5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

There are no known natural sources of 1,2-dibromo-3-chloropropane (IARC 1979). Although data on releases of 1,2-dibromo-3-chloropropane to the atmosphere, water, and soil are lacking, current releases of the chemical to the environment that result from the production and use of the chemical are probably low because the chemical is used only as an intermediate in organic synthesis and for research purposes. Relatively minor releases to the environment may still occur from contaminated soil, groundwater, and surface water. This is especially true at or near agricultural areas where 1,2-dibromo-3-chloropropane had been extensively used in the past or where a chemical spill occurred, and from hazardous waste sites where improper disposal techniques were used.

1,2-Dibromo-3-chloropropane in soil is subject both to leaching into groundwater and to volatilization to the atmosphere from near-surface soil, as has been observed in field soil studies. Small amounts of 1,2-dibromo-3-chloropropane may be absorbed through the soil roots and translocated to other plant parts. 1,2-Dibromo-3-chloropropane that is present in water is expected to volatilize to the atmosphere. 1,2-Dibromo-3-chloropropane is not expected to adsorb significantly to sediment or suspended organic matter in water, bioconcentrate in fish and other aquatic organisms, or to biomagnify from lower to higher trophic levels of the food chain. The primary degradation process for 1,2-dibromo-3-chloropropane in the atmosphere is estimated to occur via gas-phase reaction with photochemically produced hydroxyl radicals. Degradation of 1,2-dibromo-3-chloropropane in natural waters and soil is a slow process. 1,2-Dibromo-3-chloropropane may be susceptible to slow biodegradation in soil and natural waters based on the observation of biologically mediated dehalogenation in certain soils. 1,2-Dibromo-3-chloropropane residues that do not leach or volatilize appear to be very persistent in soil based upon monitoring data. Laboratory experiments using anoxic biofilm columns showed that biodegradation of 1,2-dibromo-3-chloropropane in groundwater may occur under anaerobic conditions.

The general population may be infrequently exposed to very small amounts of 1,2-dibromo-3-chloropropane through the ingestion of contaminated drinking water and food. Since 1,2-dibromo-3-chloropropane is no longer used as a fumigant and nematocide in the United States and since such use in the past was limited to certain agricultural areas, widespread exposure of the general public or of workers to 1,2-dibromo-3-chloropropane is not likely. Even in the agricultural areas, exposure is probably minor.

EPA has identified 1,177 National Priorities list (NPL) sites. 1,2-Dibromo-3-chloropropane has been found at 8 of the sites evaluated for the presence of this chemical (View 1990). However, we do not know how many of the 1,177 sites have been evaluated for this chemical. As more sites are

evaluated by the EPA, the number may change. The frequency of these sites within the United States can be seen in Figure 5-1. The Contract Laboratory Program (CLP) Statistical Database did not list 1,2-dibromo-3-chloropropane among the compounds that are most commonly found at NPL waste sites in groundwater, surface water, or soil (CLPSD 1989).

5.2 RELEASES TO THE ENVIRONMENT

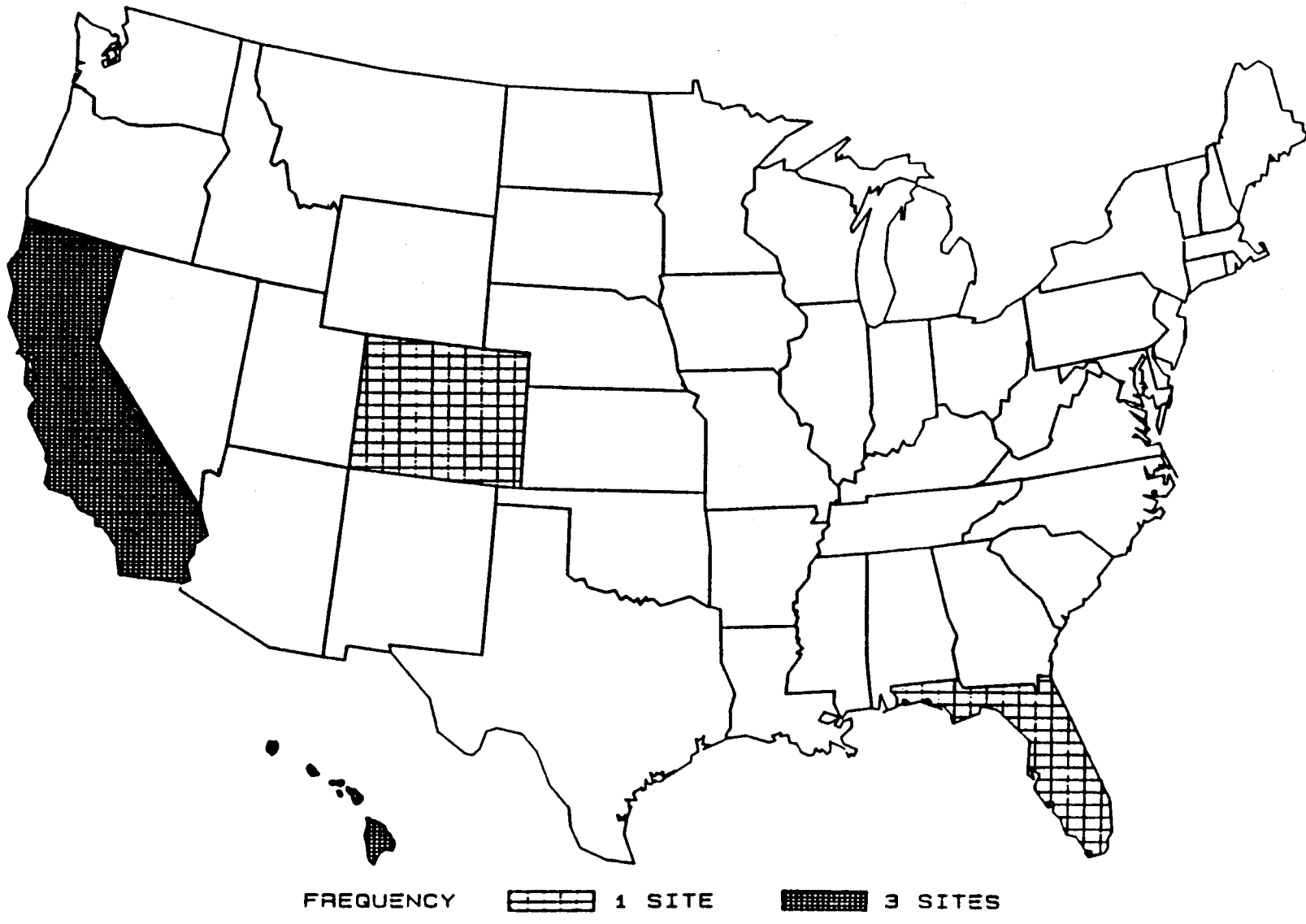
5.2.1 Air

Data on releases of 1,2-dibromo-3-chloropropane to the atmosphere are lacking. Significant releases to the atmosphere probably occurred in the past due to the extensive manufacture and use of the chemical as a soil fumigant on a wide variety of crops in the United States (Section 5.3.1) (Albrecht and Chenchin 1985; Hodges and Lear 1974; NTP 1985; Peoples et al. 1980). However, current releases of 1,2-dibromo-3-chloropropane to the atmosphere that result from the production and use of the chemical are probably very low because the chemical is used only as an intermediate in organic synthesis and for research purposes. Use of 1,2-dibromo-3-chloropropane as a soil fumigant, the only major purpose for which the chemical had been used in the past, is no longer permitted in the United States (Anonymous 1988; EPA 1977, 1979, 1985b). Releases to the atmosphere may continue to occur from soils that were treated with 1,2-dibromo-3-chloropropane in the past and that still contain residues in the soil. Further releases, may result from the use of well water and other water sources that were contaminated with the chemical due to leaching through soil. However, no data were found that would permit the estimation of the amount that is currently being released to the ambient atmosphere. Additional potential sources of release to the atmosphere include identified and unidentified hazardous waste sites that contain 1,2-dibromo-3-chloropropane either in surface water or in near-surface soil.

5.2.2 Water

Data on release of 1,2-dibromo-3-chloropropane to water are lacking. Significant releases to water may have occurred in the past due to the extensive manufacture and use of the chemical as a soil fumigant on a wide variety of crops in the United States (Section 5.3.1), but current releases are probably very low because the chemical is now used only as an intermediate in organic synthesis and for research purposes. Its use as a soil fumigant, the only major purpose for which the chemical was used in the past, is no longer permitted in the United States (Section 4.3). The potential pathways for release to surface waters include runoff from spill and hazardous waste sites where improper disposal techniques were used, runoff from farmland that was irrigated with contaminated well water or other water, and direct release during manufacture and use as an intermediate for organic synthesis and research. Releases to groundwater may occur via leaching of residues in

FIGURE 5-1. FREQUENCY OF NPL SITES WITH DIBROMOCHLOROPROPANE CONTAMINATION *



* Derived from View 1989

agricultural soils that were treated with 1,2-dibromo-3-chloropropane in the past, and via leaching through soils at hazardous waste and spill sites that contain the chemical.

The CLP Statistical Database (CLPSD) did not list 1,2-dibromo-3-chloropropane among the compounds most commonly found in groundwater or surface water at NPL waste sites (CLPSD 1989).

5.2.3 Soil

Data on current release of 1,2-dibromo-3-chloropropane to soils are lacking probably because few, if any, releases to soil are currently occurring. Significant releases to soil occurred in the past as a result of its extensive use as a soil fumigant on a wide variety of crops in the United States (Section 5.3.1). Current releases are probably very low because the chemical is used only as an intermediate in organic synthesis and for research purposes. Its use as a soil fumigant, the only major purpose for which the chemical was used in the past, is no longer permitted in the United States (Section 4.3). Potential pathways for release to soil include disposal at hazardous waste sites with improper disposal techniques, spills, and irrigation with contaminated well water or other water. The CLPSD did not list 1,2-dibromo-3-chloropropane among the compounds most commonly found in soil at NPL waste sites (CLPSD 1989).

5.3 ENVIRONMENTAL FATE

5.3.1 Transport and Partitioning

1,2-Dibromo-3-chloropropane in soil is subject both to leaching into groundwater and to volatilization from near-surface soil. The experimental K,,s of approximately 149 in Lincoln fine sand (Wilson et al. 1981) and 128 in an unspecified soil (Sabljic 1984) indicate that 1,2-dibromo-3-chloropropane is highly mobile in soil (Swann et al. 1983). Data from field and laboratory experiments confirm that 1,2-dibromo-3-chloropropane has a strong potential to leach through soil to groundwater (Bomberger et al. 1983; Carter et al. 1984; Hodges and Lear 1974; Kloos 1983; Oki and Giambelluca 1987; Wilson et al. 1981). The rate and extent that 1,2-dibromo-3-chloropropane leaches through agricultural soil depend upon various factors that include the water-holding capacity of the soil (which is related to the size of the air spaces in the soil), the amount of organic matter in the soil, the amount of water applied, and the method of 1,2-dibromo-3-chloropropane application (Hodges and Lear 1974).

In a study using primarily clay, silt, and sandy soils, mobility was lowest in the clay soil, which had a higher content of organic matter than both sandy and silt soil and a lower amount of air space between particles of soil than was found in the silt soil (Hodges and Lear 1974). Mobility was highest in the sandy soil, which had the largest spaces between soil particles

(and therefore the fastest rate of water movement) and the lowest amount of organic matter (Hodges and Lear 1974). Application of 1,2-dibromo-3-chloropropane by either injection or application in irrigation water (flood application) led to extensive and rapid penetration of the fumigant. Application of 1,2-dibromo-3-chloropropane by injection led to greater penetration in the clay and silt soils, compared to its flood application, because it was retained near the soil surface in the latter case and was subsequently lost to the atmosphere (Hodges and Lear 1974). An illustration of the volatilization behavior of 1,2-dibromo-3-chloropropane from soil was obtained in a study of a pineapple field that was treated with 4 gallons per acre of the chemical injected to a depth of 12 inches (Albrecht and Chenchin 1985). 1,2-Dibromo-3-chloropropane concentration in the air at ground level and at 42 inches above the ground reached peaks after 2 days (approximately 0.4 and 8 ppb, respectively), dropped off to non-detectable levels after 3 days, peaked after 6 days following a 6-mm rainfall on days 5-6 (approximately 1.2 and 0.5 ppb at ground level and 42 inches, respectively), and dropped off but remained at measurable levels for the remainder of the 30-day experiment (Albrecht and Chenchin 1985). These data support results obtained in modeling studies that predict that volatilization of 1,2-dibromo-3-chloropropane from near-surface soil is important (Bomberger et al. 1983; Jury et al. 1987). Estimated volatilization half-lives for 1,2-dibromo-3-chloropropane that was evenly distributed in the top 10 cm of soil varied between 0.6 days in dry soil with very low soil organic content to 26.2 days in wet soil with relatively high soil organic content (Bomberger et al. 1983). The use of plastic coverings over 1,2-dibromo-3-chloropropane treated fields retards volatilization loss from soil.

Small amounts of 1,2-dibromo-3-chloropropane may be absorbed through the roots of plants growing in 1,2-dibromo-3-chloropropane contaminated soil and may be translocated to other parts of the plants (see Section 5.4.4.) (Carter and Riley 1982; Newsome et al. 1977). 1,2-Dibromo-3-chloropropane was found in peaches and in the roots and tops of carrots and radishes that were grown in 1,2-dibromo-3-chloropropane treated soil. The generally lower amounts of the chemical found in the foliage than in the roots of the carrot and radish plants may have resulted from translocation from the roots or from absorption of 1,2-dibromo-3-chloropropane that had volatilized from the soil to the air (Newsome et al. 1977). The possibility of absorption of volatilized 1,2-dibromo-3-chloropropane by the peaches appears to be a less likely explanation than translocation because the 1,2-dibromo-3-chloropropane was applied to the fields in the fall, months before the spring harvest of the peaches (Carter and Riley 1984).

In the atmosphere, 1,2-dibromo-3-chloropropane is expected to exist predominantly in the vapor phase based upon its vapor pressure (Table 3-2) (Eisenreich et al. 1981; Munnecke and VanGundy 1979). Because significant amounts of 1,2-dibromo-3-chloropropane are not likely to be present in the particulate phase, dry deposition to the earth's surface is not a significant removal process. Based upon its high water solubility (Table 3-2), the small

amounts of 1,2-dibromo-3-chloropropane that are present in air may be removed by wet deposition; however, much of the 1,2-dibromo-3-chloropropane removed from the atmosphere by washout is likely to reenter the atmosphere by volatilization. No experimental or predictive data were located in the literature regarding the transport of 1,2-dibromo-3-chloropropane in the atmosphere; however, the expected half-life of 36 days (Section 5.3.2.1) indicates that it could be transported long distances in the atmosphere.

1,2-Dibromo-3-chloropropane that is present in water 'is expected to volatilize rapidly to the atmosphere. Using the Henry's law constant, a halflife of 13.5 hours was calculated for evaporation from a model river l-m deep, flowing at 1 m/second, with a wind velocity of 3 m/second, and neglecting adsorption to sediment (Thomas 1982). A volatilization half-life of 8 days from a model pond can be estimated using a three-compartment EXAMS model (EPA 1985d). 1,2-Dibromo-3-chloropropane is not expected to adsorb significantly to sediment and suspended organic matter based upon a K_{OC} ranging between 128 and 149 (Sabljic 1984; Wilson et al. 1981). It is not expected to bioconcentrate in fish and other aquatic organisms based upon an estimated bioconcentration factor (BCF) of 11.2 (calculated from water solubility; Table 3-2) (Bysshe 1982; Munnecke and VanGundy 1979). No data were located that would indicate a potential for 1,2-dibromo-3-chloropropane to biomagnify from lower to higher trophic states of aquatic or terrestrial food chains.

5.3.2 Transformation and Degradation

5.3.2.1 Air

The primary degradation process for 1,2-dibromo-3-chloropropane in the atmosphere is likely to be a vapor-phase reaction with photochemically produced hydroxyl radicals. The experimental rate constant for this process is 4.4×10^{-13} cm^3/molecule-set (Tuazon et al. 1986). This corresponds to a half-life of 36 days at an estimated atmospheric concentration of 5~10~ hydroxyl radicals/cm^3. Direct photolysis of 1,2-dibromo-3-chloropropane is not expected to occur in the atmosphere since the chemical lacks a chromophore that absorbs light at environmentally significant wavelengths (greater than 290 nm) (Silverstein et al. 1974).

5.3.2.2 Water

Degradation of 1,2-dibromo-3-chloropropane in natural waters is a slow process. It volatilizes from surface waters before significant degradation can occur. Hydrolysis of 1,2-dibromo-3-chloropropane in natural waters is unlikely to be an important removal process. The base hydrolysis rate constant at 25°C of 20.6 hr^{-1} M^{-1} was extrapolated from data obtained at 40° 100°C (Burlinson et al. 1982). This rate constant corresponds to half-lives for hydrolysis of 38 years and 140 days at pH 7 and 9, respectively. Direct photolysis of 1,2-dibromo-3-chloropropane is not likely to occur in environmental waters since the chemical lacks a chromophore that absorbs light

at environmentally significant wavelengths (greater than 290 nm) (Silverstein et al. 1974).

No studies were located regarding the biodegradation of 1,2-dibromo-3-chloropropane in natural waters. 1,2-Dibromo-3-chloropropane may be susceptible to slow biodegradation in natural waters based upon the observation of biologically mediated dehalogenation in certain soils amended with a nutrient (Castro and Belser 1968). In experiments using anoxic biofilm columns that were designed to resemble groundwater environments, 1,2-dibromo-3-chloropropane was susceptible to biodegradation under conditions of methanagenesis, denitrification, and sulfate respiration (Bouwer and Wright 1988). Although data from these experiments cannot be used to predict what type of aquifer is likely to support biodegradation or the rate of biodegradation to be expected, they indicate that some biodegradation of 1,2-dibromo-3-chloropropane in groundwater may occur under anaerobic conditions.

5.3.2.3 Soil

1,2-Dibromo-3-chloropropane is subject to biodehalogenation in soilwater suspensions (aerobic/anaerobic conditions not specified) in the presence of an added nutrient (Castro and Belser 1968). Biodegradation did not occur in the absence of the added glycerol nutrient or in suspensions of sterilized soil. Approximately 75% of the soil samples that were tested affected dehalogenation of 1,2-dibromo-3-chloropropane. The highest rate of dehalogenation was 20% in 1 week at pH 8, which was measured by the rate of bromide ion formation. The maximum observed yield of bromide from 1,2-dibromo-3-chloropropane was 63% of the theoretical yield in 4 weeks under unspecified conditions. The data from these experiments suggest that 1,2-dibromo-3-chloropropane may be susceptible to biodegradation in soil under certain conditions; however, it is not possible to predict the soils that will biodegrade the chemical or what the rate of biodegradation might be (Castro and Belser 1968). In another study, it appears that no degradation of 1,2-dibromo-3-chloropropane was observed in soil columns within 25 days under aerobic conditions (Wilson et al. 1981). Based upon aqueous hydrolysis data, chemical hydrolysis is not expected to be significant except in very alkaline soils.

Based upon monitoring data obtained years after the last known application, 1,2-dibromo-3-chloropropane residues that do not leach or

volatilize appear to be very persistent in soil. For example, 1,2-dibromo-3-chloropropane residues as high as 0.5 μg/kg were found in the soil at a site 6-7 years following the last known application (Nelson et al. 1981).

5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

5.4.1 Air

Few data concerning the detection of 1,2-dibromo-3-chloropropane in the atmosphere were found. Ambient air surrounding bromine industry chemical plants in the vicinity of two cities in Arkansas were analyzed for the presence of 1,2-dibromo-3-chloropropane in 1976 and 1977 (Pellizzari et al. 1978). In the vicinity of Magnolia, Arkansas, the maximum concentration of the chemical found in air surrounding a Dow Chemical Company plant was 6,653 ng/m^3. The maximum concentration in the El Dorado, Arkansas, area was 187 ng/m^3 at the Velsicol Chemical Corporation (Pellizzari et al. 1978). In a study that reported data collected primarily between 1970 and 1980, the median concentration of 1,2-dibromo-3-chloropropane was 1.8 ng/m^3 in ambient air near source-dominated areas; no data were listed for rural, remote, urban, or suburban areas (Brodzinsky and Singh 1982). This study is not comprehensive since it involved only scattered sampling of bromine industry chemical plants in one state. Furthermore, the data are old and were taken when the chemical was still being manufactured and widely used as a soil fumigant. Current releases to the atmosphere from manufacturing or research-use point sources are not likely to be significant since only limited amounts are presumed to be made and used (Sections 4.3 and 5.2.1). Significant concentrations of the chemical are probably not present in the ambient atmosphere at this time; therefore, the background level estimated for ambient air is expected to be less than'the detection limit. Exceptions may include air near hazardous waste sites where 1,2-dibromo-3-chloropropane has been disposed, although no data were found concerning atmospheric concentrations at these sites.

5.4.2 Water

Data concerning levels of 1,2-dibromo-3-chloropropane in water are lacking, and those available are neither current nor comprehensive (Table 5-1). The data in Table 5-1 indicate that contamination of municipal drinking water supplies was not widespread in the past. Where contamination was found, the concentrations had been less than 10 μg/L; however, concentrations as high as 95 and 137 μg/L have been reported in water from drinking water wells in California and Arizona, respectively, although no information was provided on possible sources of contamination (Burmaster 1982). In a study of water from drinking water wells in the Fresno area of California's Central Valley conducted between 1979 and 1983, the tested wells generally had seasonal concentration patterns ranging from a low in winter to highs in spring/summer months. The 1,2-dibromo-3-chloropropane concentration also changed with daily use patterns ranging from highs at the start of pumping with lower concentrations as pumping continued (Kloos 1983). In a

TABLE 5-1. Levels of 1,2-Dibromo-3-chloropropane in Potable Water

Location	Date of sampling	Number of samples	Number positive samples	Concentration (µg/L) Range[a]	Concentration (µg/L) Mean[a]	Reference
Municipal water supplies						
United States	1981–82	466	1	5.5	Not applicable	Westrick et al. 1984
Mainly rural California	1979	61	14	0.1–9.5	1.4	Peoples et al. 1980
Riverside & Stanislas Counties, California	1979	3	3	0.1	0.1	Kutz and Carey 1986
South Carolina - DBCP nonuse area[b]	1979–80	3	1	0.05	Not applicable	Carter and Riley 1981
South Carolina -high DBCP use area[b]	1979–80	8	4	0.008–0.05	No data	Carter and Riley 1981
Drinking water wells						
South Carolina - DBCP nonuse area[b]	1979–80	8	3	0.008–0.05	Not applicable	Carter and Riley 1981
South Carolina -high DBCP use area[b]	1979–80	49	29	0.008–>1.0[c]	No data	Carter and Riley 1981
Madera, Stanislaus, & San Joaquin Co., California	1979	7	7	0.1–10.8	3.2	Kutz and Carey 1986
Well water and groundwater in areas with agricultural or undefined uses						
California	1979–84	8,190	2,522	No data[d]	No data	Cohen 1986
Fresno County, California	1979–83	9,000–10,000	1,500[e]	0.001–32[f]	No data	Kloos 1983
Mainly rural California	1979	262	90	0.1–39.2	No data	Peoples et al. 1980
Hawaii pineapple growing regions	1980–83	No data	No data	0.002–11	No data	Oki and Giambelluca 1987
United States[g]	No data	No data	No data	0.02–20[h]	No data	Cohen et al. 1986
San Joaquin Valley, California	April 1980	4 sites	3 sites	0.54–12	4.6	Nelson et al. 1981

[a]Based upon positive values; if one value is listed, it is a maximum.
[b]Areas of no 1,2-dibromo-3-chloropropane use (nonuse) and widespread use (high use), respectively.
[c]13 of 49 sites contained greater than the background level of 0.05 µg/L, and 5 contained greater than 1.0 µg/L.
[d]1,455 wells contained greater than 1.0 µg/L 1,2-dibromo-3-chloropropane.
[e]Approximate numbers
[f]850 wells contained greater than 1.0 µg/L 1,2-dibromo-3-chloropropane.
[g]Five U.S. states: Arizona, California, Hawaii, Maryland, South Carolina
[h]Typical positive values

DBCP = 1,2-dibromo-3-chloropropane

study of various waters in South Carolina sampled between 1979 and 1980, concentrations of 1,2-dibromo-3-chloropropane in water from one of three municipal water supplies ranged from 0.008 μg/L (detection limit) to 0.05 μg/L in an area where 1,2-dibromo-3-chloropropane was not known to have been used (Carter and Riley 1981).

Few data concerning the detection of 1,2-dibromo-3-chloropropane in surface water were found. In a study of South Carolina surface waters that were sampled between 1979 and 1980, concentrations of 1,2-dibromo-3-chloropropane ranged from not detected (detection limit = 0.008 μg/L) to 0.05 μg/L in areas where 1,2-dibromo-3-chloropropane usage rates ranged from non-use to scattered use (Carter and Riley 1981). In high-use areas, 18 of 48 sites had concentrations exceeding the background level of 0.05 μg/L; concentrations as high as 0.35 μg/L were detected (Carter and Riley 1981). 1,2-Dibromo-3-chloropropane was identified, but not quantified, in surface water at a bromine industry chemical plant in the vicinity of Magnolia, Arkansas, which was sampled in 1977 (Pellizzari et al. 1978).

These data, combined with the knowledge that use of 1,2-dibromo-3-chloropropane as a soil fumigant has not been permitted in the United States for several years, suggest that widespread exposure to the chemical in drinking water is not likely. The estimated background level for groundwater in areas where the chemical has not been used or disposed of in the past and in surface water is less than the detection limit. In areas where it was used as a soil fumigant, background levels of 0.001-0.008 μg/L can be expected depending on the amount used and environmental conditions.

5.4.3 Soil

Few data concerning the detection of 1,2-dibromo-3-chloropropane in soil were found. In a study conducted in 1980, 1,2-dibromo-3-chloropropane was analyzed in soils and subsoils from fields at four sites that were known to have been treated with 1,2-dibromo-3-chloropropane (the last application was 3-6 years prior to sampling) and where groundwater contamination with the chemical had been identified (Nelson et al. 1981). The concentrations in the soil and subsoils ranged from not detected (detection limit not stated) to 9 μg/kg (dry weight basis); higher levels were generally found in clay and silt layers (Nelson et al. 1981). In 32 fields that had received 1,2-dibromo-3-chloropropane treatments 2-4 years prior to sampling, the surface of the topsoil contained approximately 2-5 μg/kg of the chemical (Peoples et al. 1980).

In another study, soil samples taken from two South Carolina peach orchards with similar histories of 1,2-dibromo-3-chloropropane usage contained mostly undetectable levels (detection limit 0.025 μg/kg), but up to less than 0.1 and less than 0.5 μg/kg of the chemical was found in soil from the two orchards (Carter et al. 1984). Soil profile samples indicated that the residues were usually found in the upper 90 cm (Carter et al. 1984). Higher

levels of contamination in the groundwater at the first site were explained by a spill in which a formulation containing 1,2-dibromo-3-chloropropane had leaked from a rusting barrel (30 m from the well) leading to concentrations as high as 7.844 μg/kg in the adjacent soil (Carter et al. 1984).

These data, combined with the knowledge that use of 1,2-dibromo-3-chloropropane as a soil fumigant has not been permitted in the United States for several years, suggest that widespread exposure to the chemical due to contamination of soil is unlikely. The estimated background level for ambient soil in areas where the chemical has not been used is less than the detection limit. In areas where it was used as a soil fumigant or disposed, background levels of up to 0.5 μg/kg can probably be expected.

5.4.4 Other Environmental Media

Few data concerning levels of 1,2-dibromo-3-chloropropane in other environmental media were found. 1,2-Dibromo-3-chloropropane was tentatively identified, not quantified, in sediment at a bromine industry chemical plant in the vicinity of Magnolia, Arkansas, which was sampled in 1977 (Pellizzari et al. 1978).

Peaches grown in soil treated by injection into the soil of 51.4 and 137.5 L/hectare of a fumigant formulation containing 1.45 kg/L of 1,2-dibromo-3-chloropropane (peaches harvested between 183 and 217 days following treatment) contained 0.13 and 0.72 ppb 1,2-dibromo-3-chloropropane (Carter and Riley 1984). No residues were found in peaches grown in nonfumigated soil or in soil treated at or below the recommended treatment rate of 46.8 L/treated hectare (Carter and Riley 1984). In another study, Carter and Riley (1982) found levels as high as 24.7 ppb in peaches that were treated 114 days prior to harvest (application rate not reported). Carrots grown in soil that was treated with 12.26 pounds/acre of 1,2-dibromo-3-chloropropane by injection to a depth of 7 inches contained up to 1.50 ppm 3 weeks after treatment, and the residues persisted for 16 weeks when fumigation was at seeding (Newsome et al. 1977). Most of the residues were contained in the pulp of the carrots and two-thirds of the residues in unpeeled carrots disappeared when the carrots were boiled for 5 minutes. The maximum concentration found in radishes from treated fields (application rate of 12.26 pounds/acre of 1,2-dibromo-3-chloropropane) was 0.194 ppm (Newsome et al. 1977).

1,2-Dibromo-3-chloropropane was found at concentrations between 15 and 25 ppb in a commercial sample of sodium humate that was apparently imported from Germany (Gabbita 1986). It was not known whether the soil from which the humate was extracted was itself contaminated with the chemical.

5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

The general population may be exposed to 1,2-dibromo-3-chloropropane through the ingestion of contaminated drinking water and food. Contaminated drinking water is most likely to be derived from contaminated groundwater sources at or near locations where 1,2-dibromo-3-chloropropane had been used as a soil fumigant. Not only are these areas limited in number and size, but the use of 1,2-dibromo-3-chloropropane as a soil fumigant has been banned for some time; therefore, although no current and comprehensive data were found to calculate an estimate of general population exposure to 1,2-dibromo-3-chloropropane from drinking water, the estimate is expected to be minimal based upon older data concerning the presence of 1,2-dibromo-3-chloropropane in drinking water and groundwater in the United States (Section 5.4.2). Since use of 1,2-dibromo-3-chloropropane has been prohibited for several years, it seems unlikely that foods recently harvested would contain 1,2-dibromo-3-chloropropane: Foods grown in fields that were irrigated with water derived from groundwater contaminated with 1,2-dibromo-3-chloropropane may contain small amounts of 1,2-dibromo-3-chloropropane based upon detection of the chemical in certain foods (Carter and Riley 1982, 1984; Newsome et al. 1977). Although data are lacking, inhalation is not expected to contribute significantly to general population exposure to 1,2-dibromo-3-chloropropane.

Due to the lack of recent comprehensive monitoring data, the average daily intake of 1,2-dibromo-3-chloropropane and the relative significance of each source of exposure cannot be determined. Since releases of 1,2-dibromo-3-chloropropane to the environment are generally limited to areas where it was used as a soil fumigant, a use which has been banned by the EPA in 1985, widespread exposure to the chemical is not likely.

The National Occupational Hazard Survey (NOHS) conducted by the National Institute for Occupational Safety and Health (NIOSH) between 1972 and 1974 statistically estimated that 9,682 workers were exposed to 1,2-dibromo-3-chloropropane in the workplace in 1972 (RTECS 1984). The NOHS database does not contain information on the frequency, concentration, or duration of exposure of workers to any of the chemicals therein. The survey provides only an estimate of the number of workers potentially exposed to chemicals in the workplace; furthermore, the NOHS data are no longer valid to predict current numbers of workers exposed to 1,2-dibromo-3-chloropropane in the United States since the use of 1,2-dibromo-3-chloropropane as a soil fumigant (by far its major use in the past) has been banned in the United States, and since it is presumed that only relatively small amounts are produced for research purposes, and for use as an intermediate in chemical synthesis. 1;2-Dibromo-3-chloropropane was not listed by the National Occupational Exposure Survey (NOES) conducted by NIOSH (NIOSH 1989).

5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

The highest levels of exposure may occur with workers who manufacture or use the compound for research or as a chemical intermediate in synthesis.

Populations with potentially higher exposure than normal for the general population include those in areas that obtain drinking water from contaminated groundwater sources. These areas are generally at or near agricultural regions where 1,2-dibromo-3-chloropropane had been used as a soil fumigant, and include, for example, the San Joaquin Valley in California (Kloos 1983), the pineapple-growing regions of Hawaii (Oki and Giambelluca 1987), and the peach-growing regions of South Carolina (Carter and Riley 1981). Drinking water derived from contaminated groundwater at or near hazardous waste sites that contain 1,2-dibromo-3-chloropropane might contain the chemical and contribute to exposure. Inhalation of contaminated air may contribute significantly to overall exposure of the general public, especially for populations living at or near hazardous waste dumps where 1,2-dibromo-3-chloropropane has been found. Most, if not all, of these exposures are expected to be rare and at relatively low levels.

5.7 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) ta assess whether adequate information on the health effects of 1,2-dibromo-3-chloropropane is available. Where adequate information is not available, ATSDR, in conjunction with the NTP, is required to assure the initiation of a program of research designed to determine the 3 health effects (and techniques for developing methods to determine such health effects) of 1,2-dibromo-3-chloropropane.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that, if met, would reduce or eliminate the uncertainties of human health assessment. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

5.7.1 Data Needs

Physical and Chemical Properties. Physical and chemical property data are essential for estimating the transport and partitioning of a chemical in the environment. Most of the essential physical and chemical properties needed to estimate the environmental fate and transport of 1,2-dibromo-3-chloropropane are available (Table 3-2) (IARC 1979; Munnecke and VanGundy 1979; Ruth 1986; Sabljic 1984; Sax and Lewis 1987; Stenger 1978; Thomas 1982; Wilson et al. 1981; Windholz 1983). No experimental values are available for

the log octanol/water partition coefficient (log K_{OW}) and BCF. Since an estimated log K_{OW} was used to estimate the K_{OC} and BCF, the availability of an experimentally determined log K_{OW} would lead to less uncertainty in those estimated properties. While the techniques used for these estimations are reasonably accurate (Bysshe 1982; EPA 1988a), having the experimentally determined values would eliminate uncertainty concerning the reliability of these data.

Production, Import/Export, Use, and Disposal. Data regarding the production methods for 1,2-dibromo-3-chloropropane are available (Windholz 1983); however, data regarding current production volumes, release, and use patterns are lacking. Current levels of production, release, and use are considered relatively low due to the banning of the chemical's major use as a soil fumigant. Use, release, and disposal data can be useful for determining areas where environmental exposure to 1,2-dibromo-3-chloropropane may be high. Based upon relatively outdated data, significant concentrations are expected to be found mainly in the groundwater and drinking water derived from the groundwater at or near areas where 1,2-dibromo-3-chloropropane was used extensively as a soil fumigant (Burmaster 1982; Carter and Riley 1981; Cohen 1986; Kloos 1983; Kutz and Carey 1986; Nelson et al. 1981; Oki and Giambelluca 1987; Peoples et al. 1980; Westrick et al. 1984). Only general data are available on the methods of disposal of 1,2-dibromo-3-chloropropane (HSDB 1989). Specific disposal information would be useful for determining the effectiveness of the disposal methods. Regulations are available pertaining to the restrictions upon the land disposal of 1,2-dibromo-3-chloropropane.

According to the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. Section 11023, industries are required to submit chemical release and off-site transfer information to the EPA. The Toxic Release Inventory (TRI), which contains this information for 1987, became available in May of 1989. This database will be updated yearly and should provide a list of industrial production facilities and emissions. Information specifically for 1,2-dibromo-3-chloropropane is dependent upon the current status of the TRI.

Environmental Fate. The ultimate environmental fate of 1,2-dibromo-3-chloropropane remains unclear due to a lack of experimental data. It is known, however, that the chemical has a tendency to partition into groundwater and into the atmosphere (Hodges and Lear 1974; Sabljic 1984; Wilson et al. 1981). It does not bind strongly to sediment or soil, but leaches rapidly through soil. It is subject to volatilization from surface water and near surface soil (Albrecht and Chenchin 1985; Bomberger et al. 1983; Thomas 1982). It degrades in the atmosphere via reaction with hydroxyl radicals (Tuazon et al. 1986). The chemical is not expected to significantly photolyze directly or to hydrolyze in water, but it is not known whether it biodegrades in water. It may biodegrade in certain soils provided adequate nutrients are available (Castro and Belser 1968). Residues of 1,2-dibromo-3-chloropropane evaporate

from near-surface soil and could leach through soil to groundwater. Experimental data regarding the processes that determine the fate and transport of 1,2-dibromo-3-chloropropane in air and soil are unavailable. Nothing definite is known about the biodegradability of the compound in soil or natural waters. Monitoring data obtained years after the last known applications of 1,2-dibromo-3-chloropropane indicate that small residues of the chemical are persistent in soil and groundwater (Carter and Riley 1981). Experimental data concerning biodegradation in soil would aid in assessing the ultimate environmental fate of 1,2-dibromo-3-chloropropane. This, in turn, would aid in understanding the levels that may be found in the environment and the observed or predicted levels of human exposure.

Bioavailability from Environmental Media. Studies have shown that 1,2-dibromo-3-chloropropane is absorbed through the gastrointestinal tract (Kato et al. 1979a) (Section 2.3.1), indicating that it may be absorbed through the ingestion of contaminated water and food. This suggests that exposure to 1,2-dibromo-3-chloropropane may occur as the result of ingestion of soil by children playing in hazardous waste sites. Thus, monitoring data on the actual number of children who eat soil while playing at toxic waste sites are needed. No data were found concerning absorption through the lungs or through dermal contact. Knowledge of the bioavailability through the various exposure routes is essential in assessing the potential body burdens that may occur as a result of exposure to known environmental concentrations.

Food Chain Bioaccumulation. Experimental data regarding the bioconcentration of 1,2-dibromo-3-chloropropane in plants, aquatic organisms, and animals were not located in the literature. However, based on an estimated BCF of 11.2, it is not expected to bioconcentrate in fish and other aquatic organisms (Bysshe 1982; Munnecke and VanGundy 1979); thus biomagnification in aquatic food chains is unlikely. Additional information on bioconcentration in plants and animals and biomagnification in terrestrial food chains would be helpful in assessing the potential for exposure of terrestrial animals at higher trophic levels.

Exposure Levels in Environmental Media. The data concerning the detection of 1,2-dibromo-3-chloropropane in the environment are so limited and outdated that estimation of human intake is not possible (Brodzinski and Singh 1982; Burmaster 1982; Carter and Riley 1981; Cohen 1986; Kloos 1983; Pellizzari et al. 1978; Peoples et al. 1980; Westrick et al. 1984). Current and comprehensive monitoring data, especially in areas where the chemical has been used in the past and is being used at the present time, would be helpful to estimate human intake. This may pertain to food survey analyses since it is difficult to ascertain whether the surveys to date tested for the presence of 1,2-dibromo-3-chloropropane.

Exposure Levels in Humans. No monitoring data were found indicating that 1,2-dibromo-3-chloropropane has been found in human tissues or blood.

The only biological monitoring studies that were found analyzed human breath samples for the presence of 1,2-dibromo-3-chloropropane (Pellizzari et al. 1978). 1,2-Dibromo-3-chloropropane was not found in any of the samples tested. Data concerning the level of 1,2-dibromo-3-chloropropane in human tissue samples would be helpful in assessing the extent of human exposure to the chemical and in estimating its body burden.

Exposure Registries. No exposure registries for 1,2-dibromo-3-chloropropane were located. This compound is not currently one of the compounds for which a subregistry has been established in the National Exposure Registry. The compound will be considered in the future when chemical selection is made for subregistries to be established. The information that is amassed in the National Exposure Registry facilitates the epidemiological research needed to assess adverse health outcomes that may be related to exposure to this compound. Determination of the number of workers who are exposed to this compound may be included in the information since occupational exposure may be the major area of exposure.

5.7.2 On-going Studies

As part of the Third National Health and Nutrition Evaluation Survey (NHANES III), the Environmental Health Laboratory Sciences Division of the Center for Environmental Health and Injury Control, Centers for Disease Control, will be analyzing human blood samples for 1,2-dibromo-3-chloropropane and other volatile organic compounds. These data will indicate the frequency of occurrence and background levels of these compounds in the general population.

Remedial investigations and feasibility studies conducted at the eight NPL sites known to be contaminated with 1,2-dibromo-3-chloropropane will add to the available database on exposure levels in environmental media, exposure levels in humans, and exposure registries and will increase current knowledge regarding the transport and transformation of 1,2-dibromo-3-chloropropane in the environment.