluted prior to filling the batteries, while the other users purchased the acid at 35% to fill the batteries directly. Recycling involved recovery of 10%-15% battery acid from expired units before immediate neutralization.

Commercial Supply

Sub-sectors of companies were identified who formulated products for use in:

- Batteries;
- Metal treatment and cleaning;
- Cleaning in place;
- Corrosion inhibitors;
- Water treatment (pH adjustment of waste water);
- Laboratory supply, and
- Miscellaneous applications.

<u>Metal treatment and cleaning</u>

Dedicated formulators purchased sulfuric acid at 98% concentration however two companies also used 60% and 78%. Companies reformulated the input product from 60% to 98% to give output product concentrations ranging from 9% to 21% for use as aluminium etch, deoxidiser or wheel cleaner. One company specialised in plating media and silver bright dip and blended at higher strengths ranging from 26%-43%.

<u>Batteries</u>

Resellers on-sold battery electrolyte with half supplying agents selling filled batteries.

The majority of suppliers purchased sulfuric acid at 30%-35%. Companies identified as formulators blended the 34% input product to give an output product concentration of 30%. This was repackaged for distribution to auto and hardware stores.

Among the resellers, concentrations of 30%-35% were reported with packaging in small volume containers.

<u>Cleaning-in-place</u>

Both resellers and dedicated formulators purchased sulfuric acid was at concentrations of 10.5% to 98%. Formulators blended the input product from either 78% or 98% to give output product concentrations ranging from 4% to 20% as dairy sanitiser or acidic detergent. All products were generally repackaged prior to resale.

Among the resellers, concentrations of 10.5%, 34.5% and 70% were commonly reported.

Water treatment
Both resellers and formulators sold sulfuric acid for pH adjustment of water used for a variety of purposes.

Half of the suppliers purchased the acid at 98%, with 30% to 78% was also reported. Companies identified as formulators blended the input product of 73%-98% to give an output product concentration of 34%-78% that was repackaged for distribution.

Laboratory
This sub-sector consisted solely of resellers. All suppliers purchased analytical grade sulfuric acid at 95%-98% concentration.

Corrosion inhibitor
Formulators purchased sulfuric acid at either 60% or 78% and generally on sold a repackaged product at 2% final concentration.

Miscellaneous
Both resellers and formulators reported either 'various' or 'general' usage of their products including water system treatment, sanitiser, batteries, fertilisers, metal leaching and pH adjustment. All purchased sulfuric acid at 98% concentration with formulators on selling products at concentrations ranging from 10% to 98%.

Water treatment
This sector consisted of organisations from diverse industries who use sulfuric acid in applications including:

- Neutralisation of effluent or trade waste;
- pH adjustment of boiler/cooling water, and
- Drinking water pre-treatment.

The concentration of acid used in this sector varied more widely than any other with users reporting purchase of sulfuric acid at 33%-35%, 50%, 60%, 69%-73% and 98%.

The smallest users were generally from the food and beverage sector. The medium volume users were from the food, textile and waste management sectors with the highest volume users from the water purification, petroleum and power generation sectors.

Metal treatment
The metal finishing industry used sulfuric acid in applications including:

- pH adjustment of electroplating solutions;
- Anodising;
- Pickle cleaning, and
- Desmutting.

All generally used 98% sulfuric acid although the stocks were diluted prior to use.

Food processing
This sector consisted of processors who use the acid to chemically modify starch, adjust the pH of food processes or hydrolyse protein to derive food ingredients. All companies used a product ranging in concentration between 50% and 98%.

Table 11: Summary of sulfuric acid downstream use

Industrial sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Mining	Digestion of gold, copper and uranium ores. Neutralisation of cyanide. Processing of glass grade sand, bauxite and phosphate rock	14/11	>1,000,000	98
Oil refining	Catalyst for the production of isooctane	5/3	>1,000,000	98
Pulp & paper	Bleaching processes	5/3	100,000-1,000,000	98
Chemical manufacture	Resins, neutralising agents, sulfate compounds, surfactants	39/23	100,000-1,000,000	98
Water system treatment	Regeneration of ion-exchange resins, descaling of boilers and heat exchangers, membrane cleaning	26/16	100,000-1,000,000	98
Batteries	Electrolyte	14/8	10,000-100,000	35, 50, 98
Water treatment	Regeneration of ion-exchange resins, descaling of boilers and heat exchangers, membrane cleaning	61/32	10,000-100,000	33-98
Leather & textiles	Pickling cattle hides, tanning leather, carbonize wool, dyeing felt hats	8/6	10,000-100,000	67, 73, 98
Food processing	Modification of starch, protein hydrolysis, pH adjustment	10/5	10,000-100,000	50-98
Commercial supply		75/41		
- *batteries*	Wholesale to automotive and hardware retailers	10	1,000-10,000	30-35
- *metal treat. & clean*	Wholesale to automotive and hardware retailers and metal finishers	5	1,000-10,000	98
- *cleaning in place*	Wholesale and retail to food & beverage processors	5	variable	10-98
- *water treatment*	Wholesale to water industry	13	1,000-10,000	30-98
- *laboratory*	Wholesale and retail to laboratories	3	100-1,000	98
- *corrosion inhibitor*	Wholesale to metal and engineering industries	2	variable	60, 78
- *miscellaneous*	Various wholesale	3	variable	98
Rural supply stores	Retail to hydroponic producers and wineries for pH adjustment of irrigation water, descaling irrigation lines and cleaning equipment	16/11	100-1,000	98
Metal treatment	Metal finishers	23/12	100-1,000	98
Other	Miscellaneous	8/3	10-100	33
Laboratory	Reagent used in analytical laboratories in the chemical, mining, food and beverage sectors as well as high school laboratories and research facilities.	15/14	1-10	98

Chlorine

There were five end user categories identified for chlorine. The overall response rate was 51% of the organisations contacted and the rates for individual use sectors are presented in Table 12. All sectors used high purity chlorine of typically 100%.

Chemical manufacture

This sector consisted of companies who use chlorine in the manufacture of:

- Titanium tetrachloride as intermediate for titanium dioxide pigments;
- Herbicides;
- Hydrogen chloride used to delint cotton seeds, and
- Petroleum products.

Food processing

Grain companies used chlorine in the oxidation of protein resulting in a modification of the properties of flour intended for use in baking.

Metal refining

Aluminium and gold refiners used chlorine in the purification of the metals.

Water disinfection

This sector included organisations using the chlorine gas to disinfect water for use in:

- Drinking, recycling and sewage;
- Swimming pools;
- Cooling towers;
- Food and beverages, and
- Miscellaneous applications.

Potable water and wastewater treatment

Introducer data had identified local councils as the major customers, but in recent years an increasing number of councils have now outsourced water treatment to utility companies. Both councils and utilities used the gas to sanitise water for safe use in drinking or to treat recycled and wastewater.

Miners of iron ore and coal also reported using the gas to treat potable water and/or effluent streams. Nurseries, vineyards and other small operations similarly used chlorine to sanitise water for use in plant irrigation or treating waste streams.

Cooling towers

Power stations and manufacturers used chlorine to sanitise the plant cooling systems. Although the gas is effective and relatively cheap, some users stated that they had recently substituted hypochlorite for the gas as a matter of safety and convenience.

On a smaller scale, three hospitals relied on the chlorine to kill water-borne legionella in cooling systems.

Swimming pools

This sub sector consisted of community- and school-based aquatic centres who used the gas to sanitise swimming pool water. Some other identified users stated that they had recently substituted hypochlorite for the gas.

Food and beverage
Manufacturers relied on the gas to sanitise the water used in the production of various foods and beverages. The majority were identified as meat processors or abattoirs.

Other
Some operations used high purity chlorine gas in the manufacture of electronic parts. A zinc refinery used the gas in pollution abatement to strip mercury from process gases and a metal finisher using it for destruction of cyanide in a waste stream.

Bromine

Two industrial use sectors were identified for bromine: one reseller and one end user category. The overall response rate was 50% of the organisations contacted and the rates for individual use sectors are presented in Table 12.

Laboratory
The chemical was used for demonstration purposes (secondary schools, colleges) or experimentation and assays (universities, R&D facilities, contract analysts).

Schools
In general, school laboratory assistants purchased bromine as supplied in ampoules (greater than 99%) or bromine water (nominal concentration of 4%). If the former were preferred, when required for a class demonstration the entire ampoule was used to prepare bromine water in-situ and the residual 4% stock solution stored for use at a later date.

Universities
In contrast to the schools, none of the tertiary institutions used bromine ampoules, but used bromine as supplied in bottles at a concentration of greater than or equal to 99.5%.

Commercial Supply
Laboratory supply wholesalers sold a 99% nominal concentration chemical as a laboratory reagent to schools, universities, R&D facilities etc.

Fluorine

Only a single end user category was identified for fluorine, and all users responded to the survey (overall response rate 100%): the data for this sector are presented in Table 12.

Manufacturing
Companies responding used fluorine in a gas mixture that fuels an excimer laser. Typically the laser is used in the production of semiconductor chips or in the micromachining of polymer banknotes.

The fluorine is supplied as a specialty gas mixture at a final fluorine concentration of less than 10% in cylinders.

Table 12: Summary of chlorine, bromine and fluorine downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Chlorine				
Water disinfection	Sanitise potable water, wastewater, swimming pools, cooling towers, beverages	173/89	10,000-100,000	100
Chemical manufacture	Intermediate for titanium dioxide, herbicides, hydrogen chloride, petroleum products	6/5	variable	100
Metal refining	Purification of aluminium and gold	8/5	variable	100
Food processing	Oxidation of wheat protein to modify flour intended for use in baking	3/2	variable	100
Other	Manufacture of microelectronics, remove mercury from process gases, cyanide kill	11/4	variable	100
Bromine				
Commercial supply	Wholesale and retail to laboratories	13/6	1-10	99.5
Laboratory	Reagent used in analytical, high school and research laboratories	41/22	<1	99.5
Fluorine				
Manufacturing	Laser gas for the production of semiconductor chips and the micromachining of polymer banknotes	2/2	<1	0.9-10

Carbon monoxide

Two end user categories were identified for carbon monoxide with an overall response rate of 58% of the organisations contacted. The rates for individual use sectors are presented in Table 13.

Chemical Manufacture
A plastics manufacturer used carbon monoxide (3%, 99.5%) to terminate polymerisation reactions.

A steel producer used the carbon monoxide as a low grade fuel to heat furnaces and boilers within the steel works. The plant produced a large volume of the gas as a by-product from their coke ovens and blast furnace, at a concentration of 4.5% and 22.3% respectively.

Laboratory
The sector consisted of laboratories associated with universities, the CSIRO and sports institutes who all reported using greater than 99.5% carbon monoxide.

Hydrogen cyanide

The sole identified importer of this gas reported that small quantities were imported for purposes of gas detector calibration, but the hydrogen cyanide was present at only 10ppm. No users of this product were nominated.

Hydrogen sulfide

A single downstream use of the gas was classified. The overall response rate was 100% of the organisations contacted and is presented in Table 13.

Importers reported the use of hydrogen cyanide as a calibration gas in hazard sensors at concentrations less than 200ppm. Downstream users of these gases were not contacted.

Metal treatment
A single responding company used 99.9% hydrogen sulfide in a hot wire galvanising process.

Nitric oxide

There was a single end user category identified for nitric oxide. The overall response rate was 100% of the organisations contacted and is presented in Table 13.

Laboratory
Laboratories used small quantities of either 2.5% or 98.5% nitric oxide.

Phosgene

A single end user category was identified for phosgene. The overall response rate was 50% of the organisations contacted as presented in Table 13.

Laboratory
There were only a small number of laboratory users of this chemical. Typically the responding laboratories used the chemical supplied as a 20% solution in toluene.

Phosphine

There were three industrial use sectors identified for phosphine; 1 reseller/formulator and two end user categories. The overall response rate was 100% of the organisations contacted as presented in Table 13.

Commercial supply
The gas was imported at a concentration of 98% and formulated/repackaged in cylinders at a concentration of 2%. The resulting product is sold for use as a fumigant through rural supply/hardware stores. The formulator also sells the product under its own label to rural users and occasionally for research purposes.

Semiconductor manufacture
A limited number of companies were using high purity phosphine for silicon semiconductor doping applications. Doping is the addition of an impurity to modulate electrical properties.

Laboratory
A single university laboratory reportedly used the 2% phosphine gas in a grain bioassay and occupational health & safety studies.

Arsine

A single downstream user of the gas was allocated to one end user category. The overall response rate was 100% of the organisations contacted as presented in Table 13.

Semiconductor manufacture
A high purity grade (100%) of arsine was used as a doping agent in the manufacture of semiconductors.

Table 13. Summary of carbon monoxide, hydrogen sulphide, nitric oxide, phosgene, phosphine and arsine downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Carbon monoxide				
Chemical manufacture	Termination of polymerisation reactions, low grade fuel	3/2	variable	5, 22, >99
Laboratory	Reagent used in research and analytical laboratories	9/5	<1	>99.5
Hydrogen sulfide				
Metal treatment	Hot wire galvanising	1/1	100-1,000	99.9
Nitric oxide				
Laboratory	Reagent used in research laboratories	2/2	1-10	2.5, 98.5
Phosgene				
Laboratory	Reagent used in research laboratories	2/1	<1	20
Phosphine				
Commercial supply	Wholesale to rural supply stores for pest control	2/2	1,000-10,000	2
Semiconductor manufacture	Silicon doping agent	1/1	<1	100
Laboratory	Reagent used in research and analytical laboratories	1/1	< 1	2
Arsine				
Semiconductor manufacture	Doping agent	1/1	<1	100

➢ Inorganic cyanides

One hundred and eighty eight (188) introducer nominated downstream users of the four cyanide chemicals were sent questionnaires. After follow up, one hundred and twenty four (124) responses were received representing a response rate of 66%. The response rates for each chemical and use sectors are presented in Table 14.

For each of the four chemicals, road transport was the delivery mode typically used with the exception of sodium cyanide where rail transport was also commonly used for delivery of the chemical to mine sites.

Potassium cyanide

There were three industrial use sectors identified for potassium cyanide: one reseller/formulator and two end user categories. The overall response rate was 76%.

Electroplating

Electroplaters use potassium cyanide in alkaline cyanide baths to deposit decorative and/or functional metal coatings onto a variety of objects. All companies reported purchasing the chemical at a concentration of at least 98%.

Laboratory

This sector consisted of laboratories using 96%-100% potassium cyanide to conduct:

- Contract analysis including pathology;
- Mineral assays, and
- Pharma and academic research.

Commercial supply

Wholesalers supplied the chemical for use in the laboratory and in metal plating.

Laboratory supply

The majority of companies were identified as resellers of products for use in the laboratory. They ordered 96%-99% potassium cyanide from larger wholesalers.

Electroplating

Companies supplied potassium cyanide for use as a 'silver brightener' prior to metal plating. Neat chemical was used as input but its final concentration was not reported.

Sodium cyanide

There were five industrial use sectors identified for sodium cyanide; one reseller/formulator and four end user categories. The overall response rate was 63%.

Ore flotation

Companies used 98% sodium cyanide in ore flotation during the smelting of metals (silver, lead, zinc). The cyanide acts as a depressor to assist the separation of minerals.

Electroplating

Companies used 98% sodium cyanide for electroplating in alkaline cyanide baths to deposit decorative and/or functional metal coatings onto a variety of objects.

Gold mining
Mining companies used sodium cyanide in the beneficiation of gold to separate it from unwanted material in the ore. All of the sodium cyanide used is manufactured in Australia with the majority sold in a briquette form. The majority of miners reported using this form directly while one third of companies used a 30% cyanide solution.

Commercial supply
Wholesalers supplied products for use in electroplating and laboratories.

Electroplating
Companies were identified as resellers of products for use in cyanide baths. All purchased 100% solid although they did not report the final concentration in products.

Laboratory supply
Several companies were identified as resellers of products for use in the laboratory. The majority sold specifically to analytical mineral testing laboratories with one of these reformulating the 100% cyanide into assay tablets that contained 75% cyanide. The other resellers did not reformulate and on sold 97%-98% chemical.

Laboratory
This sector consisted of laboratories conducting:

- Contract analysis including pathology;
- Geology/metallurgical assays, and
- Pharma and academic research.

Generally, mineral assay laboratories reported using sodium cyanide at greater than 98% concentration while other laboratories used 95%-100%.

Zinc cyanide

There were two industrial end use sectors identified for zinc cyanide. The overall response rate was 73% of the organisations contacted.

Electroplating
Companies used 100% zinc cyanide in electroplating to deposit zinc coatings onto objects. The sector is declining due to the increasing use of non-cyanide alternatives.

Laboratory
This sector consisted of research institutes and university laboratories who employed either 98% or 100% zinc cyanide as a research reagent.

Mercury cyanide

There was only one end user category identified for mercury cyanide. The overall response rate was 100% of the organisations contacted.

Laboratory
This sector consisted of a commercial analytical laboratories, research institutes and university laboratories. All laboratories reported using 100% mercury cyanide.

Table 14: Summary of inorganic cyanides downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Potassium cyanide				
Electroplating	Used in alkaline cyanide baths to deposit metal coatings onto objects	10/8	100-1,000	≥98
Commercial Supply		12/6		
- *electroplating*	Wholesale to metal plating sector	1	100-1,000	100
- *laboratory*	Wholesale to laboratory sector	5	1-10	≥98
Laboratory	Reagent used in research and analysis in the mining and pathology sectors	44/31	<1	≥97
Sodium cyanide				
Gold extraction	Beneficiation of gold from ore	49/27	>1,000,000	96-99
Ore flotation	Depressor to assist the separation of minerals during smelting	2/2	10,000-100,000	≥98
Electroplating	Used in alkaline cyanide baths to deposit metal coatings onto objects	15/11	100-1,000	>98
Commercial Supply		10/6		
- *electroplating*	Wholesale to metal plating sector	2	100-1,000	100
- *laboratory*	Wholesale to laboratory sector	4	10-100	>97
Laboratory	Reagent used in research and analysis in the mining and pathology sectors	31/21	<1	>95
Zinc cyanide				
Electroplating	Used in alkaline cyanide baths to deposit zinc coatings onto objects	2/2	1-10	100
Laboratory	Reagent used in research and analysis in the mining sector	9/6	<1	≥98
Mercury cyanide				
Laboratory	Reagent used in research and analysis in the mining sector	4/4	<1	100

➢ Industrial reactives

One hundred and sixty five (165) introducer nominated downstream users of the nine industrial reactive chemicals were sent survey questionnaires. After follow up, one hundred and ten (110) responses were received representing a response rate of 67%. The response rates for individual chemicals and use sectors are presented in Table 15.

For each of the nine chemicals, road transport was the delivery mode typically used across all use sectors.

Osmium tetroxide

Only one end user category was identified. The overall response rate was 65% of the organisations contacted.

Osmium tetroxide is primarily used in the staining of biological materials for optical and electron microscopy. It is also used in fingerprint detection and as an oxidant in chemical synthesis at the research scale.

Laboratory
This sector consisted of pathology laboratories and research facilities. There were several solutions of the chemical reported as well as a 100% solid form. Solutions varying in strength from 1% to 13% were available, with 4% the most common.

Cyanogen bromide

Only one end user category was identified with an overall response rate of 67%.

Cyanogen bromide is primarily used at small scale to immobilize proteins, to fragment proteins by cleaving peptide bonds and for chemical synthesis.

Laboratory
This sector consisted of research facilities and university laboratories. All organisations used a solid form of either 97% or 100% concentration. Additionally, a few organisations reported using a 5M solution of cyanogen bromide in acetonitrile.

Phosphorus

There were three industrial use sectors identified: one reseller/formulator and two end user categories. The overall response rate was 93% of the organisations contacted.

Chemical manufacture
A munitions company used 99% phosphorus in the manufacture of an aircraft charge spotting bomb although the final concentration in the product was not reported.

Laboratory
This sector consisted of a munitions company, research facilities, contract analytics and university laboratories. All organisations reported using a solid form of the chemical of 97%-100% concentration.

Commercial supply
Resellers generally supplied a 100% analytical grade laboratory reagent.

Phosphorus oxychloride

There were three industrial use sectors identified for phosphorus oxychloride: 3 end user categories. The overall response rate was 83% of the organisations contacted.

The chemical is known to be used for the processing of flour, in the manufacture of semiconductors and in dental products.

Chemical manufacture
This sector consisted of a personal care company who used the chemical in the manufacture of products used to remineralise teeth. The company reported using a 99.5% concentration of the chemical that was consumed in product manufacture.

Food processing
Grain companies used the chemical to modify the properties of flour via the cross-linking of starch. All purchased a 100% food grade product.

Laboratory
This sector consisted of research institutes, contract analytics and university laboratories. All laboratories purchased the chemical at 99% or 100% concentration.

Phosphorus pentachloride

There were two industrial use sectors identified; one reseller/formulator and one end user category. The overall response rate was 60%.

Phosphorus pentachloride is used as a chlorinating agent but more widely in the laboratory than at the industrial scale.

Commercial supply
This sector consisted of a single reseller who supplies science equipment to the secondary school market. The company reported supplying a 98% pure chemical.

Laboratory
Research institutes and universities used the chemical at 95%-100% concentration.

Phosphorus trichloride

There were two industrial use sectors identified for phosphorus trichloride; one reseller/formulator and one end user category. The overall response rate was 75%.

Phosphorus trichloride is employed as a chlorinating agent and as a precursor to inorganic phosphorus compounds.

Commercial supply
A single reseller supplied the chemical for the general laboratory market. The company reported supplying a 98% pure technical grade of the chemical.

Laboratory
This sector consisted of research laboratories. All reported purchasing the chemical at 99% or 100% concentration in liquid form or 100% when purchased as a solid.

Sulfur monochloride

There was a single industrial end use sector identified for sulfur monochloride. The overall response rate was 67% of the organisations contacted.

Laboratory
All research laboratories reported using 98% sulfur monochloride.

Thionyl chloride

There were two industrial use sectors identified: one reseller/formulator and one end user category. The overall response rate was 79% of the organisations contacted.

Thionyl chloride is mainly used in organic synthesis as a chlorinating agent.

Laboratory
This sector consisted of laboratories conducting:

- QC including pathology, and
- Pharma and academic research.

Generally, laboratories used 97%-100% thionyl chloride that was supplied as a liquid.

Commercial supply
This sector consisted of resellers who supply consumables and equipment for the general laboratory market. All reported supplying a chemical of at least 99% purity.

Thiophosphoryl chloride

There were two industrial end user categories identified for thiophosphoryl chloride. The overall response rate was 80% of the organisations contacted.

Chemical manufacture
A single pharma contract manufacturing company reported using the chemical as a reagent in the manufacture of candidate drug products. The company reported using 98% chemical that was consumed during synthesis.

Laboratory
This sector consisted of a pharma company and university laboratories using 98% or 100% thiophosphoryl chloride.

Table 15: Summary of industrial reactives downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Cyanogen bromide				
Laboratory	Reagent used in research laboratories	15/11	<1	11, ≥97
Osmium tetroxide				
Laboratory	Reagent used in research and pathology laboratories	37/24	<1	4, 100
Phosphorus				
Chemical manufacture	Munitions	1/1	10-100	99
Commercial supply	Wholesale to the laboratory sector	2/1	1-10	100
Laboratory	Reagent used in research and analytical laboratories	11/11	<1	≥97
Phosphorus oxychloride				
Food processing	Flour modification	2/2	1,000-10,000	100
Chemical manufacture	Dental products	1/1	100-1,000	99.5
Laboratory	Reagent used in research and analytical laboratories	20/16	<1	≥99
Phosphorus pentachloride				
Commercial supply	Wholesale to the laboratory sector	2/1	1-10	98
Laboratory	Reagent used in research laboratories	18/11	<1	≥95
Phosphorus trichloride				
Commercial supply	Wholesale to the laboratory sector	3/1	<1	98
Laboratory	Reagent used in research laboratories	9/7	<1	≥99
Sulfur monochloride				
Laboratory	Reagent used in research laboratories	6/4	<1	98
Thionyl chloride				
Commercial supply	Wholesale to the laboratory sector	4/2	1-10	≥99
Laboratory	Reagent used in research and pathology laboratories	30/25	<1	≥97
Thiophosphoryl chloride				
Chemical manufacture	Pharmaceutical drug candidates	1/1	10-100	98
Laboratory	Reagent used in research laboratories	4/3	<1	≥98

➢ Industrial inorganics

One hundred and thirteen (117) introducer nominated downstream users of the nine industrial inorganic chemicals were sent survey questionnaires. After follow up, one hundred and sixty six (166) responses were received which included over fifty two (52) responses from organisations who 'self-reported'. The response rates for individual chemicals and use sectors are presented in Table 16.

For each of the nine chemicals, road transport was the delivery mode typically used across all use sectors.

Arsenic pentoxide

Three organisations, who were nominated by introducers as downstream users of the chemical, were contacted regarding their use of arsenic pentoxide. However a further five organisations self-reported in conjunction with at least one of the other chemicals on the list. There was one industrial use sector identified for arsenic pentoxide.

Laboratory

This sector consisted of laboratories conducting either contract analysis (including pathology) or research. All reported using 100% arsenic pentoxide.

Arsenic trioxide

There were two industrial use sectors identified for arsenic trioxide; one reseller/formulator and one end user category. The overall response rate was 92% of the organisations contacted.

Commercial supply

Wholesalers supplied products for use in the laboratory. All were identified as resellers who on-sold 99% concentrated product directly without reformulation.

Laboratory

This sector consisted of laboratories conducting:

- Contract analysis including pathology;
- Geology/metallurgical assays, and
- Pharma and academic research.

Laboratories generally reported purchasing arsenic trioxide at concentrations between 99% and 100%.

Beryllium sulfate

Three organisations were contacted regarding their use of beryllium sulfate however another three self-reported in conjunction with at least one of the other chemicals on the list. There was one industrial use sector identified for the chemical.

Laboratory

This sector consisted of laboratories conducting either contract analysis (including pathology) or research. All reported using 100% beryllium sulfate.

Ethyl mercury chloride

Only three organisations were contacted regarding their use of ethyl mercury chloride however one other self-reported in conjunction with another chemical on the list. A single end user category was identified for the chemical.

Laboratory
This sector consisted of laboratories conducting either contract analysis (including pathology) or research. All laboratories reported using 100% ethyl mercury chloride.

Mercuric chloride

There were two industrial use sectors identified for mercuric nitrate: one reseller/formulator and one end user category. The overall response rate was 87%.

Commercial supply
This sector consisted of wholesalers supplying products for use in the laboratory.

All companies were identified as resellers of laboratory reagents on-selling either a 99% or 100% concentrated product directly without reformulation.

Laboratory
This sector consisted of laboratories conducting:

- Contract analysis including pathology;
- Pharma research and QC, and
- Academic research.

All generally purchased the mercuric chloride at concentrations of 99%-100%.

Mercuric nitrate

The small number of organisations contacted regarding their use of mercuric nitrate was supplemented by ten others who self-reported in conjunction with at least one of the other chemicals on the list. Consequently there were two industrial use sectors identified for mercuric nitrate; one reseller/formulator and one end user category with an overall response rate of 100%.

Commercial supply
Wholesalers supplied products for use in the laboratory. All were identified as resellers of reagents who on-sold a 100% concentrated product without reformulation.

Laboratory
This sector consisted of pathology, research institutes and university laboratories who reported purchasing the 100% mercuric nitrate.

Mercuric oxide

There were two industrial use sectors identified for mercuric oxide: one reseller/formulator and one end user category. The overall response rate was 100%.

Laboratory
This sector consisted of laboratories conducting:

- Contract analysis including pathology;
- Pharma research and QC, and
- Academic research.

Laboratories reported using the mercuric oxide at a concentration of 98%-100%.

Commercial supply
Wholesalers supplied products for use in the laboratory. All were identified as resellers who on-sold either a 99%-100% concentrated product without reformulation.

Mercurous nitrate

The small number of organisations specifically contacted regarding their use of mercurous nitrate was supplemented by nine others who self-reported in conjunction with at least one of the other chemicals on the list. Consequently there were two industrial use sectors identified for mercurous nitrate: one reseller/formulator and one end user category and the overall response rate was 100%.

Commercial supply
Wholesalers supplied products for use in the laboratory. All were resellers of reagents who on-sold a 95% concentrated product directly without reformulation.

Laboratory
This sector consisted of laboratories conducting either contract analysis (including pathology) or research. Laboratories mostly reported using 100% mercurous nitrate.

Thallium sulfate

One industrial end use sector was identified for thallium sulfate. Only four organisations were specifically contacted regarding their use of thallium sulfate however two also self-reported.

Laboratory
This sector consisted of contract analytics, research institutes and university laboratories who employed either 98% or 100% chemical as a reagent or reference standard.

Table 16: Summary of Industrial inorganics downstream use

Industry sector	Uses	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Arsenic pentoxide				
Laboratory	Reagent used in research and contract analysis including pathology	3/8	<1	100
Arsenic trioxide				
Commercial Supply	Wholesale to laboratory sector	2/2	<1	99
Laboratory	Reagent used in research and analysis in the mining and pathology sectors	36/33	<1	≥99
Beryllium sulfate				
Laboratory	Reagent used in research and contract analysis including pathology	3/6	<1	100
Ethyl mercury chloride				
Laboratory	Reagent used in research and contract analysis including pathology	3/4	<1	100
Mercuric chloride				
Commercial supply	Wholesale to laboratory sector	11/5	<1	100
Laboratory	Reagent used in research and contract analysis including pathology	36/44	<1	100
Mercuric nitrate				
Commercial supply	Wholesale to laboratory sector	1/1	<1	100
Laboratory	Reagent used in research and analysis in the pathology sector	0/10	<1	> 97
Mercuric oxide				
Commercial supply	Wholesale to laboratory sector	2/2	<1	≥99
Laboratory	Reagent used in research and contract analysis including pathology	14/24	<1	≥98
Mercurous nitrate				
Commercial supply	Wholesale to laboratory sector	0/1	<1	95
Laboratory	Reagent used in research and contract analysis including pathology	2/10	<1	100
Thallium sulfate				
Laboratory	Reagent used in research laboratories	4/6	<1	≥98

➢ Industrial organics

Three hundred and seventy six (376) introducer nominated downstream users of nine of the fourteen organic chemicals were sent survey questionnaires. No users for five chemicals (chloropicrin, ethyldiethylanolamine, fluoroacetic acid, fluoroethyl fluoroacetate and methyl fluoroacetate) were identified. After follow up, three hundred and eight (308) responses were received (including a small number from organisations who self-reported their use of chloropicrin, ethyldiethylanolamine or fluoroacetic acid). This represented a response rate of 81%. The response rates for individual chemicals and use sectors are presented in Table 17.

For each of the twelve chemicals, road transport was the delivery mode used across all use sectors.

Carbon disulfide

There were two industrial use sectors identified for carbon disulfide: one reseller/formulator and one end user category. The overall response rate was 77%.

In addition to the two sectors described below, the chemical is also used and consumed as a feedstock in manufacturing. However this sector was identified by introducers who reported that it was exclusively used in-house and not on sold.

Commercial supply

Wholesalers supplied products for use in the laboratory. All were identified as resellers who on-sold a 99% or 100% concentrated product without reformulation.

Laboratory

This sector consisted of laboratories conducting:

- contract analysis;
- pharma research and QC, and
- academic research.

The chemical was generally used as a solvent for analytics or extraction of organic compounds. All laboratories used carbon disulphide of at least 99% concentration.

Chloropicrin

No organisations were specifically contacted regarding their use of chloropicrin however three self-reported in conjunction with at least one of the other chemicals on the list. Consequently there was a single end user category identified for follow up.

A single importer of the chemical reported the formulation and supply of the chemical to rural stores for on-sale and end use in soil fumigation and rabbit control. However the stores and associated downstream users employing these chloropicrin-containing, APVMA registered products were not contacted by NICNAS as analysis of these sectors is expected to be conducted by the APVMA.

Laboratory

This sector consisted of university laboratories and contract analysis facilities. In the laboratory context, chloropicrin is used as a reference standard and in pesticide

research. Solid and solutions, in concentrations of 98%-100% for the former and 0.5%-50% for the latter, were available for use.

Dimethyl phosphite, diethyl phosphite, triethyl phosphite, trimethyl phosphite

Only one end user category was identified for each of the four organic phosphites. The overall response rate was 81% of the organisations contacted.

The phosphites are primarily used in a laboratory context as reference standards and for research scale synthesis of intermediates, polymers, drugs etc.

Laboratory
This sector consisted of contract analytical laboratories and research laboratories. Organisations reported using a solid form of the chemicals at a concentration not less than 97%. A few also reported purchase of a 100% solution of diethyl phosphite.

Dimethyl sulfate

Only one end user category was identified for dimethyl sulfate. The overall response rate was 85% of the organisations contacted.

Laboratory
Laboratories conducting research reported using 99% or 100% dimethyl sulfate as a methylating agent in organic synthesis.

Ethyldiethanolamine

Only one end user category was identified for ethyldiethanolamine. No organisations were specifically contacted regarding their use of the chemical however four self-reported in conjunction with at least one of the other chemicals on the list.

Laboratory
This sector consisted of laboratories conducting either contract analysis or research. All laboratories reported using either 98% or 100% ethyldiethanolamine.

Fluoroacetic acid, fluoroethyl alcohol

There was a single industrial end use sector identified for both fluorinated compounds. Although four organisations were contacted regarding their use of these chemicals, another two self-reported in conjunction other chemicals on the list.

Laboratory
This sector consisted of research laboratories who used the acid and alcohol as laboratory reagents. All purchased the chemicals at a concentration of 99% and above.

Methyldiethanolamine

There were three industrial use sectors identified for methyldiethanolamine; one reseller/formulator and one end user category. The overall response rate was 79%.

Laboratory
Laboratories conducting either contract analysis or research generally reported using methyldiethanolamine at a concentration of at least 99%.

Chemical manufacture
Companies used methyldiethanolamine in the production of ammonia (as a carbon dioxide absorbent) and in concrete admixtures. Although the input concentrations were either 40% or 78%, the final concentration of the methyldiethanolamine was negligible after formulation and reaction with other ingredients in the products.

Commercial supply
The majority of methyldiethanolamine was sold as 100% product for use as a pH modifier in applications such as gas scrubbing, plasticiser, fabric softener and curing.

Triethanolamine

There were three industrial use sectors identified and confirmed: one reseller/formulator and two end user categories. The overall response rate was 55%.

Commercial supply
Suppliers could be grouped into sub-sectors selling the chemical for use in:

- Cleaners
- Corrosion inhibitors
- Laboratory supply
- Personal care
- Miscellaneous applications

Cleaners
This sub-sector consisted of both dedicated formulators and resellers who purchased triethanolamine at either 85% or 99% concentration.

The companies identified as formulators blended the input product from these concentrations to 12%-22% for use in for ink wash-up, dishwashing detergent, surface cleaners and membrane cleaners. However, based on anecdotal evidence from across the sector, these products contain negligible quantities of available triethanolamine.

Resellers supplied product to formulators for use in cleaning products.

Corrosion Inhibitors
Companies blended products for use in radiator coolants, boiler water, metal cutting fluids etc. and all could be classified as dedicated formulators.

The purchased chemical was 85% concentrated and reformulated to 10.5%-35% for use in a range of consumer and commercial products.

Laboratory
Several companies were dedicated resellers of either 85% or 99% triethanolamine.

Personal care
This sub-sector consisted of both resellers and formulators who purchased as input product triethanolamine of either 85% or 99% concentration.

Companies identified as formulators repackaged the input product at concentrations between 14% and 85% for use in rinse-off products and unspecified cosmetics.

Miscellaneous
Both resellers and formulators reported a variety of end uses for their products including commercial sale, paint stripper, anti-static spray, gas rig use, flux additive, adhesives, paints and fuel additives.

Purchased triethanolamine was of 78%, 85% or 99% concentration. The formulators blended triethanolamine in concentrations ranging from 10.5% to 60%, but the final concentration of 'available' triethanolamine in the products was not specified.

Laboratory
The sector consisted of laboratories conducting:

- Contract analysis including pathology;
- Pharma including QC, and
- Research and teaching.

Laboratories used triethanolamine at concentrations ranging from 85% to 100%.

Chemical manufacture
Formulators manufactured products containing triethanolamine as an ingredient at a concentration of 10% or less for uses including:

- Adhesives
- Corrosion inhibitors
- Cleaners
- Concrete
- Drilling fluids
- Emulsifiers
- Fertilisers
- Polymers
- Personal care
- Paints & Inks

Other uses included metal treatments, oil additives & algaecides.

Companies generally reported that they used a product containing 85% triethanolamine. Approximately equivalent use of 99% triethanolamine was found in the personal care product sub-sector.

The output products were not of particular interest in this analysis due to the low final concentration of triethanolamine which, in addition to its quantitative reaction with other ingredients, would make its recovery difficult.

Adhesives
Several companies were identified as formulators of adhesive products. They purchased 85% triethanolamine and formulated at concentrations of less than 1%.

Concrete
A small number of companies were formulators of concrete admixtures. These were used in the construction industry to accelerate the setting of shotcrete and all

purchased either 78% or 85% chemical with formulation of the mixtures at concentrations of less than 3%.

Corrosion inhibitors

Several companies were identified as formulators of anti-corrosives for use in soluble metal working fluids, closed systems for the cooling of engines and water-based hydraulic fluids. All purchased 85% triethanolamine and formulated to a final concentration of less than 5%.

Cleaners

More than fifty companies were identified as formulators of products that could be broadly described as cleaners. The triethanolamine was used to adjust the pH of products including detergents, surface cleaners, degreasers, fabric conditioners, soaps, surfactants, plant and equipment washes and tyre dressing.

Most companies used 85% triethanolamine as input product. Given the variety of formulations, it was not possible to assign a common final concentration of the chemical in the finished products however the majority nominated less than 5% in the presence of several other ingredients.

Drilling fluids

Five companies were identified as formulators who used the chemical as an additive in water based dispersants, grinding aids or drilling fluids in the mining industry. All used 13%, 78% or 85% triethanolamine as input product. The chemical was neutralised upon formulation and was therefore non-recoverable.

Emulsifiers

Some formulators sold antifoams or emulsifiers destined for use by manufacturers. All purchased 85% triethanolamine and formulated at final concentrations of less than 1% with no free triethanolamine remaining in the products.

Fertilisers

A small number of companies reported as formulators of fertilisers and probably used the chemical as a pH neutraliser. They purchased 85% triethanolamine and formulated the fertilisers at small concentrations in selected blends.

Paints and Inks

Five companies were identified as using the chemical as a pH adjuster in printing inks, paints and UV curable coatings. All purchased either 85% or 99% triethanolamine and formulated to final concentrations in the 0.1% to 3% range.

Polymers

Several companies used the chemical in plastics, resins manufacture or rubber compounding. All purchased 50% to 99% triethanolamine and formulated to undisclosed final concentrations, although two plastics manufacturers used in the range of 1.4% to 2%.

Personal care products

Thirty companies were identified as formulators of products for consumer use such as an emulsifier or pH adjuster in products including skin cleansers, lotions and creams, soaps, shave gels, shampoos and hair products.

Equal numbers of companies used either 85% or 99% triethanolamine as input product. Given the variety of formulations, there was no common concentration of the chemical in the finished products however all were less than 3%. For this reason, the companies were classed as ‘chemical manufacturers’ and not ‘commercial suppliers’.

Miscellaneous

Formulators used either 85% or 99% triethanolamine in products serving various markets. Companies blended their products (anodising pre-seal, metals passivator, oil additives, fabric anticrease and algaecide) to a final concentration of less than 10%.

Table 17: Summary of Industrial organics downstream use

Use sector	Supply chain node	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Carbon disulfide				
Laboratory	Reagent used in research and analysis	42/34	1-10	≥99
Commercial supply	Wholesale to laboratory sector	6/3	1-10	≥99
Chloropicrin				
Laboratory	Reagent used in research and analysis	0/3	<1	variable
Diethyl phosphite, dimethyl phosphite				
Laboratory	Reagent used in research and analysis	18/15	<1	≥ 98
Dimethyl sulfate				
Laboratory	Reagent used in research	11/13	<1	≥99
Ethyldiethanolamine				
Laboratory	Reagent used in research	0/4	<1	≥98
Fluoroacetic acid, fluoroethyl alcohol				
Laboratory	Reagent used in research laboratories	4/8	<1	≥95
Methyldiethanolamine				
Chemical manufacture	Carbon dioxide absorbent, concrete admixtures	4/2	1,000-10,000	40, 78
Commercial supply	Wholesale to various sectors for use as a pH modifier	2/1	NR	100
Laboratory	Reagent used in research	13/12	<1	≥99
Triethyl phosphite, trimethyl phosphite				
Laboratory	Reagent used in research	25/20	<1	≥97

Table 17 (continued): Summary of Industrial organics downstream use

Use sector	Supply chain node	Contacted/ responded	Volume range (kg/year)	Conc. (%)
Triethanolamine				
Chemical manufacture		251/126		
- *adhesives*	Adhesives and bonding agents	7	100-1,000	85
- *concrete additives*	Admixtures used to accelerate setting of shotcrete	3	100-1,000	≥78
- *corrosion inhibitors*	Anti-corrosives for use in soluble metal working fluids, engine coolants and water-based hydraulic fluids	6	100-1,000	85
- *cleaning products*	Detergents, surface cleaners, degreasers, fabric conditioners, soaps, surfactants, plant and equipment washes and tyre dressings	51	100-1,000	85
- *emulsifiers*	antifoams or emulsifiers for use by manufacturers	3	10,000-100,000	85
- *polymers*	Plastics (including PVC), resins, rubber compounding.	6	10,000-100,000	≥78
- *miscellaneous*	Anodising pre-seal, metal passivators, oil additives, fabric anticrease, algaecide	8	100-1,000	≥78
- *personal care*	Skin cleansers, lotions, creams, soaps, shave gels, shampoos, hair products	30	100-1,000	≥85
- *paints & inks*	Printing inks, paints, UV curable coatings	5	100-1,000	≥85
- *drilling fluids*	Water based dispersants, grinding aids, drilling fluids for the mining industry	5	1,000-10,000	13-85
- *fertilisers*	Fertiliser formulations	2	1-100	85
Commercial supply		32/24		
- *cleaning products*	Wholesale to automotive, textile and domestic product manufacturers	6	1,000-10,000	22-99
- *personal care*	Wholesale to cosmetic manufacturers	3	1,000-10,000	14, 85
- *corrosion inhibitor*	Wholesale to metalworking, automotive and engineering supply sector	3	1,000-10,000	10.5-35
- *miscellaneous*	Wholesale to various sectors	7	100-1,000	10.5-99
- *laboratory*	Wholesale to laboratory sector	5	<1	≥85
Laboratory	Reagent used in research laboratories	68/45	<1	≥85

Summary and Discussion

NICNAS was contracted by the Australian Government AGD to collect data on sixty six (66) chemicals of security concern.

A voluntary call for information was conducted in three stages to collect information from introducers of the chemicals including introduction volumes, uses, storage, transport and downstream users. Notices on the voluntary call for information were published in the Chemical Gazette over a three year period and were directed to all organisations who introduced any of the chemicals of interest or products containing the chemicals. Letters were also sent to four hundred and eighty two (482) organisations who had been identified as possible introducers of the chemicals.

Of the 66 chemicals, useful information on 55 was obtained from responses to the voluntary call for information. No import records or manufacturers could be found for 11 chemicals for the designated periods.

With regard to the data obtained from the ACBPS, only 11 of the 66 chemicals (hydrogen peroxide, nitric acid, sodium chlorate, potassium nitrate, ammonia, chlorine, hydrochloric acid, hydrogen chloride, sulfuric acid, carbon disulphide and phosphorus) have unique Tariff Classification Numbers which were used to accurately search and download the relevant import records. However the other 54 chemicals are not afforded this unique identifier but are assigned different generic tariff classification numbers which refer instead to a group of chemicals. Therefore, for this group of chemicals, a high reliance was placed upon the ACBPS goods description to provide a degree of confidence in the specificity and comprehensiveness of the ACBPS data in relation to importer identification. There was however limitations in this approach as, for example, the identity of a chemical entered under an ACBPS goods description of 'Other chlorates' cannot be determined without further investigation.

An exhaustive follow-up was required to obtain information from non-responding organisations. Some introducers were constrained by time and resourcing limitations and, on the understanding that the call for information was voluntary, did not feel obliged to respond. After telephone contact was made to further explain the nature and importance of the call for information, a high percentage subsequently decided to provide input.

In total, three hundred and eighty five (385) organisations responded to the call for information, representing a response rate of 80%, with three hundred and fifty three (353) providing useful information.

Based on the introduction volumes obtained from companies who responded to the call for information, the top nine chemicals introduced (total aggregate volumes of greater than 10,000 tonnes per annum) were: hydrogen peroxide, nitric acid, sodium chlorate, potassium nitrate, anhydrous ammonia, hydrochloric acid, sulfuric acid, chlorine and sodium cyanide.

Not all responding introducers supplied the names and contact details of organisations who purchased their products for downstream use. However, where possible, larger suppliers of each chemical were re-contacted to obtain sufficient responses and enable

valid characterisation of the chemical's use across all industry sectors. As a result, two thousand nine hundred and sixty five (2,965) non-unique downstream users of 59 chemicals were contacted and sent survey questionnaires. No downstream users were identified for seven of the chemicals. After follow up, one thousand eight hundred and ninety seven (1,897) responses were received which represents a response rate of 64%. As was the case with the call for information to introducers, the support of the peak industry bodies and their close communication with members contributed to this level of participation. Additionally, the decision taken to separate the chemicals into seven groups based on similar use profiles, to avoid having to survey the same groups of downstream users multiple times, significantly improved the efficiency of data collection.

Although the overall response rate of downstream users of the 59 chemicals was satisfactory, of greater importance were the chemical by chemical response rates. These rates ranged from 48% to 100% and were also judged to be satisfactory considering that the lowest rates were for chemicals with a large number of users and included adequate representation of organisations of all sizes.

Overall, the voluntary call for information proved valuable in obtaining information regarding the organisations introducing and using chemicals of security concern, the import/manufacture volumes, and downstream uses in Australia, if any, for these chemicals.

Appendix 1. Introducer response rates

Chemical Name	Orgs. Contacted	Orgs. Responding	Responding (%)	% Useful information
Explosive precursors				
Hydrogen peroxide	44	33	75	59
Nitric acid	44	37	84	66
Sodium chlorate	11	8	73	64
Potassium chlorate	6	5	83	67
Ammonium perchlorate	3	3	100	100
Sodium perchlorate	14	11	79	79
Potassium perchlorate	10	7	70	50
Perchloric acid	9	8	89	78
Potassium nitrate	46	30	65	59
Sodium nitrate	18	16	89	89
Nitromethane	8	6	75	75
Sodium azide	9	8	89	89
Bulk acids and gases				
Ammonia, anhydrous	14	11	79	79
Hydrochloric acid	26	20	77	77
Hydrogen chloride	4	4	100	100
Sulfuric acid	37	27	73	73
Chlorine gas	12	9	75	73
Bromine	7	5	71	57
Fluorine gas	2	2	100	100
Carbon monoxide	9	7	78	78
Hydrogen cyanide	1	1	100	100
Hydrogen sulfide	6	4	67	67
Nitric oxide	10	9	90	70
Phosgene	1	1	100	100
Phosphine	4	4	100	75
Arsine	1	1	100	100
Inorganic cyanides				
Calcium cyanide	0	0		
Mercury cyanide	0	0		
Potassium cyanide	8	8	100	88
Sodium cyanide	10	9	90	90
Zinc cyanide	2	2	100	100
Industrial reactives				
Cyanogen bromide	2	1	50	50
Cyanogen chloride	0	0		
Osmium tetroxide	6	2	33	33
Phosphorous	6	4	67	50
Phosphorous oxychloride	11	11	100	100
Phosphorous pentachloride	4	3	75	75
Phosphorous trichloride	4	4	100	75
Sulfur dichloride	0	0		
Sulfur monochloride	1	1	100	100
Thionyl chloride	4	4	100	100
Thiophosphoryl chloride	1	1	100	100

Chemical Name	Orgs. Contacted	Orgs. Responding	Responding (%)	% Useful information
Industrial inorganics				
Arsenic pentoxide	1	1	100	100
Arsenic trioxide	8	8	100	100
Beryllium sulfate	0	0		
Ethyl mercury chloride	1	1	100	100
Mercuric chloride	4	3	75	75
Mercuric nitrate	0	0		
Mercuric oxide	6	4	67	67
Mercurous nitrate	0	0		
Dimethyl mercury	0	0		
Thallium sulfate	1	1	100	100
Industrial organics				
Carbon disulfide	6	5	83	83
Chloropicrin	3	2	67	33
Diethyl phosphite	2	2	100	100
Dimethyl phosphite	1	1	100	100
Dimethyl sulfate	1	1	100	100
Ethyldiethanolamine	0	0		
Fluoroacetic acid	0	0		
Fluoroethyl alcohol	1	1	100	100
Fluoroethyl fluoroacetate	0	0		
Methyldiethanolamine	9	7	78	78
Methyl fluoroacetate	1	1	100	100
Triethanolamine	19	17	90	84
Triethyl phosphite	2	2	100	100
Trimethyl phosphite	1	1	100	100

Appendix 2. Introducer Summary

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Hydrogen peroxide	10,000-100,000	2-10, 25-70	Pulp & paper, mining, disinfectant, bleach, sanitiser, resin catalyst, metal plating & polishing, pharmaceuticals, food & beverage, milk & dairy, detergents, rural supply, water treatment, chemical manufacturing, tanneries, textiles, personal care, laboratory and analytical	0.1L, 0.5L, 1L, 2.5L, 5L, 20L, 25L, 200L, 1100L, 20T
Nitric acid	100,000-1,000,000	7-33, 53-70, 99	Explosives, munitions, propellants, chemical manufacturing, detergents, acid cleaners, pharmaceuticals, fertilisers, metal coatings, metal passivation, anodising, water treatment, gold mining, solar cells, laboratory & analytical	0.25L, 0.5L, 1L, 2.5L, 20L, 25L, 30L, 200L, 260L, 280L, 1000L, 1360L, 20T
Sodium chlorate	10, 000-100,000	74-100	Mining, pulp & paper, agriculture, uranium oxide extraction, manufacturing aid, oxygen generation, laboratory and analytical	0.1kg – 1T
Potassium chlorate	1-10	100	Resale, laboratory and analytical	0.1-0.5kg
Ammonium perchlorate	<0.1	99	Dental products, laboratory and analytical	0.5-5kg
Sodium perchlorate	1,000-10,000	1-19, 60, 85-100	Explosives, disinfectant, intermediate, PVC stabilizer, laboratory and analytical	0.1kg-22T

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Potassium perchlorate	100-1,000	99-100	Explosives, pyrotechnics, chemical manufacture, drilling stimulant, laboratory and analytical	0.1kg-22T
Perchloric acid	10-100	70-72	Resale, laboratory and analytical	0.5-200L
Potassium nitrate	10,000-100,000	13-26, 93-100	Fertiliser, detergents, animal feeds, mining, food preservative, paint, glass, laboratory and analytical, lens hardening, toothpaste	0.5kg- 22T
Sodium nitrate	1,000-10,000	1-20, 65, 99-100	Detergents, water treatment, meat preservation, foods, fertiliser, explosives, oxidant, propellant, glass, mining, catalyst, fluxing agent, phosphate treatment, biocide, corrosion inhibitor, laboratory and analytical	0.1-1,200kg
Nitromethane	10-100	95-100	Fuel, laboratory and analytical	0.1-200L
Sodium azide	1-10	99-100	Explosives, chemical manufacture, paint, veterinary, laboratory and analytical	0.1-50kg
Ammonia, anhydrous	100,000-1,000,000	100	Refrigerant, mining, chemical manufacture, fertiliser, semiconductors, LEDs, cleaning agent, metal treatment, glass manufacture, power generation, laboratory and analytical	0.17kg-25,000T

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Hydrogen chloride	10-100	100	Pharmaceuticals, electronics, agriculture, laboratory and analytical	0.4-80L
Hydrochloric acid	10,000-100,000	10, 28-38	Mining, gold extraction, solar cells, microelectronics, cleaning, sanitizer, descaler, pH adjustment, pigment surface treatments, pickling, metal treatment, waste treatment, building & construction, laboratory and analytical.	0.25L-25,000L
Sulfuric acid	> 1,000,000	5-18, 25-41, 55-60, 90-100	Mineral leaching, battery electrolyte, solar cells, diodes, explosives, water treatment, pH adjuster, oil refining, chemical manufacture, metal treatment, laboratory and analytical	0.1L-75,000T
Chlorine	10,000-100,000	100	Semi-conductors, diodes, pigment refining, herbicides, chemical manufacture, water sanitization, laboratory and analytical	2kg-25T
Bromine	<1	3, 99-100	Laboratory and analytical	0.01-0.5L
Fluorine	<0.1	5	Lasers, laboratory and analytical	10-50L
Carbon monoxide	<1	0.01-0.2, 6, 99.5-100	Metallurgy, lasers, reaction terminator, calibration, laboratory and analytical.	10-103L

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Hydrogen cyanide	<0.1	0.001	Calibration	
Hydrogen sulfide	<0.1	0.0025, 99.5-100	Calibration, metal separation, hot wire galvanizing, petrochemical	30-58L
Nitric oxide	1-10	0.0005-0.96, 98.5-100	Calibration, laboratory and analytical	10-50L
Phosgene	<0.1	20	Laboratory and analytical	0.01-2.5L
Phosphine	1-10	2, 99-100	Fumigant, semi-conductors	2-50L
Arsine	<0.1	100	Semi-conductors, laboratory and analytical	2-10L
Potassium cyanide	1-10	96-100	Electroplating and electro-polishing agent, gold recovery, laboratory and analytical	0.1-50kg
Sodium cyanide	10,000-100,000	28-32, 95-100	Gold extraction, electroplating, laboratory and analytical	0.1kg-22.7T

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Zinc cyanide	<0.1	98, 100	Electroplating, laboratory and analytical	0.25-50kg
Cyanogen bromide	<0.1	97	Laboratory and analytical	0.005-0.1kg
Osmium tetroxide	<0.1	2.5-4, 100	Laboratory and analytical	0.1-1g
Phosphorus	0.1-1	97-100	Munitions, laboratory and analytical	0.1-50kg
Phosphorus oxychloride	10-100	99-100	Flour modification, solar cells, diodes, optical fibres, laboratory and analytical	0.025L-22T
Phosphorus pentachloride	<0.1	95-100	Laboratory and analytical	0.1-1kg
Phosphorus trichloride	<0.1	98-100	Laboratory and analytical	0.1-1kg

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Sulfur monochloride	<0.1	98	Laboratory and analytical	1kg
Thionyl chloride	1-10	99-100	Chemical manufacture, laboratory and analytical	0.1-300kg
Thiophosphoryl chloride	<0.1	98	Laboratory and analytical	0.1-1.4kg
Arsenic pentoxide	<0.1	99+	Laboratory and analytical	0.1kg
Arsenic trioxide	100-1,000	98-100	Wood preservative, laboratory and analytical, pharmaceutical, resale	0.1-200kg
Ethyl mercury chloride	<0.1	99+	Laboratory and analytical	0.25g
Mercuric chloride	<0.1	99-100	Laboratory and analytical	0.05-0.5

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Mercuric oxide	<0.1	98-100	Laboratory and analytical	0.1-0.5kg
Thallium sulfate	<0.1	100	Laboratory and analytical	5-50g
Carbon disulfide	1,000-10,000	99-100	Chemical manufacture, laboratory and analytical	0.1L-18T
Chloropicrin	100-1,000	100	Fumigation, laboratory and analytical	70kg-Bulk
Diethyl phosphite	<0.1	98	Laboratory and analytical	0.025-1kg
Dimethyl phosphite	<0.1	98	Laboratory and analytical	0.025-0.5
Dimethyl sulfate	<0.1	99+	Laboratory and analytical	1L

Chemical	Volume Range (tonnes per year)	Concentration (%)	Uses	Container Sizes
Fluoroethyl alcohol	<0.1	95	Laboratory and analytical	1-5g
Methyldiethanolamine	100-1,000	1, 10-20, 30-60, 72-92, 99-100	Gas treatment, solvent, pH adjustment, urethane catalyst, textile softening, epoxy resin curing, laboratory and analytical	0.25kg-19T
Methyl fluoroacetate	<0.1	99+	Laboratory and analytical	0.025g
Triethanolamine	1,000-10,000	10-30, 50-70, 85-100	Neutralising agent, surfactants, detergents, cleaners, fabric softeners, emulsifier, concrete additives, cleaners, waxes, polishes, metalworking fluids, paints, printing inks, corrosion inhibitor, mineral grinding agent, polyurethane manufacture, epoxy catalyst, personal care, herbicides, embalming fluid, laboratory and analytical	0.025kg-21T
Triethyl phosphite	<0.1	97, 98	Laboratory and analytical	0.1-0.5L
Trimethyl phosphite	<0.1	97+	Laboratory and analytical	0.025-1L