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Evacuations due to Chemical Accidents: Experience from 1980 to 1984

John H. Sorensen

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ENERGY DIVISION

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John H. Sorensen

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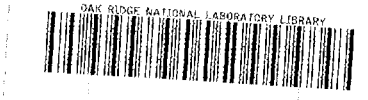

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ABSTRACT

This report describes evacuations associated with chemical accidents from 1980 through 1984. A data base describing each accident was constructed from wire service accounts of the accidents. Using this data, a profile of evacuations is developed. Each evacuation is also listed in an appendix. During the time period studied nearly 300 evacuations took place. The average size of an evacuation was 1000 people and the largest involved 30,000 evacuees. The most frequent cause of evacuations were industrial accidents followed by train derailments. For every 1000 people who evacuated, eight were injured by exposure to chemicals. Injury occurred in 25% of the evacuations. No injuries from the act of evacuating per se were found. Over the five-year period, the yearly total of evacuations fluctuated mildly, however, the number due to industrial accidents rose steadily.

PURPOSE AND APPROACH

The accident at the Union Carbide chemical plant in Bhopal, India, in December 1984, has generated increased concern over emergency preparedness in the chemical industry in the United States. Following this accident, considerable effort was expended to determine if such an event could occur in this country and what could be done to prevent or manage an event should one occur. The general results of these investigations suggested that while an event of the magnitude of Bhopal is highly unlikely, accidents that would threaten public safety could occur. While the prevailing sentiment of the investigations was that the industry was not fully prepared to handle emergencies, they generally had the capabilities to develop adequate prevention and response systems. Such capabilities were tested in August 1985, in Institute, West Virginia, when a leak occurred at a Union Carbide chemical plant. As a result of inadequate detection and warning, 133 people received injuries from inhalation of vapors from the release. Due to the inadequacy of response in this case, it is likely that further questions regarding the general emergency capabilities for handling chemical accidents will be raised.

In this context, the research reported in this paper sought to establish a historical record of chemical accidents that have led to public evacuations. This record includes the type of accidents that have caused evacuations, the frequency of evacuations, the cause of the accident, the location, the types of chemicals involved, and the number of injuries from exposure to the released chemicals. In constructing this data, we have limited the incidents to one that have had "off-site"

impacts. Thus, industrial accidents are not included unless they impacted persons off the industrial site.

The data was collected over a five-year period from 1980 through 1984. The primary source was national wire service coverage of accidents. Using an automated search of "NEXUS", a data base of newspaper and periodical publications, all stories on chemical evacuations were identified. These were arranged chronologically. A coding sheet was prepared for each event and, using the newspaper stories plus other reports, data on each incident was entered on the coding sheets. This provided a fairly comprehensive listing of all major evacuations due to chemical incidents, although it may under-report minor events (less than 10 evacuees).

INCIDENT FREQUENCY AND CAUSE

Over the five-year period studied, there were almost 300 events that led to a public evacuation. The yearly number ranged from 43 in 1980 to 68 in 1982 with a mean of 59 per year (Table 1). Of these events, the most frequent cause of an evacuation is a release at an industrial site. This category of events includes explosions, fires, spills, or accidents at warehouses and plants where chemicals are used in the manufacturing of various products. These industries range from small businesses such as a furniture stripping plant to large plants that make plastic products. The second most frequent cause of evacuations is train derailments where chemicals are released by tank leaks, fires or explosions. In some incidents, chemicals are not released but the threat of a release prompts

Table 1. Chemical accident evacuations by cause and year

Cause of evacuation	1980	1981	1982	1983	1984	Totals
Trail derailment	14	8	13	12	8	55
Train car spill/fire	3	6	5	4	5	23
Truck accident	9	9	6	6	5	35
Truck spill/fire	1	11	4	9	7	32
Chemical plant release	5	10	15	8	5	43
Industrial plant release	3	10	18	23	24	78
Pipeline	2	1	1	0	0	4
Ship incident	2	1	0	0	1	4
Waste site accident	0	1	2	3	1	7
Other	4	5	4	0	1	14
TOTALS	43	62	68	65	57	295

emergency actions. The third major cause of evacuations is releases from plants that produce chemicals. These mainly occur due to equipment failures, explosions from mixing of different chemicals, human errors, and fires. The fourth most frequent cause of evacuations is tanker truck accidents which result in leaks or fires. This category is followed by truck leaks or fires not related to traffic accidents. The sixth major category is rail car spills where no derailment occurs. Often the spills are located in rail yards where cars are being temporarily parked or being transferred to another line.

Less frequent are pipeline leaks and explosions, ship or barge accidents, and waste site accidents. This latter category involves fires or spills at a waste disposal site but does not include the discovery of chronic waste problems (such as Love Canal or Times Beach) that require relocation. In addition, other accidents were identified that did not fit into the above classes. These included a helicopter crash, a plane crash, a sewer gas episode, an oil well explosion, a swimming pool chlorine accident, a major pesticide spill in a retail store, a mine fire, two missile silo accidents, and two electrical transformer leaks.

EVACUATION SIZE

Based on the estimates derived from newspaper accounts, the evacuations identified ranged in size from two households to about 30,000 people. The 30,000 people evacuated were from the Embarcadero area of downtown San Francisco following a pipeline break which released PCB's. The Mississauga evacuation in Canada caused by a train derailment involved an estimated 225,000 people (Burton, 1981). Figure 1 depicts the

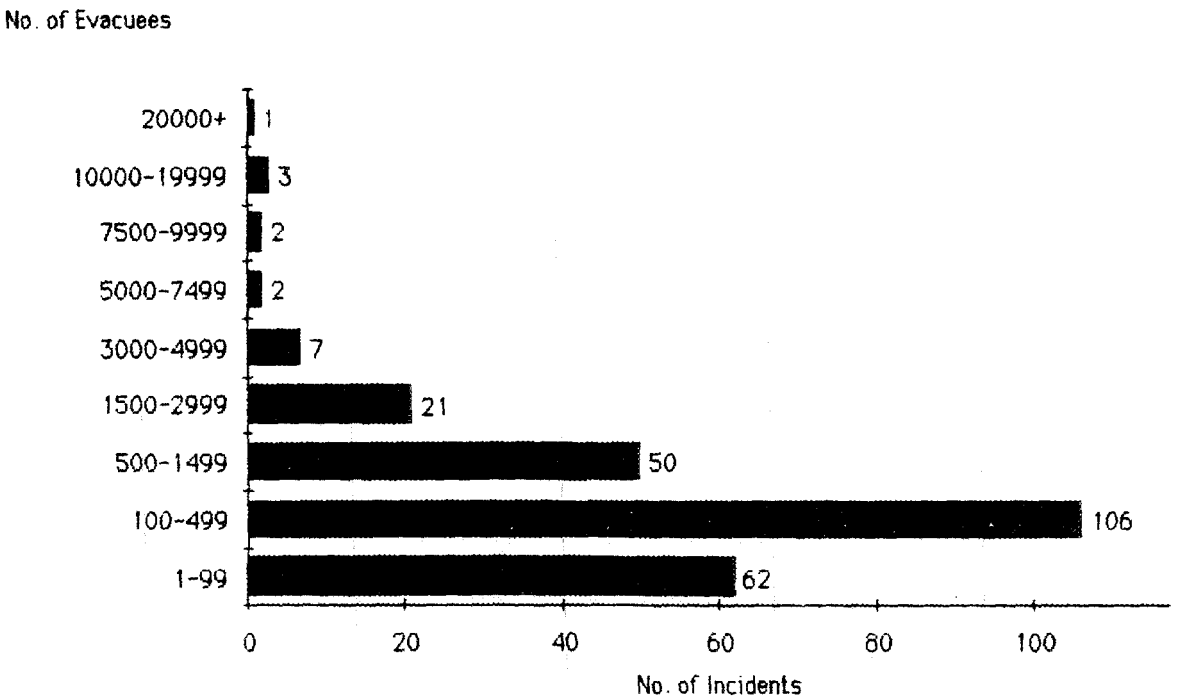

Fig. 1. Evacuation size distribution

frequency of evacuations by the number of people who evacuated for the 254 events for which estimates have been made. As might be expected, the frequency of evacuations declines as the number of evacuees increases. In total, about 250,000 people evacuated over the five-year period for an average of 50,000 per year. The average size of an evacuation was 1,000 persons. Most evacuations (n = 168) involved less than 500 people, while only a few (n = 8) involved over 5,000 people.

LOCATIONS OF THE EVACUATIONS

The evacuations were distributed over 43 of the 50 states in the country (Table 2). The greatest number occurred in states such as California, Texas, Pennsylvania, Louisiana, New York, North Carolina, and Ohio, which are heavily industrialized in manufacturing and petrochemicals and have large volumes of chemicals being transported within the state. These states also tend to have large populations. The next grouping of states, with around 10 evacuations each, contains either high volume transport states (Illinois, Indiana) or primarily industrialized states (New Jersey). Those states with a low incident of evacuation are neither high volume transport or industrialized states and tend to experience isolated events in all categories of accidents. The states without evacuations tend to be either small or isolated, have little industry, and have small populations. To a major extent, the distribution of evacuation sizes reflects the locations in which the accidents occur. Most tend to take place away from densely populated suburban or downtown locales. Most industrialized areas housing manufacturers who use chemicals

Table 2. Number of evacuations by state: 1980-1984

Alabama	8	Montana	0
Alaska	0	Nebraska	2
Arizona	8	Nevada	0
Arkansas	5	New Hampshire	2
California	28	New Jersey	10
Colorado	3	New Mexico	3
Connecticut	3	New York	13
Deleware	1	North Carolina	13
Florida	6	North Dakota	0
Georgia	5	Ohio	16
Hawaii	0	Oklahoma	2
Idaho	4	Oregon	0
Illinois	10	Pennsylvania	15
Indiana	11	Rhode Island	0
Iowa	6	South Carolina	1
Kansas	4	South Dakota	0
Kentucky	11	Tennessee	3
Louisiana	21	Texas	15
Maine	1	Utah	2
Maryland	3	Vermont	0
Massachusetts	9	Virginia	5
Michigan	11	Washington	2
Minnesota	3	West Virginia	9
Mississippi	3	Wisconsin	2
Missouri	9	Wyoming	1

and chemical producers are zoned away from populated locations. Truck accidents and train derailments frequently take place in rural areas with low population densities. Occasionally an accident occurs in a city or is of such a magnitude that it puts a urban area at risk and consequently large numbers of people are moved.

EVACUATION INJURIES

In the 300 incidents reviewed, no evidence of injuries or fatalities from the act of evacuation per se were found. This is consistent with other investigations of evacuation (Quarantelli, 1980). Injuries did occur, however, from exposure to chemicals either prior to or while evacuating. Table 3 summarizes the number of injuries by accident type and year. These do not include occupational injuries (e.g., to truck drivers, to plant workers injured by fires or explosions, or to emergency workers) but do include injuries to workers who were evacuated due to a release. In total, 2051 injuries and one death occurred because of exposure to the chemical releases. Of these, one event, an alleged illegal dumping of hazardous wastes in New Jersey, accounted for 700 reported cases of respiratory and skin problems. The remaining injuries, mostly of a similar nature, are distributed among 72 events. When injuries occurred, a mean of 28.1 people were affected. Injuries occurred in about one of every four evacuations. Overall, eight were injured for every 1000 people who left. Three indices can be used to compare different categories of events. First, the percentage of events in which exposure occurred and injury resulted is computed. Second, the average

Table 3. Chemical accident evacuation injuries by cause and year

Cause of evacuation	1980	1981	1982	1983	1984	Total injuries	Total incidents	Total with injuries	Percent with injuries	Average injuries per accident	Average injuries per evacuation
Trail derailment	10	12	5	1	0	28	55	7	13	4	0.5
Train car spill/fire	46	0	2	2	13	63	23	5	22	12.6	2.7
Truck accident	0	0	55	3	0	58	35	4	11	14.5	1.7
Truck spill/fire	105	109	10	52	26	302	32	12	38	25.2	9.4
Chemical plant release	31	39	51	12	13	146	43	12	28	12.2	3.4
Industrial plant release	49	65	224	195	139	672	78	25	32	26.9	8.6
Pipeline	1	33	0	0	0	34	5	3	60	11.3	6.8
Ship incident	3	0	0	0	0	3	4	1	25	3	0.8
Waste site accident	0	0	0	700	0	700	7	1	14	700	100
Other	0	41	4	0	0	45	14	3	21	15	3.2
Total injuries	245	299	351	965	191	2051					
Total incidents	43	62	68	65	57	296	296				
Total with injuries	14	15	19	13	12	73		73			
Percent with injuries	33	24	28	20	21	25			25		
Average per accident	17.5	20	18.5	74	15.9	28.1				28.1	
Average per evacuation	5.7	4.8	5.2	14.8	3.4	6.9					6.9

number of injuries per event in which injuries occurred is given. Third, the average injuries per total number of evacuations is computed. All three indices varied with accident type. Due to the single large event previously mentioned, waste disposal accidents account for the highest average injuries per event although only one of seven events produced injuries. Industrial plant releases and truck spills produced high injury rates as well. Pipeline accidents were the most likely to produce injuries, but they were not a common occurrence. Frequent injuries were also noted for truck spills and industrial plant releases. More moderate injury rates and frequencies were observed for chemical plant incidents and train spills. Train derailments and truck accidents produced very low frequencies of injuries and low average injury rates. It is difficult to determine if these differences in injury rates and frequencies are significant given the short time frame and uncertainties in the data, and if significant, why these differences exist.

Several hypotheses can be formed regarding injury rates. First, injuries may be more prevalent in transportation leaks and spills as opposed to derailments and accidents because an accident alerts those nearby to possible danger while the spill may go undetected. Second, injuries may be lower in chemical plant emergencies than in industrial plant emergencies because of greater attention given to safety and emergency preparation in the former (Quarantelli, 1984). Data limit drawing grounded hypotheses concerning the other categories, but several more speculative hypotheses can be offered. First, if an evacuation is needed, chemical disposal incidents may present the greatest potential for injuries because of the lack of planning and citizen awareness of the

hazard. Second, pipeline accidents result in a higher portion of events with injuries because they happen quickly and will either not impact people or confront them with an immediate threat. Third, ship incidents have a low potential for injuries because they will rarely occur in populated areas.

TRENDS IN EVACUATIONS 1980-1984

While a five-year period does not provide as long a data record as would be desirable to observe trends, patterns of evacuations during this period differ among categories of events. Figure 2 provides graphs of the seven major categories of events. Train derailment evacuations fluctuated over the five-year period with a downward trend in the last two years. Train spill evacuations remained nearly constant from year to year. Truck accident evacuations have slowly declined during this time period. Truck spill evacuations have fluctuated widely.

Chemical plant evacuations showed a peak in 1982 and have declined since then. Industrial release evacuations, on the other hand, show a gradual rise over this time period. Waste site evacuations show a slight rise with that trend reversing in 1984.

These trends suggest that the total number of evacuations will probably not increase or decrease drastically from year to year but, on the average, may gradually rise. Transportation-related evacuations will likely continue to fluctuate in a somewhat random pattern. Waste site events will also probably fluctuate. Industrial-related evacuations may continue to rise. Evacuations at chemical plants may continue to fluctuate but will probably not increase greatly.

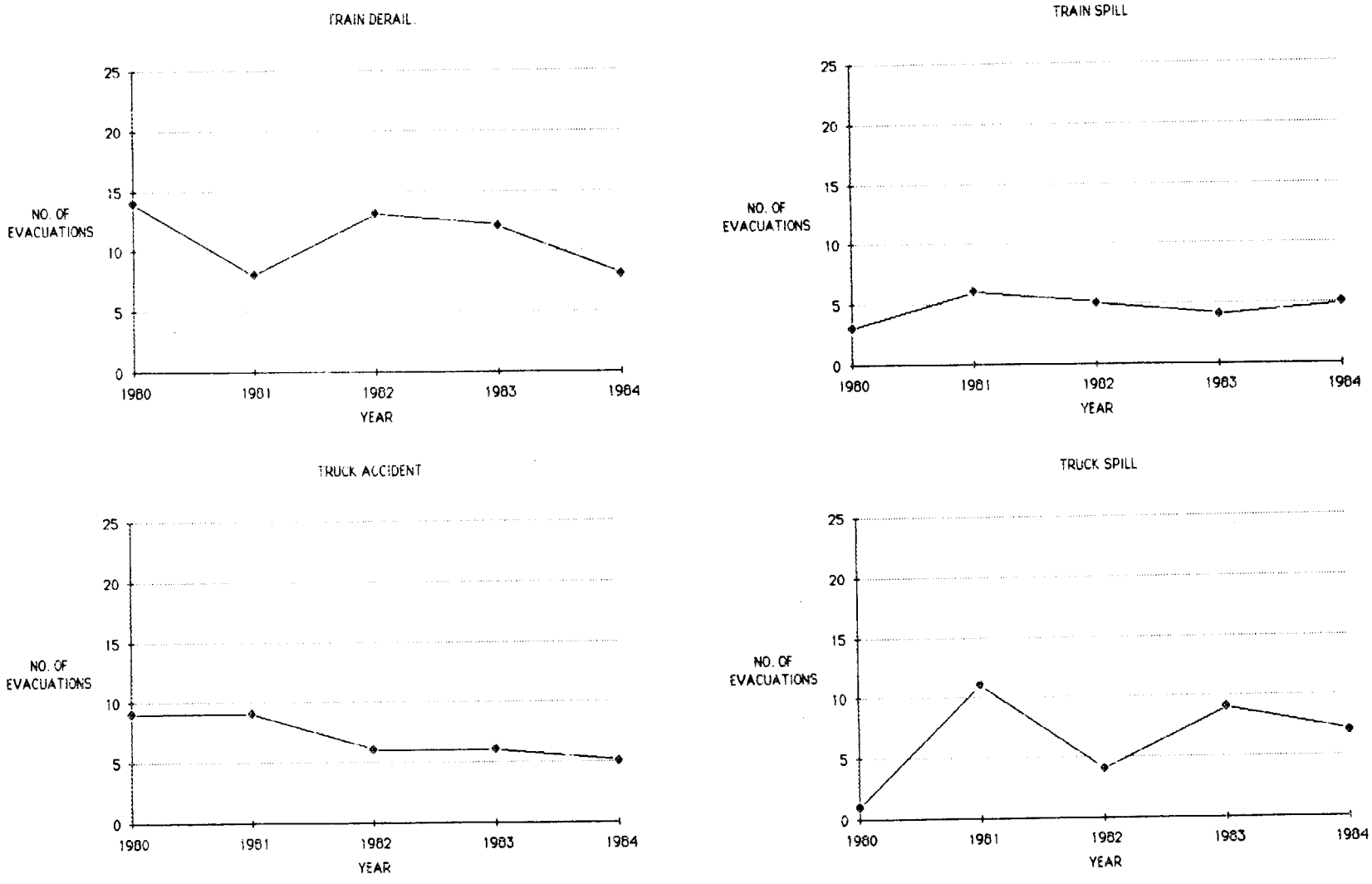

Fig. 3. Yearly evacuation frequencies by accident type

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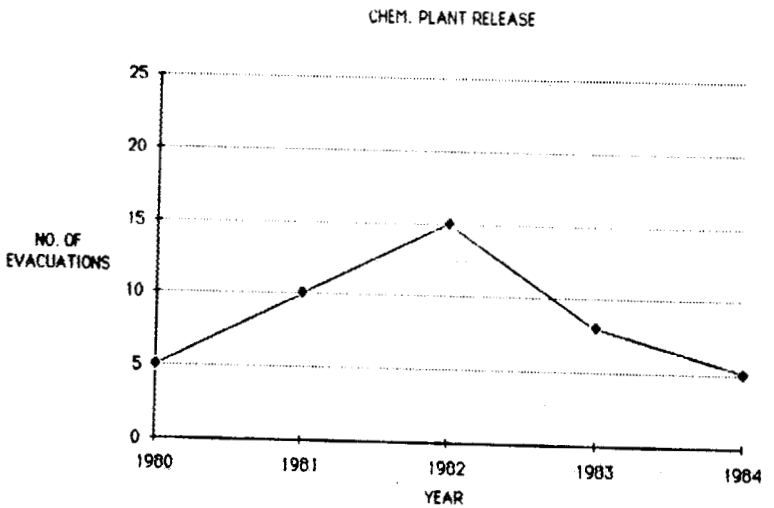

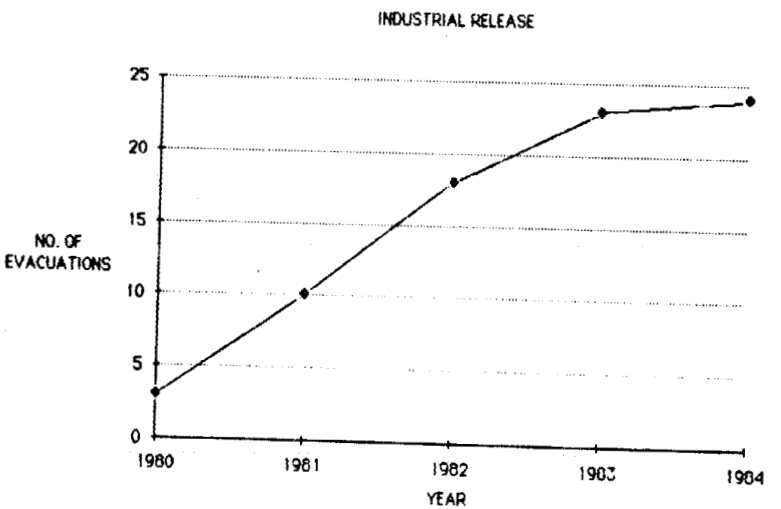

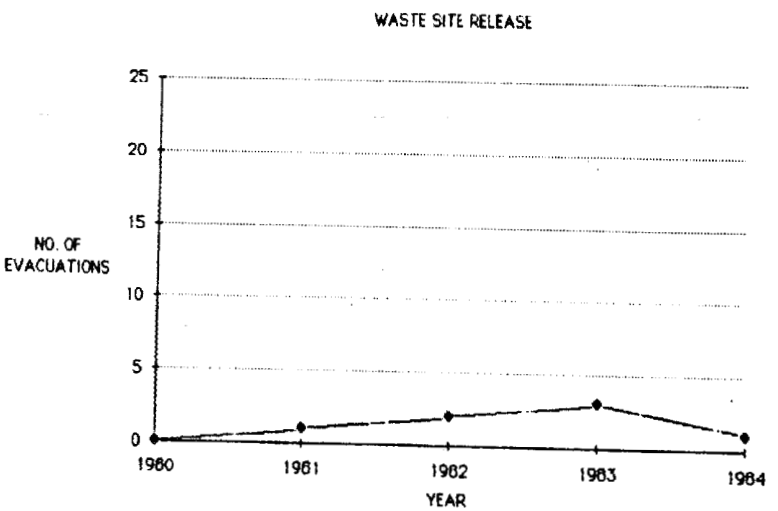

Fig. 3. (continued)

IMPLICATIONS AND DIRECTIONS

This preliminary analysis has provided a descriptive account of most evacuations due to accidents involving chemicals from 1980 through 1984. Such evacuations are not rare events; they occur on the average of once every six days somewhere in the country. Some states and even some cities have accidents with much greater frequency than others and hence have likely developed greater emergency response capabilities. Overall evacuations have been successful in preventing fatalities. In the approximately 300 cases reviewed, only one known or reported public fatality occurred and the link to the release was not at all certain. This success does not necessarily mean that further attention to the problem is not warranted. Given the frequency of events, further efforts at improving warning and response capabilities at the state and local level are justifiable and might reduce the incidence of accidents with short-term injuries and possible long-term health effects.

The research reported is preliminary. Further activities that would be desirable include:

(1) Expanding the time horizon of the data base and keeping it current.

(2) Computerizing the data into a retrievable file system.

(3) Evaluating the size of the geographic areas evacuated.

(4) Developing more precise estimates of source terms.

(5) Analyzing problems encountered in emergency response and warning activities.

(6) Analyzing occupational injuries associated with the accidents.

(7) Assessing the appropiateness of evacuation given the chemicals involved.

REFERENCES

Burton, I. 1981. The Mississauga Evacuation: Final Report. Toronto: University of Toronto, Institute for Environmental Studies.

Quarantelli, E. 1980. Evacuation Behavior and Problems: Findings From the Research Literature. Columbus, Ohio: Disaster Research Center, Ohio State University.

Quarantelli, E. 1984. "Chemical Disaster Preparedness at the Local Community Level," J. of Hazardous Materials 8:239-249.

APPENDIX A

AN INVENTORY OF CHEMICAL EVACUATIONS 1980-1984

AN INVENTORY OF CHEMICAL EVACUATIONS 1980-1984

This appendix contains a preliminary listing of evacuations due to chemical accidents that have been identified to date during the years 1980 through 1984 (Table A-1). The data are tentative and have not been validated, hence, should be interpreted accordingly.

Table A-1. Chemical-induced evacuations from 1980-1984

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
1/12/80	Buckeye, AZ	Train derailment	Propane	600	0
1/13/80	Millfield, OH	Train derailment	Tolvene diisocyanate	750	3
1/13/80	Easterville, PA	Train derailment	?	200	0
1/14/80	Ridgefield, WA	Train derailment	Ammonia	60	3
2/9/80	O'Kean, AR	Train derailment	Ethylene oxide	220	1
2/26/80	Union Station, OH	Train derailment	Vinyl chloride phosgene	300	0
2/27/80	Granville, PA	Train derailment	?	300	0
4/3/80	Somerville, MA	Tank car leak	Phosphorus Tricloride	17,000	45
4/21/80	Fort Hall, ID	Fire at chemical company	?	600	29
4/22/80	Potwin, KS	Leak from missile silo	Nitrogen textroxide	50	0
5/6/80	Saugus, CA	Chemical plant explosion	PVC	200	0
5/15/80	Crane, IN	Helicopter crash	Mustard agent	<10	0
5/15/80	Depue, IL	Pipe rupture	Sulphuric acid	500	1 injury 1 death
6/5/80	Cave City, KY	Truck accident	Cyanide	500	0
6/6/80	Garland, TX	Train derailment	Styrene momomer	8,000	0
6/12/80	Delphi, LA	Train derailment	Chlorine	1,500	0
6/13/80	Paris, MO	Chemical plant fire	Pesticides	200	2
6/17/80	Hammond, LA	Train derailment	Styrene momomer	2,500	0
6/24/80	Knoxville, TN	Chemical plant explosion	Formic and nitric acids	500	0
7/2/80	Port Wentworth, GA	Tank car leak	Ammonia	100	1
7/8/80	Safford, AL	Truck accident	Phosphorus pentasulfide	150	0
7/8/80	Paducah, KY	Train derailment	Hydrochloric acid	60	0
7/10/80	Hastings, IA	Train derailment	Multiple acids	400	0
7/21/80	Muldraugh, KY	Train derailment	Vinly chloride, chlorine acrylonitrite	7,500	3
7/22/80	Shell Beach, LA	Ship collision	Hydrochloric acid	500	0
8/29/80	Baldwin, PA	Fire on disposal truck	?	?	100
9/19/80	Damascus, AK	Industrial accident/ explosion at missile site	Acrozine 50	1,400	?
10/21/80	New Castle, NJ	Chemical pipeline explosion	Propylene	1,000	?
11/5/80	? , CA	Ship container leak	Dichloropropene	?	3
11/7/80	Binghamton, NY	Train tanker car leak	Ethyl acrylic	<100	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
7/12/81	Middletown, PA	Truck leak	Hydrochloric acid	1,000	0
7/16/81	Dayton, OH	Tanker truck leak	Nitric acid and ammonium bifluoride	200	0
7/20/81	St. Louis, MO	Rail tank leak	Nitric acid	2,000	0
7/22/81	Blythe, CA	Tanker truck fire	Nitric acid	2,000	10
7/25/81	Saukville, WI	Chemical plant fire	?	150	0
7/27/81	Newark, NJ	Fire in rail yard	Ethylene oxide	2,000	0
7/31/81	Hobbs, NM	Oil well blowout	Oil	?	0
8/3/81	Marrero, LA	Chemical plant fire	Naphtha	50	?
8/4/81	Dupo, IL	Rail tank leak	Nitric acid	200	0
8/4/81	Charlottesville, VA	Train tank car leak	Carbon disulfide	500	?
8/7/81	Bridgewater, NJ	Chemical plant fire	Phenolic foam	1,000	0
8/7/81	Houston, TX	Barge accident/fire	?	1,200	0
8/7/81	Bridgman, MI	Train derailment	Fluorosulfonic acid	2,600	12
8/19/81	Webster Parish, LA	Truck leak	Methyl parathion	30	0
8/20/81	Zellwood, FL	Chemical plant explosion	Ammonia	1,200	6
8/21/81	San Francisco, CA	Pipeline break	Silicone tetrachloride	10,000	28
8/22/81	Huntsville, AL	Industrial accident	Acids ?	180	23
8/24/81	Shreveport, LA	Tanker truck leak	Nitric acid	?	0
8/25/81	San Francisco, CA	Gas pipeline leak	PCB's	30,000	5
8/28/81	Acton, MA	Industrial leak	Styrene oxide	400	0
9/8/81	San Ramon, CA	Tanker truck leak	Acid ?	4,000	24
9/10/81	Norco, LA	Train derailment	Butadiene, propylene, chloride, monomer	20	0
9/10/81	Hutchinson, KS	Train derailment	Anhydrous ammonia	200	0
9/21/81	Rutherford, NC	Truck accident	Styrene	50	0
9/21/81	Cambridge, MA	Swimming pool tank leak	Chlorine	800	37
9/28/81	Merkel, TX	Truck accident	Ammonia	100	0
10/6/81	Dilley, TX	Industrial tank leak	Phostoxin	1,000	0
10/6/81	Marysville, WA	Train derailment	Chlorine, isobutane	5,000	0
10/14/81	Ludington, MI	Industrial accident	Bromine	300	0
10/22/81	Columbus, OH	Tanker truck leak	?	5	0
10/23/81	Paineville, OH	Industrial tank leak	Perchloromethlcaptan	100	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
11/10/80	River Rouge, MN	Oil tank fire	Oil	50	0
11/13/80	Bosser City, LA	Truck accident	Chlorosulfonic acid	60	0
12/8/80	Holly Springs, MS	Truck leak	Toxaphene	200	0
12/9/80	Morgantown, WV	Tanker truck fire	Ammonium nitrate	100 plus 4 schools	5
12/14/80	Monroe, OH	Train derailment	?	24	0
12/17/80	Concord, NH	Industrial accident	Chlorine	25	39
12/29/80	Clarkton, NC	Chemical warehouse fire	Methylbromide sodium nitrate	750	10
12/30/80	Huntingdon, PA	Industrial fire	Naphtha acetone	400	0
1/7/81	Addis, LA	Train derailment	Anhydrous ammonia	1,300	0
2/2/81	Vincennes, IN	Truck fire	Propane	200	0
2/13/81	Louisville, KY	Leak into sewer	Hexane	136	4
2/21/81	Ottawa, IL	Chemical plant fire	?	?	0
3/10/81	Marquand, MO	Industrial explosion	Nitrocellulose	380	0
3/14/81	Crofton, KY	Train derailment	Phosphoric acid	150	0
3/14/81	Park City, KY	Train car leak	Anhydrous ammonia	300	0
3/17/81	Shenango, PA	Truck accident	Boron trifluoride	200	0
4/13/81	Golden, CO	Chemical plant fire	Tetraltyra fluorine	600	2
4/14/81	Seekenk, MA	Truck leak	Chloride	35	0
4/15/81	Roxbury, KY	Plane crash (crop duster)	Ethyl Parathion	5	0
4/28/81	Eagleville, PA	Spill in retail store	Pesticides	100	24
5/4/81	Greensburg, IN	Truck accident	Hydrochloric acid	10	0
5/5/81	San Jose, CA	Truck waste disposal spill	Boron tribromide	1,000	2
5/20/81	Childersburg, AL	Industrial explosion	Dinitrophenol	900	0
5/22/81	Asthabula, OH	Industrial fire in tannery	?	1,600	18
6/3/81	Milford, CT	Chemical plant leak	Methylene chloride	200	31
6/4/81	Hancock, MD	Truck accident	Aniline	30	0
7/1/81	Lenox, GA	Warehouse fire	?	750	0
7/3/81	Elizabethtown, KY	Truck accident	Monoethanolamine	150	0
7/4/81	Shoshone, ID	Industrial tank leak	Anhydrous ammonia	50	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
10/31/81	Hamburg, NY	Train derailment	Methyl chloride	4,500	0
11/2/81	Columbus, OH	Truck leak	Thionyl chloride	300	0
11/5/81	Castaic, CA	Tanker truck leak	Propylene dichloride	300	75
11/11/81	Quapaw, OK	Train derailment	Toluene	300	0
11/14/81	McKinney, KY	Fire at waste storage site	Arsenic	80	0
11/16/81	?	Truck leak	Methanol and acetone	300	0
12/1/81	Phoenix, AZ	Truck leak	Perchloroethylene	25	1
12/17/81	Tuscon, AZ	Truck leak	Butyl alcohol	?	0
12/20/81	Texarkana, TX	Truck accident	Allyl alcohol	25	?
12/23/81	Garland, TX	Chemical plant fire	?	400?	0
12/24/81	Los Angeles, CA	Chemical plant spill	Sulphur dioxide	50	0
1/14/82	Boston, MA	Electrical transformer leak	PCB's	2,000	4
1/20/82	Haleyville, AL	Train tank car leak	Chlorosulfonic acid	2,000	0
1/22/82	Frametown, WV	Truck accident	Xylene	40	0
1/31/82	Lockbourne, OH	Train derailment	Isobutyraldehyde	350	0
2/1/82	Douglas, AZ	Warehouse fire	Acorga B5-100	200	0
2/2/82	Manchester, NH	Explosion	Benzene	1,900	0
2/3/82	Stoudsburg, PA	Truck accident	Aluminum chloride	700	0
2/3/82	Creston, IA	Train derailment	Ethylene glycol ether	?	0
2/5/82	Lovington, NM	Warehouse fire	?	500	12
2/25/82	Greensboro, GA	Train car leak	Phosphorus trichloride	3,000	2
2/25/82	Richmond, VA	Industrial leak	Pentaborane	?	3
3/9/82	Lost Creek, WV	Truck accident	Calcium carbonate	40	0
3/16/82	North Shores, MI	Train derailment	Chlorine	600	0
3/19/82	Huntsville, AL	Industrial accident	Ethylene glycol monoethylether acetate	400	0
3/19/82	Ludowici, GA	Train derailment	Phenylmercuric acetate	10	0
4/4/82	Falls City, NE	Chemical plant fire	Ammonium nitrate	1,300	0
4/10/82	Belle, WV	Chemical plant leak	Chlorine	2,500	0
4/11/82	St. Joseph, MI	Train derailment	Phenols, ethylbenzene	500	0
4/12/82	Tuscon, AZ	Industrial leak	Phosphoric acid	30	0
4/12/82	Beaver Brook, PA	Fumes from mine	?	12	?

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
4/15/82	San Jose, CA	Train tank car leak	Anhydrous ammonia	?	0
4/19/82	Parkersburg, WV	Train tank car leak	Butyraldehyde	75	0
4/21/82	Edinburg, IN	Train derailment	?	10	0
4/21/82	Hazelwood, NC	Chemical plant fire	Chlorine	2,200	0
4/22/82	Farmersburg, VA	Chemical plant fire	Ammonia	300	0
4/26/82	Akron, OH	Industrial leak	Acrylonitrile	1,500	6
5/3/82	Columbus, IN	Tank leak (farm)	?	400	0
5/4/82	Lake Charles, LA	Train derailment	Butylene, chlorine	500	0
5/6/82	Duluth, MN	Chemical plant explosion	Malic acid	3,500	0
5/12/82	Callao, MO	Train derailment	Acetaldehyde	25	0
5/26/82	Isle, MN	Industrial fire	?	50	0
5/30/82	Ritchie, MD	Chemical plant leak	Kerosene	175	0
6/2/82	Gulfport, MS	Industrial explosion	?	5,000	?
6/18/82	Avon, IN	Train derailment	Vinyl chloride	20	0
7/1/82	Danville, IL	Chemical plant leak	Hydrochloric acid	500	0
7/6/82	Charlotte, NC	Industrial chemical leak	Phenol	40	0
7/7/82	Sherwood, OH	Train derailment	Butadiene	850	0
7/9/82	Bryant, AK	Truck accident	Benzyle chloride	600	3
7/16/82	Charleston, WV	Train car leak	Hydrochloric acid	200	0
7/20/82	Dothan, AL	Chemical plant fire	Hexane	1,000	0
7/24/82	Fairmont, WV	Industrial fire	Hydrochloric acid	1,200	0
8/1/82	Casco, ME	Industrial fire	?	150	0
8/3/82	Montpelier, ID	Industrial fire	?	2,000	0
8/6/82	Adrian, MI	Chemical plant fire	Bromine/chlorine	?	?
8/11/82	Charlotte, NC	Truck leak	Acids	?	0
8/12/82	Salt Lake City, UT	Chemical plant leak	Chlorine	?	0
8/15/82	Bailey's Crossroads, VA	Gas leak at spa	Chlorine	?	0
8/16/82	Akron, OH	Chemical plant leak	Sulphur monochloride	200	9
8/24/82	Chapin, SC	Chemical plant leak	Chlorine	150	0
8/25/82	Flomaton, AL	Train derailment	Clinhydrous ammonia	350	0
8/26/82	Plainfield, IA	Warehouse fire	?	?	0
9/5/82	Terminal Island, CA	Pipeline leak	Hydrochloric acid	50	0
9/13/82	Charlotte, NC	Warehouse fire	Sodium hydrochlorite	1,500	100

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
9/15/82	Canton, MA	Hazardous waste fire	?	300	0
9/22/82	Hanford, CA	Tanker truck spill	Nitric acid	300	0
9/28/82	Livingston, LA	Train derailment	Hydrogen chloride plus mix	3,300	5
10/4/82	Henrietta, NY	Truck accident	Mix	300	2
10/7/82	Midwest City, OK	Waste site fire	Mix	300	0
10/10/82	Newark, NJ	Chemical plant explosion	?	50	0
10/13/82	Odessa, DE	Truck accident	Vinyl benzene	400	50
10/22/82	New York, NY	Industrial plant leak	Trichoroethane	100	40
11/2/82	Clear Lake, IA	Truck tank leak	Trichoroethyene	?	2
11/12/82	Irving, CA	Chemical plant leak	Ethylene oxide	2,000	30
11/31/82	Orange, CA	Chemical plant explosion	Styrene monomer	3,000	11
12/1/82	Murphysboro, IL	Train derailment	Pesticide	75	0
12/2/82	San Francisco, CA	Spill at retail ?	Malathion	250	8
12/11/82	Taft, LA	Chemical plant explosion		17,000	1
12/21/82	Memphis, TN	Train derailment	Vinyl chloride	50	0
12/22/82	Vernon, Ca	Warehouse leak	Methyl acrylate	300	55
12/27/82	New Baltimore, MI	Tanker truck leak	Nitric acid	200	8
1/5/83	Romulus, MI	Chemical plant leak	Nitric acid	?	0
1/12/83	Watertown, NY	Truck accident	Tolvene diisocyanate	700	3
1/15/83	?	Fire in farm storage	Paraquat	250	0
1/26/83	Coranado, CA	Spill from truck	Hydrochloric acid	150	0
1/26/83	Indianapolis, IN	Chemical plant release	Sulfuric acid	2,500	12
2/2/83	Avon, IN	Truck accident	Propane	30	?
2/3/83	Thermal, CA	Warehouse fire	Malathion, mix vinyl chloride	250	0
2/3/83	Vine Grove, KY	Train derailment	Hydrochloric acid	50	0
2/7/83	New Orleans, LA	Industrial leak	Sulfur dioxide	?	0
2/28/83	Golden, CO	Industrial accident	Nitrogen dioxide	?	32
3/10/83	Mariposa, CA	Tanker truck leak	Hydrochloric acid	10	0
3/10/83	Durham, NC	Chemical plant release	Butyl acetate	50	0
3/14/83	Terrytown, NE	Truck leak	Aluminum phosphate	100	2
3/14/83	Hallsburg, TX	Train derailment	Phenol	400	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
3/22/83	Marcus Hook, PA	Oil refinery explosion	Propane	200	0
3/22/83	Taft, LA	Chemical plant accident	Acrolein	600	0
3/24/83	Belmont Hills, PA	Train derailment	Sulfuric acid	?	0
3/29/83	Penderlea, NC	Truck accident	Methanol	1,000	?
4/3/83	Matewan, WV	Train derailment	Acetic anhydride	175	0
4/25/83	Greenwood, LA	Truck spill	Lead oxide	100	2
5/3/83	Niverville, NY	Train derailment	Vinyl acetate	1,000	0
5/10/83	Fullerton, CA	Waste site fumes	Mix	1,200	0
6/7/83	Muscatine, IA	Train derailment	Acrylonitrile	200	0
6/14/83	Campbell, NY	Truck accident	Benzene	500	0
6/15/83	Watkins Glen, NY	Train derailment	Naphtha	100	0
6/15/83	Utica, MI	Waste disposal site fire	Toluene, benzene	1,000	0
6/15/83	Nacogdoches, TX	Industrial accident	Parathion	1,500	118
6/19/83	Victory Mills, NY	Truck leak	Andhyrous ammonia	50	0
6/20/83	Hillsdale, NY	Industrial spill	Anhydrous ammonia	12	0
6/29/83	Boston, MA	Industrial spill	Ammonia cloride	200	0
7/2/83	Leadville, CO	Industrial chemical storage spill	Sulfuric acid	100	0
7/7/83	Exton, PA	Truck leak	?	400	0
7/13/83	New Orleans, LA	Truck accident	Ethylene diamine	7	0
7/17/83	Farmington, MO	Industrial fire	?	100	0
7/18/83	Los Fresnos, TX	Warehouse fire	Aldicarb	400	0
7/20/83	Ocean City, MD	Industrial accident	Xylene	1,000	10
7/21/83	Guilford College, NC	Chemical plant release	Chlorine	?	0
7/22/83	Seward, IL	Chemical plant fire	?	1,600	0
7/22/83	Baton Rouge, LA	Rail tanker car leak	Styrene monomer	1,100	0
7/25/83	North Rose, NY	Industrial explosion	?	300	40
7/27/83	Phoenix, AZ	Industrial fire	?	?	0
7/28/83	Douglas, Kansas	Grain elevator fire	Malathion	40	0
7/30/83	Baton Rouge, LA	Train car leak and fire	Vinyl chloride	600	0
8/2/83	Justin, CA	Industrial accident	Muriatic acid	?	2
8/3/83	Newark, OH	Industrial fire	?	200	0
8/3/83	Westford, MA	Train derailment	Methyl methacrylate	300	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
8/4/83	Newark, NJ	Hazardous waste disposal	?	?	700
8/10/83	Atlanta, GA	Truck spill and fire	Sodium hydrosulfite	170	50
8/12/83	Benicia, CA	Train car leak	Anhydrous dimethylamine	30	0
8/20/83	Pensacola, FL	Train derailment	Methanol	150	0
9/2/83	Murdock, IL	Train derailment	Propane, sulfuric oxide	175	0
9/16/83	San Jose, CA	Truck spill	Methylene bromide	?	0
9/21/83	Salisbury, NC	Chemical plant explosion	Sulfuric acid	250	0
9/30/83	Peoria, IL	Industrial fire	?	100	0
10/4/83	Portsmouth, VA	Train car fire	Ammonium nitrate	1,200	1
10/10/83	New Brunswick, NJ	Warehouse fire	Sodium nitrate	60	0
10/24/83	Glenns Ferry, ID	Industrial fire	Prophine	200	0
11/4/83	Detroit, MI	Industrial fire	Acetylene	?	0
11/10/83	Evansville, WY	Train derailment	Sulfuric acid	10	0
11/23/83	Charlotte, NC	Industrial fire	Mix	?	3
12/5/83	Miamitown, OH	Truck fire	Cesium	200	0
12/5/83	Houston, TX	Chemical plant fire	Kerosene, naphtha	2,000	0
12/27/83	Houston, TX	Industrial fire	Butane	100	0
12/29/83	Chadbourne, NC	Truck accident	Acetone, toluol	300	0
1/4/84	Shoals, IN	Train derailment	Thionyl chloride	150	0
1/11/84	Kanarraville, UT	Truck accident	Mix	?	0
1/12/84	Champaign, IL	Industrial explosion	Nitrogen	?	0
1/17/84	Liverpool, PA	Truck leak	Methyl acetate	10	0
1/24/84	Prarie Du Chien, WI	Industrial leak	Ammonia	130	0
1/29/84	Jacksonville, FL	Industrial fire	PCB's	50	0
1/31/84	Wichita, KS	Industrial leak	Sulphatep	150	20
2/5/84	Alameda, CA	Truck leak	Acetic anhydride	?	0
2/5/84	Paris, KY	Train derailment	Sulfuric acid	33	0
3/5/84	Jersey City, NJ	Chemical fire	Mix	150	3
3/16/84	Shreveport, LA	Truck accident	Hydrochloric acid	10	0
3/31/84	Bakersfield, CA	Industrial leak	Pyridine	?	0
4/5/84	Siloam Springs, AK	Train derailment	Glycol, aniline, acrylonitrile	1,000	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
4/9/84	Austin, TX	Industrial leak	Sodium hydroxide	350	2
4/10/84	Bossier City, LA	Truck spill	Gasoline	?	0
4/10/84	Marshville, NC	Train derailment	Methanol	2,100	0
4/24/84	Albuquerque, NM	Industrial fire	Oil, methanol, mix	400	0
4/25/84	Vernon, CT	Industrial fire	Sulfur dioxide	10	0
4/27/84	Phoenix, AZ	Industrial fire	Sulfuric acid	200	15
5/2/84	Oakland, CA	Railcar tank leak	Chlorine	200	13
5/14/84	Santa Barbara, CA	Truck spill	Sulfuric acid plus mix	3,500	21
5/17/84	Warsaw, IN	Industrial fire	?	?	0
5/27/84	Memphis, TN	Train derailment	Acetic anhydride	200	0
6/4/84	Montpelier, OH	Truck spill	?	20	5
6/13/84	Gainesville, FL	Warehouse fire	Pesticides	200	4
6/17/84	Charleston, WV	Power transformer leak	PCB	?	0
6/21/84	Kansas City, MO	Industrial fire	Solvents	15	0
6/25/84	Joliet, IL	Truck leak	Ammonia	?	0
7/3/84	Elizabethtown, KY	Truck accident	?	10	0
7/19/84	Flomation, AL	Train derailment	Propane	125	0
7/23/84	Riverside, NJ	Warehouse fire	?	75	0
7/28/84	Houston, TX	Ship explosion	Aluminum phosphide	?	?
8/2/84	Cadillac, MI	Industrial explosion	Trichloroethylene	5	0
8/4/84	Kittanning, PA	Industrial spill	Nitropropane	75	0
8/6/84	Hamtramck, MI	Warehouse fire	Ammonia	200	0
8/10/84	Madera, CA	Warehouse fire	Mix	?	64
8/11/84	Baton Rouge, LA	?	Chlorine	250	15
8/14/84	Lineville, IA	Train derailment	Chlorine	40	0
8/15/84	Simsburg, CT	Chemical plant explosion	?	100	0
8/16/84	Tuscon, AZ	Industrial leak	Chlorine	7	7
8/17/84	Flemington, NJ	Warehouse fire	PCB's	800	27
8/20/84	Muncie, IN	Train derailment	Acrylonitrile	250	0
8/23/84	Austin, TX	Chemical plant fire	Mix	?	0
8/24/84	Queensburg, NY	Truck accident	Hypochlorite	100	0
9/6/84	Archer, FL	Industrial fire	Pesticides	1,200	0
9/10/84	Dallas, TX	Rail tank car leak	Vinyl acetate	?	0

Table A-1. (continued)

Date	Location	Accident description	Chemical	Estimated number of people evacuated	Injuries
9/11/84	Conway, PA	Rail tank car leak	Styrene	?	0
9/24/84	St. Louis, MO	Industrial spill	?	?	0
9/28/84	Boyton Beach, FL	Chemical plant fire	Mix	200	0
10/4/84	Springfield, MO	Truck accident	Ammonium nitrate	750	0
10/10/84	Newark, NJ	Industrial fire	Cyanide, sulfuric acid	50	0
11/6/84	Tylertown, MS	Industrial spill	Anhydrous ammonia	?	0
11/14/84	Downington, PA	Train car leak	?	20	0
11/15/84	Middleport, NY	Chemical plant leak	Methyl isocyanate	600	10
11/30/84	Girard, OH	Truck leak	Titanium tetrachloride	250	0
12/25/84	Monson, MA	Chemical plant leak	?	100	0
12/29/84	Malta Bend, MO	Industrial fire	Anhydrous ammonia	150	0
12/31/84	Little Rock, AR	Train car leak	Ethylene oxide	2,500	0

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