Screening Assessment for the Challenge

1-Propene, 3-chloro-
(3-Chloropropene)

Chemical Abstracts Service Registry Number
107-05-1

Environment Canada
Health Canada

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Synopsis

The Ministers of the Environment and of Health have conducted a screening assessment of 1-propene, 3-chloro- (3-chloropropene), Chemical Abstracts Service Registry Number 107-05-1. This substance was identified in the categorization of the Domestic Substances List (DSL) as a high priority for action under the Challenge. 3-Chloropropene was identified as presenting an intermediate potential for exposure of individuals in Canada and had been classified by other agencies on the basis of carcinogenicity and genotoxicity. Although the substance met the ecological categorization criteria for inherent toxicity to aquatic organisms, it did not meet the criteria for persistence or bioaccumulation. Therefore, the focus of this assessment relates primarily to human health aspects.

Under information reported pursuant to section 71 of CEPA 1999, the total quantity of 3-chloropropene imported into Canada in 2006 was below the reporting threshold of 100 kg. It should be noted that 3-chloropropene was imported into Canada as its reacted form (as part of a polymer backbone) or as residues in end products. No manufacture or direct use of 3-chloropropene was reported by Canadian companies in the same year. However, acrylic polymers manufactured using 3-chloropropene are imported by companies in Canada to be used as formulants in personal care products. Based on information presented in the scientific and technical literature, 3-chloropropene is employed primarily in the production of epichlorohydrin, glycerine and quaternary ammonium compounds. The substance is also used as a chemical intermediate in the production of allyl compounds, cross-linking substances, pharmaceutical agents and agricultural chemicals.

3-Chloropropene does not occur naturally in the environment. However, 3-chloropropene from anthropogenic sources may be released into the atmosphere and hydrosphere during its production, use and disposal. The principal route of exposure for the general population is likely through inhalation of ambient and indoor air and the use of personal care products containing the substance as a residual. Exposures from other media are likely negligible in comparison. Due to its use as a chemical intermediate in captive reactions, releases of 3-chloropropene to the ambient environment are expected to be low.

As 3-chloropropene was classified on the basis of carcinogenicity by other national and international agencies, carcinogenicity was a key focus for this screening assessment. Small increases in the incidence of forestomach tumours and lung tumours were observed in mice exposed orally and by intraperitoneal injection, respectively. No increases in tumour incidences were observed in mice exposed dermally to 3-chloropropene alone or in a limited study in rats exposed via oral gavage. 3-Chloropropene is an alkylating agent. Although 3-chloropropene was consistently genotoxic in a range of *in vitro* assays, it was not demonstrated to be genotoxic in the limited number of *in vivo* studies identified. Information from a limited epidemiological study demonstrated no increases in deaths due to cancer in 3-chloropropene-exposed workers. Thus, in light of the only weak evidence of carcinogenicity, characterization of risk to human health was based on information on non-cancer effects.

Exposure to 3-chloropropene has been associated with non-cancer effects in experimental animals and in occupationally exposed humans, including neurotoxicity, reproductive and developmental toxicity and effects on the liver and kidneys. Margins between concentrations associated with neurological effects, considered to be the critical effects for risk characterization, and conservatively modelled estimates of exposure via inhalation during use of some personal care products that contain 3-chloropropene, and measured concentrations in ambient air, are considered to be adequately protective, although only very limited information was available on the potential presence of the substance in products in Canada.

Based on the available information on the potential to cause harm to human health and the resulting margins of exposure for neurological effects, it is concluded that 3-chloropropene is a substance that is not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

3-Chloropropene does not meet the criteria for persistence or bioaccumulation as set out in the *Persistence and Bioaccumulation Regulations*, but it may be harmful (acutely toxic) to some species at low exposure concentrations. On the basis of its relatively low ecological hazard, the low concentrations measured historically in Canadian surface water and effluents and the low quantity currently in commerce in Canada, it is concluded that 3-chloropropene is not entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity or that constitute or may constitute a danger to the environment on which life depends.

Based on available information, it is concluded that 3-chloropropene is currently not entering, nor is it likely to enter, the environment. Therefore, it is concluded that it does not meet any of the criteria set out in section 64 of CEPA 1999.

Because this substance is listed on the *Domestic Substances List*, its import and manufacture in Canada are not subject to notification under subsection 81(1). Given the hazardous properties of this substance, there is concern that new activities that have not been identified or assessed could lead to this substance meeting the criteria set out in section 64 of the Act. Therefore, it is recommended to amend the *Domestic Substances List*, under subsection 87(3) of the Act, to indicate that subsection 81(3) of the Act applies with respect to the substance so that new manufacture, import or use of this substance is notified and undergoes ecological and human health risk assessments.

Introduction

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada 1999) requires the Minister of the Environment and the Minister of Health to conduct screening assessments of substances that have met the categorization criteria set out in the Act to determine whether these substances present or may present a risk to the environment or to human health.

Based on the information obtained through the categorization process, the Ministers identified a number of substances as high priorities for action. These include substances that

- met all of the ecological categorization criteria, including persistence (P), bioaccumulation potential (B) and inherent toxicity to aquatic organisms (iT), and were believed to be in commerce; and/or
- met the categorization criteria for greatest potential for exposure (GPE) or presented an intermediate potential for exposure (IPE) and had been identified as posing a high hazard to human health based on classifications by other national or international agencies for carcinogenicity, genotoxicity, developmental toxicity or reproductive toxicity.

The Ministers therefore published a notice of intent in the *Canada Gazette*, Part I, on December 9, 2006 (Canada 2006), which challenged industry and other interested stakeholders to submit, within specified timelines, specific information that may be used to inform risk assessment and to develop and benchmark best practices for the risk management and product stewardship of those substances identified as high priorities.

The substance 3-chloropropene was identified as a high priority for assessment of human health risk because it was considered to present IPE and had been classified by other agencies on the basis of carcinogenicity and genotoxicity. The Challenge for 3-chloropropene was published in the *Canada Gazette* on May 31, 2008 (Canada 2008). A substance profile was released at the same time. The substance profile presented the technical information available prior to December 2005 that formed the basis for categorization of this substance. As a result of the Challenge, submissions of information pertaining to uses and potential exposure of the substance were received.

Although 3-chloropropene was determined to be a high priority for assessment with respect to human health and it also met the ecological categorization criteria for inherent toxicity to aquatic organisms, it did not meet the criteria for persistence or bioaccumulation potential. Therefore, this assessment focuses principally on information relevant to the evaluation of risks to human health.

Screening assessments focus on information critical to determining whether a substance meets the criteria for defining a chemical as toxic as set out in section 64 of CEPA 1999. Screening assessments examine scientific information and develop conclusions by incorporating a weight of evidence approach and precaution.

This screening assessment includes consideration of information on chemical properties, hazards, uses and exposure, including the additional information submitted under the Challenge. Data relevant to the screening assessment of this substance were identified in original literature, review and assessment documents and stakeholder research reports and from recent literature searches, up to May 2009 for the exposure, human health effects and ecological sections of the document. Key studies were critically evaluated; modelling results may have been used to reach conclusions. Evaluation of risk to human health involves consideration of data relevant to estimation of exposure (non-occupational) of the general population, as well as information on health hazards (based principally on the weight of evidence assessments of other agencies that were used for prioritization of the substance). Decisions for human health are based on the nature of the critical effect and/or margins between conservative effect levels and estimates of exposure, taking into account confidence in the completeness of the identified databases on both exposure and effects, within a screening context. The screening assessment does not represent an exhaustive or critical review of all available data. Rather, it presents a summary of the critical information upon which the conclusion is based.

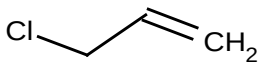
This screening assessment was prepared by staff in the Existing Substances Programs at Health Canada and Environment Canada and incorporates input from other programs within these departments. The ecological and human health portions of this assessment have undergone external written peer review/consultation. Comments on the technical portions relevant to human health were received from scientific experts selected and directed by Toxicology Excellence for Risk Assessment (TERA), including Michael Dourson (TERA), John Christopher (California Department of Toxic Substances Control) and Michael Jayjock (The Lifeline Group). Additionally, the draft of this screening assessment was subject to a 60-day public comment period. Although external comments were taken into consideration, the final content and outcome of the screening risk assessment remain the responsibility of Health Canada and Environment Canada.

The critical information and considerations upon which the assessment is based are summarized below.

Substance Identity

For the purposes of this document, this substance will be referred to as 3-chloropropene, derived from the DSL inventory name 1-propene, 3-chloro-. Its substance identity information is summarized in Table 1.

Table 1. Substance identity for 3-chloropropene

CAS RN	107-05-1
DSL name	1-Propene, 3-chloro-
NCI names	Allyl chloride (PICCS) Allylchloride (PICCS) 3-Chloro-1-propene (ECL) 3-Chloropropene (EINECS) 1-Propene, 3-chloro- (AICS, ASIA-PAC, ENCS, NZloC, PICCS, SWISS, TSCA) Prop-1-ene, 3-chloro- (PICCS)
Other names	1-Chloro-2-propene; 3-Chloropropylene; NSC 20939; Propene, 3-chloro-; 2-Propenyl chloride; UN 1100; UN 1100 (DOT)
Chemical group (DSL stream)	Discrete organics
Major chemical class or use	Chlorinated organics
Major chemical subclass	Haloalkenes
Chemical formula	C_3H_5Cl
Chemical structure	
SMILES	ClCC=C
Molecular mass	76.525 g/mol

Abbreviations: AICS, Australian Inventory of Chemical Substances; ASIA-PAC, Asia-Pacific Substances Lists; CAS RN, Chemical Abstracts Service Registry Number; DSL, Domestic Substances List; ECL, Korean Existing Chemicals List; EINECS, European Inventory of Existing Commercial Chemical Substances; ENCS, Japanese Existing and New Chemical Substances; NCI, National Chemical Inventories; NZloC, New Zealand Inventory of Chemicals; PICCS, Philippine Inventory of Chemicals and Chemical Substances; SWISS, Swiss Giftliste 1 and Inventory of Notified New Substances; SMILES, simplified molecular input line entry specification; TSCA, Toxic Substances Control Act Chemical Substance Inventory.

Source: NCI (2008)

Physical and Chemical Properties

Table 2 contains experimental and modelled physical and chemical properties of 3-chloropropene that are relevant to its environmental fate. 3-Chloropropene is a liquid at ambient temperatures and is characterized as having high water solubility, very high vapour pressure, a high Henry's Law constant and low octanol–water (log K_{ow}) and organic carbon–water (log K_{oc}) partition coefficients.

Table 2. Physical and chemical properties of 3-chloropropene

Property	Type	Value[1]	Temperature (°C)	Reference
Melting point (°C)	Experimental	−134.5		PhysProp 2008
	Modelled	−99.58 (mean value)		MPBPWIN 2000
Boiling point (°C)	Experimental	45.1		PhysProp 2008
	Modelled	61.52 (adapted Stein and Brown method)		MPBPWIN 2000
Density (kg/m^3)	Experimental	938 (liquid) (0.938 g/cm^3)	20	Lide 2007–2008
Vapour pressure (Pa)	Experimental	4.9×10^4 (368 mmHg)	25	Boublik et al. 1984
	Modelled	4.7×10^4 (355 mmHg; mean of Antoine and Grain methods)	25	MPBPWIN 2000
Henry's Law constant (Pa·m^3/mol)	Modelled	3455 (3.41×10^{-2} atm·m^3/mol; bond estimate) 942 (9.30×10^{-3} atm·m^3/mol; group estimate) 1115 (1.10×10^{-2} atm·m^3/mol; VP/WSol estimate)	25	HENRYWIN 2000

Property	Type	Value[1]	Temperature (°C)	Reference
Log K_{ow} (dimensionless)	Experimental	2.1		Bennett and Ridge 1988
	Modelled	1.93	25	KOWWIN 2000
Log K_{oc} (dimensionless)	Modelled	1.64 (corrected value)		PCKOCWIN 2000
Water solubility (mg/L)	Experimental	3370	25	Dilling 1977
	Modelled	2092	25	WSKOWWIN 2000

Abbreviations: K_{oc}, organic carbon–water partition coefficient; K_{ow}, octanol–water partition coefficient; VP, vapour pressure; WSol, water solubility.

[1] The values in parentheses are the values originally reported in the references.

Sources

3-Chloropropene is not a naturally occurring compound. It is produced through hot chlorination of propene (GDCh 1998). Effluents containing 3-chloropropene from anthropogenic sources may be released into the atmosphere and hydrosphere during its production, use and disposal (OECD 1996; HSDB 2008). However, as production and processing of 3-chloropropene occur in captive systems, emissions of 3-chloropropene to the atmosphere and hydrosphere are expected to be minimal (OECD 1996).

Based on a survey conducted under section 71 of CEPA 1999, no companies in Canada reported manufacturing or importing 3-chloropropene in 2006 in a quantity greater than or equal to the reporting threshold of 100 kg (Environment Canada 2008). The quantity reported to be manufactured, imported or in commerce in Canada during the calendar year 1986 was 201 000 kg (Environment Canada 1988).

Uses

According to information submitted under section 71 of CEPA 1999, 3-chloropropene is not used directly by any companies in Canada in quantities above the reporting limit of 1000 kg (Environment Canada 2008). Acrylic polymers synthesized using 3-chloropropene were reported to be imported and used in Canada for the manufacture of personal care products, including showering soaps or gels, hair conditioners, hair dyes, hair styling gels, hair shampoos, facial cleansers, facial makeup, aftershaves, shaving soaps, creams or foams, skin creams and skin peeling or scrubbing preparations.

Based on information identified in the literature, 3-chloropropene is utilized primarily in the production of intermediates such as epichlorohydrin and glycerine for the manufacture of resins and polymers (Kneupper and Saathoff 2000). The main industrial

use of 3-chloropropene was reported to be non-dispersive in closed systems (OECD 1996). 3-Chloropropene is also used in the production of quaternary amines for chelating agents and quaternary ammonium flocculants for raw and potable water purification (Solvay 2008). 3-Chloropropene can also be employed in the manufacture of a variety of miscellaneous products, including various allyl compounds, cross-linking agents, plasticizers, agrochemicals, pharmaceuticals, fragrances and flavour chemicals (IARC 1985; OECD 1996; Kneupper and Saathoff 2000; HSDB 2008; Solvay 2008).

3-Chloropropene is not currently listed on Health Canada's Cosmetic Ingredient Hotlist, which would prohibit its use in cosmetic products (Health Canada 2007). In Canada, it is not listed as a formulant or registered as an active ingredient in pest control products under the Registered Product Database (PMRA 2007, 2008). 3-Chloropropene is not listed in the Drug Product Database, the Nonmedicinal Ingredient Database, the Natural Health Products Ingredients Database or the Licensed Natural Health Products Database (the list of non-medicinal ingredients has now been replaced by the Natural Health Products Ingredients Database) (2009 emails from Therapeutic Products Directorate and Natural Health Products Directorate, Health Canada, to Existing Substances Division, Health Canada; unreferenced). However, acrylic polymers manufactured using 3-chloropropene may be used as a non-medicinal ingredient in pharmaceuticals and natural health products. As a non-medicinal ingredient in pharmaceuticals, acrylic polymers may be used in numerous drug products, including those intended for oral administration, although the majority are drugs for topical application, such as sunscreens, dentifrices, local anaesthetics, antifungals, skin moisturizers, corticosteroid creams, pediculicides, hand sanitizers, ophthalmics, acne products and vaginal, rectal and nasal products, as well as in hard surface disinfectants. These polymers may be present in natural health products, functioning as an adhesive, binder, controlled-release vehicle, emulsifying agent, surfactant or viscosity-increasing agent. As these polymers may be used in pharmaceuticals and natural health products, 3-chloropropene may be present as a residual or impurity in the final products from the manufacturing process (2009 emails from Therapeutic Products Directorate and Natural Health Products Directorate, Health Canada, to Existing Substances Division, Health Canada; unreferenced). In addition, the *Controlled Products Regulations* established under the *Hazardous Products Act* require this substance to be disclosed on the Material Safety Data Sheet that must accompany workplace chemicals when it is present at a concentration of 1% or greater as specified on the Ingredient Disclosure List (Canada 1988).

Releases to the Environment

3-Chloropropene is not a naturally occurring compound. The main sources of potential release of 3-chloropropene will be anthropogenic processes during its production, use and disposal. Due to its reactive nature, any release of unreacted 3-chloropropene residues from consumer products will be low.

In recent information gathered under CEPA 1999 through the section 71 notice with respect to 3-chloropropene, no companies in Canada reported environmental releases of

3-chloropropene in 2006 (Environment Canada 2008). Furthermore, 3-chloropropene was not reported to be imported into Canada in a quantity above the reporting limit of 100 kg, and the National Pollutant Release Inventory (NPRI) has no records of any releases into any environmental medium between 1994 and 2006 (NPRI 2008).

Environmental Fate

Based on its physical and chemical properties (Table 2) and compartments to which it is released, the results of Level III fugacity modelling (Table 3) suggest that 3-chloropropene will reside predominantly in air and/or water, depending on the compartment of release.

Table 3. Results of the Level III fugacity modelling (EQC 2003)

Substance released to:	Fraction of substance partitioning into each medium (%)			
	Air	Water	Soil	Sediment
Air (100%)	100	0	0	0
Water (100%)	4.27	95.4	0	0.32
Soil (100%)	89.8	0	10.2	0

Persistence and Bioaccumulation Potential

Environmental Persistence

Table 4a presents the empirical degradation data for 3-chloropropene. Based on consideration of releases and partitioning behaviour, air and water are the primary media of interest for this substance.

Table 4a. Empirical data for degradation of 3-chloropropene

Medium	Fate process	Degradation value	Degradation endpoint / units	Reference
Air	Photodegradation	Reaction with OH: 1.69×10^{-11}	Rate constant, $cm^3 \cdot molecule^{-1} \cdot s^{-1}$	Winer and Atkinson 1987
		Reaction with OH: 0.97	Half-life, days (based on 12-h daytime)	
		Reaction with NO_3: 6.0×10^{-16}	Rate constant, $cm^3 \cdot molecule^{-1} \cdot s^{-1}$	
		Reaction with NO_3: 111	Half-life, days (based on 12-h nighttime)	
		Reaction with O_3: 1.60×10^{-18}	Rate constant, $cm^3 \cdot molecule^{-1} \cdot s^{-1}$	

Medium	Fate process	Degradation value	Degradation endpoint / units	Reference
		Reaction with O_3: 7	Half-life, days (based on 24-h period)	
		Reaction with OH: 0.5	Half-life, days	OECD 1996; Albaladejo et al. 2003
Water	Hydrolysis	12	Half-life, days	OECD 1996
Water	Biodegradation	62	Ready biodegradation, %	MITI 1992

The calculated half-life for reaction with photochemically produced hydroxyl radicals in air is less than 1 day, indicating that 3-chloropropene will likely be removed rapidly from the atmosphere (OECD 1996). Degradation through reaction with atmospheric ozone and nitrate radicals has also been reported, although at slower rates than that of the hydroxyl reaction (Winer and Atkinson 1987). 3-Chloropropene does not contain chromophores that absorb at wavelengths greater than 290 nm and is therefore not likely to be susceptible to direct photolysis by sunlight (HSDB 2008).

Based on its very high vapour pressure and high Henry's Law constant, 3-chloropropene will volatilize rapidly, and volatilization is therefore expected to be the most significant loss process for the substance in water. Hydrolysis and biodegradation may also occur, but at slower rates. Dilling (1977) measured an average evaporation half-life of 0.02 day (26.6 minutes) from a dilute (approximately 1 mg/L) aqueous solution at 25°C and under still air (<0.3 km/hour) conditions, confirming that rapid volatilization of the substance occurs at the water surface. However, 3-chloropropene present in the environment following release into water is still expected to reside predominantly within the water compartment (see Table 3), due to rapid degradation of the substance entering air through volatilization. A hydrolysis half-life of about 12 days has been reported for 3-chloropropene at 20°C and pH 8 (OECD 1996).

MITI (1992) reported 62% biodegradation of 3-chloropropene over 28 days in ready biodegradation testing, indicating that the substance is "readily biodegradable" and that the ultimate biodegradation half-life for the substance in water is likely to be days to weeks—much less than 182 days and likely less than 90 days.

Volatilization is likely to be the dominant loss process for 3-chloropropene in soil, particularly close to the surface. Based on its low log K_{oc}, 3-chloropropene will not adsorb appreciably to organic materials, and it is therefore expected to be mobile in soil. 3-Chloropropene may leach downward in soil, possibly contacting groundwater, or it may diffuse upward to the surface, where volatilization will occur. Biodegradation may also be a significant removal process for 3-chloropropene in soil.

In addition to the experimental data on the degradation of 3-chloropropene presented above, quantitative structure–activity relationships (QSARs) were also applied (Environment Canada 2007) using the degradation models shown in Table 4b.

Table 4b. Modelled data for degradation of 3-chloropropene

Fate process	Model and model basis	Model output	Expected half-life (days)
Air			
Atmospheric oxidation	AOPWIN 2000	$t_{½}$ = 0.53 day	<2
Ozone reaction	AOPWIN 2000	$t_{½}$ = 7.28 days	>2
Water			
Hydrolysis	HYDROWIN 2000	n/a[1]	n/a
Biodegradation (aerobic)	BIOWIN 2000 Submodel 3: Expert Survey (ultimate biodegradation)	2.9	<<182[2]
Biodegradation (aerobic)	BIOWIN 2000 Submodel 4: Expert Survey (primary biodegradation)	3.6	<<182
Biodegradation (aerobic)	BIOWIN 2000 Submodel 5: MITI linear probability	0.55	<<182
Biodegradation (aerobic)	BIOWIN 2000 Submodel 6: MITI non-linear probability	0.55	<<182
Biodegradation (aerobic)	TOPKAT 2004 Probability	0.33	>182[2]
Biodegradation (aerobic)	Mekenyan et al. 2005; CPOPs 2008 % BOD	93.5	<<182[2]

Abbreviations: BOD, biological oxygen demand; MITI, Ministry of International Trade & Industry, Japan; n/a, not applicable; $t_{½}$, half-life.

[1] Model does not provide an estimate for this type of structure.

[2] Expected half-lives for BIOWIN, TOPKAT and CPOPs models are determined based on EPIsuite (2008).

The model-estimated atmospheric oxidation half-life of 0.53 day (see Table 4b) is consistent with the empirical hydroxyl radical half-life value, indicating that this substance will degrade rapidly in air. A slower degradation reaction with ozone is also predicted to occur. With empirical and modelled atmospheric oxidation half-life values of less than 2 days, 3-chloropropene is considered to be not persistent in air.

The weight of empirical and modelled evidence indicates that 3-chloropropene is susceptible to rapid microbial degradation and has a biodegradation half-life of <<182 days (i.e., days to weeks) in water; therefore, the substance is considered to be not persistent in water.

Using an extrapolation ratio of 1:1:4 for a water:soil:sediment biodegradation half-life (Boethling et al. 1995), the half-life in soil is also <<182 days, and the half-life in sediments is <365 days. This indicates that 3-chloropropene is not expected to be persistent in soil or sediment.

Based on empirical and modelled data (see Tables 4a and 4b), 3-chloropropene does not meet the persistence criteria for air, water, soil or sediment (half-life in air ≥2 days, half-lives in soil and water ≥182 days and half-life in sediment ≥365 days) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential for Bioaccumulation

Experimental and modelled log K_{ow} values for 3-chloropropene suggest that this chemical has low potential to bioaccumulate in biota (see Table 2 above).

Table 5a presents the empirical bioconcentration factor (BCF) values in fish.

Table 5a. Empirical data for bioaccumulation of 3-chloropropene

Test organism	Endpoint	Value (L/kg wet weight)[1]	Reference
Fish	BCF	<0.14–0.88 (0.5 mg/L) <1.3–5.6 (0.05 mg/L)	MITI 1992

[1] Values in parentheses represent the test concentrations at which the BCFs were derived.

As only a few experimental BCF data for 3-chloropropene were available, a predictive approach was applied using available bioaccumulation factor (BAF) and BCF models, as shown in Table 5b.

Table 5b. Modelled data for bioaccumulation of 3-chloropropene

Test organism	Endpoint	Value (L/kg wet weight)	Reference
Fish	BAF	6.76	Arnot and Gobas 2003 (Gobas BAF Middle Trophic Level)
Fish	BCF	6.76	Arnot and Gobas 2003 (Gobas BCF Middle Trophic Level)
		39.8	Dimitrov et al. 2005; CPOPs 2008
		8.26	BCFWIN 2000

Based on the available empirical and modelled data, 3-chloropropene does not meet the bioaccumulation criteria (BAF or BCF ≥5000) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential to Cause Ecological Harm

There is experimental and modelled evidence that 3-chloropropene may cause harm to some aquatic organisms at relatively low concentrations (see Tables 6a and 6b).

Table 6a. Empirical data for aquatic toxicity of 3-chloropropene

Test organism	Type of test	Endpoint	Value (mg/L)[1]	References
Fish	Acute (24–96 h)	LC_{50}	6.9–70 (15)	OECD 1996; HSDB 2008
	Chronic (336 h)	LC_{50}	1.2	Hermens et al. 1985
Daphnia	Acute (24 h)	EC_{50}	250	Bringmann and Kühn 1977
Alga	Chronic (192 h)	NOEC	6.3–8.2 (2)	Bringmann 1975; Bringmann and Kühn 1978
Frog	Acute (48 h)	LC_{50}	0.34[2]	de Zwart and Slooff 1987

Abbreviations: EC_{50}, the concentration of a substance that is estimated to cause some toxic sublethal effect to 50% of the test organisms; LC_{50}, the concentration of a substance that is estimated to be lethal to 50% of the test organisms; NOEC, no-observed-effect concentration, the highest concentration in a toxicity test not causing a statistically significant effect in comparison with the controls.

[1] Numbers in parentheses represent the number of study endpoint values included in the range.

[2] Categorization pivotal iT value.

Acute toxicity values for fish range from 6.9 to 70 mg/L, indicating that 3-chloropropene is moderately toxic to fish. Although only limited data are available for other aquatic species, 3-chloropropene has demonstrated moderate toxicity to algae (chronic no-effect values of 6.3 and 8.2 mg/L) and low toxicity to daphnids (24-hour EC_{50} of 250 mg/L). However, de Zwart and Slooff (1987) reported a 48-hour LC_{50} of 0.34 mg/L for the clawed toad, *Xenopus laevis*, indicating that 3-chloropropene is highly toxic to this amphibian.

A range of aquatic toxicity predictions were also obtained from the various QSAR models considered (Table 6b). In general, the modelled data predict similar or greater toxicity to fish and *Daphnia* when compared with empirical values.

Table 6b. Modelled data for aquatic toxicity of 3-chloropropene

Test organism	Type of test	Endpoint	Value (mg/L)	References
Fish	Acute (96 h)	LC_{50}	272	TOPKAT 2004
			1.8	Dimitrov et al. 2005; CPOPs 2008
			13.5	AIES 2003–2005
			9.8, 13.5	ECOSAR 2008
Daphnia	Acute (48 h)	LC_{50}	45	ECOSAR 2008
			0.8	TOPKAT 2004

Abbreviation: LC_{50}, the concentration of a substance that is estimated to be lethal to 50% of the test organisms.

Considering both the empirical and modelled data, but giving greater weight to measured values, it is considered that 3-chloropropene has the potential to harm aquatic organisms at low exposure concentrations (i.e., acute LC_{50} values may be less than 1.0 mg/L). Applying an assessment factor of 100 to the lowest empirical effect value of 0.34 mg/L in order to account for inter- and intraspecies variations in sensitivity and to extrapolate from a laboratory-based acute endpoint to a chronic effect value in the field results in a conservative predicted no-effect concentration (PNEC) of 0.0034 mg/L.

No recent Canadian monitoring data were found for 3-chloropropene. 3-Chloropropene was not detected (detection limit 0.0001 mg/L) in 42 raw water samples collected from the Great Lakes in 1987 (Otson 1987), nor was it found in effluents and sludge sampled in 1987 from 37 municipal wastewater treatment plants throughout Ontario (detection limit 0.02–0.04 mg/L; OMOE 1988).

Considering this effect and exposure information, the reported use as a manufacturing intermediate and the low quantity in Canadian commerce, based on section 71 reporting information (see Sources and Uses sections above), it may be concluded that there is a low likelihood of release into the Canadian environment in amounts that could result in significant exposure of organisms. Based primarily on the available evidence for low exposure potential, it is considered that 3-chloropropene is unlikely to be causing ecological harm in Canada.

Some uncertainties were identified in the characterization of potential ecological risk. There are uncertainties associated with the use of QSAR models to estimate the properties of persistence, bioaccumulation and toxicity; however, overall, the model-predicted values are comparable with empirical data and so provide additional support for the conclusions. Additional and more recent Canadian environmental monitoring data would be useful in providing a more definitive measure of the exposure potential; however, given the evidence for low import and use quantities in Canada, it is unlikely that these data would have indicated higher exposures than indicated by the older monitoring data.

Potential to Cause Harm to Human Health in Canada

Exposure Assessment

No data were identified on levels of 3-chloropropene in ambient air in Canada. In studies conducted in seven cities of the United States between 1980 and 1981, 3-chloropropene was not detected (detection limit 16 ng/m^3) in air samples collected from Denver, Houston, Riverside and St. Louis. A maximum 3-chloropropene concentration of 64 ng/m^3 was, however, identified in air samples obtained from Pittsburgh (Singh et al. 1982). Concentrations of 3-chloropropene in air were measured in Allen County, Ohio, from 1990 to 1991. The average concentration was reported to be 0.16 µg/m^3 in the city of Lima, with a maximum concentration of 0.32 µg/m^3 (Kelly et al. 1991). In an ambient air monitoring study of 32 US locations sampled from 1988 to 1998, the average 3-

chloropropene concentration was 0.266 µg/m^3 (range <0.156–2.57 µg/m^3) (Rosenbaum et al. 1999). Recent ambient air monitoring data retrieved from the US Environmental Protection Agency (EPA) Air Quality System indicated non-detectable (detection limit 0.0033–0.2 parts per billion [ppb] [0.010—0.63 µg/m^3]) to low levels of 3-chloropropene in a variety of US cities and states between 2003 and 2008, with a maximum of 1.6 ppb (5.01 µg/m^3) reported in Oxford County, Maine, in 2003 (US EPA 2009). Although the Canadian NPRI has no records of any releases of 3-chloropropene into any environmental medium between 1994 and 2006, data from the US Toxics Release Inventory (TRI) demonstrated a 4-fold decrease (from 67.75 to 15.96 tonnes) in 3-chloropropene releases between 1988 and 2007 in the United States (TRI 2009). It is important to note that the concentration reported in Oxford County was from two annual observations (1 and 1.6 ppb [3.1 and 5.0 µg/m^3]) in a rural parking lot in Rumford where the land was allocated for industrial use. All other ambient air monitoring data (between 2003 and 2008) retrieved from the US EPA Air Quality System indicated 3-chloropropene concentrations to be below 0.2 ppb (0.63 µg/m^3). Hence, a maximum ambient air concentration of 2.57 µg/m^3 was used to estimate exposure to the substance in air.

No data were identified on levels of 3-chloropropene in indoor air in Canada. However, two studies were identified in the United States. A 1990 study of 125 homes located in Woodland, California, revealed no detectable (detection limit of 0.6 µg/m^3) levels of 3-chloropropene (CARB 1997). A 2000 study of five homes in Olathe, Kansas, located near an industrial site possibly acting as a point source of 3-chloropropene emissions, revealed no detectable (detection limit not provided) levels of 3-chloropropene (ATSDR 2001).

The US EPA STORET database reported 3-chloropropene in whole water samples up to a maximum concentration of 0.50 µg/L (US EPA 1986). No information was identified in the literature regarding the concentrations of 3-chloropropene in foodstuffs or soil.

Upper-bounding estimates of 3-chloropropene intake for each age group in the general population of Canada from environmental media are presented in Appendix 1. These upper-bounding estimates of intake range from 0.52 µg/kg body weight (kg-bw) per day (60+ years) to 1.56 µg/kg-bw per day (0.5–4 years). Based on these estimates, air is the most important source of environmental exposure to 3-chloropropene for all age groups of the general population of Canada, typically comprising approximately 99% of the total exposure. Due to its physical and chemical properties, use patterns and reactive nature, contributions to exposure to 3-chloropropene from food, drinking water and soil are expected to be negligible in comparison with those from air.

Acrylic polymers that are synthesized using 3-chloropropene are imported into Canada. These polymers are used by companies in Canada for the manufacture of personal care products. According to the Ingredient Disclosure List (Canada 1988), a maximum 3-chloropropene residue concentration of 1% is permitted in the acrylic polymers without requirement to disclose. Information on personal care product formulations (2009 email from Cosmetics Division, Health Canada, to Existing Substances Division, Health Canada; unreferenced) indicates that acrylic polymers are used in these products at a maximum level of about 1%. Hence, as an absolute worst case, it is assumed that

personal care products that are manufactured using these acrylic polymers could contain up to approximately 0.01% residual 3-chloropropene (i.e., 1% 3-chloropropene residue in polymer × 1% polymer in product). Personal care product categories that potentially contain residual concentrations of 3-chloropropene include showering soap or gel, hair conditioners, hair dyes, hair styling gels, hair shampoos, facial cleansers, facial makeup, aftershaves, shaving soaps, creams or foams, skin creams and skin peeling or scrubbing preparations. A summary of worst-case estimates of inhalation and dermal exposure predicted using ConsExpo software (ConsExpo 2006) for users of these personal care products is presented in Appendix 2. For personal care products that are used frequently, such as shampoo, worst-case estimates of inhalation exposure to 3-chloropropene during use of the products are modelled to be up to 0.2 mg/m^3. For personal care products that are used less frequently, such as hair dye preparations, worst-case estimates of inhalation exposure to 3-chloropropene are up to approximately 0.9 mg/m^3. Worst-case estimates of average daily dermal exposure to 3-chloropropene, assuming 100% dermal absorption, could range up to around 0.02 mg/kg-bw per day (for body lotion). However, in light of the very high vapour pressure and reactivity of 3-chloropropene, it is very unlikely that the products actually used by the end consumer contain the substance in detectable quantities, as any residual amounts of the substance in the polymers used to manufacture the product would likely have reacted or volatilized during processing and packaging. Likewise, as a result of it physical andchemical properties, dermal absorption of 3-chloropropene is likely to be very low, and it is unlikely that inhalation exposures during use of personal care products potentially containing residuals would be sustained for more than the few minutes during which the product is actually applied. Therefore, actual exposure of the general population in Canada to 3-chloropropene from personal care products is likely to be several orders of magnitude lower than the values presented in Appendix 2. Indeed, the results of the indoor air survey of homes in California in which the substance was not detected (i.e., <0.6 $\mu g/m^3$) (ARB 1997) suggest that consumer exposure is more likely to be much less than 1 $\mu g/m^3$.

Confidence in the upper-bounding estimates of 3-chloropropene intake is considered to be low, as only limited information regarding environmental exposures to 3-chloropropene was available. Measured data that were identified for the relevant media are older and not from Canada. Furthermore, information regarding sample size, detection limit and analytical methods was not provided for some of the monitoring studies. Although ambient air concentrations were based on North American studies, indoor air concentrations were not detected in the homes sampled in North America. Therefore, the maximum ambient air concentration reported was used as a surrogate for indoor air concentrations of 3-chloropropene. There is also low confidence in the modelled estimates of exposure from personal care products. However, as these estimates are conservative, confidence is high that actual exposure levels do not exceed these levels.

Health Effects Assessment

An overview of the toxicological database for 3-chloropropene is presented in Appendix 3.

On the basis of investigations in experimental animals, 3-chloropropene has been classified by the US EPA as Group C ("possible human carcinogen") (US EPA 1994). The European Commission has classified 3-chloropropene as a Category 3 carcinogen ("limited evidence of a carcinogenic effect") (ESIS 2008), whereas the International Agency for Research on Cancer (IARC) has classified 3-chloropropene as Group 3 ("not classifiable as to its carcinogenicity in humans") on the basis of "inadequate evidence for the carcinogenicity of 3-chloropropene in experimental animals" and "inadequate evidence in humans" (IARC 1999). The available studies for 3-chloropropene that have been considered in this assessment are summarized below and are presented in more detail in Appendix 3.

3-Chloropropene has induced tumours in the forestomach or lungs in mice exposed via oral gavage or intraperitoneal injection, respectively. In addition, 3-chloropropene has been reported to be a skin tumour initiator in the mouse skin painting model, although it did not produce tumours when applied in the absence of a promoter. No tumour induction was observed in rats exposed orally, and no inhalation carcinogenicity bioassays have been identified. Male and female B6C3F1 mice were administered 3-chloropropene by gavage at 172 and 199 mg/kg-bw per day (male) or 129 and 258 mg/kg-bw per day (female) for up to 78 weeks (National Cancer Institute 1978). Poor survival rates were reported in the exposed mice. Increases in the incidence of squamous cell carcinomas and papillomas of the forestomach were reported to be statistically significant (females: 0/39 controls, 3/47 low dose, 3/45 high dose; males: 0/29 controls, 2/36 low dose, 0/10 high dose). However, IARC (1985) reported that the incidence of forestomach tumours in male and female mice was not statistically different from that in controls. In the same study, male and female Osborne-Mendel rats were administered 3-chloropropene by gavage at time-weighted average doses of 57 and 77 mg/kg-bw per day (male) or 55 and 73 mg/kg-bw per day (female) for 78 weeks (National Cancer Institute 1978). There were no statistically significant increases in tumour incidences in the exposed rats; however, survival was poor (i.e., no animals administered the higher dose survived to the end of the study). Although the National Toxicology Program considered that the studies were suggestive of carcinogenicity in mice, they considered the level of evidence to be "equivocal" in mice and "negative" in rats (NTP 2006).

Van Duuren et al. (1979) examined the carcinogenic potential of 3-chloropropene in female Ha:ICR Swiss mice exposed via dermal application. In an initiation–promotion study, animals were exposed once with 94 mg 3-chloropropene on the shaved back, followed 14 days later by doses of 0.005 mg of the promoter phorbolmyristylacetate every third day for approximately 500 days. The incidence of skin papillomas in the exposed mice was significantly increased. However, in female Ha:ICR Swiss mice exposed to 3-chloropropene at 31 or 94 mg per animal on the shaved back for 63–85 weeks, no skin tumours were observed, and the number of benign lung and forestomach papillomas identified did not significantly differ from that of the control group (Van Duuren et al. 1979). Thus, while 3-chloropropene exhibited tumour-initiating potential, it did not induce tumours in the absence of a promoting agent.

Intraperitoneal exposures of 3-chloropropene in male and female A/St mice at 50, 122 and 245 mg/kg-bw 3 times per week for 8 weeks resulted in a significant, but not dose-dependent, increase in the average number of lung adenomas per mouse at the highest dose relative to the vehicle controls (average numbers of lung adenomas per mouse were reported to be 0.19, 0.60, 0.50 and 0.60 in the vehicle control, low-, medium- and high-dose groups, respectively) (Theiss et al. 1979).

3-Chloropropene has also been consistently demonstrated to be genotoxic in multiple *in vitro* assays but not in the limited number of *in vivo* assays identified. 3-Chloropropene has been classified by the European Commission as a Mutagen Category 3 (causes concern for humans owing to possible mutagenic effects) (ESIS 2008). The US EPA also concluded that 3-chloropropene "is an alkylating agent and structurally related to probable human carcinogens" (US EPA 1994).

3-Chloropropene was clastogenic *in vitro* in mammalian cell lines (JETOC 1997). 3-Chloropropene also caused deoxyribonucleic acid (DNA) damage in human cell lines and microorganisms (DNA modification, elevated incorporation of [^{3}H]thymidine into the DNA) (McCoy et al. 1978; Schiffmann et al. 1983). Covalent binding of 3-chloropropene to DNA (3-allyladenine, N^6-allyladenine, N^2-allylguanine, 7-allylguanine and O^6-allylguanine) has also been demonstrated *in vitro* (Eder et al. 1987). In addition, 3-chloropropene consistently tested positive in a range of assays for mutagenicity in several strains of fungi and bacteria (McCoy et al. 1978; Bignami et al. 1980; Eder et al. 1980; Crebelli et al. 1984; Dean et al. 1985; Neudecker and Henschler 1985). In *in vivo* investigations, 3-chloropropene did not induce chromosomal aberrations in rats, nor was it genotoxic in germ cells of rats or *Drosophila* (McGregor 1981). However, 3-chloropropene was shown to be a direct alkylating agent *in vivo* (approximated via liver perfusion) by measurement of DNA adducts (3-allyladenine, 7-allyladenine, N^2-allylguanine and O^6-allylguanine) in rat livers (Eder and Zegelder 1990). In the only relevant epidemiological study identified, although equivocal increases in the frequencies of chromosome gaps, breaks and total aberrations were observed in workers exposed to 3-chloropropene, along with epichlorohydrin, the authors did not consider these increases to be of biological significance (de Jong et al. 1988).

Information on the potential carcinogenicity of 3-chloropropene in humans is limited to one retrospective cohort study of workers at a chemical facility in Texas who were employed between 1957 and 1986 (Olsen et al. 1994). Workers in this study were also exposed to epichlorohydrin, a documented carcinogen. There was no apparent increased risk of death due to cancer in this cohort relative to mortality rates either for the US national population or for an internal group of non-exposed workers from other facilities. Nor was there an association between 3-chloropropene exposure and mortality due to specific forms of cancer. However, the study was limited by the small number of total deaths due to cancer and a possibly insufficient follow-up period.

Although a thorough analysis of the potential mode of action for induction of tumours by 3-chloropropene is beyond the scope of this screening assessment, the US EPA and IARC have stated that 3-chloropropene is an alkylating agent and has the potential to react with

macromolecules such as nucleic acids (US EPA 1994; IARC 1999). However, it is noteworthy that exposure-related acanthosis and hyperkeratosis of the forestomach and irritation of the respiratory tract have been reported in 3-chloropropene-exposed animals (US EPA 1994; IARC 1999) and that the slight increase in tumours observed in mice following gavage administration was induced under chronic irritation conditions of the forestomach.

In humans and experimental animals, exposure to 3-chloropropene has also been associated with a variety of non-cancer effects, including neurological, developmental and reproductive effects, as well as effects in the liver and kidneys. Short-term 3-chloropropene exposures in humans and experimental animals have also resulted in irritation of the skin, eyes and respiratory tract.

Adverse effects in the central (CNS) or peripheral nervous system (PNS) have been observed in rats, mice and rabbits following oral and inhalation exposures to 3-chloropropene. The lowest reported lowest-observed-effect concentration (LOEC) for inhalation, the most relevant route of exposure, was 0.3 part per million (ppm) (1.1 mg/m^3). At this concentration, reversible decreases in CNS activity were observed in rats following 4 months of inhalation exposure (Guseinov 1983), although only limited information was available in the secondary account of this study. Behavioural and histopathological effects in the PNS have also been reported in other animal studies at higher exposure levels (e.g., at repeated gavage doses of 300 mg/kg-bw [He et al. 1985] and at airborne concentrations of 156 mg/m^3 [Nagano et al. 1991]; see Appendix 2).

Evidence of reproductive effects of 3-chloropropene has been demonstrated in mice and rats following inhalation or parenteral exposures. The lowest LOEC was 1.1 mg/m^3, which was associated with a decrease in sperm motility time and the average number of normal spermatogonia in rats exposed via inhalation for 4 months (Guseinov 1982). Reduced testicular weights and reduced spermatogenic index were observed at higher exposure levels (Guseinov 1982; Zhao et al. 1998). Developmental effects have also been reported in rats following inhalation and parenteral exposures. The lowest LOEC was 3.1 mg/m^3, for reductions in the number of live embryos per litter and significant increases in pre-implantation loss and resorption sites (Alizadeh et al. 1982). At higher exposure levels, delay in skeletal development and significant incidence of fetuses with oedema and short snout (with protruding tongue) have been reported (Hardin et al. 1981; John et al. 1983).

Significant effects in the liver or kidneys of mice, rats and rabbits were observed following 3-chloropropene exposures via inhalation, with the lowest reported LOEC being 3.1 mg/m^3. At this concentration, changes in both liver and kidney functions were reported in rats exposed for 4 months (Guseinov 1983). At higher exposure levels, significant histopathological changes in renal and hepatic tissues have been characterized (Torkelson et al. 1959; Hardin et al. 1981; He et al. 1981; Lu et al. 1982; Quast et al. 1982a, b; John et al. 1983).

In the limited oral repeated-dose studies identified in the literature, the lowest lowest-observed-effect level (LOEL) in a study for which sufficient information was available to characterize effects was 73 mg/kg-bw per day, which was associated with an exposure-related decrease in body weight in the long-term study in rats (National Cancer Institute 1978). At higher doses, behavioural and histopathological effects in the PNS and histopathological effects in the kidneys have also been reported (He et al. 1981, 1985).

Neurological effects have been observed in multiple studies in workers exposed to 3-chloropropene. A range of CNS effects was noted in employees occupationally exposed to concentrations ranging from 6.4 to 140 mg/m^3 for more than 1 year (Kasimova 1978). In two studies of exposed workers, polyneuropathy, characterized by electromyography abnormalities and reduced motor nerve conduction velocity, was observed (He et al. 1980, 1985). In the latter study, neurological effects were described in workers at two plants, with the frequency and severity of effects reported to be greater in workers at the plant with higher 3-chloropropene exposure (range 2.6–6650 mg/m^3; average 138 mg/m^3) than in those at the plant with lower concentrations (range 0.2–25.13 mg/m^3).

Reversible liver damage was observed in workers exposed to up to 113 ppm (414 mg/m^3) (Häusler and Lenich 1968), but not in those exposed to lower levels of 3-chloropropene (i.e., up to 2.89 mg/m^3) (Boogaard et al. 1993). Evidence of kidney damage was also reported in workers occupationally exposed to 3-chloropropene (Venable et al. 1980). These observed effects in humans are consistent with observations in experimental animals that indicate the potential of 3-chloropropene to induce neurological effects as well as, possibly, organ toxicity in the liver and kidneys, although data to confidently quantify effect levels are limited.

Irritation of the skin, eyes and respiratory tract has been reported in both experimental animals and humans exposed to 3-chloropropene. Eye and respiratory tract irritation was reported in human volunteers exposed to 3-chloropropene concentrations between 25 and 100 ppm (79 and 315 mg/m^3) (Shell 1958), whereas 75 mg/m^3 has been reported as the threshold value for irritation of the respiratory mucosa (Ruth 1986). Symptoms of eye and respiratory irritation have also been reported in several cases of incidental exposures to 3-chloropropene in the workplace (He et al. 1980; He and Zhang 1985). Signs of eye, nose and mouth irritation were also observed in rats, mice and guinea pigs exposed to lethal concentrations of 3-chloropropene (Adams et al. 1940; Lu et al. 1982; Nielson and Bakbo 1985).

The confidence in the toxicity database in experimental animals is considered to be moderate, as data were identified for acute, repeated-dose, reproductive and developmental toxicity, carcinogenicity and genotoxicity. However, the level of detail reported in some of the repeated-dose studies is limited, and there was high mortality in the critical cancer bioassay. In addition, data on non-cancer effects associated with oral or dermal exposure are more limited. As well, although several epidemiological studies were identified, available data for quantification of effect levels are limited.

Characterization of Risk to Human Health

As 3-chloropropene was classified on the basis of carcinogenicity by other national and international agencies (i.e., European Commission and US EPA), carcinogenicity was a key focus for this screening assessment. Small increases in the incidence of forestomach tumours and lung tumours were observed in mice exposed orally and by intraperitoneal injection, respectively. No increases in incidences of tumours were observed in rats exposed via oral gavage or in mice exposed dermally to 3-chloropropene in the absence of a promoter; however, 3-chloropropene has been reported to be a skin tumour initiator in the mouse skin painting model. The results of a limited retrospective cohort study did not provide evidence of carcinogenicity in humans. Although 3-chloropropene is an alkylating agent and was genotoxic in a range of *in vitro* assays, it was not demonstrated to be genotoxic in the limited number of *in vivo* studies identified. While the mode of induction of the tumours observed in mice has not been developed and elucidated, the evidence for carcinogenicity is considered to be weak, as recognized in the classifications by other regulatory agencies. Therefore, characterization of risk to human health is based on information on non-cancer effects.

Exposure to 3-chloropropene has been associated with a range of non-cancer effects in humans and experimental animals. A variety of neurological effects has been observed in workers occupationally exposed to relatively low concentrations of 3-chloropropene (e.g., in plants where levels were measured to be up to 25.13 mg/m^3). In a subchronic inhalation study in experimental animals, neurological effects, along with effects on male reproductive parameters, were observed in rodents exposed via inhalation to 1.1 mg/m^3, and developmental toxicity and effects on the liver and kidneys were observed in rats exposed to a slightly higher concentration (3.1 mg/m^3). Although there are limitations in terms of level of detail presented in available accounts of these studies or the study protocols that limit confidence in selection of critical effect levels, it is noteworthy that very similar effects have been reported in other studies at higher concentrations (e.g., neurological effects in rats at 156 mg/m^3). Eye irritation and respiratory tract irritation in humans have also been reported to occur at airborne concentrations as low as 75 mg/m^3.

The principal route of exposure to 3-chloropropene is expected to be inhalation in air and inhalation and dermal contact during the use of personal care products containing the substance. The maximum concentration measured in ambient air samples from 32 US locations monitored from 1988 to 1998 was 2.57 µg/m^3 (Rosenbaum et al. 1999). Comparison of the range of lowest effect levels for non-cancer effects in experimental animals (i.e., 1.1–156 mg/m^3) with this maximum concentration detected in air results in margins ranging from about 430 to 61 000. (There is less confidence in the lower end of this range due to limitations in the reported LOECs for the studies used to derive the lower margin of exposure value.) Similarly, a comparison of concentrations associated with neurological effects in exposed human workers (i.e., 25.13 mg/m^3) with this concentration detected in air results in a margin of approximately 10 000.

There is also potential for exposure to 3-chloropropene as a result of its possible presence as a residual in polymers used to manufacture personal care products, at an absolute worst-case concentration of 0.01%. Although, based on this maximum value, worst-case

modelled estimates of brief inhalation exposures during the application of personal care products used regularly ranged as high as 0.2 mg/m^3, in light of the very high vapour pressure of 3-chloropropene and its reactive nature, it is probable that actual concentrations of the substance in products used by end consumers are much lower, and, hence, population exposures are likely orders of magnitude less than these estimates. In addition, due to 3-chloropropene's high volatility and short half-life in air, inhalation exposure during application of personal care products potentially containing residual 3-chloropropene would be of very short duration, and concentrations within the home in which the products are used are generally not likely to be significant. Indeed, 3-chloropropene was not detected in two surveys of indoor air in homes in the United States (ARB 1997; ATSDR 2001) (with a detection limit of 0.6 µg/m^3 in one study); therefore, it is likely that exposures from products would generally be lower than 1 µg/m^3. Thus, margins between potential inhalation exposures to 3-chloroproprene and concentrations associated with effects in experimental animals and in humans are likely to be in the range of three orders of magnitude or more (i.e., greater than 1000).

Likewise, although worst-case modelled estimates of dermal exposure to 3-chloropropene from regularly used products potentially containing residual amounts ranged up to approximately 0.02 mg/kg-bw per day, these values were based on the assumption of 100% absorption. However, due to its high vapour pressure and low log K_{ow}, the substance is not expected to be absorbed to any significant degree. As a very conservative approach to assessment of risk to health associated with potential dermal exposure to 3-chloropropene from products, comparison of this worst-case estimate with the oral LOEL of 73 mg/kg-bw per day for exposure-related body weight decreases in a 78-week study in rats (in light of the absence of data to characterize dose–response for the substance administered via dermal application) results in a margin of exposure of about 3200.

With respect to potential exposure of young children to possible residual 3-chloropropene in personal care products, while dermal exposure might be similar to or slightly higher than that of adults, exposure via inhalation (the predominant route of exposure to this volatile substance) would be lower, due to the smaller quantities of such products used by younger age groups.

In light of the lower confidence in the reliability of the studies in regards to the lower end of the range of effect levels used to derive the margins of exposure and the conservative nature of the estimates of exposure, the margins between exposure to 3-chloropropene in the general environment and from use of personal care products and levels reported to be associated with non-cancer health effects are considered to be adequately protective.

However, additional information on concentrations in consumer products accessible in Canada would permit better characterization of risk of potential adverse health effects associated with use of products containing 3-chloropropene.

Uncertainties in Evaluation of Risk to Human Health

The scope of this screening assessment does not take into account possible differences in effects induced by 3-chloropropene in humans and experimental species, although it is noteworthy that similar effects have been observed in humans and laboratory animals. In addition, the available oral carcinogenicity studies are limited by high mortality, and no carcinogenicity bioassay in which animals were exposed via inhalation, a major route of exposure for humans, is available. Although the mechanism of induction for the slight increases in tumours observed has not been fully elucidated, the available data suggest that the alkylation potential of 3-chloropropene could play a role, although its potential to induce irritation could also be involved for some tumour types. There were also significant limitations to several of the studies used to characterize non-carcinogenic effects in experimental animals, although the observed effects at low concentrations reported in some studies have also been observed at higher concentrations in more robust studies in experimental animals and in some investigations in humans. No adequate dermal studies were identified in the literature to permit characterization of dose–response for dermal exposure, a potential route of exposure during use of some personal care products that might contain residual 3-chloropropene.

Furthermore, only limited data were available to estimate exposure to 3-chloropropene in the general environment. In addition, there is also significant uncertainty concerning levels of residual 3-chloropropene in products used in Canada that could result in exposure of the general population. However, based on the available information on its uses and properties, it is likely that population exposure to 3-chloropropene is very low.

Conclusion

Based on the information presented in this screening assessment, it is concluded that 3-chloropropene is not entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity or that constitute or may constitute a danger to the environment on which life depends.

Based on the available information on the potential to cause harm to human health and the resulting margins of exposure for neurological and other effects, it is concluded that 3-chloropropene is a substance that is not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

It is therefore concluded that 3-chloropropene does not meet the definition of “toxic” as set out in section 64 of CEPA 1999. Additionally, 3-chloropropene does not meet the criteria for persistence or bioaccumulation potential as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

References

Adams EM, Spencer HC, Irish DD. 1940. The acute vapour toxicity of allyl chloride. J Ind Hyg Toxicol 22: 79–86. [cited in OECD 1996].

[AIES] Artificial Intelligence Expert System. 2003–2005. Version 1.25. Ottawa (ON): Environment Canada. Model developed by Stephen Niculescu. Available from: Environment Canada, Existing Substances Division, New Substances Division.

Albaladejo J, Ballesteros B, Jiménez E, Díaz de Mera Y, Martínez E. 2003. Gas-phase OH radical-initiated oxidation of the 3-halopropenes studied by PLP-LIF in the temperature range 228–388 K. Atmos Environ 37: 2919–2926.

Alizade GA. 1979. [Renal function in workers exposed to some chemical substances (allyl chloride and metallic mercury).] Gig Tr Prof Zabol 10: 22–25. [in Russian]. [cited in OECD 1996].

Alizadeh SM, Guseinov FG, Denisko LI. 1982. [Experimental study of embryotrophic influence of chlorous allyl.] Azerb Med Zh 59: 66–70. [in Russian]. [cited in OECD 1996].

Al'meev KS, Karmazin VE. 1969. Pathomorphological changes in the organs of animals under the impact of allyl alcohol and allyl chloride. Faktory Vnesh Sredy Ikh Snach Sdorov'ya Naseleniya 1: 31–35. [cited in OECD 1996].

[AOPWIN] Atmospheric Oxidation Program for Windows [Estimation Model]. 2000. Version 1.91. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. [cited 2008 Oct 21]. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Arnot JA, Gobas FAPC. 2003. A generic QSAR for assessing the bioaccumulation potential of organic chemicals in aquatic food webs. QSAR Comb Sci [Internet] 22(3): 337–345. Available from: http://www3.interscience.wiley.com/journal/104557877/home [restricted access]

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001. Health consultation. Chemical Commodities, Incorporated site, Olathe, Johnson County, Kansas. Atlanta (GA): ATSDR. Available from: http://www.atsdr.cdc.gov/hac/pha/chemcom1/cci_toc.html

[BCFWIN] BioConcentration Factor Program for Windows [Estimation Model]. 2000. Version 2.15. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. [cited 2008 Oct 21]. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Bennett D, Ridge MA. 1988. Allyl chloride: determination of the *n*-octanol/water partition coefficient using a reverse-phase HPLC method. SGBR 88.009, January. Chester (GB): Shell Research Ltd. [cited in ECB 2000].

Bignami M, Conti G, Conti L, Crebelli R, Misuraca F, Puglia AM, Randazzo R, Sciandrello G, Carere A. 1980. Mutagenicity of halogenated aliphatic hydrocarbons in *Salmonella typhimurium*, *Streptomyces coelicolor* and *Aspergillus nidulans*. Chem Biol Interact 30(1): 9–23. [cited in OECD 1996].

Bingham E, Cohrssen B, Powell CH. 2001. Patty's toxicology, vol. 5. 5th ed. New York (NY): John Wiley & Sons. p. 224. [cited in HSDB 2008].

[BIOWIN] Biodegradation Probability Program for Windows [Estimation Model]. 2000. Version 4.02. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics;

Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Boethling RS, Howard PH, Beauman JA, Larosche ME. 1995. Factors for intermedia extrapolations in biodegradability assessment. Chemosphere 30(4): 741–752.

Boogaard PJ, Rocchi PSJ, van Sittert NJ. 1993. Effects of exposure to low concentrations of chlorinated hydrocarbons on the kidney and liver of industrial workers. Br J Ind Med 50(4): 331–339. [cited in OECD 1996].

Boublik T, Fried V, Hala E. 1984. The vapor pressures of pure substances. 2nd rev. ed. Amsterdam (NE): Elsevier. [cited in HSDB 2008].

Bringmann G. 1975. Determination of the biologically harmful effect of water pollutants by means of the retardation of cell proliferation of the blue algae *Microcystis*. Gesund Ing 96(9): 238–241. [cited in OECD 1996].

Bringmann G, Kühn R. 1977. The effects of water pollutants on *Daphnia magna*. Z Wasser Abwasser Forsch 10(5): 161–166. [cited in OECD 1996].

Bringmann G, Kühn R. 1978. Limiting values for the noxious effects of water pollutant material to blue algae (*Microcystis aeruginosa*) and green algae (*Scenedesmus quadricauda*) in cell propagation inhibition tests. Z Wasser 50: 45–60. [cited in OECD 1996 as Bringmann et al. 1980].

Canada. 1988. Ingredient Disclosure List [Internet]. SOR/88-64. [cited 2008 Nov 4]. Available from: http://www.canlii.org/ca/regu/sor88-64/part274942.html

Canada. 1999. *Canadian Environmental Protection Act, 1999*. S.C., 1999, c. 33. Available from: http://canadagazette.gc.ca/archives/p3/1999/g3-02203.pdf

Canada. 2000. *Canadian Environmental Protection Act: Persistence and Bioaccumulation Regulations*, P.C. 2000-348, 23 March 2000, SOR/2000-107. Available from: http://canadagazette.gc.ca/archives/p2/2000/2000-03-29/pdf/g2-13407.pdf

Canada, Dept. of the Environment, Dept. of Health. 2006. *Canadian Environmental Protection Act, 1999: Notice of intent to develop and implement measures to assess and manage the risks posed by certain substances to the health of Canadians and their environment.* Canada Gazette, Part I, vol. 140, no. 49, p. 4109–4117. Available from: http://canadagazette.gc.ca/archives/p1/2006/2006-12-09/pdf/g1-14049.pdf

Canada, Dept. of the Environment. 2008. *Canadian Environmental Protection Act, 1999: Notice with respect to Batch 6 Challenge substances.* Canada Gazette, Part I, vol. 142, no. 22, p. 1636–1665. Available from: http://canadagazette.gc.ca/rp-pr/p1/2008/2008-05-31/pdf/g1-14222.pdf

[CARB] California Air Resources Board. 1997. Toxic air contaminant identification list summaries. Sacramento (CA): California Environmental Protection Agency, California Air Resources Board, September. [cited in OEHHA 1999].

[ConsExpo] Consumer Exposure Model [Internet]. 2006. Version 4.1. Bilthoven (NL): Rijksinstituut voor Volksgezondheid en Milieu (National Institute for Public Health and the Environment). Available from: http://www.rivm.nl/en/healthanddisease/productsafety/ConsExpo.jsp#tcm:13-42840

[CPOPs] Canadian POPs Model. 2008. Gatineau (QC): Environment Canada, Existing Substances Division; Bourgas (BG): Bourgas Prof. Assen Zlatarov University, Laboratory of Mathematical Chemistry. [Model developed based on Mekenyan et al. 2005]. Available upon request.

Crebelli R, Conti G, Conti L, Carere A. 1984. Induction of somatic segregation by halogenated aliphatic hydrocarbons in *Aspergillus nidulans*. Mutat Res 138: 33–38. [cited in OECD 1996].

Dean BJ, Brooks TM, Hodson-Walker G, Hutson DH. 1985. Genetic toxicology testing of 41 industrial chemicals. Mutat Res 153: 57–77. [cited in OECD 1996].

de Jong G, van Sittert NJ, Natarajan AT. 1988. Cytogenetic monitoring of industrial populations potentially exposed to genotoxic chemicals and of control populations. Mutat Res 204: 451–464. [cited in OECD 1996].

de Zwart D, Slooff W. 1987. Toxicity of mixtures of heavy metals and petrochemicals to *Xenopus laevis*. Bull Environ Contam Toxicol 38: 345–351.

Dilling WL. 1977. Interphase transfer processes. II. Evaporation rates of chloro methanes, ethanes, ethylenes, propanes, and propylenes from dilute aqueous solutions. Comparisons with theoretical predictions. Environ Sci Technol 11(4): 405–409.

Dimitrov S, Dimitrova N, Parkerton T, Comber M, Bonnell M, Mekenyan O. 2005. Base-line model for identifying the bioaccumulation potential of chemicals. SAR QSAR Environ Res 16(6): 531–554.

[ECB] European Chemicals Bureau. 2000. IUCLID dataset for 3-chloropropene (CAS No. 107-05-1). Available from: http://ecb.jrc.it/iuclid-datasheet/107051.pdf

[ECOSAR] Ecological Structure Activity Relationships [Internet]. 2008. Version 1.00. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. [cited 2009 Sep 9]. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Eder E, Zegelder JP. 1990. DNA binding studies with allyl chloride and allyl bromide using the isolated perfused rat liver technique. Toxicol In Vitro 4: 661–665.

Eder E, Neudecker T, Lutz D, Henschler D. 1980. Mutagenic potential of allyl and allylic compounds. Structure–activity relationship as determined by alkylating and direct *in vitro* mutagenic properties. Biochem Pharmacol 29: 993–998. [cited in IARC 1985, 1999; OECD 1996].

Eder E, Lutz D, Jörns M. 1987. Allylic compounds bind directly to DNA: investigation of the binding mechanism *in vitro*. Chem Biol Interact 61: 97–108.

Environment Canada. 1988. Data relating to the Domestic Substances List (DSL) 1984–1986, collected under CEPA, 1988, s. 25(1). Based on Reporting for the Domestic Substances List [guide] 1988. Data prepared by: Environment Canada.

Environment Canada. 2007. Guidance for conducting ecological assessments under CEPA, 1999: science resource technical series: draft module on QSARs. Reviewed draft working document. Gatineau (QC): Environment Canada, Existing Substances Division.

Environment Canada. 2008. Data for Batch 6 substances collected under the Canadian Environmental Protection Act, 1999, Section 71: *Notice with respect to Batch 6 Challenge substances.* Data prepared by: Environment Canada, Existing Substances Program.

[EPIsuite] Estimation Programs Interface Suite for Microsoft Windows [Estimation Model]. 2008. Version 4.0. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm

[EQC] Equilibrium Criterion Model. 2003. Version 2.02. Peterborough (ON): Trent University, Canadian Centre for Environmental Modelling and Chemistry. Available from: http://www.trentu.ca/academic/aminss/envmodel/models/EQC2.html

[ESIS] European Chemical Substances Information System [database on the Internet]. 2008. Allyl chloride. [cited 2008 May 22]. Available from: http://ecb.jrc.it/esis/

[GDCh] German Chemical Society. 1998. Allyl chloride. BUA [GDCh-Advisory Committee on Existing Chemicals of Environmental Relevance] Report 186 (October 1995). Stuttgart (DE): S. Hirzel, Wissenschaftliche Verlagsgesellschaft.

Grant WM. 1986. Toxicology of the eye. 3rd ed. Springfield (IL): Charles C. Thomas. [cited in GDCh 1998].

Guseinov VG. 1982. Okhrana Truda i Zdorov'ya Rabotayushch v Vedushch Otraslyakh Prom-sti Azerbaidzhana Sumgait. p. 92–99. [cited in OECD 1996].

Guseinov VG. 1983. Toxicological characteristics of allyl chloride. Toksicol Gig Klin i Prof Vozdeistviya, Klorist Allila na Organizm Rabotsyushchikh v, 6–37. [cited in OECD 1996].

Guseinov VG et al. 1981. Vopr Okhrany Truda i Sostoyanic Zdorov'ya Rabotayushch S. p. 144–152. [cited in OECD 1996].

Häusler M, Lenich R. 1968. [Effect of chronic exposure to allylchloride.] Arch Toxikol 23: 209–214. [in German]. [cited in OECD 1996].

Hardin BD, Bond GP, Sikov MR, Andrew FD, Beliles RP, Niemeier RW. 1981. Testing of selected workplace chemicals for teratogenic potential. Scand J Work Environ Health 7(Suppl 4): 66–75. [cited in OECD 1996; IARC 1999].

Hardin BD, Shuler RL, Burg JR, Booth GM, Hazelden KP, MacKenzie KM, Piccirillo VJ, Smith KN. 1987. Evaluation of 60 chemicals in a preliminary developmental toxicity test. Teratog Carcinog Mutagen 7: 29–48. [cited in US EPA 1994; OECD 1996; HSDB 2008].

He F, Zhang S. 1985. Effects of allyl chloride on occupationally exposed subjects. Scand J Work Environ Health 11(Suppl 4): 43–45. [cited in OECD 1996].

He FS, Shen DG, Guo YP, Lu BQ. 1980. Toxic polyneuropathy due to chronic allyl chloride intoxication: a clinical and experimental study. Chin Med J 93(3): 177–182. [cited in OECD 1996].

He F, Jacobs JM, Scaravilli F. 1981. The pathology of allyl chloride neurotoxicity in mice. Acta Neuropathol 55(2): 125–133. [cited in US EPA 1994; OECD 1996; IARC 1999].

He FS, Lu BQ, Zhang SL, Dong SW, Yu A, Wang BY. 1985. Chronic allyl chloride poisoning. An epidemiology, clinical, toxicological and neuropathological study. G Ital Med Lav 7(1): 5–15. [cited in OECD 1996; IARC 1999].

Health Canada. 1998. Exposure factors for assessing total daily intake of priority substances by the general population of Canada. Unpublished report. Ottawa (ON): Health Canada, Environmental Health Directorate.

Health Canada. 2007. The cosmetic ingredient hotlist – March 2007 [Internet]. Ottawa (ON): Health Canada, Consumer Product Safety. [cited 2008 Nov 4]. Available from: http://www.hc-sc.gc.ca/cps-spc/person/cosmet/info-ind-prof/_hot-list-critique/hotlist-liste-eng.php

[HENRYWIN] Henry's Law Constant Program for Microsoft Windows [Estimation Model]. 2000. Version 3.10. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Hermens J, Busser F, Leeuwanch P, Musch A. 1985. Quantitative correlation studies between the acute lethal toxicity of 15 organic halides to the guppy (*Poecilia reticulata*) and chemical reactivity towards 4-nitrobenzylpyridine. Toxicol Environ Chem 9: 219–236.

[HSDB] Hazardous Substances Data Bank [database on the Internet]. 1983– . Bethesda (MD): National Library of Medicine (US). [revised 2006 Apr 14; cited 2008 Oct 9]. Available from: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB

[HYDROWIN] Hydrolysis Rates Program for Microsoft Windows [Estimation Model]. 2000. Version 1.67. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. [cited 2008 Oct 20]. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

[IARC] IARC Working Group on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. 1985. Allyl compounds, aldehydes, epoxides and peroxides. IARC Monogr Eval Carcinog Risk Chem Hum 36: 39–54.

[IARC] IARC Working Group on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. 1999. Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide. IARC Monogr Eval Carcinog Risk Chem Hum 71(Pt 3): 1231–1239.

[IPCS] International Programme on Chemical Safety. 1990. Allyl chloride. ICSC: 0010. Prepared in the context of cooperation between the International Programme on Chemical Safety and the European Commission. [cited in GDCh 1998].

[JETOC] Japan Chemical Industry Ecology-Toxicology and Information Center. 1997. Mutagenicity test data of existing chemical substances, supplement. Tokyo (JP): JETOC. p. 278–279. [cited in IARC 1999].

John JA, Gushow TS, Ayres JA, Hanley TR Jr, Quast JF, Rao KS. 1983. Teratologic evaluation of inhaled epichlorohydrin and allyl chloride in rats and rabbits. Fundam Appl Toxicol 3: 437–442. [cited in US EPA 1994; OECD 1996; HSDB 2008].

Karmazin VE. 1966. [No title provided]. Vopr Kommunal'n Gig 6: 108–111. [cited in OECD 1996].

Kasimova FS. 1978. [Early functional changes in the central nervous system in workers engaged in the manufacture of allyl chloride.] Gig Tr Prof Zabol 4: 24–27. [in Russian]. [cited in OECD 1996].

Kelly TJ et al. 1991. Results of air pollutant measurements in Allen County, OH, vol. 1. Final report to the Allen County Board of Commissioners, October. Columbus (OH): Battelle. [cited in Spicer et al. 2002].

Kneupper C, Saathoff L. 2000. Allyl chloride [Internet]. Kirk-Othmer encyclopedia of chemical technology, online version. Available from: http://mrw.interscience.wiley.com/emrw/9780471238966/kirk/article/allykneu.a01/current/pdf [restricted access]

[KOWWIN] Octanol–Water Partition Coefficient Program for Microsoft Windows [Estimation Model]. 2000. Version 1.67. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Lide DR. 2007–2008. CRC handbook of chemistry and physics. 88th ed. Boca Raton (FL): CRC Press Inc.

Lu B, Dong S, Yu A, Xian Y, Geng T, Chui T. 1982. Studies on the toxicity of allyl chloride. Ecotoxicol Environ Saf 6: 19–27. [cited in US EPA 1994; OECD 1996; HSDB 2008].

McCoy EC, Burrows L, Rosenkranz HS. 1978. Genetic activity of allyl chloride. Mutat Res 57: 11–15. [cited in OECD 1996].

McGregor DB. 1981. Tier II mutagenic screening of 13 NIOSH (National Institute for Occupational Safety and Health) priority compounds. Individual compound report: 3-Chloropropene. IRI report to NIOSH, NTIS No. PB86-239845, July 1. [cited in OECD 1996].

Mekenyan G, Dimitrov SD, Pavlov TS, Veith GD. 2005. POPs: a QSAR system for creating PBT profiles of chemicals and their metabolites. SAR QSAR Environ Res 16(1–2): 103–133.

[MITI] Ministry of International Trade & Industry (JP), Basic Industries Bureau, Chemical Products Safety Division. 1992. Biodegradation and bioaccumulation data of existing chemicals based on the CSCL Japan. Tokyo (JP): Japan Chemical Industry Ecology-Toxicology & Information Centre.

[MPBPWIN] Melting Point Boiling Point Program for Microsoft Windows [Estimation Model]. 2000. Version 1.42. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Nagano M, Hitoshi T, Futatsuka M. 1991. Neurotoxicity of allyl chloride in rats. Jpn J Ind Health 33: 73–80. [cited in OECD 1996; HSDB 2008].

National Cancer Institute. 1978. Bioassay of allyl chloride for possible carcinogenicity. Bethesda (MD): US Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health. Carcinogenesis Technical Report Series No. 73; DHEW Publication No. (NIH) 78-1323. [cited in IARC 1985; US EPA 1994].

[NCI] National Chemical Inventories [database on a CD-ROM]. 2008. Columbus (OH): American Chemical Society, Chemical Abstracts Service. Available from: http://www.cas.org/products/cd/nci/require.html

Neudecker T, Henschler D. 1985. Mutagenicity of chloro-olefins in the *Salmonella*/mammalian microsome test. I. Allyl chloride mutagenicity re-examined. Mutat Res 157: 145–148. [cited in OECD 1996].

[NHW] Dept. of National Health and Welfare (CA). 1990. Present patterns and trends in infant feeding in Canada. Ottawa (ON): Department of National Health and Welfare. NHW Cat. No. H39-199/1990E. [cited in Health Canada 1998].

Nielson GD, Bakbo JC. 1985. Sensory irritating effects of allyl halides and a role for hydrogen bonding as a likely feature at the receptor site. Acta Pharmacol Toxicol 57: 106–116. [cited in US EPA 1994].

[NPRI] National Pollutant Release Inventory. 2008. Gatineau (QC): Environment Canada. [cited 2008 Jul 25]. Available from: http://www.ec.gc.ca/pdb/querysite/query_e.cfm

[OECD] Organisation for Economic Co-operation and Development. 1996. SIDS Initial Assessment Report for 4th SIAM (Tokyo, 20–22 May 1996). Chloropropene, CAS No. 107-05-1. UNEP Publications. Including accompanying SIDS (IUCLID) dataset, dated February 17, 2003. Available at: http://www.chem.unep.ch/irptc/sids/oecdsids/Chloropropene.pdf

[OEHHA] Office of Environmental Health Hazard Assessment. 1999. Listed “as causing cancer” under the authoritative bodies mechanism and under review for possible delisting: allyl chloride,

chlorodibromomethane, 1,1-dichloroethane, *p*-toluidine, zineb. Sacramento (CA): California Environmental Protection Agency, OEHHA. Available from: http://oehha.ca.gov/Prop65/pdf/Delist5.pdf

Olsen GW, Lacy SE, Chamberlin SR, Albert DL, Arceneaux TG, Bullard LF, Stafford BA, Boswell JM. 1994. Retrospective cohort mortality study of workers with potential exposure to epichlorohydrin and allyl chloride. Am J Ind Med 25: 205–218.

[OMOE] Ontario Ministry of the Environment. 1988. Thirty seven municipal water pollution control plants: pilot monitoring study. Toronto (ON): Ontario Ministry of the Environment, Water Resources Branch. Report prepared by Canviro Consultants.

Omura M, Itonaga Y, Komatso H, Mangen Z, Hirata M, Tanaka A, Inoue N. 1993. The acute toxicity of allyl chloride by subcutaneous injection in mice. Fukuoka Igaku Zasshi 84(10): 427–432. [cited in OECD 1996; IARC 1999; HSDB 2008].

Otson R. 1987. Purgeable organics in Great Lakes raw and treated water. Int J Environ Anal Chem 31(1): 41–53.

[PCKOCWIN] Organic Carbon Partition Coefficient Program for Windows [Estimation Model]. 2000. Version 1.66. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

[PhysProp] Interactive PhysProp Database [database on the Internet]. 2008. Syracuse (NY): Syracuse Research Corporation. [cited 2008 Oct]. Available from: http://www.syrres.com/esc/physdemo.htm

[PMRA] Pest Management Regulatory Agency. 2007. Regulatory Note REG 2007-04: PMRA list of formulants [Internet]. Ottawa (ON): Health Canada, Pest Management Regulatory Agency. [cited 2008 Nov 4]. Available from: http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_decisions/reg2007-04/appendix1-annexe1-tab1-eng.php

[PMRA] Pest Management Regulatory Agency. 2008. PMRA product label database [Internet]. Ottawa (ON): Health Canada, Pest Management Regulatory Agency. [cited 2008 Nov 4]. Available from: http://pr-rp.pmra-arla.gc.ca/portal/page?_pageid=34,17551&_dad=portal&_schema=PORTAL

Quast JF, Henck JW, Schuetz DJ, McKenna MJ. 1982a. Allyl chloride—subchronic studies. IA. A 90-day inhalation study in laboratory rodents (CDF-Fischer 344 rats and B6C3F1 mice). OTS Document No. FYI-AX-0782-0199. Midland (MI): Dow Chemical USA, Toxicology Research Laboratory. [cited in US EPA 1994; OECD 1996].

Quast JF, Henck JW, Schuetz DJ, Dittenber DA, McKenna MJ. 1982b. Allyl chloride—subchronic studies. IB. Results of an inhalation 4-day probe and 90-day subchronic study in laboratory rodents. OTS Document No. FYI-AX-0782-0199. Midland (MI): Dow Chemical USA, Toxicology Research Laboratory. [cited in US EPA 1994; OECD 1996].

Quast JF, Henck JW, Schuetz DJ, Dittenber DA, McKenna MJ. 1982c. Allyl chloride—acute studies. Results of single 6-hour inhalation exposure studies in laboratory rodents. Report for the Chemical Manufacturers' Association from Dow Chemical USA, April 2. [cited in OECD 1996].

[RIVM] Rijksinstituut voor Volksgezondheid en Milieu. 2006. Cosmetics fact sheet: To assess the risks for the consumer. Updated version for ConsExpo 4 [Internet]. RIVM Report 320104001/2006. Bilthoven (NL): RIVM (National Institute for Public Health and the Environment). [cited 2008 Jul]. Available from: http://www.rivm.nl/bibliotheek/rapporten/320104001.pdf

Rosenbaum AS, Stiefer PS, Iwamiya RK. 1999. Air toxics data archive and AIRS combined data set: data base descriptions. Prepared for Office of Policy, Planning, and Evaluation, US Environmental Protection Agency, by Systems Applications International (SYSAPP 99/25). [cited in Spicer et al. 2002].

Ruth JH. 1986. Odour threshold and irritation levels of several chemical substances—a review. Am Ind Hyg Assoc J 47: 142–151. [cited in GDCh 1998].

Schiffmann D, Eder E, Neudecker T, Henschler D. 1983. Induction of unscheduled DNA synthesis in HeLa cells by allylic compounds. Cancer Lett 20: 263–269. [cited in OECD 1996].

Shamilov TA, Abasov DM. 1973. [Effects of allyl chloride on the organism of experimental animals.] Tr Azerb Nauchno-Issledovat Inst Gig Tr Prof Zabol 8: 12–15. [in Russian]. [cited in OECD 1996].

[Shell] Shell Chemical Corporation. 1958. Allyl chloride. Industrial Hygiene Bulletin No. SD 57-80. New York (NY): Shell. [cited in OECD 1996].

Silverman M, Abreu BE. 1938. The toxic and anesthetic properties of certain monochloropropenes. Univ Calif Berkeley Publ Pharmacol 1(10): 119–128. [cited in OECD 1996].

Singh HB, Salas LJ, Stiles RE. 1982. Distribution of selected gaseous organic mutagens and suspect carcinogens in ambient air. Environ Sci Technol 16: 892. [cited in Spicer et al. 2002].

Smyth HF Jr, Carpenter CP. 1948. Further experience with the range finding test in the industrial toxicology laboratory. J Ind Hyg Toxicol 30(1): 63–68. [cited in OECD 1996].

[Solvay] Solvay Chemicals, Inc. 2008. Allyl chloride. [cited 2008 May 22]. Available from: http://www.solvaychemicals.us/products/productshidden/0,,35893-2-0,00.htm

Spicer CW, Gordon SM, Holdren MW, Kelly TJ, Mukund R. 2002. Hazardous air pollutant handbook: measurements, properties, and fate in ambient air. Boca Raton (FL): CRC Press.

Theiss JC, Shimkin MB, Poirer LA. 1979. Induction of pulmonary adenomas in strain A mice by substituted organohalides. Cancer Res 39: 391–395. [cited in IARC 1985; US EPA 1994; OECD 1996].

[TOPKAT] TOxicity Prediction by Komputer Assisted Technology [Internet]. 2004. Version 6.2. San Diego (CA): Accelrys Software Inc. Available from: http://www.accelrys.com/products/topkat/index.html

Torkelson TR, Wolf MA, Oyen F, Rowe VK. 1959. Vapour toxicity of allyl chloride as determined on laboratory animals. Am Ind Hyg Assoc J 20: 217–223. [cited in US EPA 1994].

[TRI] Toxics Release Inventory [database on the Internet]. 2009. TRI Explorer 4.7. Washington (DC): US Environmental Protection Agency. [cited 2009 May 1]. Available from: http://www.epa.gov/triexplorer/

[US EPA] US Environmental Protection Agency. 1986. Health and environmental effects profile for allyl chloride. EPA/600/x-86/198. Cincinnati (OH): US EPA, Office of Research and Development, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office.

[US EPA] US Environmental Protection Agency. 1994. Allyl choride (CASRN 107-05-1): Carcinogenicity assessment (II). [cited 2008 May 22]. Washington (DC): US EPA, Integrated Risk Information System (IRIS). Available at: http://www.epa.gov/iris/subst/0387.htm

[US EPA] US Environmental Protection Agency. 2009. Air Quality System raw data report: 3-Chloropropene (43335). [dated 2009 Apr 7]. Washington (DC): US EPA.

Van Duuren BL, Goldschmidt BM, Loewengart G, Smith AC, Melchionne S, Seldman I, Roth D. 1979. Carcinogenicity of halogenated olefinic and aliphatic hydrocarbons in mice. J Natl Cancer Inst 63(6): 1433–1439. [cited in US EPA 1994; OECD 1996].

Venable JR, McClimans CD, Flake RE, Dimick DB. 1980. A fertility study of male employees engaged in the manufacture of glycerine. J Occup Med 22(2): 87–91. [cited in OECD 1996].

Winer LB, Atkinson R. 1987. Lifetimes and fates of toxic chemicals in California's atmosphere. California Air Resources Board, final report. Contract No. A5-104-32. Riverside (CA): University of California, Riverside.

[WSKOWWIN] Water Solubility for Organic Compounds Program for Microsoft Windows [Estimation Model]. 2000. Version 1.41 Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. Available from: http://www.epa.gov/oppt/exposure/pubs/episuite.htm

Zhao M, Omura M, Tokunaga S, Romero Y, Inoue N. 1998. Histopathological changes within the testis caused by allyl chloride exposure in mice. Bull Environ Contam Toxicol 60: 494–501. [cited in HSDB 2008].

Appendix 1: Upper-bounding estimates of daily intake of 3-chloropropene by the general population in Canada

Route of exposure	Estimated intake of 3-chloropropene (µg/kg-bw per day) by various age groups							
	0–6 months[1,2,3]			0.5–4 years[4]	5–11 years[5]	12–19 years[6]	20–59 years[7]	60+ years[8]
	Breast fed	Formula fed	Not formula fed					
Air[9]	0.72			1.54	1.20	0.69	0.58	0.51
Drinking water[10]	<0.01	0.05	0.02	0.02	0.02	0.01	0.01	0.01
Food and beverages[11]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Soil[12]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total intake	0.72	0.77	0.74	1.56	1.22	0.70	0.59	0.52

Abbreviation: N/A, not available due to insufficient data.

1 No measured data were identified on the concentration of 3-chloropropene in breast milk.

2 Assumed to weigh 7.5 kg, to breathe 2.1 m^3 of air per day, to drink 0.8 L of water per day (formula fed) or 0.3 L/day (not formula fed) or 0.74 L of breast milk per day (breast fed) and to ingest 30 mg of soil per day (Health Canada 1998). Breast-fed and formula-fed infants are assumed to consume no other foods.

3 For exclusively formula-fed infants, intake from water is synonymous with intake from food. The concentration of 3-chloropropene in water used to reconstitute formula was based on available water data. No data on concentrations of 3-chloropropene in formula were identified for Canada. Approximately 50% of infants are introduced to solid foods by 4 months of age and 90% by 6 months of age (NHW 1990).

4 Assumed to weigh 15.5 kg, to breathe 9.3 m^3 of air per day, to drink 0.7 L of water per day and to ingest 100 mg of soil per day (Health Canada 1998).

5 Assumed to weigh 31.0 kg, to breathe 14.5 m^3 of air per day, to drink 1.1 L of water per day and to ingest 65 mg of soil per day (Health Canada 1998).

6 Assumed to weigh 59.4 kg, to breathe 15.8 m^3 of air per day, to drink 1.2 L of water per day and to ingest 30 mg of soil per day (Health Canada 1998).

7 Assumed to weigh 70.9 kg, to breathe 16.2 m^3 of air per day, to drink 1.5 L of water per day and to ingest 30 mg of soil per day (Health Canada 1998).

8 Assumed to weigh 72.0 kg, to breathe 14.3 m^3 of air per day, to drink 1.6 L of water per day and to ingest 30 mg of soil per day (Health Canada 1998).

9 No Canadian data were identified for ambient air, whereas some data were identified for indoor air at locations other than Canada. As the detection limit in one of the indoor air studies was less than the maximum concentration of 3-chloropropene identified in outdoor air (Rosenbaum et al. 1999) and the other indoor air study revealed no detectable levels of 3-chloropropene, the maximum concentration in outdoor air was conservatively assumed to apply to the entire period of exposure (24 h/day), regardless of the proportion of time that an individual spends in outdoor compared with indoor settings. This maximum concentration of 3-chloropropene (2.57 µg/m^3) was identified in ambient air samples collected from 32 US locations (Rosenbaum et al. 1999) and was used in calculating the intake estimate. The critical data were selected from a dataset of US monitoring studies of ambient air (Singh et al. 1982; Kelly et al. 1991; Rosenbaum et al. 1999).

10 No reported concentrations of 3-chloropropene in tap water in Canada or elsewhere were identified in the literature. The concentration of 3-chloropropene identified in whole water samples (0.50 µg/L) was used to calculate the upper-bounding estimate of exposure. The critical data were selected from the US EPA STORET database (US EPA 1986).

11 No data for concentrations of 3-chloropropene in food were identified.

12 No reported concentrations of 3-chloropropene in soil in Canada or elsewhere were identified.

Appendix 2: Worst-case estimates of exposure to 3-chloropropene in personal care products based on ConsExpo version 4.1 (ConsExpo 2006)

Consumer product scenarios	Assumptions[1]	Estimated exposure
Skin care, body lotion	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 730×/year (RIVM 2006) **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 8 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 15 700 cm^2 (RIVM 2006) Amount product applied: 8 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.07 mg/m^3 **Dermal**: Per event applied dose = 0.01 mg/kg-bw Chronic applied dose[6] = 0.02 mg/kg-bw per day
Skin care, face cream	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 730×/year (RIVM 2006) **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 0.8 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 565 cm^2 (RIVM 2006) Amount product applied: 0.8 g (RIVM 2006)	**Inhalation**: Per event mean air concentration = 0.007 mg/m^3 **Dermal**: Per event applied dose = 0.001 mg/kg-bw Chronic applied dose[6] = 0.002 mg/kg-bw per day
Facial cleanser	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 730×/year (RIVM 2006) **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 2.5 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.02 mg/m^3 **Dermal**: Per event applied dose = 0.003 mg/kg-bw Chronic applied dose[6] = 0.007 mg/kg-bw per day

Consumer product scenarios	Assumptions[1]	Estimated exposure
	Dermal route Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 565 cm^2 (RIVM 2006) Amount product applied: 2.5 g (RIVM 2006)	
Shaving cream	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 365×/year (RIVM 2006) **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 2 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 305 cm^2 (RIVM 2006) Amount product applied: 2 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.02 mg/m^3 **Dermal**: Per event applied dose = 0.003 mg/kg-bw Chronic applied dose[6] = 0.003 mg/kg-bw per day
Aftershave	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 365×/year (RIVM 2006) **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 1.2 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 305 cm^2 (RIVM 2006) Amount product applied: 1.2 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.01 mg/m^3 **Dermal**: Per event applied dose = 0.002 mg/kg-bw Chronic applied dose[6] = 0.002 mg/kg-bw per day
Facial makeup	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 365×/year (RIVM 2006) **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006)	**Inhalation**: Per event air concentration = 0.007 mg/m^3 **Dermal**: Per event applied dose = 0.001 mg/kg-bw Chronic applied dose[6] = 0.001 mg/kg-bw per day

Consumer product scenarios	**Assumptions**[1]	**Estimated exposure**
	Amount product applied: 0.8 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 565 cm^2 (RIVM 2006) Amount product applied: 0.8 g (RIVM 2006)	
Hair gel	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 358×/year **Hair gel in hand:** **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 0.63 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 2.9 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 1010 cm^2 (RIVM 2006) Amount product applied: 2.9 g (RIVM 2006) **Hair gel retained in hair:** **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 0.3 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 580 cm^2 (RIVM 2006) Amount product applied: 0.3 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.03 mg/m^3 **Dermal**: Per event applied dose = 0.004 mg/kg-bw Chronic applied dose[6] = 0.004 mg/kg-bw per day
Showering gel	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 329×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 4 min (RIVM 2006)	**Inhalation**: Per event air concentration = 0.08 mg/m^3 **Dermal**: Per event applied dose = 0.01 mg/kg-bw Chronic applied dose[6] = 0.01 mg/kg-bw per day

Consumer product scenarios	**Assumptions[1]**	**Estimated exposure**
	Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 26.1 g (RIVM 2006) Weight fraction dilution factor: 3 (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 17 500 cm^2 (RIVM 2006) Amount product applied: 26.1 g (RIVM 2006) Weight fraction dilution factor: 3 (RIVM 2006)	
Shampoo	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 260×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 4 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 60 g (RIVM 2006) Weight fraction dilution factor: 3 (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 1440 cm^2 (RIVM 2006) Amount product applied: 60 g (RIVM 2006) Weight fraction dilution factor: 3 (RIVM 2006)	**Inhalation**: Per event air concentration = 0.2 mg/m^3 **Dermal**: Per event applied dose = 0.02 mg/kg-bw Chronic applied dose[6] = 0.02 mg/kg-bw per day
Conditioner	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 104×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 4 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 54 g (RIVM 2006) Weight fraction dilution factor: 3.9 (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 1440 cm^2 (RIVM 2006) Amount product applied: 54 g (RIVM 2006) Weight fraction dilution factor: 3.9 (RIVM 2006)	**Inhalation**: Per event air concentration = 0.1 mg/m^3 **Dermal**: Per event applied dose = 0.02 mg/kg-bw Chronic applied dose[6] = 0.006 mg/kg-bw per day

Consumer product scenarios	**Assumptions[1]**	**Estimated exposure**
Skin care, face pack	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 104×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 20 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 565 cm^2 (RIVM 2006) Amount product applied: 20 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.2 mg/m^3 **Dermal**: Per event applied dose = 0.03 mg/kg-bw Chronic applied dose[6] = 0.008 mg/kg-bw per day
Skin care, peel/scrub	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 104×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min (RIVM 2006) Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 0.8 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 565 cm^2 (RIVM 2006) Amount product applied: 0.8 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.007 mg/m^3 **Dermal**: Per event applied dose = 0.001 mg/kg-bw Chronic applied dose[6] = 0.0003 mg/kg-bw per day
Sun screen	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 75×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 10 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006)	**Inhalation**: Per event air concentration = 0.09 mg/m^3 **Dermal**: Per event applied dose = 0.01 mg/kg-bw Chronic applied dose[6] = 0.003 mg/kg-bw per day

Consumer product scenarios	**Assumptions**[1]	**Estimated exposure**
	Exposed area: 17 500 cm^2 (RIVM 2006) Amount product applied: 10 g (RIVM 2006)	
Hair dye	Weight fraction of 3-chloropropene: 1/10 000[2] **General assumptions** Exposure frequency: 10×/year **Inhalation route** Exposure type: Exposure to vapour Instantaneous release (ConsExpo 2006) Exposure duration: 5 min[3] Room volume[4]: 10 m^3 (RIVM 2006) Ventilation rate[5]: 2/h (RIVM 2006) Amount product applied: 100 g (RIVM 2006) **Dermal route** Exposure type: Direct dermal contact Instant application (ConsExpo 2006) Exposed area: 580 cm^2 (RIVM 2006) Amount product applied: 100 g (RIVM 2006)	**Inhalation**: Per event air concentration = 0.9 mg/m^3 **Dermal**: Per event applied dose = 0.1 mg/kg-bw Chronic applied dose[6] = 0.004 mg/kg-bw per day

[1] The following assumptions were applied to all scenarios: body weight: 70.9 kg for an adult
- inhalation rate of 16.2 m^3/day
- uptake fraction of 1

[2] Based on maximum concentration of 1% polyacrylic polymers used in personal care product formulations containing a maximum of 1% 3-chloropropene as an impurity in the polymers (Canada 1988).

[3] A lower value for exposure duration than that presented as default value in RIVM (2006) is assumed based on high vapour pressure and reactivity of substance.

[4] All personal care applications were assumed to have taken place in a standard bathroom.

[5] The number of times an hour that the air in a space is exchanged.

[6] Chronic dermal dose calculated through amortization over a year.

Appendix 3: Summary of health effects information for 3-chloropropene

Endpoint	Lowest effect levels[1,2]/Results
Laboratory animals and *in vitro*	
Acute toxicity	**Lowest inhalation LD_{50}** = 2504 mg/m^3 in male B6C3F1 mice (Quast et al. 1982c) [additional studies: Silverman and Abreu 1938; Adams et al. 1940; Smyth and Carpenter 1948; Shell 1958; Al'meev and Karmazin 1969; Shamilov and Abasov 1973; Lu et al. 1982; Omura et al. 1993; Bingham et al. 2001] No dermal or oral LD_{50} values were identified. Other effects: 3-Chloropropene was reported to cause irritation to the eye, nose and mouth of rats, mice and guinea pigs at lethal concentrations (Adams et al. 1940; Lu et al. 1982; Quast et al 1982c). Whereas formation of thickened skin and focal ulcerous dermatitis was observed in mice exposed to near-lethal concentrations of 3-chloropropene from air (Quast et al. 1982c), erythemas, swelling and necrotization of tissue from dermal contact to liquid 3-chloropropene were also characterized in mice (Lu et al. 1982).
Short-term repeated-dose toxicity	**Lowest oral LOEL** = 45 mg/kg-bw per day (lowest dose tested). Unspecified organs were reported to be congested and contained dystrophic changes after white rats (strain, sex and number of animals per group not specified) were administered 3-chloropropene (45 and 90 mg/kg-bw per day, 10 days) in sunflower oil (Al'meev and Karmazin 1969). [additional studies: Smyth and Carpenter 1948; Karmazin 1966; Lu et al. 1982] **Lowest inhalation LOEC** = 24 mg/m^3. Effects on the kidneys, including dilation, cloudy swelling and focal necrosis of the sinusoids, changes in the glomeruli, necrosis of the epithelium of the convoluted tubules and proliferation of the interstitial tissues, were reported in rats, guinea pigs and rabbits exposed to 3-chloropropene at 8 ppm (24 mg/m^3) for 7 h/day, 5 days/week, for 35 days (Torkelson et al. 1959). [additional studies: Shamilov and Abasov 1973; Lu et al. 1982] No short-term dermal toxicity studies were identified.
Subchronic toxicity	**Lowest oral LOEL** = 300 mg/kg-bw. Hind limb weakness in mice (unspecified number per sex per group) exposed to 3-chloropropene by gavage at 300 or 500 mg/kg-bw in arachis oil, 3 times/week, for 2–17 weeks (He et al. 1981). [No other oral studies were identified in the literature.] **Lowest inhalation LOEC** = 3.1 mg/m^3. Increased body weights and changes in liver (increased level of serum cholinesterase) and kidney (anti-diuretic effects with increased specific gravity of the urine) functions were reported in rats (unspecified strain and number per sex per group) exposed to 3-chloropropene by inhalation at 0.1, 0.3 and 1 ppm (0.29, 1.1 and 3.1 mg/m^3 (OECD 1996)), 4 h/day, 5 days/week, for 4 months, with a 1-month post-exposure period. Changes in the liver and kidney functions were reported to persist through the post-exposure period (Guseinov 1983). [additional studies: Lu et al. 1982; Quast et al. 1982a, b; Nagano et al. 1991] No subchronic dermal toxicity studies were identified.
Chronic toxicity/ carcinogenicity	**Non-neoplastic endpoints** **Lowest oral LOEL** = 73 mg/kg-bw per day. A treatment-related decrease in

Endpoint	Lowest effect levels[1,2]/Results
	body weight, from 557 to 487 g, was observed in high-dose male rats (Osborne-Mendel, 50 animals per sex per dose, 20 per sex per group served as vehicle controls and untreated controls). Experimental animals were exposed to technical-grade 3-chloropropene in corn oil at 57 and 77 mg/kg-bw per day (time-weighted average; initial doses were 140 and 70 mg/kg-bw per day; after 11 weeks, the doses were decreased to 110 and 55 mg/kg-bw per day; at 16 weeks, the doses were decreased to 55 and 55 mg/kg-bw per day) for male rats and at 55 and 73 mg/kg-bw per day (time-weighted average; initial doses were 110 and 55 mg/kg-bw per day; at week 27, the doses were lowered to 55 and 55 mg/kg-bw per day) for female rats, 5 times/week for 78 weeks. Initial doses were adjusted downward due to excessive mortality (National Cancer Institute 1978). [No additional chronic oral toxicity studies were identified.] **Lowest inhalation LOEC** = 9 mg/m^3. Slight central lobular degeneration was observed in the livers of female rats (unspecified strain, 24 per sex) exposed to 3-chloropropene (purity unspecified) at 3 ppm (9 mg/m^3), 7 h/day, 5 days/week, for 6 months via inhalation (Torkelson et al. 1959). [additional studies: Chronic inhalation studies in rabbits, guinea pigs and dogs performed by Torkelson et al. 1959.] No other non-neoplastic endpoints were identified in the available carcinogenicity studies. **Neoplastic endpoints:** *Oral:* Male B6C3F1 mice (5 weeks old, two exposure groups, 50 animals per group) were administered 3-chloropropene by gavage (98% pure, in corn oil vehicle) at 172 and 199 mg/kg-bw per day (time-weighted average; initial doses of 200 and 400 mg/kg-bw per day; at week 16, doses were increased to 250 and 500 mg/kg-bw per day; at week 17, doses were decreased to 200 and 400 mg/kg-bw per day; at week 30, doses were decreased to 200 and 200 mg/kg-bw per day), 5 days/week for up to 78 weeks (in a ventilated hood, with several 1-week interruptions). In addition, female B6C3F1 mice (5 weeks old, 50 per group) were administered 3-chloropropene by gavage (98% pure, in corn oil vehicle) at doses of 129 and 258 mg/kg-bw per day (time-weighted average; initial doses of 150 and 300 mg/kg-bw per day; in week 26, intubation ceased for 1 week and was followed by 4 weeks of intubation at 150 and 300 mg/kg-bw per day), 5 days/week, for up to 78 weeks. Negative and vehicle control groups consisted of 20 female and 20 male B6C3F1 mice each. The post-observation period was 14 weeks for the control and low-dose groups and 0 weeks for the high-dose groups. The overall state of the animals was poor during the last 6 months of the study. In male mice, the mortality rate was 48% after the 27th week, and only 50% of the low-dose male mice survived 86 weeks. For the female mice, 68% of the high-dose and 80% of the low-dose groups survived to their last exposure. 3-Chloropropene exposure-related histopathological changes were detectable only in the gastrointestinal tract in the form of acanthosis and hyperkeratosis of the gastric mucosa (at all dose levels) in both sexes. In female mice, squamous cell papillomas and carcinomas of the forestomach were reported in 0/39 controls (19 vehicle and 20 negative), 3/47 low-dose (2 carcinomas) and 3/45 high-dose females (all papillomas). In male mice, squamous cell carcinomas of the forestomach were reported in 0/29 (17 vehicle and 12 negative) controls, 2/36 low-dose and 0/10 high-dose animals (only 10

Endpoint	Lowest effect levels[1,2]/Results
	high-dose males survived past 52 weeks) (National Cancer Institute 1978). Male Osborne-Mendel rats (6 weeks old, 50 animals per group) were administered 3-chloropropene by gavage (98% pure, in corn oil vehicle) at 57 and 77 mg/kg-bw per day (time-weighted average), 5 days/week, for a total of 78 weeks. Female Osborne-Mendel rats (6 weeks old, two exposure groups, 50 animals per group) were administered 3-chloropropene by gavage (98% pure, in corn oil vehicle) at 55 and 73 mg/kg-bw per day (time-weighted average), 5 days/week, for a total of 78 weeks. Negative and vehicle control groups consisted of 20 female and 20 male Osborne-Mendel rats each. All animals had a post-observation period of 30–33 weeks. A significant reduction in the weight gain of the high-dose male rats was observed. Fifty percent of the male and female animals died within the first 14 and 38 weeks, respectively, in the high-dose groups. There was no survival for the high-dose animals to the end of the study. The high incidence of mortality was not tumour associated. A high incidence of chronic pneumonia was noted in all treatment groups. No statistically significant increases in tumour incidences in exposed rats were reported by the authors (National Cancer Institute 1978). *Dermal:* Female Ha:ICR Swiss mice (6–8 weeks old, 30 animals per group) were exposed once with 94 mg 3-chloropropene (in 0.2 mL acetone) on the shaved back skin. Phorbolmyristylacetate (a cancer promoter, 0.005 mg in 0.2 mL acetone vehicle) was applied 14 days later, 3 times/week, for approximately 500 days. The incidence of skin papillomas was significantly increased in exposed mice when compared with the control groups (phorbolmyristylacetate only and acetone only). In the same study, female Ha:ICR Swiss mice (6–8 weeks old, 30 animals per group) were exposed to 3-chloropropene (in 0.2 mL acetone) at 31 or 94 mg per animal on the shaved back skin, 3 times/week, for 63–85 weeks. No skin tumours were observed. The number of benign lung and forestomach papillomas (14 lung and 3 stomach papillomas in the low-dose group and 12 lung and 3 stomach papillomas in the high-dose group) observed did not significantly differ from that of the control (acetone only) group (Van Duuren et al. 1979). *Intraperitoneal:* Male and female A/St mice (four exposure groups per sex, 10 animals per sex per group) were exposed to 3-chloropropene (in tricaprylin) via intraperitoneal injection at 50, 122 and 245 mg/kg-bw, 3 times/week, for 8 weeks. Vehicle control animals received tricaprylin only. There was a 100% survival rate after the 24-week exposure period. Average numbers of lung adenomas per mouse were reported to be 0.19, 0.60, 0.50 and 0.60 in the vehicle control, low-, medium- and high-dose groups, respectively. The average adenoma incidence in the high-dose group was reported to be significantly increased (not dose dependent) relative to the vehicle controls (Theiss et al. 1979).
Reproductive toxicity	**Lowest inhalation LOEC** = 1.1 mg/m^3. Sperm motility time was decreased, as was the average number of normal spermatogonia and the number of tubules with desquamated spermatogenic epithelium in male rats (unspecified strain, 10–15 per group) exposed to 3-chloropropene via inhalation at 0.1, 0.3 and 1 ppm (0.29, 1.1 and 3.1 mg/m^3 (OECD 1996)), 4 h/day, 5 days/week, for 4 months. The testicular weight and spermatogenic index were also reported to be reduced (Guseinov 1982). [additional studies: Guseinov et al. 1981; McGregor 1981; Zhao et al. 1998]

Endpoint	Lowest effect levels[1,2]/Results
	No oral or dermal reproductive toxicity studies were identified.
Developmental toxicity	**Lowest inhalation LOEC** = 3.1 mg/m^3. Reductions (not significant) of live embryos per litter and significant increases in resorption sites, reduced fetal weights, increased post-implantation loss and significant increases in pre-implantation loss were reported in rats exposed to 3-chloropropene via inhalation at 0, 0.1 and 1 ppm (0, 0.29 and 3.1 mg/m^3 (OECD 1996)), 4 h/day, throughout the gestation period (Alizadeh et al. 1982). [additional studies: Hardin et al. 1981, 1987; John et al. 1983] No dermal developmental toxicity studies were identified.
Genotoxicity and related endpoints: *in vitro*	**Clastogenicity:** Positive, with and without metabolic activation (S9), in Chinese hamster lung cells for chromosomal aberration (JETOC 1997) **Mutagenicity in mammalian cell lines:** Negative for mutations in rat liver RL1 cells (Dean et al. 1985) **DNA damage or repair:** Positive, without metabolic activation (S9), in *Escherichia coli* pol A_1^- for DNA modification (McCoy et al. 1978) Positive for unscheduled DNA synthesis: Elevated incorporation of [^{3}H]thymidine into the DNA of cultured human HeLa S3 cells was reported (Schiffmann et al. 1983) Negative, with and without metabolic activation (S9), for unscheduled DNA synthesis in human embryonic intestinal cells (McGregor 1981) Five DNA adducts (3-allyladenine, N^6-allyladenine, N^2-allylguanine, 7-allylguanine and O^6-allylguanine) were identified in an *in vitro* DNA adduct assay in salmon sperm (Eder et al. 1987) **Mutagenicity in bacteria:** Positive, with and without metabolic activation (S9), in *Salmonella typhimurium* strains TA98, TA100, TA1535 and TA1538 for mutations (McCoy et al. 1978; Bignami et al. 1980; Eder et al. 1980; Dean et al. 1985; Neudecker and Henschler 1985) Positive, with and without metabolic activation (S9), in *Escherichia coli* for reverse mutations (Dean et al. 1985) **Mutagenicity in fungal cells:** Positive, without metabolic activation (S9), in *Streptomyces coelicolor* for both forward and reverse mutations either in the spot test or in the plate incorporation assay (Bignami et al. 1980) Negative, without metabolic activation (S9), in *Aspergillus nidulans* for both forward and reverse mutations either in the spot test or in the plate incorporation

Endpoint	Lowest effect levels[1,2]/Results
	assay (Bignami et al. 1980) Positive, without metabolic activation (S9), in *Aspergillus nidulans* for mutation: Significant increase in the frequency of haploid segregants and diploid non-disjunctional sectors (Crebelli et al. 1984) Positive, with and without metabolic activation (S9), in *Saccharomyces cerevisiae* JDI for mutations (Dean et al. 1985) Positive, without metabolic activation (S9), in *Saccharomyces cerevisiae* D4 for mutations (McCoy et al. 1978)
Genotoxicity and related endpoints: *in vivo*	**Clastogenicity:** Negative in Sprague-Dawley rats (inhalation) for chromosomal aberrations in the bone marrow (McGregor 1981) **Mutagenicity in germ cells:** Negative in Sprague-Dawley rats (inhalation) for heritable dominant lethal mutations (McGregor 1981) **DNA damage or repair:** Four DNA adducts (3-allyladenine, 7-allyladenine, N^2-allylguanine and O^6-allylguanine) were identified in rat livers exposed to 3-chloropropene via perfusion *ex vivo* (Eder and Zegelder 1990) **Genotoxicity in *Drosophila*:** Negative in sex-linked lethal recessive lethal tests (McGregor 1981)
Neurotoxicity and related endpoints	**Lowest oral LOEL** = 300 mg/kg-bw. Nerve fibre degeneration was observed in the peripheral nerves and roots, more marked distally and affecting motor nerves more than sensory nerves, in albino mice (20 males, 20 females) exposed to 3-chloropropene by gavage (300 or 500 mg/kg-bw, 3 times/week, 2–17 weeks) (He et al. 1985). [No other oral studies were identified in the literature.] **Lowest inhalation LOEC** = 1.1 mg/m^3. A reversible decrease in CNS activity was observed in rats (unspecified strain and number per sex per group) exposed to 3-chloropropene via inhalation at 0.1, 0.3 and 1 ppm (0.29, 1.1 and 3.1 mg/m^3 (OECD 1996)), 4 h/day, 5 days/week, for 4 months with a 1-month post-exposure period (Guseinov 1983). Other inhalation LOEC = 156 mg/m^3. Depression in the amplitude of nerve action potentials was observed in rats (Donryo, five per group) exposed to 3-chloropropene by inhalation at 10, 50 and 100 ppm (31, 156 and 313 mg/m^3), 8 h/day, 5 days/week, for 34 weeks (Nagano et al. 1991). [additional studies: Lu et al. 1982; Nagano et al. 1991] No short-term dermal neurotoxicity studies were identified.
Humans	
Epidemiological studies	A retrospective cohort mortality study was conducted in Texas. The study cohort included 1064 workers of a chemical facility employed in the epoxy resin, glycerine and 3-chloropropene/epichlorohydrin production areas between

Endpoint	Lowest effect levels[1,2]/Results
	1957 and 1986. Follow-up was carried out until 1989 for a total of 12 574 person-years. Based on evaluation of work practices, production processes, environmental monitoring data and job exposure categorization, an exposure index for 3-chloropropene was derived with the contribution of cohort person-years divided into one of the following categories: no exposure, ≤ 1 ppm (3.13 mg/m^3) or > 1 ppm (3.13 mg/m^3). It should be noted that all cohort subjects were considered to have had co-exposure to epichlorohydrin at concentrations of either >1 ppm or ≤11 ppm; therefore, there was no exposure group for 3-chloropropene alone. The cause of death in the cohort was obtained from death certificates and compared with the US national rates (external comparison) to give standardized mortality ratios and also with an internal comparison group (non-exposed workers in other Texas facilities by the same company) using the Mantel-Haenszel risk ratio. There were no significant increases in mortality due to all causes (n = 66 for total cohort), due to all cancers (all cancer deaths, n = 10) or due to specific types of cancer between the total cohort and either comparison group when analysed by 3-year or 15-year latency. When data were stratified by exposure to 3-chloropropene (no exposure, ≤ 1 ppm (3.13 mg/m^3) or > 1 ppm (3.13 mg/m^3)) and either low or high epichlorohydrin exposure, there was no apparent dose-dependent increase in cancer deaths (Olsen et al. 1994). A cross-sectional study was conducted in workers (15 females, 45 males) who were exposed to concentrations of 3-chloropropene between 1 and 113 ppm (3 and 354 mg/m^3) for 16 months. Liver function was investigated, and changes (unspecified) indicative of impaired liver function were observed. After cessation of 3-chloropropene exposure, the same liver function parameters (unspecified) returned to normal. The investigators reported that there was evidence of reversible liver damage in workers exposed to 3-chloropropene vapour (Häusler and Lenich 1968). In a cross-sectional study, workers (103 males, 52 females, n = 155, age 20–45 years) were exposed to 3-chloropropene concentrations ranging from 6.4 to 140 mg/m^3 for periods of 1–5 years and beyond. Signs of neurotoxicity, such as finger tremor, stimulation of the periosteal and tendinous reflexes, unsteadiness in the Romberg test, skin hypothermia, cyanosis, capillary spasm and persistent dermography, were reported. In addition, increased urinary excretion of noradrenaline and increased blood acetylcholine with a decrease in true cholinesterase activity were also reported. The investigators reported that there was evidence of 3-chloropropene exposures leading to adverse effects on the nervous system (Kasimova 1978). From a series of surveys of workers exposed to 3-chloropropene in a chemical plant in China in the 1970s, 17 cases of polyneuropathy were identified in women (average age = 42) who were employed in the plant during the period 1970–1977. Workers in this plant were exposed to "relatively high" levels of 3-chloropropene (actual concentrations not provided) for 4 months to 5 years before symptoms of polyneuropathy developed. These workers were also concurrently exposed to sodium sulphite at unknown concentrations. Some of the workers exhibited electromyography (EMG) abnormalities. Eight out of 13 cases of EMG abnormalities were reported to consist of fibrillation or positive sharp waves. Reduced motor nerve conduction velocity (MCV) in tibial and peroneal nerves was also reported in seven out of the eight female workers. Out of the seven female workers with reduced MCV, five had prolonged motor distal latencies. The investigators concluded from this study that the female workers exhibited polyneuropathy after "excessive" exposure to 3-

Endpoint	Lowest effect levels[1,2]/Results
	chloropropene (He et al. 1980). In a follow-up to the above study, another occupational study was conducted in workers exposed to 3-chloropropene in two different factories in China (A and B). For factory A, there were 26 workers (all female, ages 20–51) exposed to 3-chloropropene at concentrations of 2.6–6650 mg/m^3 (reported average concentration of 2966 mg/m^3) for a period ranging from 2.5 months to 6 years. In subsequent communication between the US EPA and the authors, the average exposure in factory A was reported to be 138 mg/m^3 (standard deviation [SD] = 12 mg/m^3, based on 68 area samples, location/timing/duration of sampling unknown). In factory B, there were 27 workers (14 males, 13 females, ages 18–41) exposed to concentrations of 3-chloropropene at 0.2–25.13 mg/m^3 (average concentration not reported) for a period of 1–4.5 years. Subjects reported work and health history in a questionnaire and underwent a range of clinical examinations, including physical and neurological tests, visual acuity and visual field, rheography of extremities, electrocardiography, electroneuromyography and clinical chemistry of blood and urine. In factory B, increased polyphasic potentials and duration of motor unit potentials without any denervation potentials in 13 out of 27 workers examined were reported after EMG (He and Zhang 1985; He et al. 1985). In factory A, 17 out of 26 workers developed symmetrical distal sensory deficits, and decreased muscular strength was also observed in 57% of the workers. Ankle reflexes were also reported to be reduced in 42.3% of workers. Increased polyphasic potentials and duration of motor unit potentials without any denervation potentials in 10 out of 19 workers examined were reported after EMG. The incidence of polyneuropathy in workers of both factories was found to be exposure related. Some symptoms were persistent and were reported to last for years in severe cases (He and Zhang 1985; He et al. 1985). In a cross-sectional study, workers (40 females, 60 males) were exposed to unspecified concentrations of 3-chloropropene for periods ranging from 1 to 5 and from 5 to 20 years. Urea and creatinine clearance in exposed workers showed a 12% increase when compared with age-matched controls. Chloride levels in the blood were also reported to have increased by 26%, whereas sodium and potassium levels were reported to have increased by 12%. The investigators concluded from this study that there was evidence of kidney damage attributable to occupational exposure to 3-chloropropene (Alizade 1979). In a cross-sectional study, workers (64 males: 41 participated [64%], average age 40–63 years) were exposed to 3-chloropropene at 1 ppm (3.1 mg/m^3) in concert with epichlorohydrin at 1 ppm (3.8 mg/m^3) and 1,3-dichloropropene at 1 ppm (3.8 mg/m^3). The control group consisted of 63 workers (male, age/alcohol/smoking habit matched). The investigators concluded that male fertility was not adversely affected by exposure to 3-chloropropene in combination with other three-carbon chlorinated hydrocarbons (Venable et al. 1980). In a cross-sectional study, workers (44 males) were exposed to 3-chloropropene concentrations of 4 mg/m^3 (range <0.1–54 mg/m^3, levels in 1978) in concert with epichlorohydrin concentrations (average) ranging from 1 mg/m^3 (range <0.1–3 mg/m^3, levels in 1978) to 6 mg/m^3 (range <0.1–11 mg/m^3, levels in 1977) for a period ranging from 1 to 21 years. Controls consisted of six groups of non-exposed plant workers (age/sex/smoking habit matched). Equivocal increases in the frequencies of chromosome gaps, breaks and total aberrations

Endpoint	Lowest effect levels[1,2]/Results
	were reported in the blood samples of the exposed workers when compared with controls. The difference in frequency of chromosomal aberrations between exposed workers and controls was not considered to be of biological significance (de Jong et al. 1988). In a cross-sectional study, 73 male workers (unspecified age) were exposed to 3-chloropropene concentrations ranging from 0.2 to 2.89 mg/m^3 for a period of 11 years. A control group consisted of 35 male workers (unspecified age). No differences in liver function parameters between the exposed group and the control group were reported (Boogaard et al. 1993). Other effects: Eye and respiratory tract irritation was reported in human volunteers exposed to 3-chloropropene concentrations between 25 and 100 ppm (79 and 315 mg/m^3) (Shell 1958), whereas 75 mg/m^3 has been reported as the threshold value for irritation of the respiratory mucosa (Ruth 1986). Eye irritation was reported to occur at 150–300 mg/m^3, with higher concentrations resulting in eye pain and photophobia (Grant 1986). Symptoms of eye and respiratory irritation have also been reported in several cases of incidental exposures to 3-chloropropene in the workplace (He et al. 1980; He and Zhang 1985). In addition, dermal contact with liquid 3-chloropropene has caused reddening to burn-like sensations in humans (IPCS 1990).

[1] LC_{50}, median lethal concentration; LD_{50}, median lethal dose; LOEC, lowest-observed-effect concentration; LOEL, lowest-observed-effect level.

[2] Conversion factor: $mg/m^3 = 3.13 \times ppm$ (IARC 1999).