



# A 12-year history of hazardous materials incidents in Chester County, Pennsylvania

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## Abstract

In compliance with the provisions of the Emergency Planning and Community Right to Know Act (EPCRA) of 1986, Chester County, Pennsylvania has collected information about all reported chemical releases to the environment. This paper presents an analysis of the patterns of these releases, including their composition, type, location, frequency, time and level of emergency response, over the last 12 years (1987–1999). Hydrocarbon fuels are the most frequently spilled compounds, but several extremely hazardous chemicals including sulfuric acid, chlorine, and ammonia have also been released to the environment. The patterns of hazardous materials releases in Chester County are similar to those reported in other databases at all levels: local, state, federal and international. © 2002 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Hazardous materials are used, shipped, stored and spilled throughout the United States. In recognition of this, Congress passed the Emergency Planning and Community Right to Know Act (EPCRA) in 1986. Section 304 of EPCRA requires any facility experiencing an emergency release (spill) of a hazardous material to report that release to state and local emergency planning agencies. Other US laws including the Clean Water Act, Federal Railroad Safety Act, Hazardous Materials Transportation and Uniform Safety Act, Resource Conservation and Recovery Act and the Toxic Substances Control Act also contain spill-reporting provisions. These requirements have initiated the creation of a large database of information about the type, amount, location and other aspects of hazardous materials releases to the environment that is available for analysis. The central collection point for this

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data, the National Response Center (NRC), co-chaired by the US Environmental Protection Agency (EPA) and the US Coast Guard, handles about 30,000 such incidents each year [1,2].

Gunster et al. [3] examined the NRC database to determine the extent of contamination of Newark Bay, NJ from petroleum and other hazardous chemicals. At least 1453 incidents occurred between 1982 and 1991, resulting in an estimated 19 million gallons of hazardous chemicals being spilled into the bay. There is, however, a high probability that not all such contaminant spills were reported. In 1996, Wendt et al. [4] assessed the degree of reporting between three different systems and found that an active, state-based hazardous substances emergency events surveillance system detected significantly more events than either of two passive systems. Passive systems were defined as those comprised of reports mandated by law, and their analysis included one system maintained by the EPA (which included EPA, Coast Guard and NRC data) and one maintained by the Department of Transportation. Active systems involved collection of release data by state health and environmental agencies, newspapers, police, fire and hospital officials.

Hazardous materials incidents are of international interest as well. Winder et al. [5] reported a total of 523 Australian incidents during a 6 month period in 1989, with spills and leaks comprising 42 and 37% of all reported releases, respectively. While national and international databases have been subjected to such analysis, many state and local databases that have been compiled have typically not been the subject of analysis.

The Washington State Department of Health Hazardous Substance Emergency Event Surveillance System reported 512 incidents in 1992, with 105 reported human exposures [6]. Concerns about lack of detailed information about such exposures for health care providers prompted the creation of the Hazardous Materials Exposure Information Service, administered through Washington's Poison Control Center. On a local scale, the hazardous waste incidents of three townships within Erie County, Pennsylvania from 1988 to 1994 were described by Lange et al. [7]. A total of 22 hazardous materials release incidents were listed, with diesel fuel being the most common contaminant reported.

Chester County, Pennsylvania has collected information about all reported chemical releases to the environment since October 1987. Using reports made to the Chester County Local Emergency Planning Committee (LEPC), Shorten et al. [8] analyzed patterns of these spills including their composition, type, location, frequency, time and level of emergency response during the first 5 years (1987–1992) of data collection. Over 300 releases were reported from the 76 county municipalities, with 235 of the reported releases consisting of the hydrocarbon fuels: gasoline, diesel fuel, kerosene, or home heating oil; most often in 5–10 gal quantities. Because no systematic assessment of information from the 1992 to 1999 period has been assembled for Chester County, this paper extends the existing analysis to September 1999, creating a 12-year history with comparisons to trends observed in the 1994 report and other local, national and international hazardous materials spills databases.

## 2. Methods

The EPCRA of 1986 created the LEPC as the local organization to which releases of hazardous materials should be reported. Pennsylvania mandated that each of its counties comprises the local planning district and the Chester County LEPC was formed in 1987.

Information on chemical releases, whether legally reportable or not, have been presented to the LEPC on a regular basis since its initiation. This analysis compiled the paper copies of all reports from October 1987 to September 1999, a full 12 years of data into a spreadsheet/database that could be easily downloaded and analyzed using basic computing and analytical skills. Each record in the database describes a single reported release of a hazardous material. The field headings for each record include the date, time and location of the incident (address and/or municipality); type of release (leak, spill, vehicle accident, etc.); type of facility reporting the incident (fixed facility, transportation incident, etc.); identity and quantity (with units) of the chemical released; EPA reportable quantity (RQ) for the chemical; identification of off-site release of the chemical, if any; and indication of fire department or hazardous materials team (HAZMAT Team) response to the incident.

Volume and/or mass entries in this database were provided by estimates, either self-reported by the responsible parties or in some cases, estimated by emergency response personnel based on the size of the puddle or pool created by the chemical release. Gaseous releases were the least likely to be reported accurately. It is interesting to note that many of the reported quantities fell just short of the RQ for the hazardous material. For example, only five of the 20 reported ammonia releases exceeded the RQ of 100 lb, and four incidents reported the release mass as “less than” the RQ.

To make calculations and graphical presentations easier, all amounts reported as less than “X” were entered into the database as equal to X. For that reason the database may overestimate the total amounts of contaminants released. For many substances in the database, particularly the hydrocarbon fuels, there is no RQ and reports were made in order to err on the side of safety. Additionally, the chemical identity of 35 of the 808 releases was unknown, although in many cases it was further characterized as “corrosive” or “unknown oil”.

The type of facility reporting was recorded as either a non-Sara Site, a SARA 302/303 site (one which stores or uses “extremely hazardous substances” (EHSs) in amounts greater than the threshold planning quantity), a SARA 311/312 site (one which stores or uses “hazardous substances” other than EHSs), Superfund sites, and transportation-related sites. The time, date and physical location of each incident, as well as the level of emergency response associated with each incident were recorded by the members of the Chester County Department of Emergency Services and reported to the LEPC for inclusion in this database. There is little probability of error in these components of the database.

The type and volume of chemical released have traditionally dictated the level of emergency response to each incident. Prior to 1996, the Chester County HAZMAT Team was only dispatched when an Incident Commander recognized the need for a HAZMAT Team response and requested that the county team be dispatched. The Chester County LEPC recognized that this dispatch scenario was less than ideal and identified the need to develop a comprehensive dispatch protocol for hazardous materials incidents. Once developed and approved, this dispatch protocol became the first in the Commonwealth of Pennsylvania and has since served as a catalyst for the development and implementation of similar dispatch protocols throughout the country.

The protocol was jointly developed by the Chester County HAZMAT Team, Chester County Department of Emergency Services, Chester County Fire Chiefs Association, and Chester County LEPC. This joint development effort produced a practical document in a timely manner.

The HAZMAT Team dispatch protocol has ensured the appropriate level of emergency response to hazardous materials incidents since its implementation and has significantly improved the quality of field data collection with respect to chemical releases. The dispatch protocol, which is consistent with the Pennsylvania Emergency Management Agency (PEMA) directive on HAZMAT Team dispatch, identifies 14 types of incidents to which the HAZMAT Team will be dispatched.

1. At the request of any emergency service personnel (fire, police, EMS) responding to or on location.
2. Any spill or release, excluding the following: gasoline, diesel fuel, fuel oil, and kerosene or odor investigations.
3. Any leak or spill of 100 gal or more of a flammable liquid (i.e. gasoline, aviation fuel and toluene).
4. Any leak or spill of 500 gal or more of a combustible liquid (i.e. fuel oil, diesel fuel and kerosene).
5. Any incident involving a truck, van or car transporting hazardous materials (not including vehicle fuel tank) which is on fire, leaking or overturned.
6. Any fire at a SARA Title III facility involving hazardous materials.
7. Any incident involving mixed chemicals. This does not include fluids on the highway from accidents.
8. Any incident involving radioactive materials.
9. Any fire involving hazardous materials, excluding gasoline and fuel oil fires.
10. Any flammable gas leaks in large tanks (500 lb or more) or pipelines, not including service lines.
11. Accidents, involving chemicals in chemical labs, businesses, warehouses and industrial complexes.
12. Rupture of an underground flammable liquid pipeline.
13. Any large discharge (over 55 gal) of hazardous materials into any waterway. This does not include investigation of substances on waterways.
14. Dispatcher discretion.

This dispatch protocol was developed using historical data on hazardous materials incidents and emergency responses within the county of Chester. The previous 5 year (1987–1992) study by Shorten et al. [8] served as an integral informational resource in the development of this dispatch protocol.

Database analysis was conducted primarily utilizing the sort function to aggregate and count similar properties. Counts of similar releases (e.g. by municipality, by EHS, by time of day, etc.) were generated for use in subsequent quantitative analysis. Correlation analyses were calculated using least-squares linear regression. All descriptive and other statistical calculations were made using internal functions in Microsoft Excel.

### **3. Results and discussion**

Between January 1988 and December 1999, over 800 hazardous materials incidents were reported in Chester County. These incidents, as shown in Fig. 1, can be grouped into

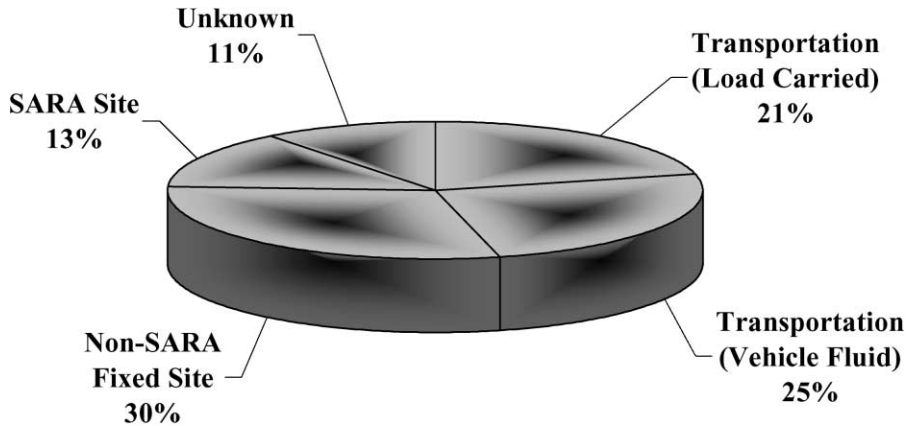


Fig. 1. Distribution of incidents in Chester County, Pennsylvania by type of facility or transportation category.

four categories: transportation sites, SARA fixed sites, non-SARA sites, and the unknown. Transportation sites included many of the most frequent accident locations in the county, as well as those roadways less notorious for vehicle accidents. SARA fixed sites and non-SARA fixed sites largely represented the industrial sector, but some private residences are also included in this category. Releases from “unknown” sites were frequently reported as odors or sheens noted on local waterways.

Most releases occurred as a result of transportation incidents with 374 or 46% of all reports emanating from various vehicles. These included both releases of on-board fuels and the vehicle’s cargo. Truck saddle tanks were frequent sources of spilled fuels. Lange et al. [7] reported diesel fuel as the most frequently spilled material in three Erie County, Pennsylvania municipalities in 1995. A 6 month Australian trial reported fuels including “motor spirits, petroleum spirits and liquefied petroleum gas” as 30, 20.5 and 6.9% of the total database, respectively [5]. Incidents at fixed facilities, not regulated under EPCRA, comprised the next highest frequency of release, with 241 or 30% of all incidents. In many cases, these releases involved small amounts of materials that were less than RQ under EPCRA. The EPCRA planning sites experienced 106 or 13% of the reported releases over this period. Finally, 87 releases, or 11% of the database citations, were unattributable as to source.

Transportation-related incidents made up almost half of the reported incidents, and six different hydrocarbon mixtures accounted for 278 of 374, or 74% of these. The majority of all incidents (355 of 808, or 44%) involved the liquid hydrocarbon fuels: diesel (24%), fuel oil (11%) and gasoline (9%). These are shown in Fig. 2. Most of these were automotive products from operating vehicles, but natural gas and fuel oils are also included in this subset. These compounds comprise a major sector of the hazardous materials database, but they do not fit the EPA definition of “hazardous materials”. Reporting of these compounds is therefore not required under EPCRA.

The most commonly spilled chemicals other than the three liquid hydrocarbon fuels are shown in Fig. 3. Of these, ammonia (24 incidents), gaseous chlorine (10 incidents) and

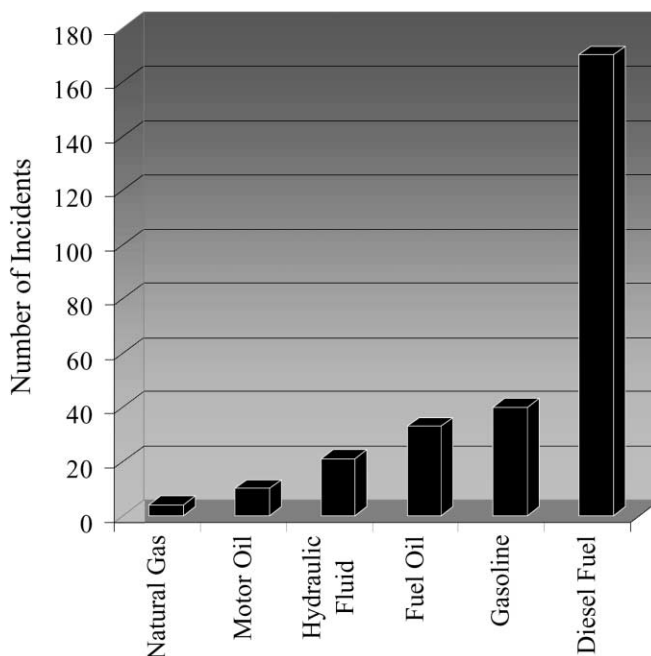


Fig. 2. Hydrocarbons released as a result of transportation incidents in Chester County, Pennsylvania, 1988–1999.

sulfuric acid (seven incidents) are considered EHSs under EPCRA. They are, therefore, subject to much more rigorous reporting requirements. One of the townships, West Goshen, showed nine releases of ammonia over the 12 years chronicled in the database. Within this municipality, a frozen food production facility, located less than 0.25 miles from an elementary school, was responsible for several ammonia releases. Other EHS releases during this period (not shown on this figure) include bromine (one incident), formaldehyde (one incident), hydrogen sulfide (two incidents), methyl mercaptan (two incidents), phenol (one incident), and phosphorus (three incidents). Many other less harmful compounds were released as well, often in significant quantities.

Most hazardous materials releases occurred on Fridays (148) and the fewest occurred on Sundays (61). Transportation incidents followed this pattern as well, with the most (72) on Fridays and the least (19) on Sundays. This trend was not as evident in the EPCRA and non-EPCRA fixed sites. A comparison is shown in Table 1. Interestingly, our database mirrors what was observed in a similar 6 month pilot study conducted in Australia, where a total of 523 incidents (nationwide) were reported [5]. The most frequently released compound in their study was petroleum product (67%) with the most incidents occurring on Fridays and the fewest on Sundays. Perhaps both databases reflect less caution in the waning hours of the workweek. What is most likely shown is the reduction of commerce-related transportation occurring during the weekends.

Most transportation-related releases of hazardous materials occurred during the middle of the day. This is most likely related to heavier traffic at those times, but

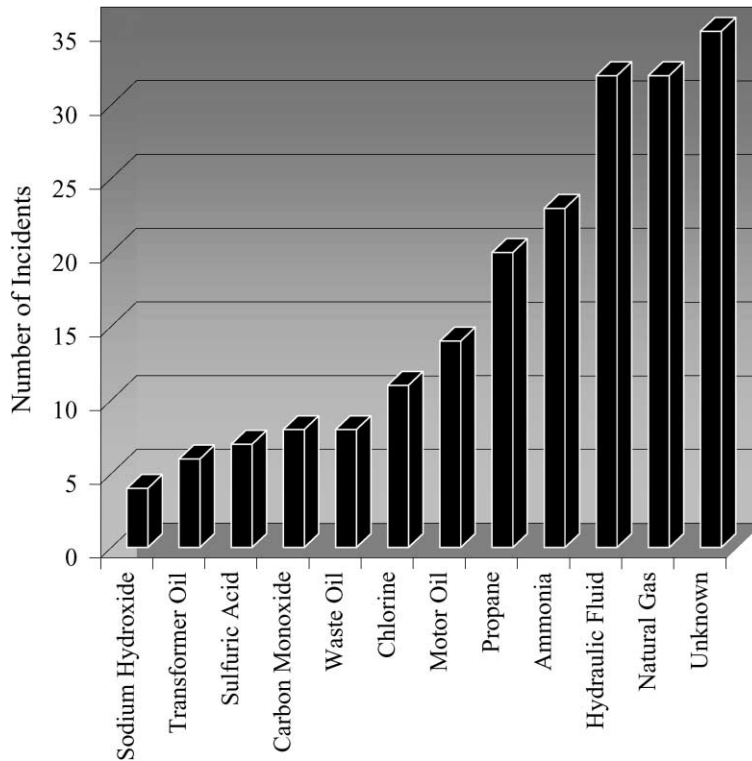


Fig. 3. Most commonly spilled hazardous chemicals (other than liquid hydrocarbon fuels) in Chester County, Pennsylvania, 1988–1999.

surprisingly there are no peaks during the 7.00–9.00 h or 16.00–18.00 h commuting rush hours. In Fig. 4, a simple polynomial expression fit to the data shows the increase in reported releases during the morning hours and the decrease through the afternoon and evening hours.

Table 1  
Hazardous materials incidents across the week in Chester County, Pennsylvania, 1988–1999

Weekday	Number of incidents (by type)			Total <sup>a</sup>
	Transportation	EPCRA planning sites	Non-EPCRA planning sites	
Sunday	19	11	21	61
Monday	68	15	34	137
Tuesday	61	14	40	120
Wednesday	54	16	37	118
Thursday	69	21	33	135
Friday	72	19	39	148
Saturday	31	10	33	89

<sup>a</sup> Total is greater than the sum of transportation, EPCRA planning sites and non-EPCRA planning sites because approximately 10% of all incidents (87) were unknown or not classified as to site type.

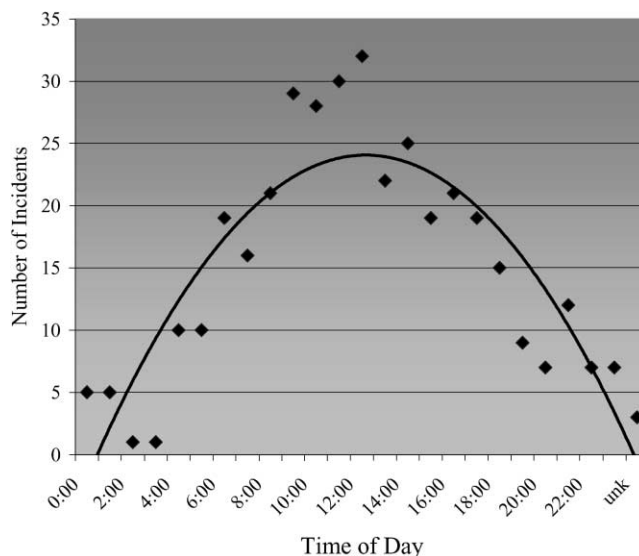


Fig. 4. Hazardous materials transportation incidents as a function of time of day. Trend line is a simple polynomial expression fitted to the data.

The insights gained through this study and the earlier study by Shorten et al. [8] have been instrumental in ensuring adequate staffing of the Chester County HAZMAT Team. Adequate staffing during every response is critical to ensuring the safety of response personnel and the involved community, and enhancing incident stabilization efforts. Failure to provide adequate staffing in addition to compromising the effectiveness and efficiency of the emergency response, can also be a cause for revocation of the hazardous material team's certification from the Commonwealth of Pennsylvania.

Following a review of the pattern of time of occurrence for hazardous materials incidents within the county, a decision was made to detail a significant number of full-time Department of Emergency Services employees as on-call members of the HAZMAT Team. These full-time personnel complement a highly qualified cadre of part-time on-call team members, to ensure staffing adequacy at all times. Other municipalities or agencies charged with hazardous materials response may find that similar analyses of their records can justify changes in staffing and/or equipment requests.

The number of transportation-related hazardous materials incidents in a municipality appears to be closely correlated with the miles of major roadway within that municipality. To assess this, the total number of linear miles of US Route 30 were calculated for the five Chester County municipalities through which this highway runs. Route 30 was chosen for this analysis because it is of historical significance in southeastern Pennsylvania. Known as the "Main Line" because it connects Philadelphia with Harrisburg, the State Capitol, it formed an early trade route to the west and grew in size and traffic as this part of Pennsylvania industrialized. Route 30 is a multi-lane, heavily traveled road and for the most part, it is not of limited-access design. Many of the large, traditional manufacturing industries that use



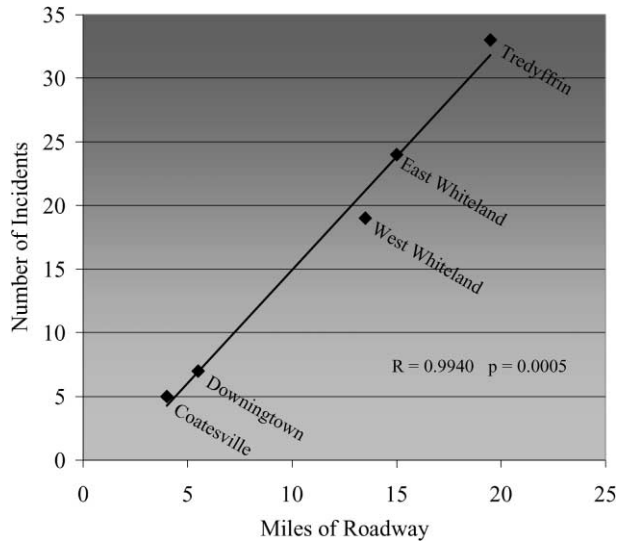


Fig. 5. Linear correlation between miles of US Route 30 contained within each of five Chester County, Pennsylvania townships and the number of transportation-related incidents occurring within each township.

hazardous materials within the county are located along this corridor. Other major routes through Chester County do not share the same historical significance, and most major routes are limited-access.

Linear mileage of US Route 30 was plotted against the number of transportation incidents for each municipality along the route. As shown in Fig. 5, the least-squares linear relationship was significant,  $R = 0.9940$ ;  $P = 0.0005$ . This pattern suggests that there does not appear to be any particularly hazardous intersections or stretches of this roadway. This may indicate that all miles are either equally safe or equally hazardous. Road access, extent of use and

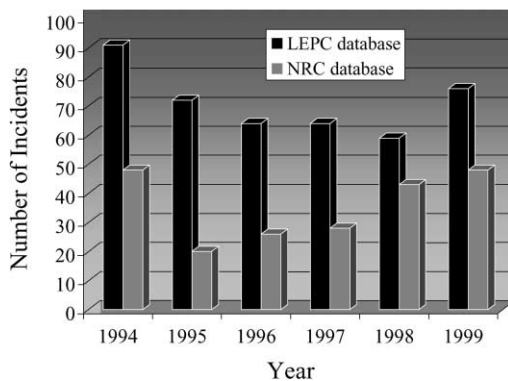


Fig. 6. Number of reported incidents in Chester County, Pennsylvania by database.

Table 2  
Similarities between the Chester County LEPC hazardous materials incidents database and other published databases/reports<sup>a</sup>

Database	Reference	Database coverage			Compounds most frequently released		Source of release		Physical state of release	
		Number of records	Area	Years	All releases	EHS only	Transportation incidents (%)	Fixed site (%)	Liquid or solid release (%)	Air emissions (%)
NRC	[1]	30000 per year	National	1982–1999		Ammonia <sup>b</sup>				
NRC Chester County	[1]	48	Chester County, PA	1999	Fuel oil		23	67	86	6
HSEES	[10]	5531	13 states <sup>c</sup>	1997		Ammonia	21	80	45	39
ARIP four states	[9]	402	Four states <sup>d</sup>	1987–1996		Chlorine	NA	Only	44	50
ARIP PA	[9]	222	PA	1987–1996		Ammonia	NA	Only	42	53
Winder	[5]	523	Australia	1989 (6 months)	Hydrocarbons	Ammonia	40	60	40	46
Lange	[7]	22	Erie County, PA <sup>e</sup>	1988–1994	Diesel fuel	Chlorine				
This LEPC database		808	Chester County, PA	1988–1999	Diesel fuel	Ammonia	46	40	42	14

<sup>a</sup> EHS: Extremely Hazardous Substance; NRC: National Response Center; HSEES: Hazardous Substances Emergency Events Surveillance; ARIP: Accident Release Information System; LEPC: Local Emergency Planning Committee.

<sup>b</sup> In 1999.

<sup>c</sup> States covered are: Alabama, Colorado, Iowa, Minnesota, Mississippi, Missouri, New York, North Carolina, Oregon, Rhode Island, Texas, Washington and Wisconsin.

<sup>d</sup> States covered are: Pennsylvania, Delaware, Maryland, New Jersey.

<sup>e</sup> Three townships in Erie County, PA: Fairview, Girard and Springfield.

condition are probably more important variables but there is no way to assess these variables using this database.

Eight municipalities (of the total 76) were the sites of almost half (40%) of all the hazardous materials releases recorded in this database. Using schools alone as an indicator of population density and potentially sensitive receptors within these eight communities, a graphic analysis showed 49 schools within 1 mile of these corridors that are used to haul hazardous materials. This adjacency brings to bear the potential exposure of a large number of children. School officials in such locations should be thoroughly trained in the use of a “shelter-in-place” option. In a Washington state assessment of individuals exposed during hazardous materials incidents, 444 students in five schools were among the total of 973 exposed individuals [6]. Materials involved were natural gas, mercury, pesticides, ethylene glycol and an unknown substance or substances.

Data from the Chester County LEPC database were compared to those from the NRC database [1], as shown in Fig. 6. The NRC generally reported fewer releases but the LEPC database reports more incidents that are less severe in nature. Both databases show an increase in the number of reported releases in 1999 and the NRC database indicates that after an initial decrease in 1995, the number of releases has been on the rise each consecutive year.

Overall, there is less than 25% duplication of NRC incident reports in LEPC database. This may indicate a substantial underestimation of the release activity in the county, and argue for aggressive local reporting requirements. Other national databases maintained by the US EPA (Accident Release Information System, or ARIP) [9], the US Department of Health and Human Services/Agency for Toxic Substances and Disease Registry (Hazardous Substances Emergency Events Surveillance, or HSEES) [10], as well as international [5] databases have also been compiled. Trends among these and one other Pennsylvania County (Erie County) [7] are compared in Table 2. The ARIP database is designed to report on certain types of serious fixed-site incidents while the HSEES system is designed to report incidents with injuries. The high percentage of air emissions in the ARIP database, and HSEES report indicates the increased consequence potential of this type of release.

#### **4. Conclusions**

The EPCRA of 1986 provided a major impetus for the collection of data related to emergency or unplanned releases of hazardous chemicals. In most databases concerned with such releases, vehicle accidents contribute to a large percentage of the chemical spills. Fixed facilities also report numerous spills that are often of larger quantities and usually of chemicals that are more hazardous, if not less familiar, than those seen on the highways.

Analysis of Chester County, Pennsylvania data for the past 12 years showed that most chemical spills occur in the middle of the day, during the workweek. This finding led to the reassignment of duties for existing county employees at considerable cost savings. The patterns of hazardous materials incidents in the county are generally consistent with those of other international, national, state and local databases with respect to type of incidents, compound spilled and spill source. Because national or regional databases often fail to capture information on smaller releases, a need exists to continue data collection and release monitoring at the local level.

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