

6. POTENTIAL FOR HUMAN EXPOSURE

6.1 OVERVIEW

1,2-Dichloroethane's production, storage, and use as a synthetic feedstock (Anonymous 1998; EPA 1985a), as a lead scavenger in leaded gasoline, and as a solvent in closed systems (Dow Chemical Company 1989b) may result in its release to the environment. The use of 1,2-dichloroethane as a lead scavenger has decreased significantly in recent years as leaded gasoline use has declined. The largest environmental releases of 1,2-dichloroethane occur to air. 1,2-Dichloroethane released to surface water and soil is expected to volatilize rapidly to the atmosphere where it will be degraded by photochemically-produced hydroxyl radicals. The half-life for this reaction is about 73 days, calculated from its measured rate constant (Arnts et al. 1989; Atkinson et al. 1989), and the overall atmospheric lifetime of 1,2-dichloroethane is >5 months (EPA 1993). Hydrolysis and photolysis do not appear to be significant in determining the environmental fate of 1,2-dichloroethane. Although biodegradation occurs slowly, it is the primary degradation process for 1,2-dichloroethane in soils and waters. 1,2-Dichloroethane has been detected in ambient air, surface water, groundwater, drinking water, human breath, urine, and milk samples. Concentrations in environmental media are generally greatest near source areas (e.g., industrial point sources, hazardous waste sites).

1,2-Dichloroethane has been identified in at least 570 of the 1,585 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (HazDat 2001). However, the number of sites evaluated for 1,2-dichloroethane is not known. The frequency of these sites can be seen in Figure 6-1. Of these sites, 569 are located within the United States and 1 is located in the Commonwealth of Puerto Rico (not shown).

Inhalation of 1,2-dichloroethane in ambient or workplace air is generally the main route of human exposure to the compound. Estimates of populations potentially exposed to 1,2-dichloroethane in workplace environments range from 80,000 to 1.4 million workers (NIOSH 1976a, 1984a). The estimated size of the general population potentially exposed to low levels of the compound through inhalation of polluted ambient air around industrial sites was . 15 million people (Kellam and Dusetzina 1980). Ingestion of contaminated drinking water and food may also be important routes of exposure.

Figure 6-1. Frequency of NPL Sites with 1,2-Dichloroethane Contamination



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6.2 RELEASES TO THE ENVIRONMENT

There are no known natural sources of 1,2-dichloroethane. Releases of this compound to the environment may result from the manufacture, use, storage, distribution, and disposal of 1,2-dichloroethane. Older consumer goods containing 1,2-dichloroethane that are still in use or have been discarded as waste also represent potential emission sources. 1,2-Dichloroethane may also be released to the environment from the microbial degradation of other chlorinated alkanes. For example, 1,2-dichloroethane is a known product of the anaerobic biodegradation of 1,1,2,2-tetrachloroethane (Chen et al. 1996; Lorah and Olsen 1999).

6.2.1 Air

Emissions to the atmosphere comprise the largest component of all releases of 1,2-dichloroethane to the environment. According to the Toxics Release Inventory (TRI) (Table 6-1), an estimated total of 546,039 pounds of 1,2-dichloroethane, amounting to 88.8% of the total on-site environmental release, was discharged to air from manufacturing and processing facilities in the United States in 1999 (TRI99 2001). The TRI data should be used with caution because only certain types of facilities are required to report. This is not an exhaustive list.

1,2-Dichloroethane has been identified in air samples collected at 39 of the 570 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2001).

6.2.2 Water

Industrial releases of 1,2-dichloroethane to surface waters are relatively minor compared to releases to the atmosphere. According to the TRI (Table 6-1), an estimated total of 904 pounds of 1,2-dichloroethane, amounting to 0.1% of the total on-site environmental release, was discharged to water from manufacturing and processing facilities in the United States in 1999 (TRI99 2001). The TRI data should be used with caution because only certain types of facilities are required to report. This is not an exhaustive list.

In England and Wales, 1,2-dichloroethane was detected in 17% of industrial waste water effluent samples at an average concentration of 117 µg/L, and in 9.5% of treated sewage at an average concentration of 1.39 µg/L (Stangroom et al. 1998). 1,2-Dichloroethane has been identified in surface water samples

Table 6-1. Releases to the Environment from Facilities that Produce, Process, or Use 1,2-Dichloroethane

State ^b	Number of facilities	Reported amounts released in pounds per year ^a						Total on-site release ^d	Total off-site release ^e	Total on and off-site release
		Air ^c	Water	Underground injection	Land					
AL	2	18	No data	No data	No data	18	10,453	10,471		
AR	4	10,143	70	0	0	10,213	150,574	160,787		
CA	2	264	No data	No data	No data	264	83	347		
GA	1	No data	No data	No data	No data	No data	No data	No data		
IA	2	307	No data	No data	No data	307	No data	307		
IL	4	20,529	No data	No data	0	20,529	147	20,676		
IN	2	26,070	5	No data	5	26,080	No data	26,080		
KS	1	3,549	38	No data	No data	3,587	No data	3,587		
KY	3	21,557	47	No data	0	21,604	255	21,859		
LA	19	222,595	343	51,116	2,972	277,026	2,472	279,498		
MA	1	1,178	No data	No data	No data	1,178	No data	1,178		
MI	3	162	No data	No data	No data	162	No data	162		
MO	3	28,815	25	No data	5	28,845	No data	28,845		
MS	1	7,420	No data	1,040	No data	8,460	No data	8,460		
NC	2	5,466	1	No data	No data	5,467	952	6,419		

**Table 6-1. Releases to the Environment from Facilities that Produce, Process, or Use 1,2-Dichloroethane
(continued)**

State ^b	Number of facilities	Reported amounts released in pounds per year ^a						
		Air ^c	Water	Underground injection	Land	Total on-site release ^d	Total off-site release ^e	Total on and off-site release
NE	1	255	No data	No data	0	255	No data	255
NJ	1	18	0	No data	0	18	2	20
NY	2	524	255	No data	No data	779	72,446	73,225
OH	3	86	1	No data	No data	87	49	136
PA	6	25,244	No data	No data	No data	25,244	No data	25,244
PR	3	470	No data	No data	No data	470	No data	470
SC	2	27,661	No data	No data	No data	27,661	0	27,661
TX	18	143,703	119	13,309	1	157,132	445,871	603,003
VA	1	5	No data	No data	No data	5	No data	5
WI	1	No data	No data	No data	No data	No data	No data	No data
Total	89	546,039	904	65,465	2,983	615,391	683,304	1,298,695

Source: TRI99 2001

^aData in TRI are maximum amounts released by each facility.

^bPost office state abbreviations are used.

^cThe sum of fugitive and stack releases are included in releases to air by a given facility.

^dThe sum of all releases of the chemical to air, land, water, and underground injection wells.

^eTotal amount of chemical transferred off-site, including to publicly owned treatment works (POTW).

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collected at 89 sites and groundwater samples collected at 492 of the 570 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2001).

6.2.3 Soil

Industrial releases of 1,2-dichloroethane to soil are relatively minor compared to releases to the atmosphere. According to the TRI (Table 6-1), an estimated total of 2,983 pounds of 1,2-dichloroethane, amounting to 0.5% of the total on-site environmental release, was discharged to land from manufacturing and processing facilities in the United States in 1999 (TRI99 2001). An additional 65,465 pounds of 1,2-dichloroethane, amounting to 10.6% of the total on-site environmental release, was injected underground. The TRI data should be used with caution because only certain types of facilities are required to report. This is not an exhaustive list.

1,2-Dichloroethane has been identified in soil samples at 166 sites and sediment samples at 42 of the 570 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2001).

6.3 ENVIRONMENTAL FATE

1,2-Dichloroethane released to the environment partitions to the atmosphere. Reaction with photochemically produced hydroxyl radicals is the primary degradation mechanism of 1,2-dichloroethane in the atmosphere. 1,2-Dichloroethane released to soil or water surfaces is expected to volatilize quickly. Biodegradation occurs slowly in water and soil surfaces. Hydrolysis and photolysis are not expected to be important environmental fate processes for 1,2-dichloroethane.

6.3.1 Transport and Partitioning

Releases of 1,2-dichloroethane to the environment as a result of industrial activity are primarily to the atmosphere (see Section 6.2). 1,2-Dichloroethane released to the atmosphere may be transported long distances before being washed out in precipitation or degraded. For example, Pearson and McConnell (1975) attributed the presence of chlorinated organic compounds, including 1,2-dichloroethane, in upland waters to long-range aerial transport and deposition in precipitation.

Based on a Henry's law constant of 1.1×10^{-3} atm-m³/mol at 20 EC (Staudinger and Roberts 1996), 1,2-dichloroethane is expected to volatilize rapidly from water surfaces. An estimated volatilization

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half-life of 28–29 minutes was reported for 1,2-dichloroethane present at a concentration of 1 mg/L in an open water column held at 25 EC and stirred at 200 revolutions per minute (Dilling 1977; Dilling et al. 1975). Removal of 90% of the compound under the same conditions occurred in 96 minutes. However, an evaporation half-life of 10 days was estimated using the EXAMS model for a eutrophic lake. Volatilization losses were shown to be the dominant fate process following a chemical spill in the Rhine River in Germany (Brüeggemann et al. 1991).

No information was found regarding partitioning of 1,2-dichloroethane from the water column onto sediments. However, structural analogs of the compound (i.e., dichloromethane, trichloromethane, and 1,1,1-trichloroethane) do not concentrate selectively onto sediments (Dilling et al. 1975; Pearson and McConnell 1975). Based on $\log K_{oc}$ values of 1.28–1.62 (Borisover and Graber 1997; Chiou et al. 1980; Sabljic et al. 1995), 1,2-dichloroethane is not expected to adsorb to suspended solids and sediment in the water column. An experimental bioconcentration factor of 2 indicates that 1,2-dichloroethane will not bioconcentrate in fish and aquatic organisms (Banerjee and Baughman 1991) and is not expected to bioaccumulate in the food chain (Farrington 1991).

1,2-Dichloroethane released to land surfaces is expected to volatilize rapidly to the atmosphere or leach into groundwater. Volatilization losses occur at a much slower rate for 1,2-dichloroethane present in subsurface soil. Jury et al. (1990) modeled the rate of volatilization of 1,2-dichloroethane from soil at a depth of 1 m to mimic the type of contamination that may occur from landfill leachate. When water evaporation was not taken into account, the yearly loss of 1,2-dichloroethane amounted to 7.1% from a sandy soil. Yearly volatilization losses increased to 30% when water evaporation was considered. Based on $\log K_{oc}$ values of 1.28–1.62 (Borisover and Graber 1997; Chiou et al. 1980; Sabljic et al. 1995), 1,2-dichloroethane is expected to have very high mobility in soil surfaces and should be available for transport into groundwater. In a laboratory experiment conducted with a sandy loam, approximately 50% of an initial concentration of 0.81 mg/L of 1,2-dichloroethane applied to the soil surface was volatilized. The remainder percolated through the soil column to a depth of 140 cm, suggesting that leaching into groundwater may occur (Wilson et al. 1981). Environmental surveys conducted by EPA have detected 1,2-dichloroethane in groundwater sources in the vicinity of contaminated sites (EPA 1985a). Large spills of 1,2-dichloroethane may contaminate groundwater because of the high density of this compound, which makes it sink into the aquifer in a vertical gravity-driven process (Corapcioglu and Hossain 1990).

6.3.2 Transformation and Degradation

6.3.2.1 Air

In the atmosphere, 1,2-dichloroethane is degraded by reaction with photochemically produced hydroxyl radicals. An experimental rate constant of 2.2×10^{-13} cm³/molecule-second at 25 EC (Arnts et al. 1989; Atkinson et al. 1989) corresponds to a half-life of 73 days using an average atmospheric hydroxyl radical concentration of 5×10^5 molecule/cm³. The estimated atmospheric lifetime of 1,2-dichloroethane was reported to be >5 months with formyl chloride, chloroacetyl chloride, hydrogen chloride, and chloroethanol reported as degradation products (EPA 1993). 1,2-Dichloroethane is not expected to undergo significant atmospheric removal by oxidation with ozone or nitrate radicals, and it will not undergo removal by direct photolysis.

6.3.2.2 Water

In groundwater and surface water, biodegradation is the primary degradation process for the removal of 1,2-dichloroethane. Abiotic degradation processes, such as oxidation and hydrolysis, are too slow to be environmentally significant.

Bacteria isolated from a mixture of activated sludge from waste water treatment plants and 1,2-dichloroethane-polluted soils have used 1,2-dichloroethane as a sole carbon source (Janssen et al. 1984; Stucki et al. 1983). Approximately 14% degradation of 5 mg/L 1,2-dichloroethane occurred after 14 days incubation in laboratory experiments using a domestic waste water inoculum (Tabak et al. 1981). The reported loss was corrected for 27% volatilization loss in 10 days from control flasks. Reported degradation losses (corrected for volatilization) for 10 mg/L of the compound were 15% at 7 days and 30% at 14 days. Following a 24-hour incubation at 25 EC under aerobic conditions, 1,2-dichloroethane was degraded (approximately 10%) by a strain of *Pseudomonas fluorescens* bacteria isolated from soil and water contaminated with various chlorinated hydrocarbons, including 1,2-dichloroethane (Vandenbergh and Kunka 1988). 1,2-Dichloroethane was not biodegraded after 35 days under anaerobic conditions in sediment-water test systems (Jafvert and Wolfe 1987) and was not biodegraded by bacteria isolated from groundwater after 8–16 weeks incubation (Wilson et al. 1983). However, recent reviews indicate that the biodegradation of 1,2-dichloroethane to ethene in anaerobic waters is a probable fate process (Kuhn and Suflita 1989; Saint-Fort 1991). The biodegradation half-life of 1,2-dichloroethane in aerobic water was reported as 100 days and the half-life in anaerobic water was reported as 400 days, but

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no details on the kinetic experiments used to establish these half-lives were reported (Capel and Larson 1995). The half-life represents the calculated time for loss of the first 50% of the substance, but the time required for the loss of half of that which remains may be substantially longer, and the rate of disappearance may decline further as time progresses. 1,2-Dichloroethane was 97% biodegraded in laboratory studies using aerobic groundwater microcosms obtained from a Superfund site in California over a 6-day incubation period (Cox et al. 1998). In the field, however, the biodegradation half-life of 1,2-dichloroethane in groundwater can range from less than a year to 30 years depending on the conditions (Bosma et al. 1998).

A growing body of evidence indicates that the co-metabolism of 1,2-dichloroethane (the biodegradation of 1,2-dichloroethane from which the degrading organism gains no energetic benefit) occurs under aerobic conditions (see Section 6.3.2.3). Pure cultures of methanotrophic (methane using) bacteria obtained from both polluted and nonpolluted sources degraded 1,2-dichloroethane in the presence of methane and oxygen (Oldenhuis et al. 1989). Aquifer solids obtained at an *in situ* bioremediation field study mineralized 1,2-dichloroethane to carbon dioxide in the presence of dissolved oxygen and methane (Lanzarone and McCarty 1990). Concentrated cell suspensions of methanogenic bacteria incubated at 37 or 55 EC for 24–96 hours reductively dechlorinated 1,2-dichloroethane to ethene, chloroethane, and ethane (Holliger et al. 1990).

The experimental first-order rate constants for the hydrolysis of 1,2-dichloroethane under neutral conditions were reported as $2.1 \times 10^{-8} \text{ second}^{-1}$ and $1.8 \times 10^{-8} \text{ second}^{-1}$ at 25 EC (Barbash and Reinhard 1989; Jeffers et al. 1989). These values correspond to half-lives of 65 and 72 years. A more recent study determined that the hydrolysis half-life of 1,2-dichloroethane was 4.9×10^4 years at pH 9 and 15 EC (Miyamoto and Urano 1996). Barbash and Reinhard (1989) found that the presence of 5.1×10^{-4} molar (16 ppm) solution of hydrogen sulfide anion decreased the hydrolytic half-life to 6 years. Although still a slow process, this latter reaction may occur in hypoxic groundwater where hydrogen sulfide occurs naturally.

6.3.2.3 Sediment and Soil

As in surface water, direct photolysis of 1,2-dichloroethane on soil surfaces and hydrolysis in moist soil and sediment are not expected to be important environmental fate processes. The primary transformation process for 1,2-dichloroethane in sediment and soil is biodegradation.

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Incubation of 1,2-dichloroethane at a starting concentration of 100 ppb with an unsaturated calcareous soil resulted in 15–23% mineralization to carbon dioxide after 4 weeks, under aerobic conditions, and 3.3–3.4% mineralization under anaerobic conditions (Watwood et al. 1991). 1,2-Dichloroethane (2 μmol) was completely dechlorinated to ethane by anaerobic microcosms and enrichment cultures derived from river sediment over a 2-week incubation period (Loffler et al. 1997). A first-order biodegradation rate constant of 0.013 day^{-1} was determined for 1,2-dichloroethane in an anaerobic sediment slurry (Peijnenburg et al. 1998). This rate constant corresponds to a biodegradation half-life of about 52 days. It was noted that degradation followed first-order kinetics for at least two successive half-lives in this study.

The presence of methane or increasing the proportion of methanotrophs can increase the rate of aerobic biodegradation of 1,2-dichloroethane in soil. In laboratory experiments conducted with different soil types (sand, sandy clay, silty loam, clay, and Lincoln fine sand), soils exposed to methane biodegraded 1,2-dichloroethane to carbon dioxide (Henson et al. 1988; Speitel and Closmann 1991). Based on these results, it was estimated that the bioremediation of soil contaminated with 100 ppm 1,2-dichloroethane could be complete within several months if methane is present (Speitel and Closmann 1991). Methane oxidizing cultures from soil of a California landfill readily biodegraded 1,2-dichloroethane, but toluene and phenol oxidizing cultures were not able to degrade this compound (Chang and Alvarez-Cohen 1995).

As the concentration of 1,2-dichloroethane increases in a soil surface, the degree of biodegradation that takes place may decrease due to microbial toxicity at the enhanced contaminant level. In a respirometer study of microbial toxicity to an agricultural soil, it was determined that a concentration of 0.51 mg of 1,2-dichloroethane per gram of soil resulted in a 50% respiratory inhibition (Regno et al. 1998).

6.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

1,2-Dichloroethane has been detected at low levels (ppb) in ambient urban and rural air, in indoor air samples of residences located near hazardous waste disposal sites, and in surface water, groundwater, and drinking water. Quantitative concentration information is presented in the following sections.

6.4.1 Air

1,2-Dichloroethane has been detected in ambient air samples taken over the north Atlantic Ocean at concentrations of $0.061\text{--}0.12 \mu\text{g}/\text{m}^3$ ($0.015\text{--}0.030$ ppb) (Class and Ballschmiter 1986) and in trace

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amounts in the southern Black Forest in southwestern Germany (concentration unspecified) (Juttner 1986). The reported average surface level background concentration of the compound in ambient air at mid-latitudes is $0.168 \mu\text{g}/\text{m}^3$ (Singh et al. 1982).

1,2-Dichloroethane has been found at higher concentrations in ambient air samples from urban areas of the United States. In a review of 950 potential papers on volatile organic compounds (VOCs) in air published from 1970 to 1987, a database of median daily atmospheric concentrations by site type was compiled (EPA 1988b). The median daily atmospheric concentration of 1,2-dichloroethane in urban sites was $0.049 \mu\text{g}/\text{m}^3$ (0.012 ppb) (1,214 samples) and $1.0 \mu\text{g}/\text{m}^3$ (0.26 ppb) (182 samples) for source-dominated samples; it was not detected in 648 samples from suburban, rural, or remote sites.

1,2-Dichloroethane was detected at 83 urban locations across the United States at a median concentration of $0.04 \mu\text{g}/\text{m}^3$ (0.01 ppb) (Kelly et al. 1994). The average concentration of 1,2-dichloroethane in seven urban locations in 1980–1981 ranged from 0.405 to $6.07 \mu\text{g}/\text{m}^3$ (0.100 to 1.50 ppb) (Singh et al. 1982). The mean concentrations of 1,2-dichloroethane in 1,412 samples of ambient air from 23 sites in 12 Canadian cities from 1988–1990 ranged from 0.070 to $0.28 \mu\text{g}/\text{m}^3$ (0.017 to 0.069 ppb) with an overall mean of $0.13 \mu\text{g}/\text{m}^3$ (0.032 ppb) (WHO 1995). Mean urban air concentrations of 1,2-dichloroethane measured during field experiments in March 1984 in Downey, California, Houston, Texas, and Denver, Colorado were $0.40 \mu\text{g}/\text{m}^3$ (0.010 ppb), $1.82 \mu\text{g}/\text{m}^3$ (0.45 ppb), and $0.089 \mu\text{g}/\text{m}^3$ (0.022 ppb), respectively (Singh et al. 1992). In a 1987 survey of 35 homes in the Kanawha Valley, West Virginia, the mean concentration of 1,2-dichloroethane was $20.8 \mu\text{g}/\text{m}^3$ (5.15 ppb) with a maximum concentration of $140 \mu\text{g}/\text{m}^3$ (34.6 ppb) (Cohen et al. 1989). A component of the Total Exposure Assessment Methodology (TEAM) compared the outdoor concentration of toxic substances to the corresponding overnight indoor concentration. The results of this monitoring study indicated that 1,2-dichloroethane was detected in 30% of the indoor samples (median concentration: $0.025 \mu\text{g}/\text{m}^3$) and 37% of the outdoor samples (median concentration: $0.025 \mu\text{g}/\text{m}^3$) in Greensboro, North Carolina (fall, 1980); 89% of the indoor samples ($3.6 \mu\text{g}/\text{m}^3$) and 100% of the outdoor samples ($2.2 \mu\text{g}/\text{m}^3$) in Baton Rouge, Louisiana (winter, 1981); 18% of the indoor ($0.04 \mu\text{g}/\text{m}^3$) and 40% of the outdoor samples ($0.045 \mu\text{g}/\text{m}^3$) in Houston, Texas (summer, 1981); 64% of the indoor ($0.22 \mu\text{g}/\text{m}^3$) and 54% of the outdoor samples ($0.21 \mu\text{g}/\text{m}^3$) in Los Angeles, California (winter, 1984); 4.3% of the indoor samples ($0.03 \mu\text{g}/\text{m}^3$) and none of the outdoor samples in Los Angeles, California (summer, 1984); 20% of the indoor ($0.12 \mu\text{g}/\text{m}^3$) and none of the outdoor samples in Antioch/Pittsburgh, California (summer, 1984) (Pellizzari et al. 1986). 1,2-Dichloroethane was detected in only 1 of the 349 samples drawn from 11 cities in the 1990 Urban Air Toxics Monitoring Program (UATMP) at a concentration of $0.32 \mu\text{g}/\text{m}^3$ (0.080 ppb) (EPA 1991c). In a survey of homes in North Carolina, 1,2-dichloroethane was detected at a concentration of $0.40 \mu\text{g}/\text{m}^3$ (0.10 ppb) in 1 out of

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25 homes of smokers and was not detected in the homes of nonsmokers (Heavner et al. 1995). In a survey of New Jersey and Pennsylvania residences, 1,2-dichloroethane was detected in the homes of nonsmokers at a mean concentration of $0.03 \mu\text{g}/\text{m}^3$ (0.007 ppb) and in the homes of smokers at a mean concentration of $0.32 \mu\text{g}/\text{m}^3$ (0.079 ppb) (Heavner et al. 1996). The maximum concentration of 1,2-dichloroethane reported in nonsmoking households was $0.54 \mu\text{g}/\text{m}^3$ (0.13 ppb), while the maximum concentration in households where at least one family member smoked was $9.72 \mu\text{g}/\text{m}^3$ (2.40 ppb).

1,2-Dichloroethane has also been detected in samples of ambient air collected in the vicinity of hazardous waste disposal sites. Trace amounts of 1,2-dichloroethane were found in samples of outdoor ambient air from two of nine residences in the Love Canal area of Niagara, New York (Barkley et al. 1980). It was also detected in indoor ambient air samples from two of the nine residences surveyed, at concentrations of $0.10 \mu\text{g}/\text{m}^3$ (0.025 ppb) and $0.13 \mu\text{g}/\text{m}^3$ (0.032 ppb). In addition, it has been found in ambient air samples from three of five hazardous waste sites surveyed in New Jersey at average concentrations of 0.04, 1.1, and $0.12 \mu\text{g}/\text{m}^3$ (0.01, 0.28, and 0.030 ppb) (LaRegina et al. 1986). Another possible source of indoor air pollution is through volatilization from contaminated potable water in domestic shower and bath systems (Andelman 1985). 1,2-Dichloroethane was detected at concentrations of $146 \mu\text{g}/\text{m}^3$ (36 ppb) and $81 \mu\text{g}/\text{m}^3$ (20 ppb) in the ambient air at municipal landfill sites in Canada (Brosseau and Heitz 1994). 1,2-Dichloroethane was detected in 11.4% of the vented air samples obtained from the Fresh Kills landfill in New York at an average concentration of $0.77 \text{mg}/\text{m}^3$ (0.19 ppm) (EPA 1996).

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In a survey of 14 heavily industrialized river basins in the United States, 1,2-dichloroethane was detected at a frequency of 53% in 204 surface water samples collected (EPA 1977a); reported concentrations in domestic surface waters used as drinking water sources ranged from trace amounts to $4.8 \mu\text{g}/\text{L}$ (Brown et al. 1984). 1,2-Dichloroethane has also been found in samples of urban runoff from Eugene, Oregon, at a concentration of $4 \mu\text{g}/\text{L}$ (Cole et al. 1984). 1,2-Dichloroethane was detected in 26% of the river samples obtained from Osaka, Japan, at a mean concentration of $0.09 \mu\text{g}/\text{L}$ (Yamamoto et al. 1997). 1,2-Dichloroethane was detected in the Tees estuary in England in 1992 at concentrations of $0.72\text{--}4.02 \mu\text{g}/\text{L}$, with the highest levels measured near an industrialized area where 1,2-dichloroethane and vinyl chloride monomer were produced (Dawes and Waldock 1994).

Groundwater samples taken from 178 hazardous waste disposal sites contained 1,2-dichloroethane at 29.1% frequency (Plumb 1987). 1,2-Dichloroethane was detected in the groundwater of the Du Pont

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Necco Park Landfill in Niagara Falls, New York at concentrations of 14–4,250 µg/L (Lee et al. 1995). Reported concentrations of 1,2-dichloroethane in domestic groundwater supplies used for drinking water ranged from trace amounts to 400 µg/L (Brown et al. 1984). 1,2-Dichloroethane was detected in 10 of 943 groundwater samples across the United States at concentrations that ranged from 0.95 to 9.80 µg/L with median concentrations ranging from 0.57 to 2.9 µg/L (Westrick et al. 1984). The disposal of organic chemicals in trenches at a waste disposal site near Ottawa, Canada resulted in 1,2-dichloroethane groundwater concentrations ranging from 3.9 to 58.0 µg/L in 30% of samples taken from a 37-well monitoring network in 1988 (Lesage et al. 1990). The concentration of 1,2-dichloroethane in the leachate samples from hazardous waste landfills in Germany ranged from 40 to 830 µg/L (Först et al. 1989). 1,2-Dichloroethane was identified, not quantified, in groundwater wells of Eau Claire, Wisconsin (Canter and Sabatini 1994). 1,2-Dichloroethane was detected in 17% of groundwater samples obtained from 479 waste disposal sites in the United States (Barbee 1994). 1,2-Dichloroethane was detected in 27 of 82 samples of groundwater at the Darling Hill Dump, Vermont at an average concentration of 3.7 µg/L and a maximum concentration of 240 µg/L (EPA 1992a). The maximum concentration of 1,2-dichloroethane in groundwater at the Fallon Naval Air Station, Fallon, Nevada was 1,400 µg/L (Kelley et al. 1998). Groundwater from a former petro-chemical refinery in California contained 1,2-dichloroethane at concentrations ranging from 1 to 9 µg/L (EPA 1992b). 1,2-Dichloroethane was detected at concentrations of 0.8–32.8 µg/L in groundwater near the Lower Llobregat aquifer in Spain (Ventura et al. 1997).

1,2-Dichloroethane was found in drinking water samples from a number of urban and rural locations in the United States. This compound has been detected in drinking water samples from New Orleans, Miami, Philadelphia, and Cincinnati (Clark et al. 1986; Suffet et al. 1980). Private drinking water wells in Wisconsin contained >7 µg/L 1,2-dichloroethane in 2 of 7 wells surveyed (Krill and Sonzogni 1986); in Iowa, 3 public well water supplies contained concentrations of 4–19 µg/L (EPA 1985g), and in Kansas, 1 of 103 farmstead wells contained 1,2-dichloroethane at an average concentration of 1.25 µg/L during 1985–1986 (Steichen et al. 1988). 1,2-Dichloroethane was detected at concentrations of 1–64 µg/L in 56 private drinking water wells in Rhode Island (Rhode Island Department of Health 1989). It was also detected at 0.050 µg/L in drinking water samples from three of nine residences surveyed in the Love Canal area of Niagara, New York (Barkley et al. 1980). 1,2-Dichloroethane was detected in 0.5% of the drinking water wells studied between 1984 and 1990 in California at a maximum concentration of 24 µg/L (Lam et al. 1994b).

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6.4.3 Sediment and Soil

The concentration of 1,2-dichloroethane in sediment samples obtained from the Southampton Water estuary, England over an 18-month period ranged from 0.070 to 11 ppb (Bianchi et al. 1991).

1,2-Dichloroethane was not detected in sediment downstream from two facilities in Canada that manufactured this compound (Oliver and Pugsley 1986). The mean concentration of 1,2-dichloroethane in soil near 20 homes in the Netherlands was 11 mg/kg, while samples in the vicinity of a garage and waste site contained <5 and 30 mg/kg, respectively (WHO 1995). 1,2-Dichloroethane was detected in soil from Claire, Michigan near seven industrial facilities at concentrations of 6–19 µg/kg (EPA 1992c).

6.4.4 Other Environmental Media

In a market basket survey of over 500 samples of table-ready and prepared foods (including cereals, oils/dressings, vegetables, baked goods, nuts, dairy products, jams/candy, meats/meat dishes, fruits, infant/toddler blends, and beverages), 1,2-dichloroethane was detected in a whiskey sample at a concentration of 30 ng/g (Daft 1988, 1989, 1991). 1,2-Dichloroethane has been detected in plain granola samples at 0.31 and 12 ng/g, shredded wheat cereal samples at 8.2 ng/g (Heikes 1987), wheat grain samples at 0–180 ng/g, and bleached flour samples at 0–6.5 ng/g (Heikes and Hopper 1986).

1,2-Dichloroethane has also been qualitatively detected as a volatile component in chickpeas (Rembold et al. 1989).

1,2-Dichloroethane was formerly used as a fumigant, but is not currently registered for use in agricultural products in the United States, Canada, and the United Kingdom. 1,2-Dichloroethane was not detected in 24 samples of rice analyzed in 1992 (WHO 1995) and was not detected in an FDA survey of 234 table ready foods (Heikes et al. 1995). In a survey of foods from Tokyo, Japan, 1,2-dichloroethane was not detected in bean sprouts, colas, juice, rice, lactic beverages, plain yogurt, tofu, or ice milk (Miyahara et al. 1995). It was detected at mean concentrations of 1.3 ng/g in butter, 0.2 ng/g (ppb) in cake, 0.03 ng/g in ice cream, and 0.03 ng/g in store-bought milk (Miyahara et al. 1995).

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6.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

The greatest source of exposure to 1,2-dichloroethane for most of the U.S. population is inhalation of the compound in contaminated air. Other potential routes of human exposure include ingestion of 1,2-dichloroethane in contaminated drinking water or food items and dermal absorption (EPA 1985a; Gold 1980). Since 1,2-dichloroethane is not currently registered for use in agricultural products in the United States, the potential exposure from ingesting contaminated food sources has likely decreased. Ingestion of drinking water contaminated with 1,2-dichloroethane is expected to be an important route of exposure for only 4–5% of the population (HSDB 2001). However, for populations with drinking water supplies containing $>6 \mu\text{g/L}$ of the compound, oral and dermal routes are expected to be more important than inhalation (EPA 1985a). The estimated daily intake of 1,2-dichloroethane in Japan attributed to food ingestion is 0.004 mg/day (Miyahara et al. 1995). Since the levels of 1,2-dichloroethane in food products of Japan are similar to those in the United States, the daily intake value may also be similar.

The National Occupational Hazard Survey (NOHS), conducted by NIOSH from 1972 to 1974, estimated that 1.35 million workers in 111,222 plants were potentially exposed to 1,2-dichloroethane in the workplace in 1970 (NIOSH 1976a). These estimates were derived from observations of the actual use of 1,2-dichloroethane (5% of total estimate), the use of trade-name products known to contain 1,2-dichloroethane (3%), and the use of generic products suspected of containing the compound (92%). The largest numbers of exposed workers were employed in medical and other health services, automotive dealerships and service stations, and wholesale trade industries. The occupational groups with the largest numbers of exposed workers were automobile mechanics, registered nurses, heavy equipment mechanics, janitors, and machinists.

Preliminary data from a second workplace survey, the National Occupational Exposure Survey (NOES), conducted by NIOSH from 1980 to 1983, indicated that 77,111 workers (including 32,891 females) in 1,526 plants were potentially exposed to 1,2-dichloroethane in the workplace in 1980 (NIOSH 1984a). The largest numbers of exposed workers were employed in the apparel and other textile products, chemical and allied products, business services, and petroleum and coal products industries as machine operators, assemblers, production inspectors, checkers, and examiners. The estimates were based on direct observation by the surveyor of the actual use of the compound (68%) and observation of the use of trade name products known to contain 1,2-dichloroethane (32%).

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Neither the NOHS database nor the NOES database contains information on the frequency, level, or duration of exposure of workers to any of the chemicals listed therein. They provide only estimates of workers potentially exposed to the chemicals. There was a large potential for exposure to 1,2-dichloroethane in the workplace during its previous use as a grain fumigant, solvent, and diluent in open-system operations (NIOSH 1978a).

1,2-Dichloroethane was detected at a mean concentration of $0.09 \mu\text{g}/\text{m}^3$ in workplaces where smoking is not permitted and at a mean concentration of $0.03 \mu\text{g}/\text{m}^3$ in workplaces where smoking is permitted (Heavner et al. 1996). These data are in contrast with the findings from the same study that showed a significantly higher concentration of 1,2-dichloroethane in the air of homes in which at least one family member smoked (see Section 6.4.1).

Exposure of the population to 1,2-dichloroethane through releases to ambient air from a number of specific emission sources has been estimated (Kellam and Dusetzina 1980). The estimates, which are probably too high because of the current limited use of leaded fuels, are presented in Table 6-2. The EPA Total Exposure Assessment Methodology (TEAM) studies measured personal and outdoor exposures of about 800 people to 25 volatile organic compounds, including 1,2-dichloroethane (Wallace 1991). The people were selected to represent more than one million residents in a wide variety of urban, suburban, and rural areas. The mean measured exposure to 1,2-dichloroethane, which was based on a 24-hour exposure of 750 people in 6 urban areas, was reported to be $0.5 \mu\text{g}/\text{m}^3$. The outdoor air concentration based on backyard measurements in 175 homes in 6 urban areas was $7 \mu\text{g}/\text{m}^3$ (Wallace 1991).

In addition to industrial releases of 1,2-dichloroethane to ambient air, the general population may have been exposed to this compound in indoor air through volatilization from consumer products and from potable water (Andelman 1985). 1,2-Dichloroethane was detected in the volatile emissions of cleaning agents and pesticides, recently glued wallpaper, and recently glued carpet at concentrations of $236 \mu\text{g}/\text{m}^3$ (58.2 ppb), $48 \pm 7.3 \mu\text{g}/\text{m}^3$ (12 ± 1.8 ppb), and $15 \pm 1 \mu\text{g}/\text{m}^3$ (3.7 ± 0.25 ppb), respectively (Wallace et al. 1987). Since 1,2-dichloroethane is no longer used in consumer products like cleaning agents and adhesives, this route of exposure is expected to be low today.

1,2-Dichloroethane has been detected in the expired breath and urine of humans in a number of studies, following exposure of the test subjects to the compound in ambient air and drinking water (Barkley et al. 1980; EPA 1982a; Wallace et al. 1984).

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Table 6-2. Estimated Population Exposure to 1,2-Dichloroethane Through Releases to Ambient Air From a Number of Specific Emission Sources^a

Emission source	Estimated population exposed	Ambient air concentration (ppb)
1,2-Dichloroethane manufacturing plants	12,500,000	0.01 to \$10
Chemical production facilities	2,621,000	0.01–0.99
Gasoline service stations ^b	1,000,000	0.01–0.029
Automobile emissions	13,000,000	0.01–0.029
Automobile refueling	30,000,000	<0.01

^aDerived from Kellam and Dusetzina 1980

^bEmissions from gasoline stations are in decline.

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6.6 EXPOSURES OF CHILDREN

This section focuses on exposures from conception to maturity at 18 years in humans. Differences from adults in susceptibility to hazardous substances are discussed in 3.7 Children's Susceptibility.

Children are not small adults. A child's exposure may differ from an adult's exposure in many ways. Children drink more fluids, eat more food, breathe more air per kilogram of body weight, and have a larger skin surface in proportion to their body volume. A child's diet often differs from that of adults. The developing human's source of nutrition changes with age: from placental nourishment to breast milk or formula to the diet of older children who eat more of certain types of foods than adults. A child's behavior and lifestyle also influence exposure. Children crawl on the floor, put things in their mouths, sometimes eat inappropriate things (such as dirt or paint chips), and spend more time outdoors. Children also are closer to the ground, and they do not use the judgment of adults to avoid hazards (NRC 1993).

There are no exposure studies or body burden measurements of 1,2-dichloroethane in children. 1,2-Dichloroethane has been detected in both ambient outdoor and indoor air as discussed in Section 6.4.1 and inhalation of contaminated air likely represents the greatest route of potential exposure for children. 1,2-Dichloroethane has also been detected in drinking water, and therefore, ingestion of contaminated water is a possible source of exposure. 1,2-Dichloroethane been detected in human milk at concentrations ranging from 0.195 to 0.63 mg/100 mL of milk (EPA 1980a; Urusova 1953). Therefore, it is possible that children may be exposed to 1,2-dichloroethane from breast-feeding mothers, although no details of the analytical methodology were reported and, the sample size was not provided in this study. Current data on the concentration of 1,2-dichloroethane in breast milk are not available. 1,2-Dichloroethane was formerly used in certain consumer household products such as cleaning agents and adhesives. The use of any household products that contained 1,2-dichloroethane to clean floors or glue carpets may result in exposure since children often crawl on floors and play on carpets. The potential for exposure is expected to diminish with time since 1,2-dichloroethane volatilizes fairly rapidly. This is expected to be a relatively minor route of exposure since most of these products have probably been used up or discarded from the majority of households.

1,2-Dichloroethane has been detected in several food products as discussed in Section 6.4.4, but consumption of these products should not disproportionately affect children. No data are available regarding the weight-adjusted intake of 1,2-dichloroethane. 1,2-Dichloroethane was formerly used as a fumigant, but is not currently registered for use in agricultural products in the United States, Canada, or

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the United Kingdom. Therefore, it is expected that exposure to 1,2-dichloroethane through food sources will continue to decrease.

Children are unlikely to be exposed to 1,2-dichloroethane from parents' clothing or other objects removed from the workplace because of its volatility. It is possible that exposure may arise from the exhaled breath of parents who are occupationally exposed to 1,2-dichloroethane, but no quantitative data are available to confirm this. 1,2-Dichloroethane has been detected in humans in a number of studies, following exposure of the test subjects to the compound in ambient air and drinking water (Barkley et al. 1980; EPA 1982a; Wallace et al. 1984).

There have been no documented exposures of children to 1,2-dichloroethane from pica. Children are unlikely to be exposed to 1,2-dichloroethane from pica since the majority of 1,2-dichloroethane released to the environment is emitted to the atmosphere. Furthermore, much of the 1,2-dichloroethane released to soil is expected to volatilize to air or leach into subsurface soil and groundwater.

6.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Human exposure to 1,2-dichloroethane is expected to be highest among certain occupational groups (e.g., chemical and allied products industry workers) (NIOSH 1984a) and members of the general population living in the vicinity of industrial point emission sources (EPA 1985a) and hazardous waste sites. 1,2-Dichloroethane has been detected in both ambient air and water in low concentrations (Fusillo et al. 1985; Isacson et al. 1985; Juttner 1986; McDonald et al. 1988; Singh et al. 1982). No information was found regarding the number of people potentially exposed around hazardous waste sites. It was estimated that . 15 million people living in the vicinity of manufacturing and formulation plants were potentially exposed to concentrations ranging from 0.01 to \$10 ppb 1,2-dichloroethane in ambient air in the late 1970s (Kellam and Dusetzina 1980).

6.8 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) to assess whether adequate information on the health effects of 1,2-dichloroethane is available. Where adequate information is not available, ATSDR, in conjunction with the National Toxicology Program (NTP), is

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required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of 1,2-dichloroethane.

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 the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

6.8.1 Identification of Data Needs

Physical and Chemical Properties. The physical and chemical properties of 1,2-dichloroethane are well characterized to permit estimation of its environmental fate (see Chapter 4). No additional studies are needed at this time.

Production, Import/Export, Use, Release, and Disposal. Information on the production and use of 1,2-dichloroethane is available (Anonymous 1998; Archer 1979; Dow Chemical Company 1989b; SRI 1998). Import and export data on 1,2-dichloroethane are also available (Anonymous 1998). More information regarding the amount of 1,2-dichloroethane that is disposed of at hazardous waste sites or abandoned would be useful. No current data are available on the amount of 1,2-dichloroethane disposed of annually.

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 TRI, which contains this information for 1999, became available in 2001. This database will be updated yearly and should provide a list of industrial production facilities and emissions.

Environmental Fate. The partitioning of 1,2-dichloroethane into air, water, and soil is well established (Brüeggemann et al. 1991; Chiou et al. 1980; Dilling 1977; Dilling et al. 1975; EPA 1981, 1985a; Jeng et al. 1992; Jury et al. 1990; Pearson and McConnell 1975; Wilson et al. 1981).

1,2-Dichloroethane is highly mobile in soil and is expected to leach into groundwater. Available laboratory data are sufficient to estimate its atmospheric lifetime, but information on degradation rates in soil and water are limited. Recent data indicates that 1,2-dichloroethane will biodegrade slowly in soil, water, and groundwater under both aerobic and anaerobic conditions. Additional data regarding the

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degradation rates of 1,2-dichloroethane in soil and water would be helpful in assessing its environmental fate.

Bioavailability from Environmental Media. 1,2-Dichloroethane has been measured in the breath, blood, urine, and adipose tissue of humans (Barkley et al. 1980; EPA 1980a, 1982a; Wallace et al. 1989). Thus, it can be concluded that 1,2-dichloroethane is bioavailable from the environment. Good quantitative data that correlate varying levels in the environment with levels in the body and associated health effects are lacking. Data are lacking regarding the extent to which 1,2-dichloroethane can be absorbed from various media (e.g., soil).

The health effects observed in humans following exposure to 1,2-dichloroethane are those generally associated with exposure to chlorinated hydrocarbons. Therefore, it may not be possible to correlate the exact levels of 1,2-dichloroethane in the environment with observed health effects in humans. The methodology to predict exposure levels of 1,2-dichloroethane from observed health effects is lacking.

Food Chain Bioaccumulation. The limited experimental data on bioconcentration of 1,2-dichloroethane in aquatic organisms (Banerjee and Baughman 1991; Farrington 1991) and the physical and chemical properties of this compound indicate that bioconcentration and biomagnification are not likely to occur. However, experimental data on food chain biomagnification will aid in determining the potential for human exposure to 1,2-dichloroethane.

Exposure Levels in Environmental Media. 1,2-Dichloroethane has been detected at low levels (ppb) in ambient urban and rural air (Class and Ballschmiter 1986; Cohen et al. 1989; EPA 1988b, 1991c; Juttner 1986; Kelly et al. 1994; Pellizzari et al. 1986; Singh et al. 1982, 1992), in outdoor and indoor air samples of residences located near hazardous waste disposal sites (Andelman 1985; Barkley et al. 1980; Heavner et al. 1996; LaRegina et al. 1986), and in surface water (Brown et al. 1984; EPA 1977a; Yamamoto et al. 1997), groundwater (Barbee 1994; Brown et al. 1984; Lesage et al. 1990; Plumb 1987; Westrick et al. 1984), drinking water (Barkley et al. 1980; Clark et al. 1986; Kelley 1985; Krill and Sonzogni 1986; Lam et al. 1994b; Steichen et al. 1988; Suffet et al. 1980), sediment (Bianchi et al. 1991; Oliver and Pugsley 1986), and food stuffs (Draft 1988, 1989, 1991; Gold 1980; Heikes and Hopper 1986, Heikes 1987; Miyahara et al. 1995; Rembold et al. 1989). Data on estimated human intake from all media have not been located.

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Reliable monitoring data for the levels of 1,2-dichloroethane in contaminated media at hazardous waste sites are needed so that the information obtained on environmental levels of 1,2-dichloroethane can be used in combination with the known body burden of 1,2-dichloroethane to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

Exposure Levels in Humans. Recent estimates of the size of the population occupationally exposed to 1,2-dichloroethane are not available, and monitoring data on workplace exposure levels (NIOSH 1984a) are generally inadequate. General population exposure estimates have been prepared by the EPA (1985a) for inhalation of the compound in ambient air, which is believed to be the most important route of exposure. However, the general population may also be exposed to low concentrations of 1,2-dichloroethane through ingestion of contaminated water and/or food. The use of old consumer products that contained 1,2-dichloroethane represents a possible, but most likely inconsequential potential exposure route. Quantitative information about the size of the exposed populations and the levels of exposure are generally incomplete. This information is necessary for assessing the need to conduct health studies on these populations.

Exposures of Children. There is no information available on the exposure of children to 1,2-dichloroethane. Children are most likely to be exposed to 1,2-dichloroethane via inhalation of ambient air. Ingestion of drinking water and food may also yield childhood exposures. Contact with older household products that contained 1,2-dichloroethane is possible, but is unlikely to be a major source of exposure since 1,2-dichloroethane is no longer used in most consumer products. Children are unlikely to be exposed to 1,2-dichloroethane from pica. Accurate data on the levels of 1,2-dichloroethane in children are needed to identify ways to reduce the potential exposure risks.

Child health data needs relating to susceptibility are discussed in 3.12.2 Identification of Data Needs: Children's Susceptibility.

Exposure Registries. No exposure registries for 1,2-dichloroethane were located. This substance is not currently one of the compounds for which a subregistry has been established in the National Exposure Registry. The substance 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 substance.

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6.8.2 Ongoing Studies

A spectroscopic investigation of the factors that affect the mobility of 1,2-dichloroethane in soil and clay surfaces is being conducted by Dr. Farmer of the University of California, Riverside (FEDRIP 1999). This project, which is sponsored by the U.S. Department of Agriculture, should provide additional information regarding the movement and leaching potential of 1,2-dichloroethane in soil surfaces. No long-term research projects or other ongoing studies of occupational or general population exposures were identified.

As part of the Third National Health and Nutrition Evaluation Survey, the Environmental Health Laboratory Sciences Division of the National Center for Environmental Health and Injury Control, Centers for Disease Control, will be analyzing human blood samples for 1,2-dichloroethane and other volatile organic compounds. These data will give an indication of the frequency of occurrence and background levels of these compounds in the general population.

