

## 5. POTENTIAL FOR HUMAN EXPOSURE

### 5.1 OVERVIEW

2-Butanone may be released to the atmosphere in fugitive emissions during its production, transport, and use. It is widely used in coating systems where its volatilization to the atmosphere is an intended outcome of its use. In urban areas, it can exist in the atmosphere as a result of automobile exhaust, the decomposition of other organic compounds, and from natural sources.

The release of 2-butanone to water or soil is not well documented. Release of 2-butanone to surface water may occur via industrial waste water emissions. 2-Butanone may also be released to soil or water from a spill or other catastrophic event. The leachate of landfills and hazardous waste sites may result in 2-butanone contamination of soil and groundwater.

According to the SARA Section 313 TRI (1989), an estimated total of 149,678,423 pounds of 2-butanone was released to the environment in 1987 by facilities that manufacture or process this compound. Of this, 149,478,640 pounds were released to the atmosphere. The quality of the TRI data must be viewed with caution since the 1987 data represent first-time, incomplete reporting of estimated releases by these facilities. Not all sources of chemical wastes are included and not all facilities. Only certain types of facilities were required to report. This is not an exhaustive list. These data are presented in Table 5-1.

2-Butanone is expected to rapidly volatilize from surface water and moist or dry soils to the atmosphere. In the atmosphere, this compound is expected to exist predominantly in the vapor phase. Wet deposition may return 2-butanone to the earth's surface.

In soil, 2-butanone is expected to display very high mobility, and it has the potential to leach into groundwater. This characteristic also suggests that it does not significantly adsorb to sediment and suspended organic matter in surface waters. 2-Butanone is not expected to bioconcentrate in fish and aquatic organisms.

Although the degradation of 2-butanone in the environment is understood on a theoretical level, data are not available to quantify all conclusions. In the atmosphere, 2-butanone is expected to undergo a vapor-phase reaction with photochemically produced hydroxyl radicals; the half-life for this process is approximately 1 day. However, laboratory experiments have suggested that the atmospheric half-life of 2-butanone is much shorter.

In water, 2-butanone is expected to undergo microbial degradation under both aerobic and anaerobic conditions. Chemical oxidation, direct photolysis, and hydrolysis of 2-butanone under environmental conditions are not expected to occur to any significant extent. Data on the fate of 2-butanone in soil are not available.

TABLE 5-1. Releases to the Environment from Facilities That Manufacture or Process 2-Butanone<sup>a</sup>

State <sup>c</sup>	No. of facilities	Range of reported amounts released in thousands of pounds <sup>b</sup>						Total Environment <sup>d</sup>	POTW <sup>e</sup> transfer	Off-site waste transfer
		Air	Underground injection	Water	Land					
AL	29	0-4,000	0-0	0-0	0-1		0-4,000	0-1	0-113	
AR	41	0-968	0-0	0-0	0-17		0-968	0-50	0-70	
AZ	21	0-125	0-0	0-0	0-0		0-125	0-0	0-151	
CA	193	0-690	0-0	0-0	0-1		0-690	0-24	0-822	
CO	14	0-159	0-0	0-0	0-0		0-159	0-0	0-8	
CT	37	0-123	0-0	0-0	0-0		0-123	0-0	0-57	
DE	10	0-623	0-0	0-0	0-0		0-623	0-10	0-230	
FL	29	0-88	0-0	0-0	0-0		0-88	0-7	0-51	
GA	58	0-812	0-0	0-0	0-0		0-812	0-12	0-692	
IA	30	0-1,201	0-0	0-0	0-0		0-1,201	0-0	0-76	
ID	1	2-2	0-0	0-0	0-0		2-2	0-0	14-14	
IL	133	0-440	0-0	0-0	0-0		0-440	0-11	0-839	
IN	104	0-1,400	0-0	0-0	0-0		0-1,400	0-1	0-466	
KS	26	0-777	0-0	0-1	0-0		0-777	0-0	0-130	
KY	30	0-130	0-0	0-0	0-0		0-130	0-0	0-390	
LA	29	0-745	0-5	0-0	0-0		0-746	0-0	0-39	
MA	60	0-601	0-0	0-0	0-0		0-601	0-27	0-508	
MD	21	0-714	0-0	0-0	0-0		0-714	0-0	0-242	
ME	5	0-111	0-0	0-0	0-0		0-111	0-0	0-30	
MI	119	0-1,300	0-0	0-0	0-1		0-1,301	0-15	0-294	
MN	35	0-10,219	0-0	0-0	0-4		0-10,219	0-0	0-1,734	
MO	72	0-1,000	0-0	0-1	0-0		0-1,000	0-5	0-302	
MS	21	1-4,529	0-0	0-0	0-0		1-4,529	0-4	0-1,290	
MT	1	8-8	0-0	0-0	0-0		8-8	0-0	14-14	
NC	133	0-980	0-0	0-0	0-0		0-980	0-0	0-276	
ND	3	2-15	0-0	0-0	0-0		2-15	0-0	0-14	
NE	14	0-277	0-0	0-0	0-0		0-277	0-0	0-8	
NH	23	0-146	0-0	0-0	0-0		0-146	0-0	0-350	
NJ	103	0-678	0-0	0-2	0-0		0-678	0-56	0-277	
NM	1	12-12	0-0	0-0	0-0		12-12	0-0	0-0	
NV	4	0-26	0-0	0-0	0-0		0-26	0-0	0-17	
NY	85	0-470	0-0	0-3	0-0		0-470	0-59	0-196	
OH	174	0-1,890	0-0	0-0	0-1		0-1,890	0-43	0-890	
OK	17	0-1,242	0-0	0-0	0-0		0-1,242	0-0	0-555	
OR	13	2-492	0-0	0-0	0-0		2-492	0-4	0-12	
PA	109	0-1,259	0-0	0-2	0-4		0-1,259	0-4	0-264	
PR	9	0-230	0-0	0-0	0-0		0-230	0-0	0-0	
RI	13	0-542	0-0	0-0	0-0		0-542	0-0	0-110	
SC	36	0-668	0-0	0-1	0-0		0-668	0-0	0-172	
SD	5	19-48	0-0	0-0	0-0		19-48	0-0	0-40	
TN	60	0-504	0-0	0-1	0-1		0-504	0-1	0-166	
TX	107	0-1,304	0-52	0-9	0-1		0-1,304	0-6	0-400	

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TABLE 5-1 (Continued)

State <sup>c</sup>	No. of facilities	Range of reported amounts released in thousands of pounds <sup>b</sup>						
		Air	Underground injection	Water	Land	Total Environment <sup>d</sup>	POTW <sup>e</sup> transfer	Off-site waste transfer
UT	10	0-48	0-0	0-0	0-0	0-48	0-0	0-15
VA	64	0-1,495	0-0	0-0	0-10	0-1,495	0-3	0-214
VT	4	1-55	0-0	0-0	0-0	1-55	0-0	1-9
WA	32	0-2,130	0-0	0-0	0-1	0-2,130	0-1	0-180
WI	71	0-890	0-0	0-39	0-0	0-890	0-91	0-720
WV	8	0-235	0-0	0-6	0-0	0-235	0-2	0-45
WY	1	83-83	0-0	0-0	0-0	83-83	0-0	0-0

<sup>a</sup>TRI 1989

<sup>b</sup>Data in TRI are maximum amounts released by each facility.

<sup>c</sup>Post office state abbreviation

<sup>d</sup>The sum of all releases of the chemical to air, land, water, and underground injection wells by a given facility.

<sup>e</sup>publicly owned treatment works

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Various data are available regarding the concentration of 2-butanone in environmental media. It has been qualitatively detected in U.S. drinking water supplies and as a naturally occurring constituent of foods. It has also been detected in the air.

EPA has identified 1,177 NPL sites. 2-Butanone has been found at 137 out of the sites evaluated for its presence. However, we do not know how many of the 1,177 NPL sites have been evaluated for this chemical. As more sites are evaluated by EPA, this number may change (View 1989). The frequency of these sites within the United States can be seen in Figure 5-1.

The general population is exposed to 2-butanone by drinking contaminated water or by the ingestion of food containing it. Members of the general population living near hazardous waste sites may be exposed to contaminated drinking water if their household water source is well water. The general population is also expected to be exposed to 2-butanone by inhalation, especially in urban areas. The use of commercial coatings containing 2-butanone also results in exposure by inhalation, and possibly by dermal contact as well. High levels of exposure may occur for members of the general population if these coatings are used in an enclosed, unventilated area. Occupational exposure to 2-butanone may occur by inhalation during the production, formulation, use, or transport of this compound.

### 5.2 RELEASES TO THE ENVIRONMENT

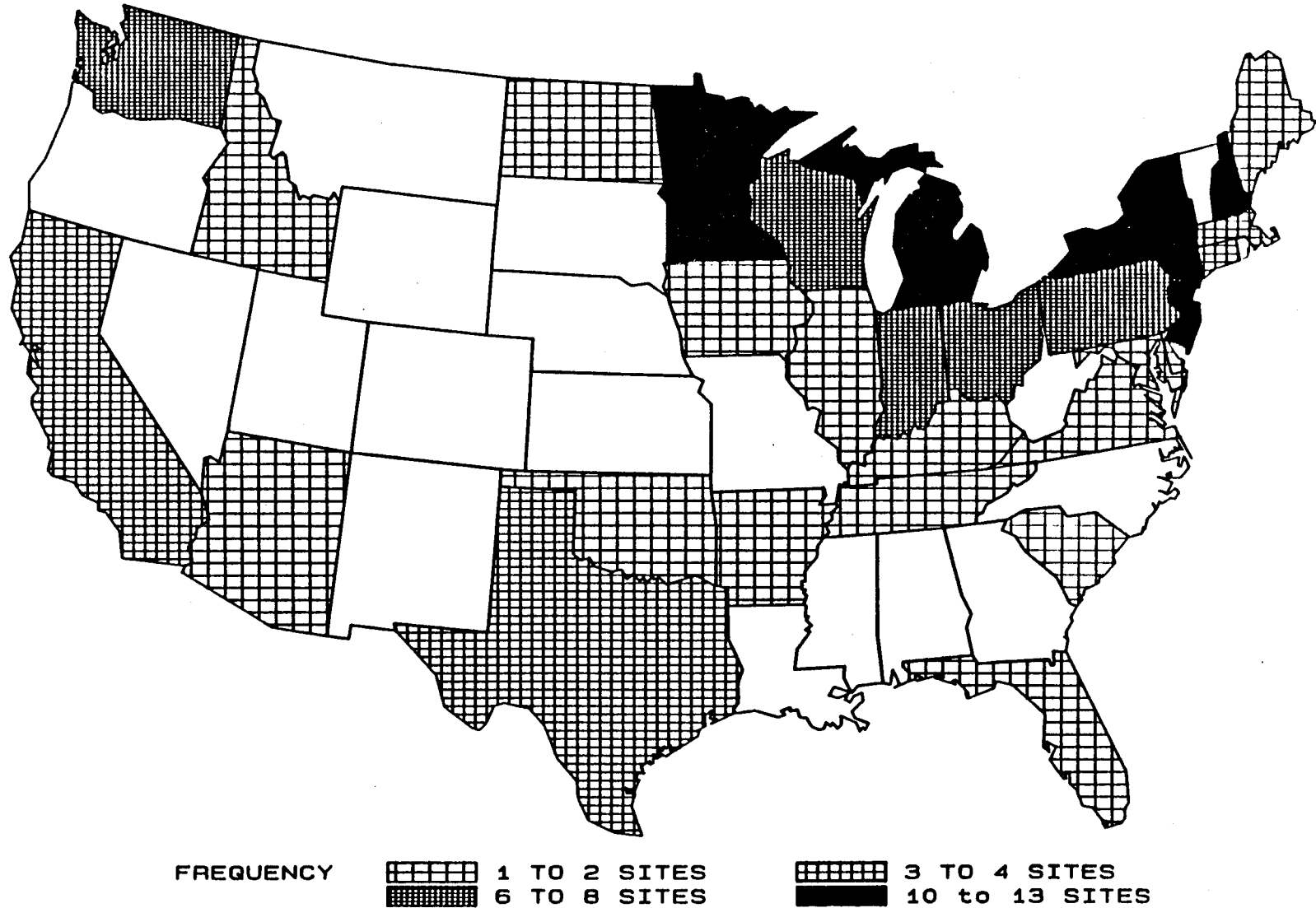
#### 5.2.1 Air

2-Butanone may be emitted to the atmosphere during its production, formulation, storage, or use in commercial products. 2-Butanone may also be released to the atmosphere as a result of its use as a solvent in commercial products. It was identified as an emission from a variety of indoor building materials: latex caulk, particle board, latex paint, and polyurethane floor finish (Tichenor 1987; Tichenor and Mason 1988). Since 2-butanone is prevalent in adhesives and coatings (Papa and Sherman 1981), it may be released to the atmosphere during the curing of these products.

According to the SARA Section 313 TRI (1989), an estimated total of 149,478,640 pounds of 2-butanone was released to the atmosphere in 1987 by facilities that manufacture or process this compound. The quality of the TRI data must be viewed with caution since the 1987 data represent first-time, incomplete reporting of estimated releases by these facilities. Only certain types of facilities were required to report. This is not an exhaustive list.

2-Butanone is present in the exhaust of automobiles (Seizinger and Dimitriadis 1972). In a Swedish study, 2-butanone was detected in automobile exhaust, although the ambient air levels measured in Stockholm did not correlate with these emissions (Jonsson et al. 1985). Thus, the prevalence of other sources is indicated, as the air levels of 2-butanone were higher than

FIGURE 5-1. FREQUENCY OF NPL SITES WITH 2-BUTANONE CONTAMINATION \*



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\* Derived from View 1989

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could be explained solely by automobile emissions. Other potential sources of 2-butanone in the atmosphere include the burning of polyethylene (Hodgkin et al. 1982) and the photochemical degradation of hydrocarbons (Grosjean 1982), especially those emitted from motor vehicles. 2-Butanone is also emitted to the atmosphere from such natural sources as European firs, junipers, cedars, cypress trees, and ferns (Isidorov et al. 1985) and ant secretions (Cammaerts et al. 1978).

### 5.2.2 Water

Limited data are available regarding the release of 2-butanone to surface and groundwaters. It has been detected in waste water effluents from commercial processes (Dunovant et al. 1986; Hawthorne and Sievers 1984; Jungclaus et al. 1978; Pellizzari et al. 1979). 2-Butanone may also be present in water from the microbial oxidation of butane (Phillips and Perry 1974). Its relatively high water solubility, 136,000 mg/L at 25°C (Tewari et al. 1982), suggests that wet deposition of atmospheric 2-butanone results in the contamination of surface water. Evidence for this comes from the fact that 2-butanone has been detected in rain water (Grosjean and Wright 1983).

According to the SARA Section 313 TRI (1989), an estimated total of 75,858 pounds of 2-butanone was released to water in 1987 by facilities that manufacture or process this compound, a very small amount compared to what is released to the atmosphere. The quality of the TRI data must be viewed with caution since the 1987 data represent first-time, incomplete reporting of estimated releases by these facilities. Only certain types of facilities were required to report. This is not an exhaustive list.

The contamination of groundwater with 2-butanone has occurred at hazardous waste sites (Francis et al. 1980; Sawhney and Kozloski 1984) and landfills (Sabel and Clark 1984) due to infiltration of contaminated leachate. 2-Butanone was detected in 180 groundwater samples from 357 hazardous waste sites monitored by the Contract Laboratory Program (CLP) at a geometric mean concentration of 302 ppb for the positive samples (CLPSD 1988). Note that the CLPSD includes data from both NPL and non-NPL sites. 2-Butanone is also likely to enter groundwater as a result of a spill to soil during a catastrophic event, such as a tanker spill (Halvorsen and Ohneck 1985).

2-Butanone may also enter water from natural sources. It has been detected in various species of macroalgae at concentrations as high as 2,600 ng/g (Whelan et al. 1982).

### 5.2.3 Soil

Limited data are available regarding the release of 2-butanone to soil. The presence of this compound in the groundwater at hazardous waste sites and landfills (Francis et al. 1980; Sabel and Clark 1984; Sawhney and Kozloski 1984) suggests that leachate at these facilities will be a source of

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2-butanone release to soil. Wet deposition of atmospheric 2-butanone may also result in its contamination of soil. 2-Butanone may enter soil during a catastrophic event, such as a tanker spill (Halvorsen and Ohneck 1985). 2-Butanone has been found in 309 of 357 hazardous waste sites monitored by the CLP at a geometric mean concentration of 87 ppb (CLPSD 1988). Note that the CLPSD includes data from both NPL and non-NPL sites.

According to the SARA Section 313 TRI (1989), an estimated total of 48,675 pounds of 2-butanone was released to soil in 1987 by facilities that manufacture or process this compound; a very small amount compared to what is released to the atmosphere. The quality of the TRI data must be viewed with caution since the 1987 data represent first-time, incomplete reporting of estimated releases by these facilities. Only certain types of facilities were required to report. This is not an exhaustive list.

### 5.3 ENVIRONMENTAL FATE

#### 5.3.1 Transport and Partitioning

In the atmosphere, 2-butanone is expected to exist predominantly in the vapor phase (Eisenreich et al. 1981; Riddick et al. 1986). This is consistent with experimental data, which demonstrated that the gas-phase concentration of 2-butanone in Los Angeles, California, was from 220 to 3,000 times greater than the particulate phase concentration (Grosjean 1982). The relatively high water solubility of 2-butanone, 136,000 mg/L at 25°C (Tewari et al. 1982), suggests that wet deposition may remove 2-butanone from the atmosphere. 2-Butanone has been identified in rain water (Grosjean and Wright 1983). The absence of significant amounts of particulate 2-butanone indicates that dry deposition to the earth's surface is not an important fate process. The short residence time expected for 2-butanone in the atmosphere, less than 1 day, suggests that it is not transported long distances from its original point of release.

Based on an experimental soil adsorption coefficient ( $K_{oc}$ ) of 3.55 (Roy and Griffin 1985) 2-butanone is expected to display very high mobility in soil (Swann et al. 1983). 2-Butanone was found in groundwater samples shortly after a tanker spill (Halvorsen and Ohneck 1985) and in the groundwater underneath hazardous waste sites and public landfills (Francis et al. 1980; Sabel and Clark 1984; Sawhney and Kozloski 1984). The vapor pressure of 2-butanone, 90.6 mmHg at 25°C (Riddick et al. 1986), and the Henry's law constant,  $5.77 \times 10^{-5}$  atm m<sup>3</sup>/mol at 25°C, suggest that volatilization from either dry or moist soil to the atmosphere will be an important environmental process.

If 2-butanone is released to water it is expected to rapidly volatilize to the atmosphere. Based on its Henry's law constant, an estimated volatilization half-life from a model river 1 m deep, flowing at 1 m/set with a wind velocity of 3 m/sec, is approximately 15 hours (Lyman et al. 1982).

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2-Butanone is not expected to significantly adsorb to sediment and suspended organic matter. It is also not expected to bioconcentrate in fish and aquatic organisms (Lyman et al. 1982). These conclusions are based on an experimental  $K_{oc}$  of 3.55 (Roy and Griffin 1985), and a calculated bioconcentration factor of 0.98 obtained from its octanol/water partition coefficient, 0.29 (Hansch and Leo 1985), and an appropriate regression equation (Lyman et al. 1982).

### 5.3.2 Transformation and Degradation

#### 5.3.2.1 Air

2-Butanone is expected to undergo atmospheric destruction by the gasphase reaction with photochemically produced hydroxyl radicals. Rate constants for this reaction ranging from  $1.85 \times 10^{-11}$  to  $9.8 \times 10^{-13}$  atm/molecule-sec in the temperature range of 22-32°C have appeared in the literature (Cox et al. 1980, 1981; Edney and Corse 1986; Edney et al. 1986; Darnall et al. 1976; Gusten et al. 1984; Wallington and Kurylo 1987; Wallington et al. 1988). Using a recommended rate constant of  $1.85 \times 10^{-11}$  atm/molecule-sec at 25°C and an average atmospheric hydroxyl radical concentration of  $5 \times 10^5$  molecule/cm<sup>3</sup> (Atkinson 1985), a half-life of 21 hours for this reaction can be calculated. However, experiments performed under simulated atmospheric conditions in the laboratory have shown that 2-butanone has a half-life of only 9.8 hours for photo-initiated processes (Dilling et al. 1976). The rate of its destruction increased in the presence of other anthropogenic compounds. The atmospheric destruction of 2-butanone as a result of direct irradiation is not expected to be significant under atmospheric conditions (Cox et al. 1980). Therefore, direct photolysis cannot account for the enhanced rate of atmospheric destruction observed in the laboratory. However, the data suggest that other mechanisms are responsible for the destruction of 2-butanone in the atmosphere, which are yet to be defined.

#### 5.3.2.2 Water

2-Butanone is expected to be removed from environmental waters by microbial degradation under both aerobic and anaerobic conditions. Limited data specific to the chemical degradation of 2-butanone in water are available; however, it is not expected to occur to any significant extent.

Numerous investigations have concluded that 2-butanone undergoes biological degradation under aerobic conditions. At an initial concentration of 1 ppm, 2-butanone completely degraded in aerated water obtained from a deep Florida aquifer within 14 days after a 5-day lag period (Delfino and Miles 1985). Screening studies using a microbial seed from domestic waste treatment plants have indicated that 2-butanone has a 5-day biological oxygen demand (BOD<sub>5</sub>) which is between 59% and 74% of the theoretical amount after a short lag period (Babeu and Vaishnav 1987; Bridie et al. 1979; Gaudy et al. 1963; Price et al. 1974; Urano and Kato 1986; Vaishnav et al. 1987; Young et al.



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1968). A pure culture study indicated that propionate is produced as a result of the microbial oxidation of 2-butanone (Phillips and Perry 1974).

2-Butanone has been listed as a compound amenable to degradation by anaerobic biotechnology (Speece 1983). At an initial concentration of 500 ppm, 2-butanone was completely reduced to methane within 8 days in a fermentor using a domestic sludge inoculum that had been adapted to acetate (Chou et al. 1979).

An experimentally determined rate constant of  $5.4 \times 10^8$  L/mol-sec has been determined for the reaction of 2-butanone with hydroxyl radicals in water (Anbar and Neta 1967). This value corresponds to a half-life of 4 years for this reaction, given a hydroxy radical concentration of  $1 \times 10^{-17}$  M (Mill et al. 1980). Hydrolysis of ketones is generally not believed to be an environmentally important process (Lyman et al. 1982; Mill 1982). A rate constant of 0 L/mol-year was listed for the hydrolysis of 2-butanone under neutral, acidic, and basic conditions at 25°C (Kollig et al. 1987), indicating that this process does not occur in the environment. By analogy to the gasphase photolysis of 2-butanone (Cox et al. 1980), direct photochemical breakdown of 2-butanone in water is not expected. Therefore, the chemical degradation of 2-butanone in environmental waters is not expected to occur to any significant extent.

The chemical alteration of 2-butanone in rain water has been postulated. In acid rain, hydroxy sulfonates may be formed by the reaction with bisulfite, and ammonia adducts may be formed in ammoniated rain (Grosjean and Wright 1983). The concentration of these reactive species is likely to be much higher in rain water than in surface water; therefore, a more rapid rate of reaction would be expected in rain.

### 5.3.2.3 Soil

No specific data concerning the fate of 2-butanone in soil were available. By analogy to the experimental results on the microbial degradation of 2-butanone in water, this compound may degrade in soil under aerobic and anaerobic conditions given suitable time for adaptation of the microbial population. Again by using an analogy to the fate of 2-butanone in aqueous systems, it is not expected to hydrolyze, photolyze on the surface, or undergo chemical degradation.

## 5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

### 5.4.1 Air

2-Butanone has been detected in a limited number of sites in rural, urban, and indoor locations. It was detected in 17 samples taken in Tucson, Arizona, in 1982 at an average concentration of 2.8 ppb. In the mountains of Arizona, the concentration was 0.50 ppb (Snider and Dawson 1985). The range

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of 2-butanone measured in Los Angeles air in 1980 was 0-14 ppb in 70 samples (Grosjean 1982). 2-Butanone was found in one-third of samples taken downwind of a solvent recycling facility in Maryland in 1970, at a maximum concentration of 94 ppm (Smoyer et al. 1971). Although it has been detected in the exhaust of gasoline engines, it was not found in the air of a highway mountain tunnel (Hampton et al. 1982).

2-Butanone was detected in the air of the Kin-But chemical waste site, located in New Jersey, at concentrations ranging from trace to 1.5 pg/m<sup>3</sup> (0.51 ppb), and 0.5 to 33 µg/m<sup>3</sup> (0.17-11.3 ppb) in samples surrounding the site (Pellizzari 1982). It was qualitatively detected in the air at four of four hazardous waste sites and one landfill in New Jersey (LaRegina et al. 1986).

In a survey of 36 homes taken in Chicago, Illinois, 2-butanone was detected in the indoor air at 3 residences (Jarke et al. 1981). It was also found in three outdoor samples in this survey. It is not clear, however, if the positive indoor and outdoor samples were collected at the same location. In a compilation and analysis of ambient monitoring data collected from 1970 to 1987, the daily concentration of 2-butanone was 0 ppb in urban, suburban, and rural areas (Shah and Heyerdahl 1988). 2-Butanone has been qualitatively detected in the indoor air of homes in Chicago (Jarke et al. 1981) and in Canadian residential and office buildings (Tsuchiya 1987).

The sporadic ambient air monitoring data available for 2-butanone suggest that the average background concentration of this compound may be very low. However, the available data also suggest that there are dramatic, temporal, and diurnal variations in its concentration.

### 5.4.2 Water

Numerous studies have qualitatively detected 2-butanone in drinking water supplies (Kool et al. 1982). It has been found in drinking water from the District of Columbia; Cincinnati, Ohio; Miami, Florida; Ottumwa, Iowa; Philadelphia, Pennsylvania; Seattle, Washington; Tuscaloosa, Alabama; and New Orleans, Louisiana (Bertsch et al. 1975; Coleman et al. 1976; EPA 1974, 1975; Kopfler et al. 1977; Scheiman et al. 1974). It was detected in Des Moines, Iowa, drinking water samples at an estimated concentration of 1.6 ppb (Ogawa and Fritz 1985). 2-Butanone was detected in tap water 8 months after the installation of new polyvinyl chloride (PVC) pipes at a concentration ranging from 0.4 to 4.5 ppm (Wang and Bricker 1979). It resulted from the glue used to cement the water pipes together. The concentration of 2-butanone in the water increased with the amount of time the water sat in the pipes.

2-Butanone has been qualitatively detected in rain water and the clouds of Henninger, California, at 0.04 ppb, and in the mist of Long Beach, California (Grosjean and Wright 1983). Trace amounts have also been found in the ice in Fairbanks, Alaska (Grosjean and Wright 1983).

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2-Butanone was listed as being detected in less than 5% of U.S. groundwater supplies (Dyksen and Hess 1982). At U.S. hazardous waste sites, 2-Butanone was listed as being frequently detected in the groundwater (Garman et al. 1987). This statement should be interpreted with caution, as "frequently" was defined as greater than 0.1%, of the samples. 2-Butanone was detected in 180 groundwater samples from 357 hazardous waste sites monitored by the CLP at a geometric mean concentration of 302 ppb in the positive samples (CLPSD 1988). Examples of the presence of 2-butanone at hazardous waste sites and landfills can be found in Table 5-2. It was detected in groundwater samples underneath a tanker truck spill at concentrations up to 2,200 ppm (Halvorsen and Ohneck 1985). Interpretation of the concentration of 2-butanone found in groundwater samples should be made carefully, and should take into account the experimental methods used in the determinations; results may be skewed due to the presence of 2-butanone in the adhesives used to cement PVC well pipes together (Sosebee et al. 1983).

2-Butanone has been detected in the effluent of various industrial processes. It was found in six of seven waste water samples from energyrelated processes at a concentration up to 645 ppb (Pellizzari et al. 1979). 2-Butanone was detected in the waste water of a specialty chemical manufacturing plant at a concentration of 8-20 ppm, but not in the receiving river water or its sediment (Jungclaus et al. 1978). It was also detected in the waste water from shale oil processing at a concentration of 0.4-18 ppm (Hawthorne and Sievers 1984). In 1982, 2-butanone was detected at concentrations of 83 ppb or less in the waste water entering Cincinnati treatment plants (Dunovant et al. 1986).

2-Butanone has been detected in 77 of 357 surface water samples at U.S. hazardous waste sites at a geometric mean concentration of 11 ppb for the positive samples (CLPSD 1988). It was qualitatively detected in the Black Warrior River, located in Tuscaloosa, Alabama (Bertsch et al. 1975), and in sea water from the straits of Florida at 0-22 ppb in 1968 (Corwin 1969).

### 5.4.3 Soil

Limited data are available on the detection of 2-butanone in soil samples. It has been found in 309 of 357 hazardous waste sites monitored by the CLP at a geometric mean concentration of 87 ppb for the positive samples (CLPSD 1988).

### 5.4.4 Other Environmental Media

2-Butanone has been detected as a natural component of numerous types of foods. It has been qualitatively identified as a volatile constituent in raw chicken breast muscle, milk, roasted filberts (nuts), Beaufort (Gruyere) and cheddar cheese, bread dough, and intact tree-ripened nectarines (Dumont and Adda 1978; Gordon and Morgan 1979; Grey and Shrimpton 1967; Keen et al. 1974;

TABLE 5-2. Detection of 2-Butanone in the Groundwater  
of Hazardous Waste Sites and Landfills

Type/Location	Sampling Dates	No. of Samples	No. of Positive	Concentration	Reference
Waste sites, groundwater Connecticut Low-level radioactive	1982-1983	5	1	4,800 ppm	Sawhney and Kozloski 1984
Waste sites, surface water Valley of the Drums, KY	No data	No data	No data	≤690 ppb	Stonebraker and Smith 1980
Landfills, groundwater Municipal solid waste	No data	13	7	6.8-6,200 ppb	Sabel and Clark 1984
Landfills, leachate Municipal solid waste	No data	6	6	110-27,000 ppb	Sabel and Clark 1984

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Kinlin et al. 1972; Sosulski and Mahmoud, 1979; Takeoka et al. 1988). The mean concentration of 2-butanone in dried beans, split peas, and lentils was 148, 110, and 50 ppm, respectively (Lovegren et al. 1979). 2-Butanone has been detected in southern peas at a median concentration of 120 ppb (Fisher et al. 1979), and it has been qualitatively detected in winged beans and soybeans (Del Rosario et al. 1984). It has also been detected in cigarette smoke (Higgins et al. 1983; Osborne et al. 1956).

### 5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

Available monitoring data suggest that the general population is exposed to 2-butanone. In the early stages of the Total Exposure Assessment Methodology (TEAM) study, 2-butanone was qualitatively detected in 3 of 8 personal air samples, 5 of 12 breath samples, and 1 of 1 drinking water sample obtained from 12 volunteers living in urban areas of New Jersey or North Carolina (Wallace et al. 1984). 2-Butanone has also been detected in the expired air of 206 of 387 samples (53.2%) taken from 54 adult, nonsmoking, urban dwelling subjects, at an average concentration of 3.6 ng/L (Krotoszynski et al. 1979). It was detected in the expired air of six of eight male volunteers, three of whom were smokers (Conkle et al. 1975). 2-Butanone was found in 5 of 12 samples of human mothers' milk from subjects in 4 different U.S. urban areas (Pellizzari et al. 1982). It has been qualitatively detected in the indoor air of homes in Chicago (Jarke et al. 1981) and in Canadian residential and office buildings (Tsuchiya 1987).

Exposure to 2-butanone by the general population may occur by ingestion of contaminated drinking water. This compound has been identified in U.S. drinking water supplies (Bertsch et al. 1975; Coleman et al. 1976; EPA 1974, 1975; Kopfler et al. 1977; Ogawa and Fritz 1985; Scheiman et al. 1974). Inhalation is also a likely route of exposure to 2-butanone, especially during the household use of commercial coatings that use 2-butanone as a solvent. Exposure by dermal contact may also occur during the use of such coatings.

2-Butanone is a naturally occurring constituent in a variety of common foods (Del Rosario et al. 1984; Dumont and Adda 1978; Gordon and Morgan 1979; Grey and Shrimpton 1967; Keen et al. 1974; Kinlin et al. 1972; Lovegren et al. 1979; Takeoka et al. 1988). Ingestion of these foods will result in exposure to 2-butanone. Exposure to 2-butanone may also occur while smoking (Higgins et al. 1983; Osborne et al. 1956). Students taking undergraduate general chemistry laboratory courses may be also exposed to 2-butanone (Kolb 1988).

According to the National Occupational Exposure Survey (NOES) conducted by NIOSH between 1980 and 1983, 1,221,587 workers, of which 201,308 were women, were potentially exposed to 2-butanone during that time period (NIOSH 1989). Of these workers, 84% (80% for the women) were exposed during the use of trade name products containing 2-butanone. Occupational exposure is expected to occur by inhalation and dermal contact.

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A study of three companies involved in spray painting and spray gluing operations reported that, for 89 workers exposed to 2-butanone, the mean air concentration was 0.3 ppm (Whitehead et al. 1984). 2-Butanone was detected in the air of Cincinnati waste water treatment plants in 1982; 3 of 17 samples were positive at concentrations of 5.7 ppb or less (Dunovant et al. 1986). It has also been detected in the air above shale oil waste waters (Hawthorne and Sievers 1984). The breathing zone air for workers at an organic solvent recycling plant averaged 11 ppm during drum decantation operations, and 10 ppm during all other work activities (Kupferschmid and Perkins 1986). The ambient concentration was not greater than exposure limits of 200 ppm in any of these examples (NIOSH 1984). The concentrations of 2-butanone in air samples obtained from the Skylab, 1973-74, ranged from 2.4 to 1,505 ppb (Liebich et al. 1975). Personal exposure to 2-butanone at a waste solvent incineration facility ranged from <0.01 to 1.2 ppm (Decker et al. 1983).

### 5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

For the general population, high levels of exposure to 2-butanone may occur for those living near commercial settings where this compound is used. For example, the downwind 2-butanone concentration near a solvent recycling facility was measured at concentrations up to 94 ppm (Smoyer et al. 1971). High levels of exposure may also occur during the use of commercial coatings containing 2-butanone, especially when working in enclosed, unventilated spaces. Members of the general population living near hazardous waste sites and drawing their drinking water from groundwater sources may be exposed to high levels of 2-butanone through ingestion of contaminated water, although no information on the size of the population can be provided.

High levels of occupational exposure to 2-butanone may occur by inhalation and dermal contact during the loading and unloading of large quantities of this material during shipment. The application of commercial coatings containing 2-butanone without adequate protection may also lead to high levels of exposure, primarily by inhalation.

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

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

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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.** The physical and chemical properties of 2-butanone are well documented. The environmental fate of 2-butanone can be predicted from these properties and compared to experimental results once they are obtained in areas where deficiencies exist.

**Production, Import/Export, Use, and Disposal.** The significant amounts of 2-butanone produced in the United States, combined with its prevalence in commercial and household products, suggest that large numbers of citizens are potentially exposed to, anthropogenic sources of this compound. The production, use, and international trading of 2-butanone is well described in the available literature (Chemical Marketing Reporter 1987; Neir and Strehlke 1985; Papa and Sherman 1981; USITC 1987, 1988, 1989). Methods for the disposal of 2-butanone are established (HSDB 1989; OHM/TADS 1989), but the amounts processed by each method cannot be ascertained. Therefore, disposal of 2-butanone cannot be compared to the regulations controlling this practice. Knowing the amount of 2-butanone released to the environment and its disposal pattern will aid in determining routes and levels of exposure to the general population by indicating which media should be monitored carefully.

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 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.

**Environmental Fate.** There is sufficient predictive information to indicate that 2-butanone is not likely to partition from water (Hansch and Leo 1985; Lyman et al. 1982; Roy and Griffen 1985); yet, there are few field studies to verify these predictions. Similarly, 2-butanone's transport, transformation, and degradation in the environment can be predicted (Atkinson 1985; Babeu and Vaishnav 1987; Cox et al. 1980; Delfino and Miles 1985), but not as yet experimentally substantiated in all areas. Experimental studies in this area would allow the determination of 2-butanone's lifetime in the environment and aid in determining levels and routes of human exposure.

**Bioavailability from Environmental Media.** Numerous toxicokinetic and toxicity studies in humans and animals have demonstrated the bioavailability of 2-butanone from air, ingestion of food and water, and dermal contact. Absorption of 2-butanone after inhalation is well established, and it appears to be adsorbed after ingestion. These mechanisms are consistent with what one would expect, based on 2-butanone's physical and chemical properties (Lyman

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et al. 1982). Given the potential for exposure to 2-butanone because of its prevalence in commercial products available to the public (Neier and Strehlke 1985) and its ability to enter the immediate areas of the environment (TRI 1989), further research on the bioavailability of this compound will allow the quantification of human exposure and risk.

**Food Chain Bioaccumulation.** 2-Butanone is not believed to appreciably bioconcentrate in fish and aquatic organisms (Hansch and Leo 1985; Lyman et al. 1982). It is also not expected to biomagnify in the food chain. Quantitative data supporting these conclusions are not available in the literature. Additional information on bioconcentration and biomagnification would be useful in confirming the predicted behavior of this compound.

**Exposure Levels in Environmental Media.** Data are available regarding the level of 2-butanone in environmental media (Grosjean and Wright 1983; Shah and Heyerdahl 1988) and foods (Dumont and Adda 1978; Grey and Shrimpton 1967; Kinlin et al. 1972; Lovegren et al. 1979; Takeoka et al. 1988); however, the data available are often qualitative and only generalized trends regarding the occurrence of this compound can be derived. Its presence in environmental media near hazardous waste sites is not well documented (CLPSD 1988). Quantitative determination of the levels of 2-butanone in environmental media and foods will allow the estimation of levels on human intake of this compound from each media.

**Exposure Levels in Humans.** 2-Butanone has been found in the human blood samples of urban dwellers, but the observed levels have not been correlated with personal activities. Studies on the level of 2-butanone in human tissues near hazardous waste sites are not complete. A correlation of the levels of 2-butanone in humans with their personal activities or the areas where they live will allow an assessment of potential exposure to the general population. Similarly, correlations of occupational exposure by profession will allow a determination of human exposure levels.

**Exposure Registries.** No exposure registries for 2-butanone 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 the exposure to the compound.



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**5.7.2 On-going Studies**

On-going studies on water purification techniques and transformation of 2-butanone in the environment have been identified (EPA 1989b), although no specific information was provided.

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 2-butanone 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.