Screening Assessment Report

Ethane, 1,2-dibromo-
(1,2-Dibromoethane)

Chemical Abstracts Service Registry Number
106-93-4

Environment Canada
Health Canada

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Synopsis

Pursuant to section 74 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the Ministers of the Environment and of Health have conducted a screening assessment of Ethane, 1,2-dibromo- (1,2-dibromoethane), Chemical Abstracts Service Registry Number (CAS[1]RN) 106-93-4.1,2-Dibromoethane was identified as a priority for assessment because it met the criteria for persistence and/or bioaccumulation and inherent toxicity to non-human organisms. It was also identified as a priority on the basis of greatest potential for human exposure.

1,2-Dibromoethane is considered to be predominantly anthropogenic in origin, though detection of 1,2-dibromoethane in marine air and water suggests possible natural formation as the result of macroalgae growth. In Canada, 1,2-dibromoethane is solely used as a lead scavenger in leaded gasoline for high-performance competition vehicles and piston engine aircraft. Internationally, 1,2-dibromoethane may be used as a grain fumigant; moth control agent in beehives; wood preservative in the timber industry; activator of magnesium in the preparation of Grignard reagents; chemical intermediate in the production of vinyl bromide, plastic and latex; and in the formulation of flame retardants, polyester dyes, resins and waxes. Based on a survey issued under section 71 of CEPA 1999, between 10 000 and 100 000 kg of 1,2-dibromoethane were imported into Canada in the 2000 calendar year.

According to the available information, 1,2-dibromoethane does not degrade quickly in air, and it has a high potential for long-range transport in this medium. It also does not degrade quickly in groundwater. Low experimental bioconcentration factor values suggest that 1,2-dibromoethane has limited bioaccumulation potential in organisms. Therefore, 1,2-dibromoethane meets the criteria for persistence but not for bioaccumulation potential as set out in the *Persistence and Bioaccumulation Regulations.* In addition, experimental toxicity data for 1, 2-dibromoethane suggests that this substance is not expected to cause acute harm to aquatic organisms at low concentrations.

In Canada, 1,2-dibromoethane is routinely monitored in ambient air but not in water, soil or sediments. Risk characterization using conservative exposure concentrations measured in ground water and soil from industrial and non-industrial sites, as well as modelled concentrations for surface water, and critical toxicity values for aquatic and soil organisms indicates that 1,2-dibromoethane is unlikely to cause ecological harm.

Based on the information available with regard to the environment, it is concluded that 1,2-dibromoethane 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.

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A critical effect for the characterization of risk of 1,2-dibromoethane exposure to human health is carcinogenicity, as there is strong evidence of carcinogenicity of 1,2-dibromoethane in rats and mice following oral or inhalation exposure. 1,2-Dibromoethane was also genotoxic in several *in vivo* and *in vitro* assays. Therefore, although the mode of induction of tumours has not been fully elucidated, it cannot be precluded that the tumours observed in experimental animals resulted from direct interaction of 1,2-dibromoethane with genetic material.

As mentioned, the sole use of 1,2-dibromoethane in Canada is as a lead scavenger in leaded gasoline for specialized applications. Increases in the releases of this substance to the environment from leaded gasoline are not anticipated, as recent data suggests that the use quantities of these fuels are not increasing. Extensive outdoor and indoor air monitoring data exists for this substance. Although, the substance has occasionally been detected at very low levels, it was not detected in > 99% of the samples analyzed from recent studies. No consumer products containing 1,2-dibromoethane were identified in Canada, and thus exposure from use of consumer products is not expected.

On the basis of the use pattern of 1,2-dibromoethane and the very limited potential for general population exposure, it is concluded that 1,2-dibromoethane 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.

Based on available information for environmental and human health considerations, it is concluded that 1,2-dibromoethane does not meet one or more of the criteria set out in section 64 of CEPA 1999.

Because this substance is listed on the Domestic Substances List, it is not subject to notification under the *New Substance Notification Regulations (Chemicals and Polymers)*. However, given its hazardous properties, there is concern that new activities that have not been identified or assessed under CEPA 1999 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 this substance, so that any significant new activity is notified and undergoes ecological and human health risk assessments before the substance is imported, manufactured or used for the significant new activity.

Introduction

This screening assessment was conducted pursuant to section 74 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada 1999). This section of the Act requires that the Ministers of the Environment and of Health conduct screening assessments of substances that satisfy the categorization criteria set out in section 73 of the Act in order to determine whether they meet or may meet the criteria set out in section 64 of the Act.

Screening assessments focus on information critical to determining whether a substance presents, or may present, a risk to the environment or to human health, according to the criteria 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.[2]Ethane, 1,2-dibromo- (1,2-dibromoethane), CAS RN (Chemical Abstracts Service Registry Number) 106-93-4 was identified as a priority for assessment because it met the criteria for persistence and/or bioaccumulation and inherent toxicity to non-human organisms and was also identified on the basis of greatest potential for human exposure.

The 2004 version of the *State of the Science Report for a Screening Health Assessment* of 1,2-dibromoethane was posted on the Health Canada website on November 29, 2004(Health Canada 2004). The *State of the Science Report for a Screening Health Assessment* was externally reviewed by staff of Toxicology Advice and Consulting Limited and by V.C. Armstrong (consultant) for adequacy of data coverage and defensibility of the conclusions. The external comments were taken into consideration in drafting the *State of the Science Report*. The health screening assessment included here is an update of the *State of the Science Report*.

This screening assessment includes consideration of information on chemical properties, hazards, uses and exposure. 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 January 2010 for ecological sections of the document and September 2009 for human health sections of the document. Also, Canadian monitoring studies, initially reported from draft reports, were updated in this assessment based on finalized reports published in 2010, and another Canadian monitoring study published in 2012, has been included. In addition, an industry survey was conducted in

[2]A determination of whether one or more of the criteria of section 64 are met is based upon an assessment of potential risks to the environment and/or to human health associated with exposures in the general environment. For humans, this includes, but is not limited to, exposures from ambient and indoor air, drinking water, foodstuffs, and the use of consumer products. A conclusion under CEPA 1999 is not relevant to, nor does it preclude, an assessment against the hazard criteria specified in the *Controlled Products Regulations*, which is part of the regulatory framework for the Workplace Hazardous Materials Information System [WHMIS] for products intended for workplace use. Similarly, a conclusion based on the criteria contained in section 64 of CEPA 1999 does not preclude actions being taken under other sections of CEPA 1999 or other Acts.

2001 through a *Canada Gazette* notice issued under authority of section 71 of CEPA 1999 (Canada 2001). This survey collected data on the Canadian manufacture and import of substances selected for the DSL screening assessment pilot project (Environment Canada 2001a). Key studies were critically evaluated; modelling results may have been used to reach conclusions. When available and relevant, information presented in hazard assessments from other jurisdictions was considered. This screening assessment does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies and lines of evidence pertinent to the conclusion.

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.

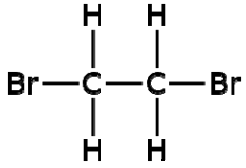
This final screening assessment was prepared by officials in the Existing Substances Programs at Health Canada and Environment Canada. As mentioned above, the *State of the Science Report* for a screening health assessment was also previously externally reviewed. The ecological component of this assessment has undergone external written scientific peer review/consultation and comments received were considered in the production of this report. Comments on the technical portions relevant to human health were received from Ms. Joan Strawson, Toxicology Excellence for Risk Assessment, Dr. Michael Jayjock, The LifeLine Group, and Dr. Susan Griffin, U.S. Environmental Protection Agency (EPA). Additionally, the draft of this screening assessment was published on December 16, 2011, subject to a 60-day public comment period and to commenting via the OECD Cooperative Chemicals Assessment Programme. Although external comments were taken into consideration, the final content and outcome of the screening assessment remain the responsibility of Health Canada and Environment Canada.

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

Substance Identity

Information on the identity of 1,2-dibromoethane is presented in Table 1.

Table 1.Substance identity for 1,2-dibromoethane

CAS RN	106-93-4
DSL name	Ethane, 1,2-dibromo-
National Chemical Inventories names	1,2-Dibromoethane (DSL, ECL, EINECS) Ethane, 1,2-dibromo- (AICS, ASIA-PAC, DSL, ENCS, NZIoC, PICCS, SWISS, TSCA) Ethylene dibromide (PICCS)
Other names	Aadibroom, Bromofume, α,β-Dibromoethane, α,ω-Dibromoethane, Ethylene dibromide,
Chemical group (DSL stream)	Discrete organics
Major chemical class or use	Alkanes
Major chemical subclass	Halogenated alkanes
Chemical formula	$C_2H_4Br_2$
Chemical structure	
SMILES	C(CBr)Br
Molecular mass	187.86 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; NZIoC, New Zealand Inventory of Chemicals; PICCS, Philippine Inventory of Chemicals and Chemical Substances; SMILES, Simplified Molecular Input Line Entry Specification; SWISS, Swiss Giftliste 1 and Inventory of Notified New Substances; TSCA, *Toxic Substances Control Act* Chemical Substance Inventory.
Source: National Chemical Inventories (2006).

Physical and Chemical Properties

Physical and chemical properties identified for 1,2-dibromoethane are summarized in Table 2 below.

Table 2. Physical and chemical properties of 1,2-dibromoethane

Property[1]	Type	Value[2]	Temperature
Melting point (°C)	Experimental	9.9	–
Boiling point (°C)	Experimental	131.6	–
Vapour pressure (Pa)	Experimental	1493 (11.2 mmHg)	25°C
Henry's Law constant ($Pa \cdot m^3/mol$)	Experimental	65.9 (6.50×10^{-4} $atm \cdot m^3/mol$)	25°C
Log K_{ow} (dimensionless)	Experimental	1.96	–
Log K_{oc}[3] (dimensionless)	Estimated	1.70 (K_{ow} method)	–
Water solubility (mg/L)	Experimental	3910	25°C
k_{OH}(cm^3/molecule per second)	Experimental	2.50×10^{-13}	25°C

Abbreviations: K_{oc}, organic carbon-water partition coefficient; k_{OH}, rate constant for gas-phase reaction with hydroxyl radical; K_{ow}, octanol-water partition coefficient.

[1] All physical and chemical properties were obtained from the Syracuse Research Corporation's PhysProp database (PhysProp 2009) except as noted.

[2] Values in parentheses are original values given in the database.

[3] The estimated value was calculated by PCKOCWIN (2008).

Sources

1,2-Dibromoethane is considered to be predominantly anthropogenic in origin, although its detection in marine air and water suggests possible natural formation as the result of macroalgal growth (Class and Ballschmiter 1988). Commercial production involves an exothermic reaction of liquid bromine and gaseous ethene in a glass reactor column packed with coiled heat exchangers (Gerhartz 1985). Synthesis of 1,2-dibromoethane is also possible using acetylene (ethyne) and hydrobromic acid as starting materials (Budavari et al. 2001).

Based on responses to a survey issued under section 71 of CEPA 1999, between 10 000 and 100 000 kg of 1,2-dibromoethane were reported to be imported into Canada in the 2000 calendar year for use as a fuel additive (Environment Canada 2001a). Such quantity indicates a considerable decrease from the 11 million kilograms reported during the period of compilation of the DSL (1984–1986).

1,2-Dibromoethane was also reported to be manufactured in or imported into Canada in the 2000 calendar year, in a mixture of a product at a low concentration (< 1% w/w); however the total quantity of 1,2-dibromoethane in the product at a low concentration (<1% w/w) in 2000 was unknown.

Uses

Based on responses to a survey issued under section 71 of CEPA 1999, 1,2-dibromoethane is solely used in Canada as a lead scavenger to prevent build-up of lead oxide in engines running on leaded gasoline (Environment Canada 2001a). Leaded gasoline was banned in cars in 1990 when the *Gasoline Regulations* came into force under CEPA (Canada 1990) and was further phased out after an amendment to the Regulations removing an exemption on leaded gasoline used in farm machinery, boats and trucks over 3856 kg in April 2008. This reduction in use of leaded gasoline coincides with the reduction in import volumes of 1,2-dibromoethane in Canada from the period of compilation of the DSL (1984–1986) to the 2000 calendar year. Presently, 99.8% of gasoline used in Canada is unleaded (Environment Canada 2009a).

The *Gasoline Regulations* do not apply to leaded gasoline for aviation. In addition, the Regulations allow for leaded gasoline use in competition vehicles (Canada 2010). Use of leaded gasoline in aircraft represented 98% of total leaded fuel in Canada in 2009, while high-performance competition vehicles represented 2% (June 2009 email from Oil, Gas and Alternative Energy Division, Environment Canada, to Existing Substances Risk Assessment Bureau, Health Canada; unreferenced). Leaded aviation gasoline represents a small percentage (approximately 1.5%) of total aircraft fuel in Ontario (Patriarche and Campbell 1999).

1,2-Dibromoethane was introduced worldwide as a soil and grain fumigant in 1946. Canada and the United States discontinued its use in pesticide products in 1984, and it was subsequently banned as an agricultural pesticide in member states of the European Union and many other countries (Packer 1980; UNEP and FAO 2003; PPDB 2009). There is evidence that 1,2-dibromoethane may still be applied by some individual beekeepers in Greece to control moth infestations in honeycombs (Tananaki et al. 2005, 2006). In addition, 1,2-dibromoethane may be used as a wood preservative against pest damage in Australia, and therefore post-application residues of 1,2-dibromoethane in imported wood and wood products may exist (NPI 2006).Today, 1,2-dibromoethane is listed under the Prior Informed Consent (PIC) procedure of the Rotterdam Convention, 1998, under the sponsorship of the United Nations Food and Agriculture Organization and the United Nations Environment Programme (UNEP and FAO 2003).

Globally, 1,2-dibromoethane is used principally as a chemical intermediate and industrial solvent. Uses include activation of magnesium in the preparation of Grignard reagents; use as a chemical intermediate in the production of plastic, latex, and vinyl bromide; a flame retardant used in modacrylic fibres; and use in the formulation of polyester dyes, resins and waxes (HSDB 2010; NTP 2005). As no chemical reaction is completely efficient, some 1,2-dibromoethane may remain as an unintended manufacturing residue in articles.

Use of 1,2-dibromoethane in consumer products has not been identified.

1,2-Dibromoethane is not expected to be present in cosmetic products in Canada, as it is not listed as an ingredient in the Cosmetic Notification System database (CNS 2009). There are no registered pesticides that contain 1,2-dibromoethane as an active ingredient or formulant in Canada (PMRA 2007), and 1,2-dibromoethane is not listed as an approved food additive under Division 16 of the *Food and Drug Regulations* (Canada [1978]).

Releases to the Environment

1,2-Dibromoethane is not reportable to Canada's National Pollutant Release Inventory (NPRI 2008). According to the United States Toxics Release Inventory Program, total on-site and off-site disposal or other releases of 1,2-dibromoethane in the 2007 calendar year amounted to 1921 kg, where 1686 kg were released as fugitive air emissions, 96 kg as point source air emissions, 0.45 kg as surface water discharges and 0 kg as land treatment (TRI 2007). These release details suggest that air may also be the primary receiving compartment of 1,2-dibromoethane releases in Canada.

1,2-Dibromoethane will primarily enter the atmosphere from fugitive emissions associated with its use as a scavenger in leaded gasoline, which converts lead oxides to lead halides (ATSDR 1992). Some of the 1,2-dibromoethane is broken down during the scavenging process and some is emitted in the non-transformed form (IPCS 1996). Methyl bromide is also emitted. According to the US EPA (1999), the 1,2-dibromoethane emissions from mobile sources were estimated to be equal to zero. Therefore, engine exhaust releases of the substance are likely negligible and most of the releases come from fugitive emissions like spills, leaks and evaporation from reservoirs containing leaded gasoline. Evaporative losses can also occur during refilling and transfers. Based on the 1999 Inventory of Toxic Air Emissions for the Great Lakes states and the province of Ontario (Great Lakes Commission 2002), releases of 1,2-dibromoethane were estimated at 10.69 pounds/year (4.86 kg) from point sources (separately identified device/process at each facility source) and at 13.34 pounds/year (6.06 kg) for area sources (aggregation of similar or identical devices/processes within a defined area) for a total of 24.03 pounds (10.92 kg) released in 1999. No other anthropogenic release information in Canada has been found for 1,2-dibromoethane.

In addition, 1,2-dibromoethane appears to be formed naturally by microalgae growth and has been detected in ocean waters and air (IRIS 2002). Laturnus (1996) mentions that Arctic brown, red and green macroalgae release volatile halogenated organic compounds including 1,2-dibromoethane. The extent of the contribution of these natural sources to global emissions is unknown. Class and Ballschmiter (1988) found baseline concentrations of 1,2-dibromoethane in air (20 ng/m^3) and in marine waters (0.02 ng/L) collected from open areas of the North and South Atlantic Ocean. The source of the compound could be the natural production by algae and/or the anthropogenic emissions.

Environmental Fate

Environmental fate analysis integrates information on the chemical behaviour of the substance with the properties of the receiving environment. The objective of fate analysis is to determine the multimedia distribution of the substance after its release into the environment. This includes consideration of the persistence and bioaccumulation of the substance in the environment.

Based on its physical and chemical properties (Table 2), the results of Level III fugacity modelling (Table 3) suggest that 1,2-dibromoethane is expected to predominantly reside in air, water or soil depending on the compartment of release.

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

	Percentage of substance partitioning into each compartment			
Substance released to:	**Air**	**Water**	**Soil**	**Sediment**
Air (100%)	93.7	5.28	0.90	0.072
Water (100%)	13.7	85.9	0.141	0.327
Soil (100%)	14.4	6.54	79	0.025

If released to air, a high amount of the substance is expected to reside in air (see Table 3 above). Based on the high vapour pressure of 1493 Pa and the moderate Henry's Law constantof65.86 $Pa \cdot m^3/mol$, 1,2-dibromoethane is volatile. Therefore, if released solely to air, it will tend to reside in this compartment (~94%, see Table 3).

If released into water, 1,2-dibromoethane is expected to weakly adsorb to suspended solids and sediment based upon its low log K_{oc} value of ~1.70. Volatilization from water surfaces is expected to be a moderate fate process based upon this compound's experimental Henry's Law constant. Thus, if water is a receiving medium, 1,2-dibromoethane is expected to mainly reside in water and to some extent partition to air (see Table 3).

If released to soil, 1,2-dibromoethane is expected to have moderate adsorptivity to soil and is expected to be fairly mobile based upon its estimated log $K_{oc.}$ Volatilization from moist soil surfaces seems to be a moderate fate process based upon its experimental Henry's Law constant. This chemical may volatilize from dry soil surfaces based upon its high vapour pressure. Therefore, if released to soil, 1,2-dibromoethane will mostly reside in this environmental compartment, and also partition to water and air, as illustrated by the results of the Level III fugacity modelling (see Table 3).

These results represent the partitioning of the substance in a hypothetical evaluative environment resulting from intermedia partitioning, and loss by both advective transport (out of the modelled region) and degradation/transformation processes. The partitioning values shown in Table 3 represent the net effect of these processes under conditions of continuous release when a non-equilibrium "steady-state" has been achieved.

In addition, the Transport and Persistence Level III Model (TaPL3) version 3 (TaPL3 2000) has been used to estimate a characteristic travel distance (CTD) for 1,2-dibromoethane in air, defined as the maximum distance traveled in air by 63% of the substance.. The CTD of the substance was 51 022 km. Furthermore, Beyer et al. (2000) have defined 3 classes estimating the potential for long-range transport in air according to the CTD: class 1 (long CTD) > 2000 km; class 2 (intermediate CTD) 700-2000 km and class 3 (short CTD) < 700 km. Therefore, 1,2-dibromoethane belongs to the class 1 and is considered to have a high potential for long-range transport in air.

Persistence and Bioaccumulation Potential

Environmental Persistence

1,2-Dibromoethane degrades very slowly in the atmosphere. It degrades by reaction with photochemically produced hydroxyl radicals, with a half-life of 64 to 69 days (IUCLID 2000). A half-life of 138 days was calculated by Qiu et al. (1992) in the troposphere. According to Howard et al. (1991), the photo-oxidation half-life in air is between 10.7 and 107 days.

1,2-Dibromoethane has been found to degrade both aerobically and anaerobically (ATSDR 1992; Falta et al. 2005). In surface waters, the main removal process for 1,2-dibromoethane is by volatilization, with a half-life within 1 to 5 days (IUCLID 2000) and up to 16 days (ATSDR 1992). 1,2-Dibromoethane is not expected to readily volatilize from water; however, it can evaporate from the free-phase gasoline (Falta et al. 2005). Little degradation of 1,2-dibromoethane occurs through direct photolysis in water, as evidenced by the half-life greater than 1 year (IUCLID 2000).

In groundwater, where volatilization is not possible, studies have shown that 1,2-dibromoethane can persist for years (Pignatello and Cohen 1990). In Florida groundwater, the substance has been determined to have a chemical half-life of 1.5 to 2 years at 22ºC (Weintraub et al. 1986). In addition, 1,2-dibromoethane tends to be mobile in groundwater due to its low octanol-water partition coefficient (Falta et al. 2005). Hydrolysis is the major mode of degradation, giving ethylene glycol and bromide ion (Weintraub et al. 1986). In the laboratory, Vogel and Reinhard (1986) estimated a hydrolysis half-life for 1,2-dibromoethane of 2.5 years in water at 25ºC and pH 7. Half-lives as long as 354 days to 13.2 years are reported for the water compartment in IUCLID (2000). Finally, Howard et al. (1991) reported a half-life interval of 28 to 180 days for surface waters and of 19.6 to 120 days for groundwater. These values are lower than the other sources possibly because of the influence of biotic degradation in addition to abiotic degradation. As a result of its hydrolytic stability and the limited biological activity in subsurface soils, 1,2-dibromoethane leached to groundwater is expected to persist for years (ATSDR 1992).Uncertainty about the mechanism and rates of biotic and abiotic degradation poses a challenge to the understanding of the subsurface fate and transport of this substance (Falta et al. 2005).

In soils, 1,2-dibromoethane is used as a fumigant, and most of the substance is expected to be rapidly lost by volatilization to the atmosphere and leaching to surface waters and groundwater (IPCS 1996). According to results from a study on biodegradation of 1,2-dibromoethane by soil microorganisms, the substance was almost completed degraded within 1 week; however, a small fraction may persist in topsoil for up to several years (Pignatello 1986). It may be due to that the substance could react with nucleophilic O or S groups on soil organic matter, developing any covalent attachment. According to Walton et al. (1989), the degradation half-lives are 3.1 and 1.9 days, in silt loam and sandy loam, respectively.

Partitioning to sediment is not expected to be an important process in the environment because of the low sorption potential, high vapour pressure, and high water solubility for 1,2-dibromoethane. This was shown in the results of the Level III fugacity modelling where the proportion of the substance in sediments at equilibrium is very low (0.1%). For these reasons, persistence in sediments has not been assessed.

Based on the empirical data available and calculated values, 1,2-dibromoethane meets the persistence criteria in air (half-life in air ≥ 2 days) and water (half-lives in water ≥ 182 days) but does not meet the criteria for soil (half-life in soil ≥ 182 days) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential for Bioaccumulation

An experimental log K_{ow} value of 1.96 for 1,2-dibromoethane suggests that this chemical has low potential to bioaccumulate in biota (see Table 2).

Bioconcentration factor (BCF) data exist in the literature, but no bioaccumulation factor (BAF) data have been found for 1,2-dibromoethane. BCF values for this substance range from < 1 to 20. Two key studies are reported herein.

A mean BCF value of 2.7 was found for a nematode, *Aphelenchus avenae* (Marks et al. 1968). Individuals were exposed for 30 minutes at 4°C and 20°C to the following three concentrations of 1,2-dibromoethane: 488, 996 and 1991 mg/L. The authors also reported BCF values of 6, 9 and 20 for other nematode species: *Pellodera* sp., *Tylenchulus semipenetrans* and *Anguina tritici*, respectively. Carp (*Cyprinus carpio*) exposed to an aqueous solution containing 1,2-dibromoethane at 15 and 150 µg/L had a BCF ranging from < 3.5 to 14.9 and 1.6 to 3.2, respectively (CITI 1992).These low BCF values indicate that 1,2-dibromoethane does not bioconcentrate to a great extent in organisms. Therefore, the compound is not expected to bioaccumulate in organisms or biomagnify in food chains.

Based on the empirical data available, 1,2-dibromoethane does not meet the bioaccumulation criterion (BCF and BAF ≥ 5000) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential to Cause Ecological Harm

Ecological Exposure Assessment

1,2-Dibromoethane has been detected in ambient air, soils, groundwater and food (ATSDR 1992). Environmental concentrations in the United States have been reported frequently, but Canadian data are scarce. Where available, Canadian ambient environmental concentrations were used in the determination of predicted environmental concentrations (PECs) for the purpose of characterizing ecological risk. Where recent Canadian data were unavailable, predictive models have been used. It should be noted that many concentrations reported in this section were measured in the 1970s and 1980s, when 1,2-dibromoethane was widely used. As it is no longer widely used, this has been taken into account when selecting environmental concentrations to be used as PECs. The details of measured and predicted environmental concentrations of 1,2-dibromoethane are summarized in Appendices 2 to 6.

In Canada, 1,2-dibromoethane is routinely monitored in air, but not in water, soil or sediments. Air measurements in Canada for the years 2004–2009 indicated a maximum concentration of 60 ng/m^3 (Environment Canada 2009b), a decrease from the previously measured maximum level of 143 ng/m^3 in 2002 (Environment Canada 2004). Additionally, a conservative air concentration of 1,2-dibromoethane was estimated with the SCREEN3 model (SCREEN3 1995); the resulting value was 377.4 ng/m^3 (see Appendix 2). This more conservative modelled value was selected as the PEC for air.

For surface waters, the predictive model ChemSim (2003) was run. ChemSim is a geographic information system-based aquatic exposure estimation model designed to estimate the dispersion and transport of substances released to watercourses. ChemSim combines estimated release quantities with information regarding the receiving watercourses to estimate aquatic exposure values (see Appendix 4). The following assumptions were used:

- The effluent release type was continuous from a steady point source.
- 1% of the total amount reported annually by a company was assumed to be the release quantity at one plant or divided among eight facilities. Of this, 10% was assumed to be released surface water either directly or via a sewage treatment plant.
- 10, 25 and 50 percentile flow estimates were considered for the receiving river.
- Sewage treatment plant (STP) removal rates were used for some of the simulations.

The only reported measurement for groundwater in Canada is 5.0 µg/L (Environment Canada 2001b).

For soils, the highest Canadian concentration was found at a depth of 3 m (see Appendix 6). However, this concentration was not used as the PEC since the shallow subsurface of soil is the most representative zone where soil invertebrates live. Thus, the

reported soil measurement of 8×10^{-2} mg/kg dry weight measured in surface soil 0.2-0.76 m deep was used (Environment Canada 2001b).

Ecological Effects Assessment

Several studies relating to acute and chronic toxicity of 1,2-dibromoethane to fish, soil and aquatic invertebrates, and microorganisms were identified and critically reviewed. Studies with the most sensitive and reliable results are discussed below. The appropriate median lethal concentration (LC_{50}) values were selected as critical toxicity values (CTVs) for the purposes of ecological risk characterization.

Chronic toxicity of 1,2-dibromoethane was evaluated in the fruit fly larvae, *Drosophila melanogaster* (Chroust et al. 2007). Fruit flies, kept in glass bottles, were exposed to 1,2-dibromethane by inhalation for 48 hours to induce chronic effects. Ambient concentration of the substance in the experimental bottles was monitored by a gas chromatograph every 12 hours; however, these measurements were not provided. Rather, LC_{50} values resulting from exposure were expressed in µg/L. For this reason, the LC_{50} value for *Drosophila melanogaster* could not be used in the environmental risk assessment since the risk quotient (RQ) could not be calculated for this exposure scenario.

Holcombe et al. (1995) conducted a flow-through 96-hour acute test using larval Japanese medaka (*Oryzias latipes*). Concentrations of 1,2-dibromoethane were measured throughout the course of experiment. The measured 96-hour LC_{50} was 32.1 mg/L.

The carcinogenicity of the substance towards the same species was investigated by Hawkins et al. (1998). Juvenile fish were chronically exposed to three concentrations in a flow-through system for 73 to 97 days. The measured concentrations in water in the low, intermediate and high concentration groups were 0.13mg/L, 6.20mg/L and 18.58 mg/L, respectively. Samples were taken for histological examination at 24, 36 and 58 weeks from the beginning of the tests. 1,2-Dibromoethane was clearly carcinogenic to the Japanese medaka in the intermediate and high concentration groups, causing: (i) hepatocellular adenomas and carcinomas, (ii) cholangiomas, (iii) cholangiocarcinomas and (iv) gall bladder papillary adenomas and adenocarcinomas.

The authors also evaluated the toxic effects during an approximately 90-day exposure period, by looking at mortalities, fecundity, viable embryos, hatch, fry survival, and abnormal embryos (Hawkins et al. 1998). Toxic responses varied and the trends were not associated with the concentration levels of 1,2-dibromoethane in the test solutions. For the overall survival and fecundity (measured by the total number of viable eggs produced during a 23-day collection period), the intermediate concentration group demonstrated a lower survival (46% of mortality) and lower fecundity (0%) than the low concentration group (0.3% of mortality and 59% of fecundity) and high concentration group (1.1% of mortality and 2% fecundity). Fry survival rate was much lower in the low concentration group (43%) than the control groups (91.9% for the static control, and 84.2% for the

flow-through control), while data was not available for the intermediate and high concentration groups. For the gross abnormal embryos, the low concentration group demonstrated a higher incidence (6.8%)than both control groups, however data were not available either for the intermediate and high concentration groups.

Based on the observation from the study, the flow-through control group didn't demonstrate significantly more toxic effect than the static control, and 0.034 mg/L was considered as no-observed-effect-concentration (NOEC). The very next exposure level, 0.133 mg/L used in the low concentration group, was then considered as the lowest-observed-effect-concentration (LOEC). The resulting maximum acceptable toxicant concentration (MATC), i.e., the concentration falling between the highest concentration showing no effect and the next higher concentration showing a toxic effect when compared to the controls, was 0.067 mg/L, calculated as the geometric mean between the NOEC and LOEC values in the study.

Kszos et al. (2003) evaluated the acute toxicity of 1,2-dibromoethane on three species: larval fathead minnow (*Pimephales promelas*), *Daphnia magna* and *Ceriodaphnia dubia* in a static closed system. The concentrations of 1,2-dibromoethane were monitored during the experiments. The 48-hour LC_{50} for *C. dubia* was 3.61 mg/L, and 6.5 mg/L was reported for *D. magna.* The 96-hour LC_{50} for the fathead minnow was 4.30 mg/L.

Reliable data on aquatic algae were not identified.

Reliable acute or chronic toxicity data have not been found either for soil organisms. Therefore, a quantitative structure-activity relationship (QSAR) model was used to estimate a 14-day LC_{50} value of 330 mg/L for the earthworm (ECOSAR 2008).

No studies have been found for benthic organisms. Had they been available, they would not have been relevant for this assessment, given that 1,2-dibromoethane is unlikely to partition to sediments.

No ecological studies were identified for terrestrial wildlife.

Laboratory studies on mammals have been conducted with 1,2-dibromoethane to evaluate the potential for impacts to human health; relevant data from these studies are presented in the Potential to Cause Harm to Human Health section of this screening assessment.

Characterization of Ecological Risk

The approach taken in the ecological risk characterization is to examine various supporting information and develop conclusions based on a weight-of-evidence approach. Particular consideration has been given to risk quotient analyses, persistence, inherent toxicity, environmental realism of the exposure scenario used to derive PECs, and widespread occurrence in the environment. Endpoint organisms have been selected based on analysis of exposure pathways. For each endpoint, a conservative (reasonable worst-case) PEC and a predicted no-effect concentration (PNEC) are determined. The

PNEC is arrived at by selecting the lowest CTV for the relevant organism and dividing it by an application factor appropriate for the data point. A risk quotient (PEC/PNEC) is calculated for each of the endpoint organisms in order to contribute to the characterization of ecological risk in Canada. A summary of data used in the ecological risk characterization of 1,2-dibromoethane is presented in Table 4.

Assessment endpoints were evaluated in a few different exposure scenarios. CTVs were selected for the most sensitive endpoints from pelagic (aquatic) organisms and soil organisms. CTVs were selected as the lowest critically reviewed literature value for each group of organisms. For pelagic organisms, acute and chronic data were used. Since no reliable acute or chronic toxicity data were found for soil organisms, a modelled value was selected for the aquatic compartment. No studies were identified for benthic organisms, and they are not considered further in this assessment. The CTVs for each group of organisms are presented in Table 4 below.

Table 4. Summary of data used in the risk characterization of 1,2-dibromoethane

Assessment endpoint	Organism	CTV	Application factor	PNEC	PEC	Risk quotient (PEC/ PNEC)
Pelagic organisms (reproduction)	Japanese medaka (*Oryzias latipes*)	67 µg/L (chronic)[a]	10	6.7 µg/L	5.0 µg/L (groundwater, see Appendix 4)	0.75
					2-3 µg/L[b] (surface water, see Appendix 4)	0.30-0.45[b]
Soil organisms (mortality)	Earthworm (modelled value)	329.75 mg/kg dry weight for soil [c]	100	3.3 mg/kg dry weight for soil	8×10^{-2} mg/kg dry weight (industrial site, see Appendix 6)	2.4×10^{-2}
					3.9×10^{-4} mg/kg dry weight (non-industrial site, see Appendix 6)	1.2×10^{-4}

[a] Hawkins et al. 1998.

[b] Based on ChemSim (2003) simulations with realistic scenarios: the total amount reported is divided among eight facilities. Concentrations and risk quotients calculated at a distance of 50 m downstream from the point of discharge with 10% flow and with or without sewage treatment plant (STP) removal. At a distance of 10 m from the point of discharge, risk quotients are still below 1.

[c] CTV for soil organisms was calculated using modelled an LC_{50} value of 329.75mg/L for earthworm (ECOSAR 2008) with application of the equilibrium partitioning equation (EqP) (Environment Canada 1996) as follows: $CTV_s = CTV_i \times f_{oc} \times K_{oc}$ where:
CTV_i = critical toxicity value for invertebrates (329.75mg/L)

f_{oc} = mass fraction of organic carbon in the solid phase (0.02 default value for soil)
K_{oc} = organic carbon partition coefficient ($10^{1.7}$ = 50, log K_{oc} =1.70, Table 2, $10^{1.7}$ = 50 is an average from Table 2)

For pelagic organisms, Japanese medaka (*Oryzias latipes*) was the most sensitive to 1,2-dibromoethane, with a maximum acceptable tolerable concentration of 67 µg/L for chronic effects (reproduction). This value was chosen as the CTV; it may be most representative and realistic of the threshold where chronic effects might occur. The CTV was divided by a factor of 10 to account for extrapolation from laboratory to field conditions and interspecies and intraspecies variations in sensitivity, resulting in the PNEC of 6.7 µg/L.

For the characterization of risk to pelagic organisms, PEC values were selected to represent exposure from surface waters and from groundwater. For surface waters, the lowest values predicted by ChemSim simulation (ChemSim 2003) using a point source release scenario were used as PEC. For groundwater, it is assumed that the contaminated groundwater will recharge surface waters; therefore, potential effects are examined using pelagic species. Thus, the measured groundwater concentration of 5.0µg/L was used as the PEC for estimating potential risk from the seepage of contaminated groundwater to surface water.

The risk quotient (RQ), (PEC/PNEC), for pelagic organisms exposed to seepage of contaminated groundwater is therefore 5.0 µg/L /6.7 µg/L = 0.75. It is thus concluded that 1,2-dibromoethane-contaminated groundwater that is released to surface water is unlikely to cause direct adverse effects on populations of pelagic organisms in Canada.

In addition to the RQ calculated above for pelagic organisms, ChemSim model simulations were done to estimate the distance downstream from point of discharge where the acute and chronic threshold for 1,2-dibromoethaneis exceeded. These simulations considered three flow estimates (10th, 25th and 50th percentile) and two loading rates (0.1% with or without STP removal) as shown in Table 5 below. The 0.1% loading rate is calculated as 1% of the total release multiplied by the proportion of release to surface waters (10%).

In order to verify impacts of acute toxic effects of 1,2-dibromoethane, the lowest acceptable acute toxicity value was used in these simulations. Kszos et al. (2003) determined a 48-hour $LC_{50}$of 3.61 mg/L for *Ceriodaphnia dubia*. An application factor of 10 was used to account for species variability, to give a threshold for acute effects of 0.361 mg/L. This acute threshold is never exceeded along the plume centreline in any of the scenarios for more than 5 m downstream from the point of discharge.

For chronic effects, the PNEC for pelagic organisms (6.7 µg/L) was used. Seven simulations were run (Table 5). The most conservative scenario (scenario 1) led to a situation where the chronic toxicity threshold is exceeded for a maximum of 755 m from the source along the plume centreline. However, it is considered very unlikely that this situation will occur because of the combination of worst-case assumptions, i.e., discharge

to a small river, low (10th percentile) flow and all of the substance used at one facility. For more realistic (less conservative, or protective) scenarios, this threshold is not exceeded for more than 100 m downstream from the point of discharge. Scenarios 6 and 7 are believed to be the most likely worst-case releases with low-flow conditions. For these, the concentrations of 1,2-dibromoethane at a distance of 50 m from the point of discharge are 3 and 2 μg/L, respectively. The RQs, calculated as PEC/PNEC, for pelagic organisms exposed to surface waters are therefore 3 μg/L/6.7 μg/L = 0.45 and 2 μg/L / 6.7 μg/L = 0.30, respectively. Even at 10 m from the point of discharge, the RQs do not exceed 1. Consequently, the impacts seem very limited.

Table 5.ChemSim modelling results for the distance downstream from point of discharge where the PNEC for 1,2-dibromoethaneis exceeded along the centreline of the plume

Run	Percentile flow	Release quantity divided among 8 facilities	STP removal	Release (kg/day)	PNEC exceeded (m)
1	10	no	no	0.075	755
2	10	no	yes	0.057	453
3	25	no	no	0.075	101
4	25	no	yes	0.057	53
5	50	no	no	0.075	13
6	10	yes	no	0.0094	8
7	10	yes	yes	0.0071	5

For soil organisms, the modelled LC_{50} value of 329.75 mg/L for the earthworm (ECOSAR 2008) was chosen as the CTV (with application of EqP equation to accommodate unit conversion from mg/L to mg/kg dw for soil), since reliable acute or chronic data were not identified. A PNEC of 3.3 mg/kg dw was derived by dividing the CTV by a factor of 10 to account for interspecies and intraspecies variations in sensitivities and by an additional factor of 10 to extrapolate from a modelled to an empirical value.

Two PEC values are used to characterize risk to soil organisms: one representative of industrial sites at 8×10^{-2} mg/kg dw and one for outside of non-industrial sites at 3.9×10^{-4} mg/kg dw.

The calculated RQs are 2.4×10^{-2} for industrial sites and 1.2×10^{-4} for non-industrial locations. It is therefore concluded based on the maximum measured concentrations in soil on industrial (as the worst-case scenario) as well as non-industrial sites that 1,2-dibromoethane is not likely to cause direct adverse effects on soil organisms in Canada. Furthermore, according to a report on environmental conditions at a chemical plant located in Ontario (Environment Canada 2001b), there is no evidence of contamination in either the shallow or deeper groundwater from monitored wells located in the periphery of the main chemical plant.

In summary, the risk quotient analysis indicates that 1,2-dibromoethane released to the Canadian environment is unlikely to cause adverse effects to pelagic and soil organisms.

Uncertainties in Evaluation of Ecological Risk

1,2-Dibromoethane is used as a scavenger of lead antiknock agents in leaded gasoline that is still used in Canada for some specific purposes, namely in piston engine aircrafts and competition vehicles. Based on its properties and empirical measurements, 1,2-dibromoethane is expected to be found in air, water and soil, but not in sediments. This substance has been found to be persistent in air and water, and has a high potential for long-range transport in air. It is not bioaccumulative. The confidence for the conclusions reached in this assessment is high. However, a few uncertainties are present and affect this assessment.

In the absence of measured values for releases of 1,2-dibromoethane other than for air, the proportions had to be estimated considering the uses and the chemistry of the substance. The estimated proportion of release to surface waters (10%) was used for simulations with ChemSim software.

For soil toxicity, no reliable empirical data have been found. In the absence of empirical data, a modelled QSAR value has been considered. Because of these uncertainties, conservative assumptions were made and high application factors were used.

No monitoring data for 1,2-dibromoethane have been found for soil and groundwater near storage tank systems in Canada. However, since presently in Canada there is limited approved use of leaded gasoline for piston engine aircraft (AvGas) and racing fuels for competition vehicles based on an exemption in the *Gasoline Regulations* under the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the numbers of tanks containing 1,2-dibromoethane and that are potentially leaking should be limited.

Potential to Cause Harm to Human Health

Exposure Assessment

Environmental Media and Food

Empirical data were identified for environmental concentrations of 1,2-dibromoethane in raw and treated drinking water, soil, indoor air, ambient air, and food and beverages in Canada. Empirical data were also identified for environmental media in other locations. All studies identified containing empirical data for each environmental medium are summarized in Appendices 2–6.

In a recent study of contaminant levels in outdoor air conducted as part of the ongoing National Air Pollution Surveillance (NAPS) network, 1,2-dibromoethane was detected in only 7 of 1896 (or approximately 0.4%) samples, at a maximum concentration of 0.013

μg/m^3, collected from 43 Canada-wide sites during the period January–December 2008 (NAPS 2008). The substance was detected near the method detection limit (0.025μg/m^3) in a limited number of samples in outdoor air in Halifax in 2009 (Health Canada 2012). In 2007 in Regina, Saskatchewan and in 2005-2006 in Windsor, Ontario, 1,2-dibromoethane was not detected in outdoor air in either the summer or winter season (above the detection limits of 0.054 μg/m^3 and 0.123-0.15 μg/m^3, respectively) (Health Canada 2010b).

1,2-Dibromoethane was not detected in indoor air of residences in the summer and winter seasons of 2005 and 2006 in Windsor, Ontario, with detection limits of 0.123-0.15μg/m^3 (Health Canada 2010b). In a 2007 study in Regina, Saskatchewan, the maximum 1,2-dibromoethane concentration in indoor air of 0.080 μg/m^3 was measured in only one of 400 home samples at a detection limit of 0.054 μg/m^3 (Health Canada 2010a). In addition, the substance was not detected in 643 indoor air samples in a study conducted in Halifax in 2009 above the detection limit of 0.025 μg/m^3 (Health Canada 2012).

During the summer and winter seasons of 2005, a maximum concentration of 1,2-dibromoethane in personal breathing-zone air of 0.190 μg/m^3 was measured in Windsor, Ontario (Health Canada 2010b). Participants wore padded backpacks with samplers that provided concentrations of selected volatile organic compounds averaged over a 24-hour period for five consecutive days (Health Canada 2010b). Less than 0.5% of the samples were above the detection limit of 0.123 μg/m^3.

In an expansive survey of raw, treated and distribution water in Ontario collected between January 1, 2005, and December 31, 2006, 1,2-dibromoethane was not detected in any sample (detection limit = 0.1 μg/L) (Ontario MOE 2006). Other Canadian studies conducted between 2002 and 2008 did not detect 1,2-dibromoethane in drinking water (City of Victoria 2008; Ville de Montréal 2006; NSEL 2005; COWQS 2003). A summary of drinking water data obtained from sites distributed across the United States provided by the United States Geological Survey over a sampling period of 1985–2001 revealed median 1,2-dibromoethane levels of "< 0.10 μg/L" and "< 0.04 μg/L" for public wells and domestic wells, respectively (Zogorski et al. 2006).

Data on 1,2-dibromoethane concentrations in food in Canada were identified. Ten flour samples in 1984 in Saskatoon, Saskatchewan, contained a maximum concentration of 405.3 μg/kg (McKay 1986). However, 1,2-dibromoethane was discontinued as an agricultural pesticide in Canada in 1984 (UNEP and FAO 2003), and there have been no reports of concentrations in cereals or cereal products since then in Canada. Residuals of 1,2-dibromoethane in foodstuffs are not currently monitored by the Canadian Food Inspection Agency (August 2009 email from Canadian Food Inspection Agency to Existing Substances Risk Assessment Bureau, Health Canada; unreferenced). In general, processing, cooking, baking and market circulation of food items decrease residual levels of 1,2-dibromoethane (Konishi et al. 1986). The ban on the use of 1,2-dibromoethane as an agricultural pesticide in North America and Europe (UNEP and FAO 2003) has reduced the likelihood of exposure of the Canadian population to the chemical in domestic and imported food. While a few countries that still apply 1,2-dibromoethane to

foodstuffs have been identified—namely, five countries identified in a search of 90 countries in the Homologa database (Tanzania, South Africa, India, Zimbabwe and Zambia) and some honey producers in Greece (Tananaki et al. 2005, 2006), the contribution of these foods to the Canadian food supply is considered minimal. As the majority of food studies identified had sampling periods in the 1980s when substantial global use of 1,2-dibromoethane as a pesticide may have still occurred, the data are not considered applicable to the current context.

A study released by the United States Food and Drug Administration (US FDA) in 2003 identified a 1,2-dibromoethane concentration of 13 µg/kg in one sample of imported sweet cucumber pickle (US FDA 2003). In studies in Greece with sampling periods from 2003 to 2005, the maximum concentration of 1,2-dibromoethane in bulk honey was 331.2 µg/kg (Tananaki et al. 2005, 2006). Despite a recommendation by the Greek Hellenic Food Authority to beekeepers to abandon use of 1,2-dibromoethane as a moth control agent, some individual beekeepers may still use it (Tananaki et al. 2006).

In a 1993 Canadian study, the maximum 1,2-dibromoethane concentrations detected in urban parkland and rural parkland soils in Ontario in the early 1990s were 0.032 ng/g and 0.390 ng/g, respectively (OMEE 1993). 1,2-Dibromoethane was discontinued as an agricultural pesticide in Canada in 1984.

Based on the current use pattern of 1,2-dibromoethane and the recent Canadian monitoring data, particularly for air, exposure to the general population is expected to be low to negligible.

Consumer Products

No consumer products containing 1,2-dibromoethane were reported in responses to the section 71 survey issued under CEPA 1999 (Environment Canada 2001a), and no data were identified on exposure to 1,2-dibromoethane through use of consumer products. Therefore, exposure to 1,2-dibromoethane from use of consumer products is not expected.

Confidence in Exposure Assessment

Confidence in the environmental exposure database is considered to be moderate while for the food database, it is considered to be low. Empirical data were obtained for all environmental media, and the data were specific to Canada; however, the information for foodstuffs was not specific to Canada. Given current use patterns of the substance in Canada and internationally, and on the sporadic detection of 1,2-dibromoethane in monitoring studies, there is confidence that actual exposures to the general population are low to negligible.

Health Effects Assessment

Appendix 7 provides an overview of the health effects information for 1,2-dibromoethane.

The International Programme on Chemical Safety (IPCS 1996) concluded that 1,2-dibromoethane is a carcinogen in rodents and a potential human carcinogen. The International Agency for Research on Cancer (IARC 1999) concluded that there is inadequate evidence in humans and sufficient evidence in experimental animals for the carcinogenicity of 1,2-dibromoethane; 1,2-dibromoethane was classified as probably carcinogenic to humans (Group 2A). In addition, it is classified in the European Union as Carcinogen Category 1B, with the hazard statement "May cause cancer" (European Union 2008). These conclusions were based on significant increases in tumour incidences in rats and mice exposed via multiple routes. Significant increases in the incidences of squamous cell carcinomas of the forestomach were observed in male and female rats administered 1,2-dibromoethane by gavage at 37 mg/kg-bw per day or more for up to 61 weeks (NCI 1978). Rats were exposed by inhalation to 0, 10, or 40 ppm (equivalent to 0, 77 or 308 mg/m^3) for 88–103 weeks. There were significant increases in the incidence of nasal cavity carcinomas at high doses (males: controls, 0/50; high dose, 21/50; females: controls, 0/50; high dose, 25/50), adenocarcinomas at both doses (males: controls, 0/50; low dose, 20/50; high dose, 28/50; females: controls, 0/50; low dose, 20/50; high dose, 29/50) and adenomas at low doses (males: control, 0/50; low dose, 11/50; females: controls, 0/50; low dose, 11/50). In addition, significant increases in the incidences of mammary gland fibroadenomas in females and tunica vaginalis mesotheliomas and nasal cavity adenomatous polyps in males were reported (NTP 1982). Dermal exposure of mice to 25 or 50 mg/day (equivalent to 357 or 714 mg/kg-bw per day, respectively; as per Health Canada 1994) for up to 594 days resulted in an increased incidence of papillomas of the lungs in female mice (and a significant increase in the incidence of skin papillomas and carcinomas at 50 mg/day) (Van Duuren et al. 1979). In each of these bioassays, these significant increases were observed at the lowest exposure level tested and higher.

1,2-Dibromoethane was genotoxic in a large number and variety of assays, including *in vivo* deoxyribonucleic acid (DNA) binding and DNA damage in mice and rats and mammalian cell mutagenicity assays and *in vitro* mutagenicity, clastogenicity and DNA damage assays (see Appendix 7).

The United States Environmental Protection Agency (US EPA) has derived cancer potency estimates for 1,2-dibromoethane. A cancer oral slope factor of 1.8 $(mg/kg\ bw/day)^{-1}$ was derived, based on the incidence of forestomach tumours in male rats in the oral carcinogenicity study mentioned above, but this "…factor should not be used with exposures greater than approximately 0.5 mg/kg/day, since the observed dose-response would not be expected to continue linearly above this estimated lifetime-equivalent exposure level." An inhalation cancer slope factor of 0.6 $(mg/m^3)^{-1}$ was estimated based on the incidence of nasal cavity tumours in male rats in the inhalation carcinogenicity study mentioned above, but this "…unit risk should not be used with exposures greater than

0.023 mg/m^3 (0.18 ppm), because above this level, the dose-response is not linear." (see US EPA 2004). Several uncertainties limit the confidence in use and derivation of these slope factors, such as the high mortality limiting the duration of the study and close dose spacing in the oral rat study, and high mortality in both rats and mice, especially in the high-dose groups, in the inhalation carcinogenicity studies (see Appendix 7).

Cancer potency factors were also derived by Health Canada. A lowest tumorigenic dose 05 (TD_{05}) of 0.04 mg/kg-bw per day was calculated, based on the incidence of squamous cell carcinomas in the forestomach of male rats in the oral carcinogenicity study mentioned above. The TD_{05} is defined as the total intake associated with a 5% increase in incidence or mortality due to tumours scaled, where appropriate, to reflect interspecies variations. Although the exposure levels and the overall duration of the oral rat study were reduced due to excessive mortality, note that the derived TD_{05} is based on the low doses. A highest tumorigenic concentration 05 (TC_{05}) was not calculated due to the high mortality in both rats and mice, especially in the high-dose groups, in the inhalation carcinogenicity studies mentioned above. The TC_{05} is defined as the concentration, generally in air, associated with a 5% increase in incidence or mortality due to tumours (Health Canada 1996).

Male reproductive effects are considered to be the critical non-cancer effect. In a short-term longitudinal study in male forestry workers (engaged in the application or spraying of 1,2-dibromoethane [4% by volume] emulsion), significantly decreased sperm velocity and semen volume were observed in subjects exposed via inhalation to 1,2-dibromoethane levels of 0.46 mg/m^{3}or greater (occupational time-weighted average) in conjunction with dermal exposure (Schrader et al. 1988; also cited in IPCS 1996). The authors did not report exposure to any other chemicals in the forestry workers engaged in the application or spraying activities. Longer-term exposure to 1,2-dibromoethane ranging from mean concentration of 88 ppb to peak exposure of up to 262 ppb (0.68 to 2.0 mg/m^3; IPCS 1996) in the fumigation workers caused significant reductions in sperm count, viable sperms and increase in number of abnormal sperms (Ratcliffe et al. 1987). Male reproductive effects were also observed in multiple species of experimental animals exposed to the lowest doses or concentrations tested and higher. The lowest lowest-observed-effect level (LOEL) for reproductive effects for the oral route of exposure was 2 mg/kg-bw per day based on reversible low sperm density, poor motility and altered spermatozoa morphology observed in a 2-year study in bulls (Amir and Volcani 1965). In another study, testicular atrophy was seen in male rats following long-term oral exposure (38 mg/kg-bw per day) to 1,2-dibromoethane (NCI 1978). Testicular degeneration in male rats was observed at an inhalation concentration of 77 mg/m^{3}in conjunction with other non-cancer effects, including toxic nephropathy in males, retinal atrophy and adrenal cortex degeneration in females and increases in hepatic necrosis in both sexes (NTP 1982). Similarly, the reproductive effects were reported in male or female rats following inhalation exposure to 89 or 80 ppm (equivalent to 684 or 614 mg/m^3 as per IPCS 1996) for 10 or 3 weeks, respectively. Effects in male rats included reduction in testicular weight; decreased serum testosterone levels; atrophy of testes, epididymis, prostate and seminal vesicles; and changes in reproductive behaviour.

Female rats exposed to 1,2-dibromoethane had altered estrous cycle until several days after cessation of exposure (Short et al. 1979).

Limited information was available regarding the acute effects of 1,2-dibromoethane in humans. A review of 64 cases of acute poisoning in humans reported that ingestion of 1.5 ml (estimated to be more than 3000 mg) of 1,2-dibromoethane may be fatal in humans. Effects observed included nausea, vomiting, abdominal pain and signs of hepatotoxicity, nephrotoxicity, nervous system toxicity and cardiotoxicity in male and female patients (Singh et al. 2007).

Characterization of Risk to Human Health

General population exposure to 1,2-dibromoethane is expected to be low to negligible from air based on the specialized use pattern of the substance and as the substance has not been detected (> 99% of the time) at low levels in recently conducted monitoring studies of outdoor and indoor air and personal air. As no consumer products containing 1,2-dibromoethane had been identified in Canada, consumer product exposure is not expected.

A critical effect for the characterization of risk of 1,2-dibromoethane exposure to human health is carcinogenicity, as there is evidence of carcinogenicity of 1,2-dibromoethane in rats and mice following oral or inhalation exposure. Moreover, the positive genotoxicity results reported in several *in vivo* and *in vitro* studies suggest that the potential for 1,2-dibromoethane to induce tumours through direct interaction with genetic material cannot be precluded.

On the basis of the use pattern of 1,2-dibromethane and the very limited potential for general population exposure, it is concluded that 1,2-dibromoethane is not a substance that is 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.

Uncertainties in Evaluation of Risk to Human Health

Based on the extensive dataset on carcinogenicity and *in vivo* and *in vitro* genotoxicity assays, there is high confidence in the conclusion that 1,2-dibromoethane is considered to induce tumours through direct interaction with genetic material. However, uncertainties exist regarding inter- and intraspecies variation, extrapolation of data from animals to humans and lack of data in humans for several endpoints. Based on the use pattern and extensive monitoring of 1,2-dibromoethane in outdoor and indoor air, there is confidence that exposure to the general population is low to negligible. Targeted ambient air monitoring of 1,2-dibromoethane in the vicinity of sites of its known use would reduce any remaining uncertainty in this conclusion.

Conclusion

Based on the information available with regard to the environment, it is concluded that 1,2-dibromoethane 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. Additionally, it is concluded that 1,2-dibromoethane meets the criteria for persistence but not for bioaccumulation potential as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

On the basis of the use pattern of 1,2-dibromethane and the very limited potential for general population exposure, it is concluded that 1,2-dibromoethane 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 1,2-dibromoethane does not meet one or more criteria under 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.

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Appendix 1: Robust Study Summaries for Ecotoxicity Studies

Description of the reliability evaluation

For determination of the reliability of experimental data for key ecological endpoints (i.e., inherent toxicity to aquatic organisms, bioaccumulation potential, persistence), an evaluation approach has been developed, which is analogous to that of Klimisch et al. (1997). It involves the use of a standardized Robust Study Summary form, including a scoring system to quantitatively evaluate the studies.

The Robust Study Summary (RSS) is an adaptation of the OECD Robust Study Summary templates (OECD 2009). It consists of a checklist of items or criteria relating to identity of the substance, experimental protocol or method, test organism, specific test design/conditions, ecological relevance, and results. Most items are weighted according to their criticality to the quality and reliability of the study. The most important or critical items (which describe parameters/factors that have the most direct influence on the quality of the study) have been given a higher weight (5 points), while the less critical items have been given a lower score (1 or 2 points). For each item, the evaluator must indicate whether the item has been addressed appropriately in the study by answering "yes", "no" or "non-applicable (n/a)".Specific information relating to the items is also provided the RSS as well.

Once answers to all the items have been provided in the template, an overall Robust Study Summary score for the study is calculated as:

$$\textbf{Overall Study Score (\%)} = \frac{\sum W_{Yes}}{\sum W_{Yes+No}} \times \textbf{100\%}$$

Where:
W_{Yes} = weight of applicable "Yes" answers;
W_{Yes+No} = weight of applicable "Yes" and "No" answers.

The overall score's corresponding reliability code and category is determined using the four categories adapted from the Klimisch approach and based on the score ranges as described in Table A.

Table A. Scoring Grid for Overall Study Reliability

Reliability Code	Reliability Category	Overall Study Score Range
1	High confidence	≥ 80%
2	Satisfactory confidence	60 – 79%
3	Low confidence	40 – 59%
4	Not acceptable	< 40%

Study 1

No	Item	Weight	Yes/No	Specify
1	Reference: Holcombe GW, Benoit DA, Hammermeister DE, Leonard EN, Johnson RD. 1995. Acute and long-term effects of nine chemicals on the Japanese medaka (*Oryzias latipes*). Arch Environ Contamin Toxicol 28:287-297.			
2	Substance identity: CAS RN	n/a	Y	
3	Substance identity: 1,2-dibromoethane	n/a	Y	
4	Chemical composition of the substance	2	Y	
5	Chemical purity	1	Y	
6	Persistence/stability of test substance?	1	Y	
	Method			
7	Reference	1	Y	
8	OECD, EU, national, or other standard method?	3	-	Not applicable
9	Justification of the method/protocol if a non-standard method was used	2	Y	
10	GLP (good laboratory practice)	3	-	Not applicable
	Test organism			
11	Organism identity: medaka	n/a	Y	
12	Latin or both Latin and common names reported?	1	N	
13	Life cycle age / stage of test organism	1	Y	28–43 days old for acute tests
14	Length and/or weight	1	Y	18–71 mg
15	Sex	1	N	
16	Number of organisms per replicate	1	Y	10
17	Organism loading rate	1	Y	
18	Food type and feeding periods during the acclimation period	1	Y	
	Test design / conditions			
19	Test type (acute or chronic)	n/a	Y	Both
20	Experiment type (laboratory or field)	n/a	Y	Lab
21	Exposure pathways (food, water, both)	n/a	Y	Water
22	Exposure duration	n/a	Y	Acute 96h
23	Negative or positive controls (specify)	1	Y	
24	Number of replicates (including controls)	1	Y	
25	Nominal concentrations reported?	1	Y	
26	Measured concentrations reported?	3	Y	
27	Food type and feeding periods during the long-term tests	1	Y	
28	Were concentrations measured periodically (especially in the chronic test)?	1	Y	
29	Were the exposure media conditions relevant to the particular chemical reported? (e.g., for the metal toxicity – pH,	3	Y	

	DOC/TOC, water hardness, temperature)			
30	Photoperiod and light intensity	1	Y	
31	Stock and test solution preparation	1	Y	
32	Was solubilizer/emulsifier used if the chemical was poorly soluble or unstable?	1	-	Not applicable
33	If solubilizer/emulsifier was used, was its concentration reported?	1	-	Not applicable
34	If solubilizer/emulsifier was used, was its ecotoxicity reported?	1	-	Not applicable
35	Monitoring intervals (including observations and water quality parameters) reported?	1	N	
36	Statistical methods used	1	Y	
Information relevant to the data quality				
37	Was the endpoint directly caused by the chemical's toxicity, not by the organism's health (e.g. when mortality in the control > 10%) or physical effects (e.g. "shading effect")?	n/a	Y	
38	Was the test organism relevant to the Canadian environment?	3	Y	
39	Were the test conditions (pH, temperature, DO, etc.) typical for the test organism?	1	Y	
40	Do system type and design (static, semi-static, flow-through; sealed or open; etc.) correspond to the substance's properties and organism's nature/habits?	2	Y	
41	Was pH of the test water within the range typical for the Canadian environment (6 to 9)?	1	Y	
42	Was temperature of the test water within the range typical for the Canadian environment (5 to 27°C)?	1	Y	
43	Was toxicity value below the chemical's water solubility?	3	Y	
Results				
44	Toxicity values (specify endpoint and value)	n/a	Y	
45	Other endpoints reported – e.g., BCF/BAF, LOEC/NOEC (specify)?	n/a	N	
46	Other adverse effects (e.g. carcinogenicity, mutagenicity) reported?	n/a	N	
47	***Score*: ... %**	***36/39 = 92%***		
48	***EC reliability code*:**	***1***		
49	***Reliability category (high, satisfactory, low)*:**	***High***		
50	***Comments***			

Study 2

No	Item	Weight	Yes/No	Specify
1	Reference: Kszos LA, Talmage SS, Morris GW, Konetsky BK, Rottero T. 2003. Derivation of aquatic screening benchmarks for 1,2-dibromoethane. Arch Environ Toxicol 45:66-71.			
2	Substance identity: CAS RN	n/a	Y	
3	Substance identity: 1,2-dibromoethane	n/a	Y	
4	Chemical composition of the substance	2	Y	
5	Chemical purity	1	-	Not specified but not needed
6	Persistence/stability of test substance?	1	Y	
Method				
7	Reference	1	Y	
8	OECD, EU, national, or other standard method?	3	-	Not applicable
9	Justification of the method/protocol if a non-standard method was used	2	Y	
10	GLP (good laboratory practice)	3	-	Not applicable
Test organism				
11	Organism identity: *Daphnia magna*, *Ceriodaphnia dubia* and *Pimephales promelas* (fathead minnow)	n/a	Y	
12	Latin or both Latin and common names reported?	1	Y	
13	Life cycle age / stage of test organism	1	Y	Fish (5 days old)
14	Length and/or weight	1	N	
15	Sex	1	N	
16	Number of organisms per replicate	1	Y	8
17	Organism loading rate	1	Y	5 concentrations on *D. magna* and *C. dubia* 4 concentrations on fish
18	Food type and feeding periods during the acclimation period	1	Y	
Test design / conditions				
19	Test type (acute or chronic)	n/a	Y	Acute
20	Experiment type (laboratory or field)	n/a	Y	Lab
21	Exposure pathways (food, water, both)	n/a	Y	water
22	Exposure duration	n/a	Y	48 h for *D. magma* and *C. dubia* 98 h for fathead minnow
23	Negative or positive controls (specify)	1	Y	Negative control
24	Number of replicates (including controls)	1	Y	4 (for *D. magna* and *C. dubia*) 8 (fathead minnow)
25	Nominal concentrations reported?	1	Y	5 for *D. magna* and *C. dubia* 4 for P. promelas
26	Measured concentrations reported?	3	Y	

27	Food type and feeding periods during the long-term tests	1	Y	Feeding fish with brine shrimp nauplii 2 h prior to test solution renewal in 48 h
28	Were concentrations measured periodically (especially in the chronic test)?	1	Y	At least 2 times
29	Were the exposure media conditions relevant to the particular chemical reported? (e.g., for the metal toxicity – pH, DOC/TOC, water hardness, temperature)	3	Y	
30	Photoperiod and light intensity	1	Y	
31	Stock and test solution preparation	1	Y	
32	Was solubilizer/emulsifier used if the chemical was poorly soluble or unstable?	1	-	Not applicable
33	If solubilizer/emulsifier was used, was its concentration reported?	1	-	Not applicable
34	If solubilizer/emulsifier was used, was its ecotoxicity reported?	1	-	Not applicable
35	Monitoring intervals (including observations and water quality parameters) reported?	1	Y	
36	Statistical methods used	1	Y	
Information relevant to the data quality				
37	Was the endpoint directly caused by the chemical's toxicity, not by organism's health (e.g. when mortality in the control > 10%) or physical effects (e.g. "shading effect")?	n/a	Y	
38	Was the test organism relevant to the Canadian environment?	3	Y	
39	Were the test conditions (pH, temperature, DO, etc.) typical for the test organism?	1	Y	
40	Do system type and design (static, semi-static, flow-through; sealed or open; etc.) correspond to the substance's properties and organism's nature/habits?	2	Y	
41	Was pH of the test water within the range typical for the Canadian environment (6 to 9)?	1	Y	
42	Was temperature of the test water within the range typical for the Canadian environment (5 to 27°C)?	1	Y	
43	Was toxicity value below the chemical's water solubility?	3	Y	
Results				
44	Toxicity values (specify	n/a	Y	

	endpoint and value)			
45	Other endpoints reported – e.g., BCF/BAF, LOEC/NOEC (specify)?	n/a	N	
46	Other adverse effects (e.g. carcinogenicity, mutagenicity) reported?	n/a	N	
47	***Score*: ... %**	***37/39 = 95%***		
48	***EC Reliability code*:**	***1***		
49	***Reliability category (high, satisfactory, low)*:**	***High***		
50	***Comments***			

Study 3

No	Item	Weight	Yes/No	Specify
1	Reference: Hawkins WE, Walker WW, James MO, Manning CS, Barnes DH, Heard CS, Overstreet RM. 1998. Carcinogenic effects of 1,2-dibromoethane (ethylene dibromide; EDB) in Japanese medaka (*Oryzias latipes*). Mutat Res 399(2):221-32.			
2	Substance identity: CAS RN	n/a	N	
3	Substance identity: 1,2-dibromoethane	n/a	Y	
4	Chemical composition of the substance	2	N	Not specified but not needed
5	Chemical purity	1	N	Not specified but not needed
6	Persistence/stability of test substance?	1	N	
Method				
7	Reference	1	Y	
8	OECD, EU, national, or other standard method?	3	-	Not applicable
9	Justification of the method/protocol if a non-standard method was used	2	Y	
10	GLP (good laboratory practice)	3	-	Not applicable
Test organism				
11	Organism identity: Japanese medaka	n/a	Y	
12	Latin or both Latin and common names reported?	1	N	
13	Life cycle age / stage of test organism	1	Y	Fish (7 days old)
14	Length and/or weight	1	N	
15	Sex	1	N	
16	Number of organisms per replicate	1	Y	350
17	Organism loading rate	1	Y	1 static control 1 flow-through control 3 test concentrations
18	Food type and feeding periods during the acclimation period	1	Y	

Test design / conditions				
19	Test type (acute or chronic)	n/a	Y	Chronic
20	Experiment type (laboratory or field)	n/a	Y	Lab
21	Exposure pathways (food, water, both)	n/a	Y	Water
22	Exposure duration	n/a	Y	73-97 days
23	Negative or positive controls (specify)	1	Y	Negative control
24	Number of replicates (including controls)	1	Y	350
25	Nominal concentrations reported?	1	Y	1 flow-through control 3 test concentrations
26	Measured concentrations reported?	3	Y	
27	Food type and feeding periods during the long-term tests	1	Y	Very detailed
28	Were concentrations measured periodically (especially in the chronic test)?	1	Y	Twice every week
29	Were the exposure media conditions relevant to the particular chemical reported? (e.g., for the metal toxicity – pH, DOC/TOC, water hardness, temperature)	3	Y	
30	Photoperiod and light intensity	1	N	
31	Stock and test solution preparation	1	Y	
32	Was solubilizer/emulsifier used if the chemical was poorly soluble or unstable?	1	-	Not applicable
33	If solubilizer/emulsifier was used, was its concentration reported?	1	-	Not applicable
34	If solubilizer/emulsifier was used, was its ecotoxicity reported?	1	-	Not applicable
35	Monitoring intervals (including observations and water quality parameters) reported?	1	Y	
36	Statistical methods used	1	Y	
Information relevant to the data quality				
37	Was the endpoint directly caused by the chemical's toxicity, not by organism's health (e.g. when mortality in the control > 10%) or physical effects (e.g. "shading effect")?	n/a	Y	
38	Was the test organism relevant to the Canadian environment?	3	Y	
39	Were the test conditions (pH, temperature, DO, etc.) typical for the test organism?	1	Y	

40	Do system type and design (static, semi-static, flow-through; sealed or open; etc.) correspond to the substance's properties and organism's nature/habits?	2	Y	
41	Was pH of the test water within the range typical for the Canadian environment (6 to 9)?	1	Y	
42	Was temperature of the test water within the range typical for the Canadian environment (5 to 27°C)?	1	Y	
43	Was toxicity value below the chemical's water solubility?	3	Y	
Results				
44	Toxicity values (specify endpoint and value)	n/a	Y	
45	Other endpoints reported – e.g., BCF/BAF, LOEC/NOEC (specify)?	n/a	N	
46	Other adverse effects (e.g. carcinogenicity, mutagenicity) reported?	n/a	Y	
47	***Score*: ... %**	***35/40 = 87.5%***		
48	***EC Reliability code*:**	***1***		
49	***Reliability category (high, satisfactory, low)*:**	***High***		
50	***Comments***			

Appendix 2: Concentrations of 1,2-dibromoethane in ambient air

Location	Sampling period	Number of samples	Detection limit (µg/m^3)	Mean concentration (µg/m^3)[1]	Reference
Halifax, Nova Scotia	January to April, 2009	287	0.025	ND (ND-0.025)	Health Canada 2012
	June to September, 2009	324	0.025	ND (ND-0.026)	Health Canada 2012
Windsor, Ontario	January 23 to March 25, 2006	214	0.15	ND	Health Canada 2010b
	July 3 to August 26, 2006	214		ND	
Windsor, Ontario	January 24 to March 19, 2005	201	0.123	ND	Health Canada 2010b
	July 4 to August 27, 2005	216		ND	
Regina, Saskatchewan	January 8 to March 16, 2007	94(winter; 24-h canisters)	0.054	ND	Health Canada 2010a
	June 20 to August 29, 2007	97 (summer; 5-day canisters)		ND	
43 Canadian sites	January to December 2008	10–119 (total of 1896 samples)	0.012	0.006[3] (0.002–0.013) [detected in 7 samples]	NAPS 2008
Twenty-nine Canadian cities	2004–2009	-	-	0–0.060	Environment Canada 2009b
Twenty-nine Canadian cities	1998–2002	-	-	< 0.012–0.143	Environment Canada 2004
40 Canadian sites	January to December 2003	14–145 (total of 1854 samples)	0.012	(ND–0.11) [detected in 458 samples]	2003 personal communication from Analysis and Air Quality Division, Environment Canada to Existing Substances Division; unreferenced
Ottawa, Ontario (vicinity of 75 homes)	Fall 2002	75	0.018	ND	Zhu et al. 2005

Location	Sampling period	Number of samples	Detection limit (µg/m^3)	Mean concentration (µg/m^3)[1]	Reference
50 Canadian sites	January 1998 to December 2002	14–293 (total of 8275 samples)	0.012	(0.002–0.143) [detected in 6766 samples]	2002 personal communication from Analysis and Air Quality Division, Environment Canada to Existing Substances Division; unreferenced
37 Canadian sites	2000	9–62 (total of 1573 samples)	0.012	0.06 (0.01–0.12)	2001 personal communication from Analysis and Air Quality Division, Environment Canada to Existing Substances Division; unreferenced
Montréal, Quebec (urban)	1993	160	0.38[2] (0.05 ppbv)	0.02 (ND–0.67) [6% > detection limit]	Environment Canada 1995
Brossard, Quebec (suburban)	1993	24	0.38[2] (0.05 ppbv)	ND	Environment Canada 1995
Sainte-Françoise, Quebec (rural)	1993	34	0.38[2] (0.05 ppbv)	ND	Environment Canada 1995
Montréal, Quebec (urban)	1992	166	0.38[2] (0.05 ppbv)	0.01 (ND–1.73) [1% > detection limit]	Environment Canada 1995
Montréal, Quebec (urban)	1991	91	0.38[2] (0.05 ppbv)	0.03 (ND–0.48) [10% > detection limit]	Environment Canada 1995
Montréal, Quebec (urban)	1990	110	0.38[2] (0.05 ppbv)	ND–0.12 [1% > detection limit]	Environment Canada 1995
Montréal, Quebec (urban)	1989	79	0.38[2] (0.05 ppbv)	0.03 (ND–0.43) [11% > detection limit]	Environment Canada 1995

Location	Sampling period	Number of samples	Detection limit (µg/m^3)	Mean concentration (µg/m^3)[1]	Reference
Modelled local air dispersion (at 100 m from the source)	-	-	-	0.3774	SCREEN3 1995
Windsor, Ontario	1988–1992	410	0.1	ND–0.80 [ND 80% of the time]	OMEE 1994
Greater Vancouver Regional District	1989–1992	473	0.38[2] (0.05 ppbv)	0.06[3] [4% > detection limit]	Environment Canada 1994
Canada-wide	1989–1990	1100	0.38[2] (0.05 ppbv)	0.06[3] [5% > detection limit]	Environment Canada 1994
Walpole Island, Ontario	1989–1991	94	0.1	ND–0.76	OMEE 1994
Walpole Island, Ontario	January 1988 to October 1990	61	0.1	ND–0.80 [above detection limit in 9 samples]	Environment Canada 1992
Windsor, Ontario	July 1987 to October 1990	123	0.1	ND–0.4 [above detection limit in 7 samples]	Environment Canada 1992
Canadian urban sites	1989	17	0.1	ND	Environment Canada 1991
Kitchener, Ontario	April 16 to May 24, 1989	10	ns	(ND–0.30)	CMHC 1989
North and South Atlantic Ocean	1985	0	0	0.020	Class and Ballschmiter 1988
Seven U.S. cities	1980	-	-	0.122–2.822	Singh et al. 1982

Abbreviations: ND, not detected; ns, not specified; ppbv, parts per billion by volume.

[1] Values in parentheses indicate range of concentrations when available.

[2] Value given for the detection limit is the target or typical detection limit reported for volatile organic compounds.

[3] Values below the detection limit set at one-half the detection limit.

Appendix 3: Concentrations of 1,2-dibromoethane in indoor air

Location	Sampling period	Number of samples	Detection limit (µg/m^3)	Mean concentration (µg/m^3)[1]	Reference
Halifax, Nova Scotia	January to April, 2009	312	0.025	ND	Health Canada 2012
	June to September, 2009	331	0.025	ND	Health Canada 2012
Windsor, Ontario (personal breathing-zone air)	January 24 to March 19, 2005	225	0.123	ND	Health Canada 2010b
	July 4 to August 27, 2005	207		ND (ND–0.190)	
Windsor, Ontario	January 24 to March 19, 2005	232	0.123	ND	Health Canada 2010b
	July 4 to August 27, 2005	217		ND	
Windsor, Ontario	January 23 to March 25, 2006	224	0..15	ND	Health Canada 2010b
	July 3 to August 26, 2006	211		ND	
Regina, Saskatchewan (5-day canister data were selected, as they represent time-weighted average over longer period than 24-h canisters)	January 8 to March 16, 2007	97(winter)	0.054	ND	Health Canada 2010a
	June 20 to August 29, 2007	101 (summer)		ND [maximum 0.080]	
Ottawa, Ontario (75 homes)	Fall 2002	75	0.018	ND	Zhu et al. 2005
International locations (literature review of 50 studies)	1978–1990	50 studies	ns	1 – <5	Brown et al. 1994
Canada-wide	August–October and January–March 1983–1984	10	0.4	ND	Otson 1986

Location	Sampling period	Number of samples	Detection limit (µg/m^3)	Mean concentration (µg/m^3)[1]	Reference
Woodlands, California, USA (residential)	June 1990	128	ns	Not quantifiable	Cal EPA 1992
Kanawha Valley, West Virginia, USA (residential)	August 1987	35	8.5	6.06 [maximum 23.53; 29% > detection limit]	Cohen et al. 1989

Abbreviations: ND, not detected; ns, not specified.
[1] Values in parentheses indicate range of concentrations when available.

Appendix 4: Concentrations of 1,2-dibromoethane in water

Location	Sampling period	Number of samples	Detection limit (µg/L)	Mean concentration (µg/L)	Reference
Victoria, British Columbia (drinking water)	2008	2	0.005	ND	City of Victoria 2008
Ontario, Canada (drinking water)	January 1, 2005 to December 31, 2006	2901	0.1	ND	Ontario MOE 2006
Montréal, Quebec (drinking water)	2006	ns	0.04	ND	Ville de Montreal 2006
Nova Scotia, Canada (drinking water)	June 2002 to May 2005	24	1	ND	NSEL 2005
Ottawa, Ontario (drinking water)	2003	19	0.10	ND	COWQS 2003
United States	1985–2001	462 (public well samples)	ns	< 0.10 (median for all samples)	Zogorski et al. 2006
United States	1985–2001	2085 (domestic well samples)	ns	< 0.04 (median for all samples); 0.55 (median for samples with detection)	Zogorski et al. 2006
United States	1985–2001	2851 (groundwater)	ns	< 0.10 (median for all samples); 0.72 (median for samples with detection)	Zogorski et al. 2006
Lemieux Island, Ottawa, Ontario	1987	48 (raw and treated)	50	Not quantifiable at detection limit	Ontario MOE 1988
Toronto, Ontario	November–December 1988	7 (bottled) 27 (tap)	0.04	Not quantifiable at detection limit	City of Toronto 1990
New Jersey, USA (surface water)	1977–1979	-	-	0.2 (maximum)	Page 1981
Oil refining and manufacturing facility, Sugar Creek, Missouri, USA (surface water)	1975 or earlier	-	-	1.05 – 1.13	Going and Long 1975
Pincher Creek, Alberta, at 50 m from the source (surface water)	-	-	-	16–21[a] 2–3[b]	ChemSim 2003

North and South Atlantic Ocean (marine water)	1985	-	-	0.00002	Class and Ballschmiter 1988
Site of a chemical plant, Ontario (groundwater)	1997	-	-	5.0	Environment Canada 2001b
Three U.S. states[c] (groundwater)	1981 – 1987	-	-	Detected	Pignatello and Cohen 1990
Six U.S. states[d] (groundwater)	1988 or earlier	-	-	14 (maximum) 9 (median)	Williams et al. 1988
New Jersey, USA (groundwater)	1977–1979	-	-	48 (maximum)	Page 1981

Abbreviations: ND, not detected; ns, not specified.

[a] Most conservative scenarios: modelled value based on the assumption that the total amount reported in Canada is used at the Pincher Creek, Alberta, facility, with or without sewage treatment plant removal.

[b] More realistic scenarios (less conservative): modelled value based on the assumption that the total amount reported in Canada is divided among eight facilities, with or without sewage treatment plant removal.

[c] Arizona, Wisconsin and Florida.

[d] California, Connecticut, Georgia, Massachusetts, New York and Washington.

Appendix 5: Concentrations of 1,2-dibromoethane in food

Item sampled	Sampling period	Number of samples	Detection limit (µg/kg)	Mean concentration[1] (µg/kg)	Reference
Greece (domestic honey)	2004	25	0.8	Quantified in only two samples: 75 ± 3 and 12 ± 0.5	Tananaki et al. 2005
Greece (honey)	2003	142	0.8	Maximum 132.5	Tananaki et al. 2006
	2004	737		Maximum 331.2	
	2005	266		Maximum 95.2	
fir honey	2003–2005	24		Maximum 12.7	
blossom honey		60		Maximum 10.5	
thymus honey		49		Maximum 2.9	
pine honey		283		Maximum 16.0	
United States (sweet cucumber pickles)	September–October 1991 to July–August 2001	1	0.5	13	US FDA 2003
United States	April 1982 to April 1986	16	LOQ 1.0[2]		Gunderson 1988a
- cottage cheese				0.9 (ND–2.7)	
- popcorn in oil				0.4 (ND–1.3)	
- onion rings, breaded/fried				0.3 (ND–1.0)	
- frozen fried chicken				0.6 (ND–1.9)	
- honey, bottled				0.7 (ND–2.0)	
- chocolate cake/icing				4.0 (ND–11.9)	
- yellow cake				2.8 (ND–8.4)	
- doughnuts				2.2 (ND–6.5)	
- cookies, chocolate chip				2.4 (ND–7.3)	
- cookies, sandwich				0.6 (ND–1.9)	
- apple pie, frozen				0.3 (ND–1.0)	
- carbonated soda				0.003 (ND–0.0084)	
Florida (grapefruit)	April–June 1987	5	0.5	Pulp: 1.84 (ND–5.3) Peel: 3.12 (0.6–10.0) Seeds: 336 (ND–591)	Nakamura et al. 1989

Item sampled	Sampling period	Number of samples	Detection limit (µg/kg)	Mean concentration[1] (µg/kg)	Reference
Israel (grapefruit)	April–June 1987	2	0.5	Pulp: 0.95 (0.6–1.3) Peel: ND Seeds: 776 (521–1031)	Nakamura et al. 1989
Philippines (mango)	April–June 1987	6	0.5	Pulp: 1.57 (ND–2.8) Peel: 4.4 (2.7–6.3) Seeds: 2.47 (ND–4.1)	Nakamura et al. 1989
Mexico (mango)	April–June 1987	4	0.5	Pulp: 4.1 (ND–7.9) Peel: 6.4 (ND–15.6) Seeds: 58 (2.3–137)	Nakamura et al. 1989
Hawaii (papaya)	April–June 1987	10	0.5	Pulp: 0.75 (ND–2.4) Peel: 0.66 (ND–1.5) Seeds: 1.0 (ND–3.0)	Nakamura et al. 1989
Taiwan (lychee)	April–June 1987	6	0.5	Pulp: 2.77 (ND–10.0) Peel: 6.8 (2–23.2) Seeds: 12.9 (2.2–47.2)	Nakamura et al. 1989
China (lychee)	April–June 1987	1	0.5	Pulp: 0.9 Peel: 4.3 Seeds: 9.7	Nakamura et al. 1989

Item sampled	Sampling period	Number of samples	Detection limit (µg/kg)	Mean concentration[1] (µg/kg)	Reference
United States (found in one sample of peanut butter and one sample of whiskey)	1988	231 samples (derived from US FDA market basket collection)	ns	Whiskey (80 proof): 2 Peanut butter: 11	Daft 1988
United States	1980				Rains and Holder 1981
- flour		22	5	807 (ND–4200)	
- biscuits		22	0.5	36 (ND–260)	
Japan (wheat; authors note that processing and market circulation would likely decrease levels)	1985	3	0.5	1.11 (0.74–1.70)	Konishi et al. 1986
United States	1985				Clower et al. 1986
- flour, enriched		3	2	24	
- flour, unbleached pastry		3		140	
- meal, corn		3		55	
- wheat, whole grain red winter		3		167	
United States (cooked rice)	1984	4	0.4	2.5 (ND–8.3)	Clower et al. 1985
Saskatoon, Saskatchewan (flour)	1984	10	ns	81 (4.1–405.3)	McKay 1986

Abbreviations: ND, not detected; ns, not specified.

[1] Values in parentheses indicate range of concentrations when available.

[2] The limit of quantitation (LOQ) was obtained from a related total diet study of eight U.S. FDA market baskets during the period from April 1982 to April 1984 (Gunderson 1988b). The Gunderson (1988a) study incorporated the results of Gunderson (1988b) and included an additional two years of sampling (April 1984 to April 1986).

Appendix 6: Concentrations of 1,2-dibromoethane in soil

Location	Sampling period	No. of samples	Detection limit (ng/g)[1]	Mean Concentration (ng/g)[2]	Reference
Site of a chemical plant, Ontario	1997	-	-	3 m depth: 4.24×10^6 (dry weight) 0.8 m depth: 1.19×10^4 (dry weight) 0.2–0.76 m depth: 80 (dry weight)	Environment Canada 2001b
Ontario regions (rural parkland, soil)	ca. 1993	59	MDL 4.0	0.032[3] (0.012–0.390)[4] [dry weight]	OMEE 1993
Ontario (soil)	1986	5	MDL 0	0.032[3] (0.012–0.390)[4] [dry weight]	OMEE 1993
Port Credit, Ontario (soil)	1987	8	MDL 0.2 [wet weight]	ND	Golder Associates 1987
Oakville/ Burlington, Ontario (soil)	1986	8	MDL 0.2–10 [wet weight]	ND	Golder Associates 1987

Abbreviations: MDL, method detection limit; ND, not detected.

[1] The MDL is defined as 3 times the within-run analytical standard deviation and is considered only an estimate that may vary with time (OMEE 1993).

[2] Values in parentheses indicate range of concentrations when available.

[3] The concentration is the 97.5th percentile Ontario typical range value. This concentration is two standard deviations above the mean value.

[4] The ranges are derived from the Ontario typical range model released in 1993 (to replace the previous "upper limit of normal" contaminant guidelines).

Appendix 7: Summary of health effects information for 1,2-dibromoethane

Endpoint	Lowest effect levels[1]/Results
Laboratory animals and *in vitro*	
Acute toxicity	**Lowest oral LD_{50}**(rabbit) = 55 mg/kg-bw (Rowe et al. 1952) **Lowest inhalation LC_{50}**(rat) = 3080 mg/m^3 (Rowe et al. 1952) [Additional studies: Koptagel and Bulut 1998]
Short-term repeated-dose toxicity	**Lowest oral LOEL** (mice) = 125 mg/kg-bw per day based on increased cholesterol levels and increased *in vitro* phagocytosis of pooled cultured cells from 2–3 dosed animals at 125 mg/kg-bw per day and higher doses. Ethylene bromide (in corn oil) was injected intragastrically at doses of 100, 125, 160 or 200 mg/kg-bw per day for 14 days (n = 10 per treatment) (Ratajczak et al. 1994).
Subchronic toxicity	**Lowest oral LOEL** (mice) = 125 mg/kg-bw per day based on alterations in *in vivo* serum and hematology parameters and *in vitro* lymphocyte response. Ethylene bromide (in corn oil) was injected intragastrically at doses of 31.25, 62.5 or 125 mg/kg-bw per day, 5 days a week for 12 weeks (n = 6–9 per treatment) (Ratajczak et al. 1995). **Lowest inhalation LOEC** (rats) = 77 mg/m^3 based on epithelial hyperplasia of the nasal turbinates at 77 and 307 mg/m^3. Rats were exposed to ethylene bromide at doses of 0, 3, 10 or 40 ppm (equivalent to 0, 23, 77 or 307 mg/m^3 as per IPCS 1996), 6 hr/day, 5 days per week for 13 weeks (n = 10 per treatment) (Nitschke et al. 1981). [Additional studies: Reznik et al. 1980]
Chronic toxicity/ carcinogenicity	**Oral (gavage) carcinogenicity bioassay in rats:** Males were exposed to a time-weighted average of 0, 38 or 41 mg/kg-bw per day (5 days/week for up to 49 weeks). Females were exposed to 0, 37 or 39 mg/kg-bw per day (5 days/week for up to 61 weeks). Both sexes initially received 0, 40 or 80 mg/kg-bw per day of 1,2-dibromoethane, but, due to excessive mortality, the exposure levels and the overall duration of the study were reduced. In both sexes, there were significant increases in the incidence of squamous cell carcinomas of the forestomach in exposed groups (0/20 for both male and female controls, 45/50 for low-dose males, 33/50 for high-dose males, 40/50 for low-dose females, 29/50 for high-dose females). In males in the low-dose group, there was a significant increase in the incidence of hemangiosarcomas of the circulatory system (0/20 controls, 11/50 low dose); after time-adjusted analysis in high-dose females, there was a significant increase in the incidence of hepatocellular carcinomas (0/20 controls, 5/25 high dose) (NCI 1978). **Oral (gavage) carcinogenicity bioassay in mice:** Mice were exposed to time-weighted average doses of 0, 62 or 107 mg/kg-bw per day

Endpoint	Lowest effect levels[1]/Results
	(5 days/week for 53 weeks). Mortality was high in all treated groups and due to this, all males and high-dose females were sacrificed at wk 78 (25 wks after dosing ceased). Low-dose females were sacrificed at wk 90. There were significant increases in the incidence of squamous cell carcinomas of the forestomach (males: vehicle control, 0/20; low dose, 45/50; high dose, 29/49; females: vehicle control, 0/20; low dose, 46/49; high dose, 28/50) and in alveolar/bronchiolar adenomas (males: control, 0/20; high dose, 10/47; females: control, 0/20; low dose, 11/43) (NCI 1978). [Additional study: Van Duuren et al. 1985 (drinking water): evidence of carcinogenicity was observed] **Inhalation carcinogenicity bioassay in rats:** Rats were exposed by inhalation to 0, 10 or 40 ppm (equivalent to 0, 77 or 308 mg/m^3) 6 h/day, 5 days/week, for 88–103 weeks). High mortality at the high concentration (90% in males, 84% in females) resulted in sacrifice of the remaining high-dose animals at wks 88 (males) or 91 (females). There were significant increases in the incidence of nasal cavity carcinomas at high doses (males: controls, 0/50; high dose, 21/50; females: controls, 0/50; high dose, 25/50) and adenocarcinomas at both doses (males: controls, 0/50; low dose, 20/50; high dose, 28/50; females: controls, 0/50; low dose, 20/50; high dose, 29/50) and adenomas at low doses (males: control, 0/50; low dose, 11/50; females: controls, 0/50; low dose, 11/50). There was a significant increase in the incidence of hemangiosarcomas of the circulatory system in the high-dose groups of both sexes (males: controls, 0/50; high dose, 15/50; females: controls, 0/50; high dose, 5/50). Female rats had a significantly increased incidence of mammary gland fibroadenomas (controls, 4/50; low dose, 29/50; high dose, 24/50), and the highest-dose females exhibited significant levels of alveolar/bronchiolar adenomas combined with carcinomas (controls, 0/50; high dose, 5/47). Male rats had a significant increase in the incidence of tunica vaginalis mesotheliomas at both doses (controls, 0/50; low dose, 7/50; high dose, 25/50) and nasal cavity adenomatous polyps at the low dose (controls, 0/50; low dose, 18/50) (NTP 1982). **Inhalation carcinogenicity bioassay in mice:** Mice were exposed by inhalation to 0, 10, or 40 ppm (equivalent to 0, 77 or 308 mg/m^3) 6 h/day, 5 days/week, for 78–103 weeks). High mortality in both treated and control males resulted in sacrifice of all remaining males at wk 78. In females, high mortality was observed only at the high concentration (86%), and all remaining females at this concentration were sacrificed at wk 90. There were significantly increased incidences of alveolar/bronchiolar carcinomas (males: control, 0/41; high dose, 19/46; females: control, 1/49; high dose, 37/50) and adenomas (males: controls, 0/41; high dose, 11/46; females: controls, 3/49; high dose, 13/50) in the highest-dose groups of both sexes. In dosed females, there was also a significantly increased incidence of hemangiosarcomas of the circulatory system (controls, 0/50; low dose, 11/50; high dose, 23/50), subcutaneous fibrosarcomas (controls, 0/50; low dose, 5/50; high dose, 11/50), nasal cavity carcinomas (controls, 0/50; high

Endpoint	Lowest effect levels[1]/Results
	dose, 6/50) and mammary gland adenocarcinomas (controls, 2/50; low dose, 14/50; high dose, 8/50) (NTP 1982). [Additional studies: Stinson et al. 1981; Wong et al. 1982: evidence of carcinogenicity was observed in both studies] **Dermal carcinogenicity bioassay in mice:** Female mice were given 0, 25 or 50 mg/mouse in acetone, dermally, 3 times a week for 440–594 days (equivalent to 357 or 714 mg/kg-bw per day, respectively; as per Health Canada 1994). There was a significant increase in the incidence of benign lung papillomas at both dose levels (low dose, 24/30; high dose, 26/30) and a significant increase in the incidence of combined squamous skin papillomas and carcinomas (3/30), as well as skin papillomas (5/30) at the high dose(Van Duuren et al. 1979). **Lowest non-neoplastic oral (gavage) effect level** (rats) = 38 (male) and 37 (female) mg/kg-bw per day, based on hyperkeratosis and acanthosis of the forestomach in females, degenerative changes in the liver, cortical cell degeneration of the adrenal gland and testicular atrophy in males (lowest dose tested, carcinogenic dose) (NCI 1978) **Lowest non-neoplastic inhalation concentration** (rats) = 77 mg/m^3, based on toxic nephropathy and testicular degeneration in males, retinal atrophy and adrenal cortex degeneration in females and increases in hepatic necrosis in both sexes (lowest dose tested, carcinogenic dose; NTP 1982). [Additional studies: Stinson et al. 1981; NTP 1982; Wong et al. 1982]
Reproductive toxicity	**Lowest oral (feed) LOEL** (bulls) = 2 mg/kg-bw per day for 12 months (followed by 4 mg/kg-bw every 2 days for 10–12 months), based on reversible low sperm density, poor motility and altered spermatozoa morphology (Amir and Volcani 1965) Oral (gavage) at 38 mg/kg-bw per day for 49 weeks caused testicular atrophy in male rats (NCI 1978) [Additional study: Shivanandappa et al. 1987] **Lowest inhalation LOEC** (rats) = 77 mg/m^3, based on testicular degeneration in males rats in a 88–103-week study (NTP 1982) Reproductive effects were reported in male or female rats following inhalation exposure to 0, 19, 39 or 89 ppm (equivalent to 146, 300 or 684 mg/m^3 as per IPCS 1996) in males or 0, 20, 39 or 80 ppm (equivalent to 154, 300, or 614 mg/m^3 as per IPCS 1996) in females for 10 or 3 weeks, respectively. In male rats, a reduction in testicular weight; decreased serum testosterone levels; atrophy of testes, epididymis, prostate and seminal vesicles; and changes in reproductive behaviour were reported only in the high-dose group. Also, female rats in the high-dose group showed abnormal

Endpoint	Lowest effect levels[1]/Results
	estrous cycle until several days after cessation of exposure. Mortality occurred in both sexes in the high-dose group (Short et al. 1979).
Developmental toxicity	**Lowest inhalation LOEC** (rats) = 51.2 mg/m^3, based on decreased maternal body weight and improved rotorod performance and T-maze brightness discrimination acquisition in offspring (Smith and Goldman 1983) [Additional study: Short et al. 1978]
Genotoxicity and related endpoints: *in vitro*	**GENE MUTATION** **Positive results:** *Salmonella typhimurium* TA98 (+/-S9), TA100 (+/-S9), TA100 (GSH-) (−S9, +GSH), TA100 (GSTA1-1 or GST1-1) (−S9), TA100W (Strr, 8AGr) (−S9), TA102 (activation not specified), TA1530 (−S9), TA1535 +/-S9), TA1535 (GST1-1) (−S9), TA2638 (activation not specified), G46 (−S9), BA13 +/-S9) (Ames and Yanofsky 1971; Von Buselmaier et al. 1972; Brem et al. 1974; McCann et al. 1975; Rosenkranz 1977; Rannug and Beije 1979; Elliott and Ashby 1980; Shiau et al. 1980; Stolzenberg and Hine 1980; van Bladeren et al. 1980, 1981; Barber et al. 1981; Principe et al. 1981; Barber and Donish 1982; Kerklaan et al. 1983, 1985; Moriya et al. 1983; Buijs et al. 1984; Dunkel et al. 1985; Tennant et al. 1986, 1987; Hughes et al. 1987; Zoetemelk et al. 1987; Ong et al. 1989; Roldán-Arjona et al. 1991; Zeiger et al. 1992; Simula et al. 1993; Novotná and Duverger-van Bogaert 1994; Thier et al. 1996; Watanabe et al. 1998) *Escherichia coli* WP2 (+/-S9), WP2/pKM101 (activation not specified), WP2 *uvr*A/pKM101 (activation not specified), CHY832 (−S9), 343/286 (+/-S9), K12 (+/-S9), KI201 (−S9), KI211 (−S9), *uvr*B5 (Scott et al. 1978; Hemminki et al. 1980; Izutani et al. 1980; Moriya et al. 1983; Hayes et al. 1984; Mohn et al. 1984; Dunkel et al. 1985; Foster et al. 1988; Watanabe et al. 1998) *Bacillus subtilis* TKJ5211, TKJ6321 (+S9) (Shiau et al. 1980) *Streptomyces coelicolor* (−S9, spot test) (Principe et al. 1981) *Aspergillus nidulans* (Scott et al. 1978; Principe et al. 1981) *Neurospora crassa* ad-3 (forward mutation) (De Serres and Malling 1983) Mouse L5178Y (+/-S9) (Clive et al. 1979; Tennant et al. 1986, 1987) Chinese hamster CHO-K1(+/-S9) (Tan and Hsie 1981; Brimer et al. 1982) Human cell line AHH-1, TK6 (−S9) (Crespi et al. 1985) Human cell line EUE (−S9) (Ferreri et al. 1983) *E. coli* lacZ reversion assay (Josephy et al. 2006) **Negative results:** *Salmonella typhimurium* TA98 (+/-S9), TA100 (+/-S9), TA1537 (+/-S9), TA1538 (+/-S9), E503 (Brem et al. 1974; Alper and Ames 1975; Shiau et al. 1980; Principe et al. 1981; Wildeman and Nazar 1982; Moriya et al. 1983; Dunkel et al. 1985; Tennant et al. 1986) *Serratia marcescens* a21 (−S9) (Von Buselmaier et al. 1972) *Escherichia coli* 343/113 (−S9) (Mohn et al. 1984) *Streptomyces coelicolor* (−S9, plate method) (Principe et al. 1981) **UNSCHEDULED DNA SYNTHESIS**

Endpoint	Lowest effect levels[1]/Results
	Positive results: Rat hepatocytes (Williams et al. 1982; Tennant et al. 1986; Working et al. 1986) Rat spermatocytes (Working et al. 1986) Opossum lymphocytes (Meneghini 1974) Human lymphocytes (+/-S9) (Perocco and Prodi 1981) Mouse (C3Hf×101)F1 germ cells (Sega and Sotomayor 1980) **SISTER CHROMATID EXCHANGE** **Positive results:** Chinese hamster V79 cl-15 (−S9) (Tezuka et al. 1980) Chinese hamster ovary (+/-S9) (Tennant et al. 1987; Ivett et al. 1989) Human lymphocytes (−S9) (Tucker et al. 1984; Ong et al. 1989) **CHROMOSOMAL ABERRATIONS** **Positive results:** Chinese hamster V79 cl-15 (−S9) (Tezuka et al. 1980) Chinese hamster ovary (+/-S9) (Tennant et al. 1987; Ivett et al. 1989) **MICRONUCLEI INDUCTION** **Positive results:** Human lymphocytes (Channarayappa et al. 1992) **DNA DAMAGE** **Positive results:** *Escherichia coli* polA1−/polA+(−S9) (Brem et al. 1974) Human nasal mucosa cells, rat ethmoidal mucosa, rat nasal mucosa cells (Holzer et al. 2008) **Negative results:** *Bacilis subtilis* TKJ5211, TKJ6321 (+/-S9) (Shiau et al. 1980) **SOS INDUCTION** **Positive results:** *Salmonella typhimurium* TA1535/pSK1002 (+/-S9), NM5004 expressing GST 5-5 (Ong et al. 1987; Oda et al. 1996) *Escherichia coli* (Ohta et al. 1984; Quillardet et al. 1985) **Negative results:** *Salmonella typhimurium* TA1535/pSK1002 (−S9) (Oda et al. 1996) **MITOTIC GENE CONVERSION** **Positive results:** *Saccharomyces cerevisiae* ade2, trp5 (Fahrig 1974) **SOMATIC SEGREGATION** **Positive results:** *Aspergillus nidulans* diploid 35×17 (−S9) (Crebelli et al. 1984)

Endpoint	Lowest effect levels[1]/Results
	CELL PROLIFERATION **Positive results:** Human lymphocytes (Channarayappa et al. 1992) **DNA STRAND BREAKS** **Positive results:** Rat hepatocytes (Sina et al. 1983) Rat testicular cells (Bradley and Dysart 1985) Rat and human testicular cells (Bjørge et al. 1996) **DNA BINDING** **Positive results:** Calf thymus DNA (Arfellini et al. 1984; Colacci et al. 1985; Prodi et al. 1986) Rat hepatocytes (Inskeep et al. 1986; Cmarik et al. 1990) Human hepatocytes (Cmarik et al. 1990) **Negative results:** *Escherichia coli* Q13 (+/-S9) and mouse Ehrlich ascites (+/-S9) (Kubinski et al. 1981) **CELL TRANSFORMATION** **Positive results:** Balb/c 3T3 mouse cells (Perocco et al. 1991; Colacci et al. 1995) **Negative results:** Balb/c 3T3 mouse cells (−S9) (Tennant et al. 1986)
Genotoxicity and related endpoints: *in vivo*	**GENE MUTATION** **Positive results:** *Drosophila melanogaster* (Graf et al. 1984; Ballering et al. 1993) *Salmonella typhimurium* G46 host-mediated (Von Buselmaier et al. 1972) **Negative results:** *Serratia marcescens* host-mediated (Von Buselmaier et al. 1972) Silk worm (Sugiyama 1980) **RECOMBINATION** **Positive results:** *Drosophila melanogaster* (Graf et al. 1984; Ballering et al. 1993) **SEX-LINKED RECESSIVE LETHAL MUTATIONS** **Positive results:** *Drosophila melanogaster* (Vogel and Chandler 1974; Kale and Baum 1979a, 1979b, 1981, 1982, 1983; Yoshida and Inagaki 1986; Ballering et al. 1993, 1994; Foureman et al. 1994; Kale and Kale 1995) **CHROMOSOMAL ABERRATIONS** **Negative results:** Mouse (intraperitoneal) bone marrow (Krishna et al. 1985) (IARC reports weakly positive) (IARC 1999)

Endpoint	Lowest effect levels[1]/Results
	Mouse (intraperitoneal) bone marrow (NTP 1993) **DNA STRAND BREAKS** **Positive results:** Rat hepatocytes (Nachtomi and Sarma 1977; Kitchin and Brown 1994) Mouse hepatocytes (White 1982; Storer and Conolly 1983) Rat testicular cells (Bradley and Dysart 1985) **MICRONUCLEI** **Positive results:** Mouse (peripheral blood) (Witt et al. 2000) **Negative results:** Mouse (Krishna et al. 1985; Asita et al. 1992) **DNA BINDING** **Positive results:** Mouse (liver, stomach, kidney, lung) (Arfellini et al. 1984; Prodi et al. 1986) Mouse hepatocyte DNA (Kim and Guengerich 1990) Mouse (liver, kidney) (Watanabe et al. 2007) Rat (liver, stomach, kidney, lung) (Arfellini et al. 1984; Prodi et al. 1986) Rat hepatocyte DNA (Inskeep et al. 1986; Kim and Guengerich 1990) Rat (liver, kidney) (Watanabe et al. 2007) **SPECIFIC LOCUS TEST** **Negative results:** Mouse (Russell 1986; Barnett et al. 1992) **SISTER CHROMATID EXCHANGE** **Negative results:** Mouse (intraperitoneal) bone marrow (Krishna et al. 1985) Mouse (intraperitoneal) bone marrow (NTP 1992) **DOMINANT LETHAL** **Negative results:** Rat (Short et al. 1979; Teramoto et al. 1980; Teaf et al. 1990) Mouse (Epstein et al. 1972; Teramoto et al. 1980; Barnett et al. 1992) **DNA REPAIR EXCLUSIVE OF UNSCHEDULED DNA SYNTHESIS** **Negative results:** Mouse hepatocytes (White et al. 1981) **UNSCHEDULED DNA SYNTHESIS** **Positive results:** Rat hepatocytes (Working et al. 1986) **Negative results:** Rat spermatocytes (Working et al. 1986; Bentley and Working 1988)

Endpoint	Lowest effect levels[1]/Results
	DNA DAMAGE **Positive results:** Mouse (stomach, liver, kidney, bladder, lung) (Sasaki et al. 1998)
Humans	
Acute toxicity	Estimated fatal dose in adult male and female (human) = 1.5 ml or 3240 mg (46 mg/kg-bw for a 70-kg person). Effects observed included nausea, vomiting, abdominal pain and signs of hepatotoxicity, nephrotoxicity, nervous system toxicity and cardiotoxicity in male and female patients (Singh et al 2007 - review of 64 cases of acute 1,2-dibromoethane poisoning). Estimated **inhalation lethal concentration** (human) = 154 mg/m^3 for more than 30 min (IPCS 1996) [Additional studies: Alexeeff et al. 1990 ; Peoples et al. 1978; Letz et al. 1984; Jacobs 1985; Sarawat et al. 1986; Singh et al. 1993; Prakash et al. 1999; Raman and Sain 1999; Mehrotra et al. 2001]
Chronic toxicity/ carcinogenicity	Mortality assessed in employees occupationally exposed to 1,2-dibromoethane in two production units while working as still and reactor operators (level of exposure was not provided in secondary accounts). In the first production unit, there were 2 deaths from malignant neoplasms (3.6 expected), and in the second production unit, there were 5 deaths from malignant neoplasms (2.2 expected). However, employees of the second production unit were also exposed to other chemicals, and overall there was no increase in total deaths or malignant neoplasms with increased exposure (Ott et al. 1980). [Additional study: Ter Haar 1980]
Reproductive and developmental toxicity	**Lowest inhalation LOEC** = 0.46 mg/m^{3}based on significantly decreased sperm velocity and semen volume in male forestry workers (occupational time-weighted average) in male forestry workers. Forestry workers engaged in applying or spraying of 1,2-dibromoethane emulsion (4% 1,2-dibromoethane by volume) were examined following short-term inhalation and dermal exposure (Schrader et al. 1988; IPCS 1996). Male forestry workers conducting fumigation (n = 46) with 1,2-dibromoethane for 5 years, showed significant decreases in sperm count, number of viable sperms and increase in sperms with abnormal morphology. 1,2-Dibromoethane concentration ranged from a geometric mean of 88 ppb to peak concentration of up to 262 ppb (equivalent to 0.68 mg/m^{3}to 2.0 mg/m^3 as per IPCS 1996) for 8-hr time-weighted average. The authors did not report exposure to any other chemicals in the forestry workers engaged in the application or spraying activities (Ratcliffe et al. 1987). [Additional studies: Ter Haar 1980; Wong et al. 1985; Dobbins 1987;Schrader et al. 1987]
Genotoxicity and	**Negative results:**

Endpoint	Lowest effect levels[1]/Results
related endpoints	Chromosomal aberrations and sister chromatid exchange were not detected in men who worked in papaya-packing plants and used 1,2-dibromoethane to fumigate the fruit. These workers were exposed to mean concentrations ranging from 0.12 to 1.35 mg/m^3 (Steenland et al. 1986). [Additional study: Steenland et al. 1985]

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