HazMat Incidents (Chemical / Radiological Releases and Explosions)

Key Points

- The 1984 disaster in Bhopal, India that killed over 2,200 people focused world-wide attention on the dangers of toxic chemical releases. In the U.S., it led to the 1986 Emergency Planning and Community Right-to-Know Act or SARA Title III. This law led to a lot of new planning and response infrastructure.
- The U.S. Department of Transportation (DOT) collects data on hazardous materials incidents occurring in the U.S. during transportation. Most are received from shippers, e.g., UPS or Federal Express. Since 1998, U.S. DOT record 545 incidents in Seattle resulting in total of $1,316,452 in damage, but no fatalities or injuries requiring hospitalization. Nine incidents were classified as serious.
- The Seattle Fire Department (SFD) records hazardous materials-related dispatches. It lists 1,086 incidents since 1995, with a sharp spike in 2001-2003 following 9/11 and the 2001 anthrax attack. A rough measure of severity is the recorded alarm level, which ranges from 1 to 3. Only three incidents were over level 1. Two were fires with hazmat components.
- Fixed sites are the most frequent locations for accidents, but transportation accidents are often riskier because they happen in uncontained spaces and responders usually have less information about the materials involved.
- Areas up to one-half mile downwind from an accident site are considered vulnerable, according the US Dept. of Transportation. An incident could affect thousands of people in densely populated sections of Seattle.
- Other disasters such as earthquakes and landslides could produce hazardous materials incidents.

Context

Harmful material in the environment has been a problem for a long time, but it has only been since the publication of books like Silent Sprint (1962) and tragedies like the Bhopal chemical disaster (1984) that hazardous materials have become recognized one of the most significant hazards facing society. The problems hazardous materials pose vary widely in intensity and duration. While many materials pose long term problems (like asbestos, PCBs, etc…), this chapter focuses on incidents that pose an immediate threat to large numbers of people. Chronic problems have their own regulatory infrastructure outside emergency management.

The federal government plays a large role in all phases of hazardous materials management. Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA) and the Clean Air Act of 1990 mandate “cradle to grave” tracking of designated hazardous materials by requiring users to report what chemicals they are using and releasing into the air, and how they will respond to an emergency. Under the act, EPA delegates implementation to the states. Washington State has passed the responsibility to local districts known as Local Emergency Planning Committees (LEPC). The reporting requirements mandated by these acts have produced a rich set of data of chemicals in the community.

Around 80% - 90% of accidents involving hazardous materials accidents occur at fixed sites such as factories and storage facilities; the remaining 10% - 20% occur during transportation. Most of these incidents are small, however, and not reported to the Seattle Fire Department because personnel at the sites where they occur can handle them.

Transport incidents are usually more difficult to fight since they often happen in uncontained settings and/or populated areas. Responders to transportation accidents do not have detailed site plans and chemical inventories. Hazardous waste dumps also present problems because they often house unidentified and unstable chemicals.

The Fire Prevention Division of the Seattle Fire Department, commonly referred to as the Fire Marshal's Office, provides the leadership and inspection services to help prevent fires, explosions and release of hazardous materials and to assure fire and life safety for Seattle's residents, workers and visitors. The Hazardous Materials Section of the Fire Marshal's Office provides inspection services for the storage and use of flammable and combustible liquids and other hazardous materials and processes as required by the Seattle Fire Code and Administrative Rules.

The Fire Department can call on help from private and governmental resources. On the private side, large companies often have response teams and the Chemical Manufacturers Association has an organization, CHEMTREC, which runs a 24-hour hotline for emergency that happen in transit. Additionally, several companies specialize in responding to chemical emergencies. At the federal level, the EPA, Coast Guard, and the US Department of Transportation's Bureau of Explosives have strike teams that assist local responders in special situations. Washington State provides teams from the Department of Ecology and the Department of Natural Resources.

The Seattle Local Emergency Planning Committee (LEPC) was set up in 2002 to foster a working relationship between private industry and public agencies in addressing hazardous materials issues. In addition to promoting public awareness and industry reporting, the LEPC takes a cooperative approach toward the prevention and preparation for hazardous materials releases.

LEPC membership includes city personnel and representatives from the Washington State DOT, Washington State Department of Ecology, Seattle/King County Public Health, Harborview Hospital, Port of Seattle, Boeing, Burlington Northern Santa Fe Railway, Bank of America and a member of the public.

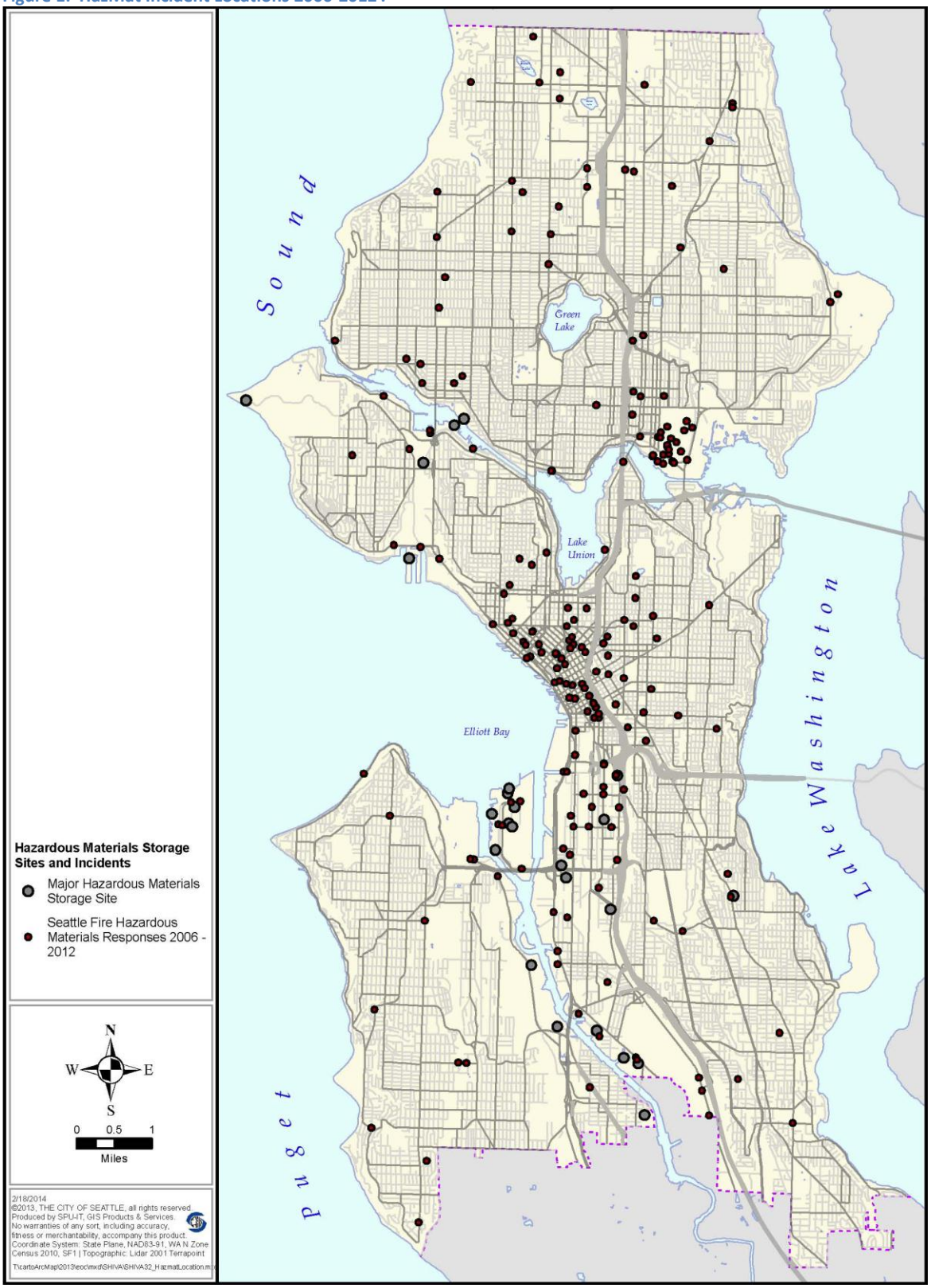
The number of chemicals in use today makes it critical to know which ones are at a particular site. OSHA lists 28,000 toxic chemicals and each of them has a unique way of interacting with their environment and with other chemicals, including the ones used to clean up spills. Responders can make matters worse by applying a material that will react adversely with the spilled chemical.

The possible use of chemical, radioactive and especially explosives in a terrorist act significantly alters the risk profile for hazardous material incidents. Bombs are one of the most common methods of attack in many parts of the world. The use of chemicals is rare due to the difficulty of manufacturing the chemicals; however, the Tokyo Gas Attack killed 12 and injured thousands in 1995. The use of radiological devices is also rare. Radiological attacks are not nuclear bombs; they use a variety of means, including conventional explosives, to disperse radioactive substances. There is a debate about the effectiveness of these devices, however. The two examples of actual attacks using radiological devices come from Russia and Chechnya. Neither bomb exploded.

History

Hazardous materials emergencies have emerged as a public concern only within the past 30 years, so the historical record does not extend far. Older records mix hazardous materials emergencies with fire emergencies. Constructing a long history is difficult, but since federal reporting requirements have taken effect, there is a wealth of data from local, state and federal sources.

Figure 1. HazMat Incident Locations 2006-2012[i].



Prior to 1995, it is difficult to get consistent data. Two incidents stand out, however, in a review of multiple alarm incidents dating back to 1912.

December 4, 1975. Fuel Tanker Explosion/Fire on Alaskan Way Viaduct. (Also listed under Transportation Incidents and Hazardous Materials). A gasoline tanker truck crashed and leaking gasoline caught fire causing extensive damage to surrounding buildings. The fire caused a major downtown power outage when it burned though a power trunk line.

March 4, 1985. Health Sciences Center. A complex fire occurred on the 13th story of a 17-story building housing an infectious disease lab and trace amounts of radioactive material.

The Seattle Fire Department (SFD) responses have been recorded since 1995. These data show SFD has responded to 1,082 incidents, of which only three (or 0.2%) required more than one alarm. Of these three, only one was a pure hazardous materials incident; the other two were associated with fires. All three had biological functions. They were:

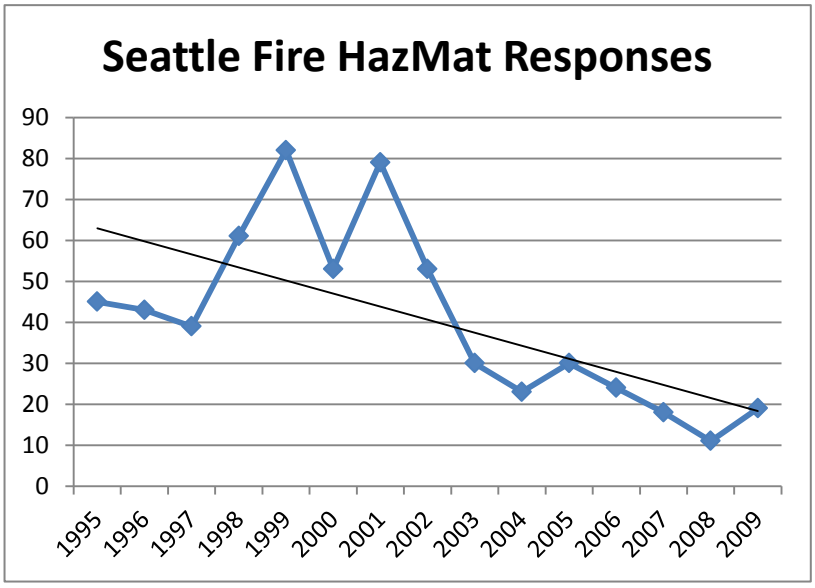
March 24, 1997. Fire with Hazardous Materials. Kincaid Hall, University of Washington. The zoology lab burned.

June 10, 1999. Bellingham Pipeline Explosion. Although this incident did not occur in Seattle, it focused attention regionally on pipeline safety. Seattle has a spur of the same pipeline that runs from Harbor Island to Renton. It transports mostly gasoline.

May 21, 2001. Center for Urban Horticulture, University of Washington. Arson fire.

May 26, 2001. 509 Olive Way. Fire in a building housing many medical offices.

Besides being mostly single alarm incidents, the total number of incidents is declining. (Note: After the 2001 Anthrax attack there was huge spike in 911 calls related to white powder. These calls have been removed).



Some older data exists on transportation of hazardous materials. The Washington State Department of Health studied incidents that occurred in 1992. Most of the analysis covers the whole state and disaggregates the information by county. These data are too general for specific planning but do give some indication of the dangers faced in Seattle, especially when it is correlated with the logs of the Seattle Fire Department.

According to the report, there were 118 events in King County in 1992. Twelve (10.2%) of these involved transportation and 106 (89.8%) were at fixed facilities. Twenty-six incidents caused a total of 66 injuries. The most common injury

incidents involved acids and volatile organic compounds. The report states there was one fatality in the state, but it does not indicate if it occurred in King County. Additionally, 29 incidents resulted in the evacuation of nearly 1,400 people. The report indicates that 44 incidents in King County occurred within one-quarter mile of residential areas, indicating some risk to people who are not directly involved with the released chemicals.

A 1994 King County study shows that the most common material transported along I-5 is gasoline[ii]. The most commonly released chemicals in transportation accidents were volatile organic compounds, acids, herbicides and insecticides.

The U.S. Department of Transportation collects incident data at the state level and on the transportation mode. Washington ranks in the middle third in terms of the number of annual incidents. In 1999 it was 33rd with 141 and in 2009 in was 22nd with 230. None were listed as major incidents. Nationally, the number of incidents is declining, however, so Washington's growing number of incidents is running counter to the trend. The most common transport mode is highway by far.

Likelihood of Future Occurrences

The length of the record on hazardous materials incidents is limited, but what does exist suggests the chance of an acutely disastrous incident has a low probability of occurring. Many programs exist to reduce the likelihood of an accident and to mitigate the effects of releases. These programs seem to be effective in limiting damage. The increase in transportation incidents from 1999 to 2009 runs counter to the general decline and bears watching.

While there may be very significant long-term problems involving the build-up of toxic chemical in the environment, there have been very few large releases of chemicals that pose immediate risks to large numbers of people. Most of the largest past events have been secondary impacts to fires and transportation accidents. It seems most likely that a future event would be related to another type of hazard.

Vulnerability

The most likely location of a hazardous material emergency is at a user site, an abandoned dump or landfill, or on a major transportation route. If the chemical finds its way into the sewer system, treatment facilities or sewer overflow locations could become additional damage locations.

One exception is that if the emergency is an induced incident caused by some other type of event like an earthquake, accidents could occur in non-typical locations. This possibility and recognition that no tracking system can be complete highlights the need to maintain a watchful eye over all parts of the city.

The Washington State and Seattle Fire Department information refine this set of assumptions with some empirical data. The vast majority of accidents in the county (90%) occur at fixed facilities, which theoretically means 90% of the spill locations are identifiable prior to an incident. The State's data shows more transportation accidents happen in rural areas, while most of the fixed facility accidents occur in industrial areas. On the basis of this information, the picture of a typical hazardous material accident site is in an industrial area or along a major transportation corridor such as I-5, I-90, SR 99 and SR 520. The most vulnerable locations are where high density, vulnerable populations and critical infrastructure occur close to the areas that are more likely to have incidents. Besides these areas, the University of Washington also has a large share of serious hazardous materials incidents.

The most common sources of large accidents are petroleum, metal and chemical plants. There are relatively fewer of these facilities in Seattle compared to other U.S. cities, decreasing the probably of a large event.

Consequences

The effects of a large hazardous materials incident are unpredictable because there is not a long history of such large incidents in Seattle. Hazardous materials emergencies can be complex because chemicals have so many ways they affect

people. They can disperse through the air or water and can enter the body through the lungs, digestive system or skin. Many can explode. Some will react with water and other common agents that fire-fighters use. Every chemical has a unique set of properties that pose a unique set of dangers and call for a unique response. In most cases, a fire will multiply the threat of direct contact either by causing the material to explode and/or dispersing it.

If future large incidents follow the historical pattern, only magnified, then they would most likely occur as a secondary effect or another type of hazard, especially a fire. It would most likely be at a fixed facility, although the 1975 tanker fire showed that transportation cannot be ruled out. In that incident, a crowded tavern was near the incident site. If it had been affected, there could easily have been multiple fatalities.

These types of incidents are likely to be limited in geographic scope. The city is likely to have a quick and complete recovery. Unless there is a large explosion or fire in a crowded and enclosed location, fatalities are likely to be few, although the number of injuries due to chemical exposure could be quite large. In the Tokyo sarin gas attack there was about one fatality for each 200 injuries.

The most serious hazardous materials incidents would probably either involve an attack or multiple incidents occurring at the same time as a result of another primary incident like an earthquake or flood. Attacks would be serious because of the deliberate intent to harm. Extremely dangerous substances would most likely be involved and would be released in locations such as transit systems, entertainment venues and other locations where people are crowded together. In a scenario where numerous hazardous materials releases occur as a secondary impact to another incident, response resources would be diminished. In past events bystanders have been injured because people were not removed quickly enough or allowed to return in a prolonged evacuation[iii].

The economic effects extend beyond immediate damage because chemicals produce a high amount of anxiety. A serious event would probably lower property values in the surrounding area, compounding the damage into the future. They can also cause extreme environmental damage, especially if chemicals enter the water or sewer systems where they can spread and leach into groundwater or discharge into bodies of water. If dangerous gases escape in large quantities, or if chemicals enter the water system through a Combined Sewer Overflow or direct runoff, an accident could escalate from a localized emergency to a wider disaster.

Most Likely Scenario

A fire and explosion releases large amounts of anhydrous ammonia from rail cars parked on Harbor Island. A southeasterly wind blows the material toward Sodo and downtown. The Mariners are playing at Safeco Field which is just on the edge of the modeled plume. The release necessitates the evacuation of the surrounding residential area and closure of major transportation corridors. Many people are severely ill at the site. Schools, nursing homes and day care centers affected.

Category	Impacts 1 = low 5 = high	Narrative
Frequency	3	Hazardous materials incidents are common occurrences in Seattle but most are small and easily handled in the field by the Seattle Fire department. The most dangerous and complex hazardous materials incident in modern Seattle history was a fire at a lab storing pathogenic bacteria. Even this did not require activating the City's emergency response plan. Balancing the lack of disastrous incidents historically is the presence of facilities housing large amounts of hazardous materials and transportation of those materials. Combining the history and exposure, we estimate the most likely scenario is a 1 in 100 per year event.

Category	Impacts 1 = low 5 = high	Narrative
Geographic Scope	3	The plume from the release and fire blows toxic smoke into a residential area. People within the area must shelter in place and then evacuate.
Duration	1	The fire is put out in 24 hours, but 2 more days of clean-up are required to stabilize the site.
Health Effects, Deaths and Injuries	2	1 person is killed on the site. 39 people require hospitalization. 325 people are treated by medical personnel.
Displaced Households and Suffering	4	900 people are forced to leave their homes and businesses but are allowed to return in less than 48 hours. 300 of them need short term shelter. The release does not cause any commodity shortages.
Economy	2	The incident has a large impact on the business that released the material. Businesses in the plume are forced to close for 2 days. Most are able to reopen. Some must clean their buildings and merchandise.
Environment	2	The release degrades air quality. Most of the material diffuses into the atmosphere but some is left as toxic residue on buildings, sidewalks and streets.
Structures	2	The building where the fire occurred is destroyed. 12 more buildings are temporarily damaged when their exteriors are coated in dangerous chemicals. Additionally, the HVAC systems for these buildings pulled chemicals inside the buildings damaging the interiors.
Transportation	2	Major transportation corridors (SR 99, West Seattle bridge, 1st Ave S and 4th Ave S) are closed for 24 hours. Traffic must be detoured.
Critical Services and Utilities	2	Due to the closure of the West Seattle bridge, West Seattle residents face longer emergency response times. Some local utility damage happens on Harbor Island due to the incident. No emergency responders are killed or injured.
Confidence in Government	1	The incident's danger is readily apparent to the public. Swift response to the incident makes the public appreciate Seattle's emergency response capabilities.
Cascading Effects	2	The hazardous material release occurred when dynamite in the same train exploded. Some minor power and water outages occur near the explosion.

Maximum Credible Scenario

BP is fixing the pipeline normally used to supply fuel to tank farms on Harbor Island. An oil tanker is brought in to supply the farm. As it enters Elliott Bay it collides with the Bainbridge Ferry. Both ships are crippled but not in danger of sinking. Thousands of gallons of oil spill into the Bay.

Category	Impacts 1 = low 5 = high	Narrative

Frequency	1	This is a very low probability event. Oil tankers do not regularly come into Elliott Bay and a large ship collision has not happened in the waters off Seattle in over 100 years.
Geographic Scope	3	The oil spill would affect all of Elliot Bay and its shoreline.
Duration	3	It takes crews working from multiple agencies five days to remove most of the oil, but the oil has reached the shore at Alki Beach and Myrtle Edwards Park. Cleaning these areas will take months.
Health Effects, Deaths and Injuries	2	2 people are killed in the ship collision and 24 require hospitalization.
Displaced Households and Suffering	2	No households are displaced but many residences near the shore are indirectly affected by the oil on the short, especially along Alki. 452 people must be evacuated off the stricken ferry and sheltered temporarily.
Economy	3	The spill response interrupts port activity for five days. An emergency shipment of fuel must be brought into the region. The public is sensitive about bringing in another oil tanker while the pipeline is down for repairs.
Environment	4	The oil spill is a major disaster for the Elliott Bay marine environment. The ecosystem will take years to repair.
Structures	2	No buildings are destroyed by the oil spill, but infrastructure on the shore is coated with oil and must be cleaned or replaced.
Transportation	3	Spill response affects maritime traffic on Elliott Bay and indirectly on roads surrounding the Bay.
Critical Services and Utilities	2	Because most of the incident is in the water and shoreline, critical services and utilities remain intact. Fuel supplies are a problem. Some gas stations run low.
Confidence in Government	5	The public is upset and blames a lack of government oversight for the accident and spill.
Cascading Effects	3	The oil began with a significant accident. The oil emerges as the primary hazard in the incident.

Conclusions

Minor incidents are fairly common, making them high probability events. Fortunately, more serious threats, including fatal accidents, are extremely rare. Many of the decisions that govern the use of hazardous materials rest with the state and federal governments

[i] Some incident locations are plotted on top of each other. As a result an area may seem to have a higher density than the number of incident locations seems to indicate.
[ii] King County, 1994.
[iii] Cashman, 1988.