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Case Studies of Transportation Accidents Involving Hazardous Materials

Introduction

In this module, three case studies of transportation accidents involving hazardous materials are presented. The first, which took place near Dunsmuir, California in 1991, involved a train derailment that spilled a large quantity of the pesticide metam sodium. The second case study, a truck accident on Interstate-65 in Alabama, was far smaller and far less serious than the Dunsmuir case. It is noteworthy, however, because it illustrates how an accident involving even a very small quantity of hazardous material can produce significant problems. The third case study was a large loss of gasoline, and subsequent explosion, from a pipeline leak in Bellingham, WA. This explosion which occurred in June 1999 killed a man and two children and had a profound effect on the community.

Major transportation accidents involving hazardous materials can produce serious economic, social and psychological impacts in affected communities. These impacts can be both widespread and long lasting. This module finishes with a general review of the economic, social, and psychological effects of hazardous materials transportation accidents. Current scientific research is reviewed, examples are provided, and implications are considered.

Case Study: Train Derailment near Dunsmuir, California, July 14, 1991

This case study is based upon excerpts from *Train Derailments and Toxic Spills: A Hearing before the Government Activities and Transportation Subcommittee of the Committee on Government Operations of the House of Representatives*, One Hundred and Second Congress, First Session, October 3, 1991, Washington, D.C. (U.S. Government Printing Office, 1992).

The town of Dunsmuir, California lies near the base of Mt. Shasta along the Sacramento River. The town itself sits close to the river, and is a popular destination for fisherman from throughout the country who come to fish for wild trout. As U.S. Representative C. Christopher Cox noted, "tourism, and fishing in particular, have been vital to the town's economy." At the same time, Dunsmuir is also a railroad town, with many of its citizens having worked for Southern Pacific through the years.

At approximately 9:40 pm on July 14, 1991, a 6000-foot long train operated by Southern Pacific Railroad derailed outside of Dunsmuir. The train had 4 diesel electric locomotives and 97 cars, 86 of which were empty. A car containing metam sodium landed partially inverted in the water, sending approximately 19,000 gallons of the chemical into the Sacramento River. Developed during World War Two, metam sodium is a herbicide that is used as a soil fumigant. When it interacts with water, it breaks down quickly into several byproducts, including methylisothiocyanate (MITC), methylamine and hydrogen sulfide. These breakdown products are immediately released as a gas and are respiratory irritants. According to Dr. Lynn R. Goldman, Acting Chief of the Office of Environmental and Occupational Epidemiology within the California Department of Health Services, MITC has some similarities to methyl isocyanate (MIC), the chemical that caused serious respiratory effects in victims of the 1984 Bhopal, India, chemical disaster. "MITC is very similar in structure to MIC; it has similar toxicological effects, although it has different potency."

Early the next morning, the environmental damage caused by the spill was evident, with dead fish in the river and the foliage above the river beginning to wither. Howard Sarasohn, Deputy Director of the California Department of Fish and Game stated:

"… the damage caused by the spill took a number of different forms. As the plume of airborne contaminants moved down the river, all plants and animals in its path were exposed, as were all life forms in the river as the waterborne plume moved down it. We observed that virtually all of the plants and animals in the river were killed instantly: fish, algae, plankton, insects, and other organisms. It literally sterilized the stream. Many of the effects were visible in the form of dying fish and, of course, the foliage began to turn brown and fall off."

In addition, according to statements by Southern Pacific, a report of an odor and burning, teary eyes came in early that morning from Dunsmuir, as did word of a light yellow-green plume being spotted about a half-mile south of Southern Pacific's Dunsmuir yard office. By noon, the California Highway Patrol closed a major highway adjacent to the Sacramento River after complaints of discomfort from fumes. A mandatory evacuation of Dunsmuir was also ordered by the City Manager, but this was downgraded to a voluntary evacuation about an hour later.

This combination – mandatory highway closing and voluntary evacuation of the town – was viewed angrily by some area residents. In testimony before Congress, Kristi Osborn from Concerned Citizens of Dunsmuir said the following:

"Most people, if notified at all, were told that evacuation was voluntary and definitely not necessary. This included some pregnant women and senior citizens with preexisting health conditions. Traffic on the freeway was stopped and rerouted, but if you were local, it was perfectly safe to be here. After the freeways was reopened, travelers were told to drive through Dunsmuir without stopping, and they were told not to use their air conditioners or vents and keep their windows shut tight. It was safe for us to live here, but it was not safe for motorists to breathe while driving through. When we complained about the double standard, the people traveling through were no longer warned. We had hoped instead for some concern over the townspeople."

There was also controversy over the quality of information that was available. Dr. Lynn Goldman, from the California Department of Health Services, complained that inadequacies in available information hampered efforts by public health officials to protect the public:

"In the first place, metam sodium was not contained in the emergency response manual that is compiled by the Department of Transportation…. Second, the material safety data sheet (MSDS) that is available in almost every workplace is largely inadequate. Lack of information about long-term effects and releases of the substances at high levels and poor quality assurance are the major shortcomings. So, even though an MSDS was quickly available, the information provided was inadequate. Third, because metam sodium is a pesticide, much of the detailed data about its toxicity are considered to be 'trade secrets'."

Information related to birth defects was of particular concern, as further explained by Dr. Goldman:

"In this case, public health agencies did not have prompt access to very important information related to birth defect hazards (neural tube defects) of the metam sodium, and possibly of MITC as well. The data summaries that had been prepared by the regulators at the EPA and within the state of California did not include this information. To be sure we had all the information that was available, we sent a toxicologist into the locked room at the California Department of Pesticide Registration in order to dredge through an enormous shelf of dense technical documents. As soon as we were able to evaluate the information, we shared it with the public. Unfortunately, this was a few weeks after the spill occurred, so that we were not able to use it to inform the public during the spill. We were able to warn the public about the possibility of neural tube defects if a woman had been exposed during the first few weeks of pregnancy. There is a blood test called the AFP that detects this type of birth defect during the early part of pregnancy. But… we learned that three women who were pregnant in the area have suffered adverse reproductive effects: two had premature births and one had a child that was still born. Were these problems caused by the spill? We may never know. But any parent who is placed in this situation will naturally suspect this as a cause for their misfortune."

The lack of complete and timely health information left some residents disillusioned and angry. As citizen group leader Kristi Osborn put it, "When can we trust our public health officials? They have destroyed their credibility, and there is no way to take our fear away."

A preliminary evaluation of the spills health effects by the California Department of Health Services (Goldman) noted the following impacts:

"During the week after the spill, 6 persons were admitted to the hospital for illnesses most likely related to spill by-products.

Three others, a person with chronic lung disease and two persons with asthma were admitted for worsening of their prior medical problems.

Three others were admitted for new problems, one with nausea, vomiting and dizziness and a second with pneumonia. The last was a worker who had helped with the initial response and was admitted to the hospital for an unusual cardiac arrhythmia.

Many more minor illnesses were observed in the aftermath of the spill. A review of emergency room records between July 15 and July 31 found a total of 252 visits, compared to 8 visits the first three weeks of August. The most common symptoms that occurred were nausea (51%), headache (44%), eye irritation (40%), throat irritation (26%), dizziness (23%), vomiting (22%), and shortness of breath (21%)."

In addition, workers who were brought in to clean up the spill in and near the river on July 21 and 22 developed unusual skin rashes on the feet and ankles, despite the fact that contamination levels were thought to be extremely low.

Finally, Dr. Lynn Goldman also expressed concern about the psychosocial impacts of the accident:

“The community may be experiencing considerable stress, as a result of the spill, the relocation, and the uncertainties that they have had to experience. This can cause symptoms during the immediate period but can also have significant long-term medical consequences.”

Later studies would show that such concerns were well-founded, with residents affected by the spill showing a range of psychosocial impacts.

Southern Pacific has taken steps to help the community of Dunsmuir recover from the chemical spill. Among other things, the company

- Offered to fund the re-stocking of the river and assist with logistics.
- Opened a community assistance office in Dunsmuir and opened two claims offices, one in Dunsmuir and one at Lake Head.
- Settled over 500 claims.
- Paid for over 500 physical examinations in a community of 2100 people.
- Begun paying a bill totaling $1,400,000 submitted by government agencies for their emergency response costs.

The railroad paid approximately $2 million on the cleanup and for individual and community assistance. They also worked with Dunsmuir on a public relations campaign to encourage the return of tourists. This included promotional train trips for Southern Pacific employees and others with the proceeds going to the restoration efforts within the community. In addition, they agreed to pay the startup costs of a computer database and library that will contain all current and future information about the spill and its aftermath.

There are varying views within the community about the short-term and long-term effects of the accident. Dr. William Baker, an area physician expressed the view that “the long term effects of exposure will be very minimal.” Ron Martin, a member of the Dunsmuir Chamber of Commerce, called on the EPA to “give our air and water a clean bill of health and publicize it.” Martin criticized the media and the need to restore the town’s tarnished image:

“The air is still fresh and the water is still the best on earth. People are not dying in Dunsmuir due to our air and water. In general, they are very healthy and have a very delightful town to visit and reside in. Our economy had suffered a severe blow due to inaccurate and negative media coverage. What we need is our town to be made whole.”

In the view of Kristi Osborn of Concerned Citizens of Dunsmuir, making the town whole would be difficult. In the aftermath of the accident, Osborn said the town was split:

“Tourism, and fishing in particular, have been vital to the town’s economy. The town is built around the river, physically, economically, and emotionally. However, Dunsmuir is also a railroad town. Train memorabilia is everywhere. Generations of families have made their livings with Southern Pacific. Now, sadly the community is divided, and it is difficult for some to choose sides.”

Osborn said the effects of the spill were profound: “There are hundreds of people still sick in a town with a population of considerably less than 3000. I’d call that a ‘significant’ number. We didn’t cause this disaster, but we are paying for it with our everyday lives.” Furthermore, Osborn did not expect the lingering impact of the spill to go away anytime soon. The “biggest concern is, in 5 years, how will our health be? Or in 10 years?” Concluded Osborn: “We all want to forget the spill, but we, as people who have been forced to live in the midst of the disaster, have changed. The spill affects our lives daily and will for a very long time.”

Case Study: A Rural Community Responds to a Highway Accident on Interstate-65, February 7, 1994

A March 8, 2000 story in the *Birmingham News* noted that “One in every 20 tractor-trailer rigs traveling through Birmingham contains hazardous cargo, according to a survey conducted for the Jefferson County Emergency Management Agency.” Birmingham has a hazardous materials response unit. However, many small communities do not, and the question becomes “what happens when an accident happens in the jurisdiction of a small community?” The community of Warrior, Alabama found out on February 7, 1994.

The chemical involved in this accident was acrylonitrile (also known as 2-propenenitrile or vinyl cyanide), a toxic substance used in the making of acrylic fibers. Acrylonitrile is the 39th highest volume chemical produced in the United States. According to Catherine Lamar, spokesperson for the Alabama Department of Environmental Management (ADEM), acrylonitrile is in a category with those chemicals classified as “poisonous or fatal if inhaled, swallowed or absorbed through the skin. Contact may cause burns to skin and eyes” (*Birmingham News*, February 7, 1994). According to the International Safety Card information, acrylonitrile can enter the body through inhalation, ingestion, and skin absorption [occupational exposure limits: threshold limit value (TLV) 2 ppm vapor, 4.3 mg/m^3 by skin]. Inhalation can be expected to cause headaches, dizziness, nausea, vomiting, tremors and uncoordinated movements. Non-fatal exposure is treated with fresh air and rest. The symptoms of ingestion include, in addition to the nausea and headaches, abdominal pain and shortness of breath. Treatment of ingested acrylonitrile is drinking a slurry of activated charcoal and inducing vomiting. Long-term effects of exposure to non-lethal levels during short-term exposure may be on the liver and central nervous system, and medical observation is recommended. Long-term, or repeated, exposure may cause dermatitis if exposure is through the skin, and acrylonitrile is a probable carcinogen. Periodic medical follow-up is recommended on the International Safety Card.

A transportation accident involving a carrier of acrylonitrile occurred near the Warrior-Robbins exit of Interstate-65, about 20 miles north of Birmingham, Alabama. About 4:15 a.m., firemen from the Warrior City (pop. 3357) volunteer fire department responded to the call involving a tanker truck that had overturned on the interstate median (*Birmingham News*, February 7, 1994). The accident apparently occurred when the truck driver lost control of the vehicle (*Birmingham News*, February 8, 1994) when he tried to avoid a cinder block in the road (*Birmingham News*, February 9, 1994). A later investigation by the Alabama State Police reported that the driver lost control of the truck when he fell asleep, although the driver and the trucking company deny this (*Birmingham News*, February 23, 1994). The firefighters removed the two injured men from the vehicle, discovered that the truck was carrying a hazardous material, and pulled back and established a perimeter (unidentified firefighter, personal communication). The truck, a tanker from Miller Transporters Inc. of Jackson, Mississippi, was carrying a load of acrylonitrile (*Birmingham News*, February 8, 1994).

Although the tanker was carrying approximately 6,000 gallons of acrylonitrile (*Birmingham Post-Herald*, February 8, 1994a), only about 1 gallon of this substance was released as a result of the accident (*Birmingham News*, February 10, 1994). The tanker leaked, but did not rupture, in the accident. The firemen looked up acrylonitrile in their “yellow/orange book” (Emergency Response Guide), and realized that this cleanup was beyond their expertise. Although some of the firemen had gone through hazardous materials training, they did not have the appropriate equipment, both for personal protection and for actual cleanup. They had responded to the accident and removed the injured persons from the truck wearing only their regular turn-out gear (unidentified firefighter, personal communication). The guidelines from the “yellow/orange book” (and the International Safety Card on acrylonitrile) state that acrylonitrile is a colorless or pale yellow liquid with a pungent odor. The vapor is heavier than air, i.e., it can travel along the ground, and vapor/air mixtures may be explosive. The substance decomposes on heating, producing toxic fumes including nitrogen oxides, and hydrogen cyanide. It reacts violently with strong oxidants and strong bases, causing a fire and explosion hazard. The recommendation is that the immediate area should be evacuated. Cleanup includes collecting leaking liquid in covered containers and absorbing any remaining liquid with sand or an inert absorbent. Acrylonitrile should not be washed into the sewer system because it is toxic to aquatic organisms. One concern with the location of this accident was that “there are storm drains in the median that run directly into an unnamed tributary of Cane

Creek" (James Davidson of the Alabama Department of Environmental Management, in the *Birmingham Post-Herald*, February 8, 1994a).

The Warrior City volunteer fire department, with the help of the Warrior city police and the Jefferson County Sheriff's Department, established a perimeter of one-half mile around the accident site and evacuated about 100 persons (initial reports were of 200 evacuated) from area homes and businesses in the perimeter area by going door-to-door (*Birmingham News*, February 8, 1994). The Jefferson County Sheriff's department and the Alabama state troopers were mobilized to handle traffic control as four miles of both the northbound and southbound lanes of Interstate 65 were closed to traffic. At least 60,000 cars were re-routed through Warrior along U.S. Highway 31 between the time of the accident and 1 p.m., and an unknown number followed before the interstate was re-opened at 7:30 p.m. Willis Graves, a Warrior resident who lives along Hwy 31, spent most of the day watching the long line of traffic in front of his house. As he said that day about the traffic blocking him from leaving his driveway, he was thankful that he "wasn't planning on doing much today anyway." Re-routed drivers spent an average of four hours navigating the detour (*Birmingham News*, February 8, 1994). Warrior public schools were dismissed forty-five minutes early due to the traffic. "The traffic was moving at such a slow pace, it would be night before some of the children got home," according to William Leatherwood, acting Warrior Police Chief (*Birmingham Post-Herald*, February 8, 1994a).

Once the perimeter was established and the traffic situation under control, the volunteer firemen called upon the local Emergency Management Agency (EMA) and the Alabama Department of Environmental Management (ADEM) for assistance. The Occupation Safety and Health Agency (OSHA) also became involved, as did Emergency Response Specialists, a private firm hired by Miller Transporters that specializing in hazardous-materials clean-up (unidentified firefighter, personal communication). Clean-up began about three hours after the accident and took about 12 hours to complete. The crew from Emergency Response Specialists had to transfer the remainder of the load from the tanker before it could be righted and moved. Once the tanker was away from the scene, the crews removed the visibly-contaminated soil from the median (*Birmingham Post-Herald*, February 8, 1994a). Tests of the soil surrounding the accident site were taken both by Emergency Response Specialists and ADEM. Preliminary results of these tests showed only minimal contamination (16 ppm at one sample site and 0.094 ppm at a second site), according to Lisa Moore, president of Environmental Response Specialists (*Birmingham News*, February 9, 1994). Workers were required to return to the site a week later to remove the top 12 inches of soil from the area surrounding the spill because it was contaminated by diesel fuel that also spilled (*Birmingham News*, February 8, 1994).

The two men who were pulled from the truck were taken to Carraway Methodist Medical Center in Birmingham where they were treated for minor cuts and released (*Birmingham Post-Herald*, February 8, 1994a). At least 12 firefighters, state police officers, and other emergency workers were treated at the scene or at Carraway (*Birmingham News*, February 8, 1994). The original responders as well as the other volunteer fire personnel who helped in this situation were encouraged to go to the hospital by emergency management personnel (unidentified firefighter, personal communication). One firefighter from the Kimberly, Alabama, fire department reported that they "could smell the chemical all around us. There were guys getting headaches. Some of them said they could taste it." Another firefighter reported tightness in his chest. All those who went to the hospital were given blood tests and released. The results of these tests showed that 11 firefighters suffered some inability to oxygenate blood, potentially as a result of inhaling the acrylonitrile. One firefighter's wife reported that her husband's blood work showed an oxygen level of about seventy-five percent of normal levels. However, a spokesperson for Miller Transporters, Inc., said that "such a small leak wouldn't be enough to harm the suits or the firefighters. He [the spokesperson] suggested heat exhaustion may have caused their symptoms" (*Birmingham News*, February 11, 1994).

The reports from the *Birmingham Post-Herald* (February 8, 1994b) indicated that the spill and resulting evacuation also affected the area residents. "It was not a normal day for 94-year old Henry Montcrief. He was having breakfast with his brother-in-law when a police officer knocked on his door. 'We did not even finish breakfast. I had to drive eight or nine miles around and it is usually just a mile.' The brother-in-law, C.M. Hunter said the news of a chemical spill made him nervous. 'I was just afraid of a gas of some kind. I just wanted to get away as quick as I could." Lt. Carl Johnson described the meeting that he had with a young mother who was trying to return to her apartment in the restricted area. “I told her that everyone was being evacuated to Warrior City Hall or the community center, and she started crying and saying, ‘But I have to get home. My baby is wet.’ People get upset when you do anything to disturb their sense of security.”

The first concern of the emergency personnel after the incident was that the firefighters’ gear was contaminated. “Until Warrior can be assured the suits are safe, firefighters won’t use the gear, said Clay Neely, the fire department’s adviser. “We can’t send someone into a fire with a question mark” (*Birmingham News*, February 11, 1994). The spokesperson for Emergency Response Specialists said that no evidence existed that the gear would have absorbed the acrylonitrile, and that even if contamination was found, the gear could be treated and reused (*Birmingham News*, February 10, 1994). Tests were performed on all of the gear by Emergency Response Specialists and six firefighter suits were replaced as a result of the incident (unidentified firefighter, personal communication). Two lawsuits were filed after the incident. The city of Warrior filed a $21,000 claim to have the transportation company replace the other eighteen sets of firefighter suits that the city feared were contaminated. “Firefighters fear that clothing exposed to the extremely flammable chemical will ignite when exposed to a fire,” according to Brad Fuller, the deputy fire chief of Warrior. The Kimberly fire department, a second responder to this accident, had twelve of its firefighters’ suits replaced by its insurance company, who was then planning to pursue reimbursement from the trucking company (*Birmingham News*, March 17, 1994).

The city of Warrior also sued for lost tax revenue as a result of the accident. The city alleged that the closure of the interstate resulted in lost earnings, and therefore lost tax revenue, from those businesses along the highway. The owner of the T & G Family Restaurant said, “It (chemical spill) has hurt my business. All I got were restroom customers today” (*Birmingham Post-Herald*, February 8, 1994b). The owner of a small store forced to close estimated that he lost $8,000 in gasoline sales on the day of the spill. A local building supply company estimated that it lost at least $4,000 (*Birmingham News*, March 17, 1994).

There was some beneficial impact of the spill on the fire department itself. No firemen quit the department following the incident, nor was there an increase in interest in becoming a member of the department from the larger community. However, there was an increase in desire for further training among members of the department as a result of the accident. A dozen or more are now ‘technicians’ in the fire department and have more training than the regular fire fighters, especially in the area of hazardous material management. At the time of the accident, there were three technicians with this training. While the department has become better trained, there is still no hazardous material gear for them to use, because it is too expensive for Warrior to purchase (Fire Chief Tommy Hale, personal communication). If another hazardous-materials accident were to occur, firefighters would still be forced to respond to the call in only their regular turn-out gear.

In the small town of Warrior, where this accident is still referred to in the fire station as “the big one,” some fear one day another tanker truck will lose control on the interstate that passes about a mile from the downtown. Another day in which they will get the call for which they are still unprepared, for in the words of their current chief Tommy Hale, his voice filled with frustration, “we have the training, we just don’t have the equipment to deal with this” (Hale, personal communication). Even though the town of Warrior is only 20 minutes away from Birmingham, the town was responsible for dealing with the accident with minimal help from surrounding areas.

In the state of Alabama, acrylonitrile is transported on the waterways in larger quantities than seen in this accident. Just over one year after the Warrior accident, a tank barge carrying 903,000 gallons of acrylonitrile ran aground in the Tenn-Tom Waterway about three miles above the Bevill Lock at Pickensville. Fortunately, no material was released to the environment in this incident. The lessons from Warrior should, however, cause concern in many small communities, such as Pickensville, that may be forced to deal with a major transportation-related chemical emergency (*Birmingham News*, March 13, 1995).

Figure 9-1. "Firefighters in golf cart look on from safe distance as workers in protective clothing load spilled chemical into a tanker from an overturned truck on Interstate 65" (Feb. 8, 1994) (Copyright Photo by *The Birmingham News*, 2000. All rights reserved. *Reprinted with permission*).

Case Study: Pipeline Explosion, Bellingham, Washington, June 10, 1999

<u>Accident Description</u>

Olympic Pipe Line Company owns and operates a 400-mile system of pipes that carries gasoline, diesel and aviation fuel from several refineries to users in the Puget Sound area of Washington State. This series of pipelines, some sections of which are 35 years old, supplies all the aviation fuel used at the Seattle-Tacoma International Airport. The pipe that ruptured was a 16-inch flexible, high-strength steel pipe. It was designed to withstand external loads of soil, rail and car traffic, and the pressure of the fuels flowing within. Normal operating pressures for this pipe were between 1000 and 1400 psi. In the area of the rupture/leak, the pipe was buried eight feet underground.

On June 10, 1999, at 3:18 p.m., Olympic Pipe Line operators at the Renton, WA, control room began switching the operation to supply fuel to a new customer. They had difficulty starting one of the pumps, and the computers that control a series of valves and pumps began malfunctioning. At 3:24 pm, one of the computers crashed. At 3:28 p.m., the backup computer system started up at the same time that a valve in the line closed. The quick closing of the valve caused a pressure surge of up to seven times the normal operating pressure to go back up the pipe. According to initial reports, due to the extreme pressure, a 27-inch gash occurred at a weakened spot in the line. (Later reports in the *Bellingham Herald* on October 2, 1999 stated that a simulation of the line indicated that the pressure in the line at the time of the rupture may not have been above normal operating pressures).

The rupture occurred near Whatcom Creek, close to the local water treatment plant. The computer malfunction also caused the pumps at the start of the pipeline to shut off, thus preventing fuel from continuing to enter the pipeline. Operators were unaware of the break and so at 3:46 p.m., they restarted the pumps, sending fuel into the broken line. At 4:29 p.m., a leak alarm sounded in the control room. In the meantime, Bellingham residents, starting at 4:24 p.m., called the fire department to report the strong odor of gasoline. At 4:31 p.m., the operators started another pump, sending additional fuel into the line. At 4:32 p.m., the pumps shut down automatically, another alarm sounded, and operators began closing off the pipe (*The Seattle Times*, June 11, 1999, June 3, 2000b). At 5:02 p.m., the massive fire was reported (*The Seattle Times*, June 12, 1999, June 24, 1999, June 3, 2000b). About 280,000 gallons of gasoline were pumped into Park Creek and Whatcom Creek during this spill.

Shortly before the explosion, the Bellingham Fire Department began responding to the calls regarding the strong gasoline odor. When they approached the park, the firemen saw the fumes rising from the creek. According to firefighter Ryan Provencher, "the creek had turned yellow, a 'river of gasoline'" (*The Seattle Times*, June 13, 1999a). The firefighters immediately began closing off the streets and evacuating the surrounding area. Neighbors also began to alert others. When the gasoline exploded, the fireball reached 30,000 feet into the air and "the fire raced half a mile down the creek until it ran out of fuel." The hottest part of the fire burned itself out in an hour but hotspots remained for another 48 hours. According to Whatcom County's fire chief Gary Crawford, "You can tell how hot it got. It singed the hills behind it. We had some 2,000-degree heat" (*The Seattle Times*, June 11, 1999). Bellingham's Fire Captain Bill Boyd said the day after the incident, "It was ugly. I've never seen anything like it. It was like Mount St. Helen's" (*Bellingham Herald*, June 11, 1999).

The initial investigation reported that the leak occurred within a mile of where a 1996 test discovered the pipeline wall was thinner than normal but within specification. The cause of the pipe weakening was reported to be external damage from construction at the water-treatment plant (*The Seattle Times*, June 11, 1999, June 24, 1999, July 1, 1999). According to the National Transportation Safety Board (NTSB) review, the rupture occurred on the pipeline at a location where water lines (as part of an improvement project at the water treatment plant) were installed above and below the pipeline in 1994 and 1995. In 1996, approximately two years after the construction, Olympic Pipe Line had inspected the line using electronic devices ("smart pigs" that test the wall thickness) and found anomalies (termed 'sub-critical'). Based on a review of the data from the "smart pigs," Olympic determined that the anomalies did not warrant additional investigation, which would have necessitated excavating the pipe (*The Seattle Times*, October 27, 1999).

Three people were killed as a result of the fire and explosion. Two ten-year old boys, Wade King and Stephen Tsiorvas, were playing along the creek with a plastic fire-starter and ignited the gasoline in the creek. They were burned over 90% of their bodies and died the next morning at the hospital as a result of their injuries. An eighteen-year old fisherman, Liam Wood, suffocated from the gasoline fumes (*The Seattle Times*, June 11, 1999, June 13, 1999b, June 24, 1999).

<u>Impacts of the Bellingham Pipeline Explosion</u>

The immediate impact was on the families of the boys that were killed. "I held his feet, because those were the only things that were really him any more… I don't know if he heard me tell him how much I loved him." Katherine Dalen was speaking of her son Stephen Tsiorvas. "You worry about cuts and insect stings. You don't worry about the water burning them to death" (*The Seattle Times*, July 28, 1999). Firefighters called Wade King and Stephen Tsiorvas "unwitting heroes," for if the blast had not happened where it did and if the gasoline had traveled further downstream, the loss of life and property would have been "significantly greater." According to one Bellingham firefighter, the fire department found "highly explosive bubbles of gasoline fumes in the sewer system that could have blown up the city's entire sewer system" (*The Seattle Times*, June 13, 1999b).

In the days following the explosion, the community impacts became apparent. City leaders called the accident "the most devastating thing we've ever had happen to this community. This has shaken the community's sense of security to the core" (*The Seattle Times*, June 17, 1999). In an attempt to control public curiosity about the explosion site and fire, the city of Bellingham arranged public tours of the area on the Saturday following the explosion (*The Seattle Times*, July 1, 1999). Reaction among the evacuees to the initial emergency response to the incident was mixed. Evacuation notification was called 'haphazard,' and residents accused officials of taking "an hour to broadcast a warning on the emergency broadcast system. People were left wondering whether their health was threatened by the thick cloud of black smoke" (*The Seattle Times*, June 13, 1999b). Residents have talked among themselves about 'getting back to normal,' but normal was different. Before the disaster, few residents even knew about the pipeline, but now they knew where it was located (a hundred yards from the middle school) and what was in it (*The Seattle Times*, June 13, 1999a, June 17, 1999).

The families of the two ten-year old boys killed in the blast filed lawsuits against Olympic Pipe Line, and against one of its partners, Equilon, for both compensatory and punitive damages for the loss of their children as well as for the pain and suffering. This experience was especially traumatic because the two boys did not die immediately in the blaze, instead they were found and rescued by an older brother of one of the two boys. To date, the family of Liam Woods, the fisherman who drowned when overcome by the fumes, has not filed suit against the companies (*The Seattle Times*, July 28, 1999, September 25, 1999). This accident has also resulted in a federal criminal investigation relating to whether "Olympic met its requirement to closely monitor the construction work [by the City of Bellingham], given that such activity is the leading cause of pipeline ruptures. Also under examination is the company's decision not to inspect the anomaly firsthand after remote sensors discovered it" (*The Seattle Times*, December 9, 1999).

Since the accident, the civil and potential criminal investigations have often conflicted, and these conflicts have delayed a sense of closure for the families. Because of the potential criminal case, several Olympic Pipe Line employees, when questioned about the accident in regards to the civil case, invoked their Fifth Amendment rights. Other delays in the civil case have included the delay of destructive testing of the 20-foot segment of ruptured pipe because of the potential for compromising the criminal defense. In order to not incriminate himself in a criminal case (including the potential federal inquiry), the president of Olympic Pipe Line requested a one-year delay, to December 2000, in responding to the families' civil lawsuit. Other Olympic employees have also requested delays in responding to attorneys' questions, and immunity from criminal prosecution has been proposed for some employees who were on duty the day of the explosion (*The Seattle Times*, December 4, 1999).

Olympic accused and later sued a local construction firm who installed the water lines near the pipeline. They accused the firm of fatally damaging the pipeline and failing to notify Olympic of the damage when it occurred. This has led to the local newspaper airing the accusations between the two companies. The construction firm said that they did not damage the pipe and that the faulty valve and resulting pressure wave caused the rupture. Olympic contends that the pipeline would not have ruptured had the pipe been intact/undamaged. When questioned about their availability during the construction in 1994 and 1995, the Olympic spokesperson said that a company representative was on-site during the work, but that they were not present when the damage occurred or when the pipes were covered. However, according to the president of the construction firm, "They [Olympic] are clearly liable under the law. They are a large corporation, and I can't believe they are blaming their negligence on us and trying to ruin our reputation" (*The Seattle Times*, February 11, 2000).

Residents near the pipeline have also been affected. One resident commented several days after the explosion that "the park was a quiet sanctuary for residents across the region, including her own family. But innocent sounds now jar her emotionally. 'Whenever I hear a jet go over, it's like thunder and feels like the explosions. My nerves are rattled. Some nights I've woken up and it smells like smoke. It's definitely on my mind a lot.'" Another person, whose home is near the pipeline, but not near the area where the pipe ruptured, said that "now he wonders just how old the pipeline is and whether the earth piled on top of the pipeline from new construction projects … could become a problem" (*Bellingham Herald*, June 16, 1999). According to Dr. Frank James of Bellingham, he has treated "a Vietnam veteran who believed his home had been napalmed, a young child whose sleep is still disturbed by the vision of a huge black cloud, and a boy who found the body of Liam Wood, the 18-year-old fisherman." As Dr. James said at a public meeting of the state's pipeline safety task force (formed after the accident), "They will not be the same again. It comes as a shock to me how much suffering remains in this community because of this." At the same hearing, Wade King's father said "residents must maintain a 'controlled, reasonable, logical anger' to prevent a recurrence." However, not all residents were as greatly affected as those seen by Dr. James. One resident defended the pipeline with the following statement "When you take the amount of years (the pipeline) has been going through this area, it's been quite well taken care of" (*The Seattle Times*, November 17, 1999). This public debate over whether the pipeline and the company are 'good' or 'bad' has put additional stress on the community.

There have been economic impacts on the community as well. Several residents along the pipeline found that their houses were now valued at less than they were before the accident. One man seeking a loan for improvements to his home found the value of that loan lowered by half. Another family watched as their house sold for $8,500 less than expected. Area real estate agents were waiting for the year 2000 tax assessments to determine the extent of the lowered housing values. "Under state and federal law, appraisers must note 'adverse environmental conditions present in the improvements on the site or in the immediate vicinity of the subject property.'" As a result of this disaster, pipelines may become one of those 'immediate-vicinity' conditions (*The Seattle Times*, September 19, 1999a).

Local utilities were also affected by the explosion. The local water pumping station was destroyed, forcing up to 70,000 system users to heavily restrict their water usage. According to the assistant director of the Bellingham Public Works Department, "For all practical purposes, the pump station was destroyed. The concrete shell was salvageable. All the control systems melted. The fire extinguisher melted" (*Bellingham Herald*, June 11, 1999). For at least a week, 15,000 to 20,000 people had water to cook and drink, but not to bathe or wash clothes. Power lines were also singed (and shut down for protection), disrupting power to thousands of area residents. The resultant smoke also closed Interstate 5 to traffic for several hours on the evening of the accident (*The Seattle Times*, June 11, 1999).

In addition to the human costs of the disaster, the explosion killed more than 30,000 fish in Whatcom Creek (*The Seattle Times*, June 17, 1999). "As the fire burned and the water temperature rose, the oxygen was sucked out of the water. Some of the fish tried to dive, some hid in the rocks, and those who tried to get to air on the surface were burned to a crisp (*The Seattle Times*, June 13, 1999a). Prior to the accident, the creek had been the focus of a restoration effort, including attempts to bring back fish that were listed as threatened under the Endangered Species Act (*The Seattle Times*, June 17, 1999). The dead fish, gathered by volunteers and state biologists, included sea-run cutthroat trout, rainbow trout, steelhead, coho and chinook salmon, sculpin, and lamprey. According to Mark Kaufman, an environmental specialist for the Washington Department of Ecology, "This flash destroyed five hard years of stream restoration in a few moments. The stream will recover, but it will be a long recovery" (*The Seattle Times*, June 13, 1999b). The good news for the environment was that two months after the accident, algae had returned, as had mayflies. In addition, green leaves began reappearing on the trees along the creek and ferns covered the ground. As stated in the newspaper, "Olympic Pipe Line pledged millions of dollars toward the reconstruction and recovery of the Whatcom Falls Park, but for now, the community waited and hoped for the annual appearance of the salmon" (*The Seattle Times*, August 10, 1999).

Approximately three months after the accident, Olympic Pipe Line requested permission to reconstruct the pipeline. The City of Bellingham tentatively agreed once federal regulators approved the restart. The new constraints on operation included improved operator training and more detailed standard operating procedures. They also included additional pipeline inspections, testing and replacement (*The Seattle Times*, September 11, 1999). Hydrostatic pressure testing was required on the remaining sections of the line that ruptured. When this test was performed, the pipe burst again, approximately one and one-half miles from where it ruptured in June. This rupture, which occurred before the pressure reached the required test pressure, prompted federal regulators to require testing of all of the older pipeline around the Bellingham area (*The Seattle Times*, September 19, 1999b). Because of additional valve problems on the pipeline and the lack of visual inspections of the defects seen in the 1996 "smart pig" tests, on September 24, 1999, federal regulators required Olympic to reduce the amount of fuel shipped by the still-operating sections of pipeline through a reduction in pipeline pressure of twenty percent (*The Seattle Times*, September 25, 1999b). "The shutdown has been costly to Olympic because it charges field companies for every gallon it transports. The shutdown also contributed to fuel shortages last summer that raised gasoline prices in the West" (*The Seattle Times*, January 19, 2000).

Based upon the newspaper accounts, it appeared that the residents and local officials have mixed feelings about the pipeline. They understood the economic benefits of the pipeline and the fuel it carries. However, they are obviously concerned about the potential safety problems associated with fuel traveling at high pressures below neighborhoods and business areas. In many instances, the question appeared to be one of timely and effective communication. When officials from the areas along the pipeline met in December 1999, "a straw poll found that no one was satisfied with Olympic's responsiveness." According to the Bellevue franchise manager, "We wish we had gotten more information from Olympic. An issue of this nature, if you want to allay people's fears you want to do it on a factual basis" (*The Seattle Times*, January 21, 2000). Public response to the accident and its impact on regulations was expressed by a resident at a public forum for improving pipeline regulation when he said, "we have to step in and regulate, and regulate – yes – with the cooperation of the industry, but not with the industry calling the shots" (*The Seattle Times*, September 9, 1999). Olympic held several public forums in 2000 to let pipeline neighbors ask questions and also to allow Olympic to explain their improved safety and training programs. However, these forums apparently did not necessarily improve the locals' feelings of safety. According to one attendee, "My faith is even more eroded by being here." Referring to the new safety procedures, she said, "You have just started thinking about it. That's what worries me" (*The Seattle Times*, March 17, 2000). U.S. Representative Jack Metcalf, from Langley, WA, stated, "Testing along full length of the pipeline will help ease the fears of state residents, and serve as an excellent indicator of the overall safety of the pipeline." The Olympic Pipe Line spokesperson responded, "We don't think that's necessary," and added that "pressure tests stress the pipes." Olympic proposed the use of electronic devices to inspect the pipeline from inside (*The Seattle Times*, October 8, 1999). When Olympic requested re-opening the line in January 2000, without subjecting the complete line to the more rigorous tests, Congressman Jay Inslee of Bainbridge Island commented, "I think the folks in Snohomish and East King County are deserving of the same level of confidence that was obtained in Whatcom County before it is reopened" (*The Seattle Times*, January 19, 2000).

According to Wade King's father, "This company is an outrage. They basically have no requirements on them whatsoever. They put profits before people." However, he recognizes that the Office of Pipeline Safety allowed Olympic to operate in that manner. Therefore, he does not completely blame Olympic Pipe Line. "I blame the Office of Pipeline Safety for not doing their job. I loved my son so much that I can't allow that he be buried along with the pipeline. His death has to stand for something" (*The Seattle Times*, March 12, 2000). When discussing the Congressional hearings on the Bellingham disaster and pipeline safety, NTSB chairman Hall stated, "It is a sad state of affairs that regulatory oversight is basically coming out of the Department of Justice and not the Department of Transportation" (*The Seattle Times*, October 28, 1999). Regulatory response to the accident has included a proposal to require federal certification of pipeline operators, increase pipeline inspections and allow states to impose stricter regulations than the federal ones. The proposal also would require internal inspections and pressure testing every five years, the reporting of small spills (40 gallons or more), and the creation of an Internet site that shows where the pipelines are located. It would also require research into whether pipelines should be buried deeper and what leak detection and prevention equipment (double-walls, leak detection systems) should be installed. Additional legislation would increase the public's right to know about safety problems and increase the funding for pipeline inspectors (*The Seattle Times*, February 1, 2000).

The first penalty, $3.05 million, imposed upon Olympic Pipe Line Company, resulted from the findings of the Department of Transportation investigation which concluded Olympic "failed to properly inspect and operate its pipeline and train its workers." According to Stephen Tsiorvas' grandmother, "I certainly think it's appropriate. I don't know what would ever be adequate" (*The Seattle Times*, June 3, 2000c).

The local and regional newspapers, including *The Bellingham Herald, The Seattle Times,* and *The Seattle Post-Intelligencer*, has helped keep the issue alive both through their reporting of the investigations and through their use of human interest stories regarding how people are coping with the aftermath of the explosion. On June 3, 2000 (a), *The Times* ran a feature story on the three people killed in the explosion. This was a very effective technique for reminding people about the human cost, especially since most of the recent discussion had been about the legal matters. The Internet is also being used to assist people in locating additional information about the accident and the follow-up investigations. *The Seattle Times* has listed four websites where the public can find this additional information. The federal Office of Pipeline Safety can be located at http://ops.dot.gov. The website for the NTSB is http://www.ntsb.gov. The community group lobbying for improved pipeline regulations, SAFE Bellingham, has a website at http://www.safebellingham.org (*The Seattle Times*, June 4, 2000a). Also, a memorial gathering and march was planned. The gathering would mark the disaster but also "celebrate the beginning of the restoration of Whatcom Park (*The Seattle Times*, June 4, 2000b).

Figure 9-2. Aerial photo of explosion scene (copyright *Bellingham Herald* June 11, 1999, *Reprinted with permission*).

Figure 9-3. Burned Whatcom Creek from the air on Sunday June 20, ten days after the explosion that took the lives of three boys in Bellingham (photo by David Willoughby copyright *Bellingham Herald*, *Reprinted with permission*).

Figure 9-4. Fire fighters from Tosco Refinery spray foam on hot spots along Woburn St. (copyright June 10, 1999 *Bellingham Herald*, *Reprinted with permission*).

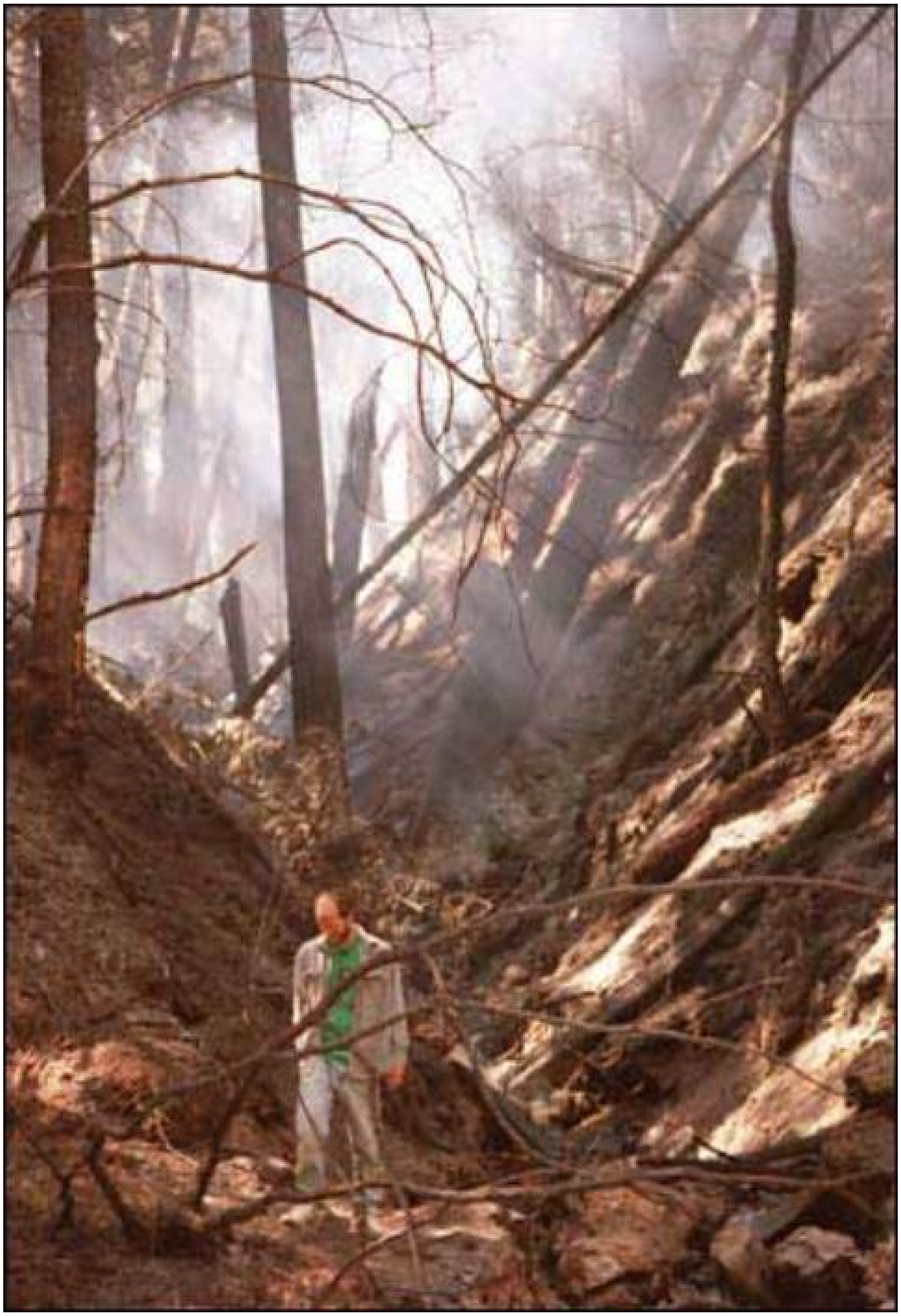

Figure 9-5. An unidentified person walks the point where Park Creek enters Whatcom Creek in Whatcom Falls Park in Bellingham, WA (copyright June 10, 1999 *Bellingham Herald*, *Reprinted with permission*).

Figure 9-6. Larry Bateman, operations supervisor for the Bellingham Public Works Dept. walks past a crater near the water treatment plant Friday afternoon, June 11, 1999 (copyright June 11, 1999 *Belligham Herald*, *Reprinted with permission*).

Photo 9-7. Photo of where the 277,200 gallon gasoline leak occurred (copyright 1999 nwcitizen.com. *Reprinted with permission*).

Community Impacts of Transportation Accidents Involving Hazardous Materials

Stakeholder Commentary on Problems Highlighted by the Case Studies

The interviews with stakeholders highlighted a number of issues that need to be addressed in future state planning for transportation accidents involving hazardous materials.

1. From a planning standpoint, concerns were raised about the routing of hazardous materials in the state, particularly in relation to the tunnel in Mobile.

2. Shipments of transuranic waste from both Oak Ridge and Savannah River are scheduled to travel through Birmingham on I-59/I-20. Concern was expressed about whether public safety personnel would be notified when shipments are scheduled to pass through the state. These shipments will pass through the most populous city in the state and are likely to be contentious.

3. Several of the larger fire departments (Birmingham, Tuscaloosa, Montgomery, Mobile and Huntsville) have hazardous-materials responders who have had the required training. Fort Rucker also has its own hazmat responder unit. However, much of the state is served by volunteer/semi-volunteer fire departments. Most of the departments are not prepared to effectively or safely respond to a hazardous-materials incident. In order to combat this lack of preparedness, several volunteer fire departments have begun cooperating with each other in order to create a hazmat unit for a county/region. This cooperative effort would require each department in the area to contribute equipment and/or personnel for the endeavor, but it would mean that each department would not have to have its own functioning hazmat unit.

4. Concern was expressed over the limited resources available to both responder agencies and local emergency planning committees (LEPCs) in Alabama. Mandated under the Emergency Plannning and Community Right to Know Act of 1986, LEPCs are a key component in preparedness and response for contamination incidents. Concern was expressed that current responder agency and LEPC resources are not adequate.

Other concerns raised during stakeholder meetings included (1) recovery of resources spent on a hazmat incident, (2) communications' difficulties during an incident, and (3) appropriateness of response to 'unusual' chemicals. First, the State has no mechanism for recovering its expenses relating to a hazardous-materials incident response. Not only is there no money in the state budget for expenses relating to this type of emergency, but there are no requirements for the responsible party to reimburse the State for the money expended on a response. Second, there is no uniform standard for communications equipment between the Department of Public Safety (DPS) and local police, fire and emergency responder departments. Even inside the DPS, there are three communications systems, which can cause "major problems with internal coordination, much less trying to communicate with outside departments." Third, there is a concern about responders, especially local departments, having the knowledge or the ability to get the knowledge quickly to respond to incidents involving 'unusual' chemicals, i.e., those chemicals that are not encountered frequently during a transportation accident.

Research, Examples and Implications

As the Bellingham case study dramatically demonstrates, transportation accidents involving hazardous materials can produce profound economic, social and psychological impacts in affected communities. These impacts can range from short-term financial losses to long-term emotional distress, community division, loss of trust, and social stigma.

Evacuation

Some of the most immediate effects of toxic transportation emergencies result when an accident forces people to evacuate. Evacuations are highly disruptive, affecting businesses, schools, and every other aspect of community life. For example, during the first 6 days after the Dunsmuir, California train derailment and pesticide spill, 483 residents left their homes and moved to evacuation centers. While some people's stays in the centers were short, others were there for several weeks. Many other residents also left the area and went to the homes of relatives or friends in unaffected communities (Bowler, *et al*. 1994a).

The 1979 train accident in Missasauga, Ontario provides a vivid illustration of widespread, evacuation-related disruption after a major incident. A train consisting of 3 engines, a caboose and 106 cars derailed at a level crossing. In the wreckage were 11 cars of propane, 4 cars of caustic soda, 3 cars of styrene, and, most worryingly, a car of chlorine. Not long after the derailment, a massive propane explosion occurred, followed by two other propane explosions within 25 minutes. As a result of serious concerns about the threat posed by the chlorine, a large-scale evacuation was ordered. This was no small undertaking. Missasauga is one of Canada's biggest suburban cities, and in all, 217,000 people were evacuated. This included not only residences and businesses, but also a range of institutions and facilities such as major hospitals (Scanlon 1989).

Economic Effects

The economic effects of toxic emergencies can be considerable. Contamination, or even the *perception* of contamination, can seriously damage industries such as farming, fishing and tourism, resulting in unemployment and loss of financial security. As was evident from the Bellingham case study, property values can decrease in the aftermath of an incident. In addition, response operations after hazardous materials emergencies can also be costly. The Dunsmuir train derailment again provides a useful illustration. The accident spilled approximately 18,000 gallons of metam sodium into the Upper Sacramento River. The pesticide was carried downstream for 40 miles, killing fish and aquatic life and contaminating vegetation. State and local expenses related to the July 1991 train derailment and pesticide spill exceeded $1.4 million. Meanwhile, other expenses (i.e., clean-up, medical, economic, etc.) came to over $2 million (Committee on Government Operations 1992).

Psychological Impacts

Less apparent than the immediate disruption and economic effects – but potentially more problematic and complex to address – are the psychological effects of accidents involving hazardous materials. Disaster specialist James Thompson (1990) suggests that, in terms of chronic effects, the number of people psychologically affected by a chemical accident can far exceed the immediate casualty list. "From some of the data we have on chemical and 'contamination' incidents, it might well be that the psychological impact rate is about one order of magnitude higher."

Baum and other researchers have argued that technological disasters are more likely to produce chronic, widespread psychosocial sequelae than natural disasters (Baum, *et al*. 1983a; Baum 1987; Baum, *et al*. 1983b; Weisaeth 1994). Just why this should be the case relates to the particular nature of technological accidents, particularly those involving hazardous materials. Natural disasters like a tornado have a low point, after which things can be expected to get better. Damage is visible and can be assessed, after which people may begin a process of recovery. In disasters involving possible exposure to toxic agents, however, there is no clear low point for those who may have been affected. There is usually considerable uncertainty about the consequences of exposure. Medical knowledge is frequently limited, and both contaminants and their resulting damage may be invisible. Further, potential long-term health consequences (e.g., cancer) may take years or even decades to develop. Thus it is not clear to people whether the worst is over or whether the worst is yet to come (Baum, *et al*. 1983a).

"In a sense," Baum (1987) explains, "this pattern of influence extends the duration of victimization." Rather than being struck and then having a chance to recover, as in the case of a flood, the threat here is viewed as a chronic and continuing one. "One does not know when the impact of what happened is really going to hit" (Reko 1984a). People wonder whether they have been contaminated, and they worry about their health and the health of loved ones (especially children). Even when an accident is officially declared "over," it is, in an important sense, not really over for those who may have been exposed (Erikson 1995). The "point of worst impact may not pass with the event. Perceived threats may continue indefinitely" (Baum, *et al*. 1983b)

As Ursano, *et al*. (1994) wrote, contamination incidents "produce long-term anticipatory stress of the possible, the probable and the imagined risks to health and family." At the same time, in the face of the medical uncertainty, the necessity of relying on expert assessments, and the invisibility of contaminants, people often feel a continuing sense of vulnerability and powerlessness. They cannot be certain what is going on, nor can they do anything to protect themselves (Brown and Mikkelsen 1990; Aaronen and Mikkeslsen 1993). Victims of chemical or radiological accidents, then, often live in what Erikson characterizes as a "permanent state of alarm and anxiety." Beyond whatever possible toxicological or other health effects people may experience in the aftermath of a chemical accident, the unremitting tension and profound apprehension about the future can take its own considerable toll on health and well-being (Erikson 1993).

Another characteristic of technological accidents that has psychosocial implications concerns the matter of responsibility and blame. Erikson (1995), employing the analytic comparison with natural disasters, said the following.

“Natural disasters are almost always experienced as acts of God or caprices of nature. They happen to us. They visit us, as if from afar. Technological disasters, however, being of human manufacture, are at least in principle preventable, so there is always a story to be told about them, always a moral to be drawn from them, always a share of blame to be assigned.”

In the aftermath of technological disasters, people want to know why technology under human control has failed, why suffering that could have been avoided has not been. Thus, rather than ultimately producing resignation or acceptance, human-caused disasters generate mistrust, anger, fear and outrage. Erikson (1995) noted:

> “[P]eople who are victimized by such events feel a special measure of distress
>
> when they come to think that their affliction was caused by other human beings.
>
> And that sense of injury becomes all the sharper and more damaging when those
>
> other human beings respond to the crisis with what is seen as indifference or
>
> denial.”

Human-made disasters, argued Weisaeth (1994), “frequently cause withdrawal and social isolation.” Indeed, the more clearly people perceive a human cause behind a disaster, the more distressing and potentially pathogenic the situation seems to be (Weisaeth 1994; Brown and Mikkelsen 1990). As Vyner (1988) wrote, accidents involving hazardous materials can be highly traumatic. “All evidence indicates that adapting to an invisible exposure is a toxic process. It is a process that can severely traumatize the exposed persons and change their lives for the worse.”

Various examples of the psychological impacts of transportation accidents involving hazardous materials may be found in the scientific literature. One example is provided by the March 1989 Exxon Valdez oil spill. The accident, in which a tanker ran aground on a reef, spilled 258,000 barrels of crude oil into Alaska’s Prince William Sound (Davis 1996). A follow-up study conducted a year after the accident (Palinkas, *et al*. 1993) found a significant relationship between exposure to the spill and the prevalence of psychiatric disorders. Problems included increased (post-spill) rates of generalized anxiety disorder, post-traumatic stress disorder, and depression. Forty-three percent of people in the “high exposed” groups were reported to have experienced one or more such problems.

Studies of other transportation-related accidents have also identified various psychological sequelae. Bowler, *et al*. (1994a) conducted follow-up research after the July 1991 freight train derailment at Dunsmuir. Researchers found a wide range of psychological, psychosocial, and psychophysiological effects in people from the affected area. In comparison with controls, the exposed group experienced higher blood pressure and more sleep disorders, headaches, visual problems, skin rashes, gastrointestinal symptoms, cardiac/respiratory symptoms, anxiety symptoms and depression symptoms.

An analysis by Gill and Picou (1998) of a 1982 train derailment in Livingston, Louisiana, provides further evidence of psychological effects after a hazardous materials transportation incident. The accident caused 43 cars to derail, including 36 cars containing hazardous materials. Most of these leaked, burned or exploded, forcing the evacuation of approximately 2,500 people for up to 17 days. Despite the fact that there were no deaths or serious injuries, and although property destruction was limited, the level of event-related psychological stress was significant. According to the researchers, this was clearly evident on the Impact of Events (IES) Scale, which is used to measure "stress arising from traumatic events that are generally outside the range of human experience" (Gill and Picou 1998). On the "Intrusive Stress" subscale, which measures "recurring, unbidden, and distressing thoughts and feelings," the mean among Livingston residents was 13.7. In the words of Gill and Picou (1998), "the mean levels of intrusive stress observed for... Livingston (13.7)... were comparable with that experienced by clinical patients 6 months after therapy for bereavement resulting from the death of a parent (13.8)...."

Studies also suggest that some groups may be especially at risk for psychological effects after contamination incidents. For example, work carried after the 1989 Exxon Valdez oil spill (Palinkas, *et al*. 1993; Picou, *et al*. 1992) identified several groups as being among those who were particularly hard hit. In the words of Palinkas, *et al*. (1993):

"Younger age groups, women, and Alaskan Native residents of these communities appear to have been especially vulnerable to these negative impacts as evidenced by higher rates of psychiatric disorders."

In addition, other research has called attention to the mental health impacts of chemical contamination episodes on children (Breton, *et al*. 1993).

Social Impacts

Just as hazardous materials accidents can have substantial and long-lasting mental health effects, they can leave profound social impacts in their wake. One such impact that is frequently experienced is social division (Edelstein and Wandersman 1987; Kroll-Smith and Couch 1993; Couch and Kroll-Smith 1985). Here again, the contrast with natural disasters is useful. In the post-impact phase of natural disasters, people typically pull together to overcome a common problem and get things back to normal. In the context of a sense of "common suffering and altruistic concern," a kind of therapeutic community emerges, providing an ambience of camaraderie, solidarity, unity of purpose, and mutual support (Cuthbertson and Nigg 1987).

In the case of chemical and radiological accidents, however, this is often not the case. More than anything else, contamination situations are characterized by haziness and ambiguity. Hazardous agents are often invisible, so there is great uncertainty as to which areas have been exposed and who has been affected. The uneven spread of contaminants frequently means that people who live near each other, even on the same street, can have vastly different experiences of the incident and resulting problems. People's assessments of the degree of risk posed by the contamination may differ enormously, and their views as to what should be done may clash as well (Cuthbertson and Nigg 1987; Kroll-Smith and Couch 1993). The matter of assigning blame for the accident can be a source of disagreement as well.

With high-stakes issues involved (e.g. health, children's well-being, property values), such differing definitions of the situation can produce hostility, factionalism and fragmentation. Environmental accident situations "produce increased conflict and deleterious long-term strain on community structures...." (Couch and Kroll-Smith 1985). They have the capacity to damage the very fiber of a community, to be, in a sense, what Taylor (1986 and 1989) calls "sociotic." Rather than producing consensus and a therapeutic community, they tend to create the exact opposite: social division and a dissensus community (Edelstein and Wandersman 1987). Such social division can impair the social support network that people normally rely upon in time of crisis.

Evidence of social conflict has been found in various studies of communities affected by transportation accidents. In the aftermath of the Exxon Valdez oil spill, for example, researchers noted conflicts among friends and family members, arguments between community members and outsiders, divisiveness over whether or not to work for Exxon as part of the cleanup, and friction over compensation issues (Palinkas, *et al*. 1993).

Studies have also identified various social impacts after hazardous-materials train derailments. In the aftermath of the Dunsmuir accident, Bowler, *et al*. (1994a) noted the presence of a split in the community. In addition, the researchers found that on the Perceived Social Support Scale, there was a significant difference between people in the exposed group and matched controls. The Perceived Social Support Scale measures an individual's perception of the extent to which he or she has access to emotional support systems. According to Bowler, *et al*. (1994b), in the aftermath of the accident, spill residents “had significantly ... lower perceived social support than their matched controls.”

Another important social impact is stigma, which is also common after environmental accident situations. Residents of affected communities may be seen by others as “tainted” and as “people to be avoided.” (Edelstein 1988; Kroll-Smith and Couch 1993) The point is well illustrated by the words of a local councilwoman from Triana, a small North Alabama town that was contaminated with DDT. “Once you are branded a contaminated person, you are a contaminated person. You are branded everywhere you go. That’s our schoolchildren. That’s everybody” (*Birmingham Post-Herald*, November 1, 1997).

Social stigma can be powerful and pervasive. Following a radiological contamination incident in Goiania, Brazil, people from the city found themselves the focus of fears and the target of discrimination. As Kasperson and Kasperson (1996) have noted: “Hotels in other parts of Brazil refused to allow Goiania residents to register. Some airline pilots refused to fly airplanes that had Goiania residents aboard. Cars with Goias license plates were stoned in other parts of Brazil.”

Community division and stigma are not the only important social impacts of hazardous-materials accidents. Other effects include chronic loss of trust (Levine 1982 and 1983) and impairment of the pattern of community life due to destruction of natural resources (Dyer, *et al*. 1992). In addition, the experience of a contamination episode can powerfully alter people’s view of their place of residence. As Gill and Picou (1998) commented:

“When communities experience a technological disaster, one response is to contemplate leaving one’s place of residence. Contamination and subsequent uncertainty regarding exposure, long-term environmental damage, and the alteration of a lifescape reduce the quality of life in contaminated communities.”

This point was apparent in research carried out after the Livingston train derailment. Whereas only 28 percent of people in a control community expressed a desire to move, for Livingston the figure was 48 percent. Even more strikingly, whereas only 1 percent of those in the control community indicated that they *expected* to move, the figure for Livingston was 14 percent (Gill and Picou 1998).

Finally, sometimes the effects of a hazardous materials accident are so widespread that they tear apart a community. The contamination and resulting evacuation of a small Missouri town in 1983 is one of the best-known examples of an environmental accident producing what Erikson (1976) terms “loss of communality.” When Times Beach was found to be heavily contaminated with dioxin from tainted waste oil that had been applied to area roads, officials evacuated the town’s 2,240 residents, erected a security fence to keep anyone from entering the area, and officially closed the town. The evacuation tore apart the tight-knit community bonds upon which people had relied in the past. Further, once former residents had been scattered through relocation, they were unable to find each other, since privacy laws prevented government officials from sharing their lists of new addresses with victims. Therefore, even as the frightening reality of dioxin contamination was still settling in, victims “lost their sense of place and identity as the social fabric of the community disintegrated” (Reko 1984a).

In summary, hazardous-materials accidents can produce a wide range of damaging community impacts. This complex constellation of economic, psychological and social effects can harm individuals, families and entire neighborhoods. Given the severe psychosocial damage that such accidents can cause, Baum (1987) has argued that these events can be thought of as disasters regardless of how controversies about biological impacts are resolved. Such “human-made accidents involving toxic substances are disasters, whether or not the amount of toxic exposure involved can be proven to be dangerous to health.”

Strengthening Preparedness and Response Capabilities

It is clear from the previous discussion that social, psychological and other community impacts are among the most significant consequences of major transportation-related hazardous materials accidents. At the present time, however, states and localities across the U.S. are only beginning to recognize such issues and fully integrate them into preparedness and response mechanisms. For example, response plans and protocols rarely devote adequate attention to the psychosocial effects of contamination incidents. When psychosocial content is included, it is usually limited to *generic* information about disasters, debriefing, and mental health. Plans rarely include *specific* information about contamination incidents and the complex psychosocial challenges, immediate and longer term, that they pose. Thus, guidance related to the specific challenges posed by hazardous materials accidents – fears associated with invisible agents, the stress of being in a potentially-contaminated environment, the problem of social stigma – is generally absent. This is particularly true with regard to social impacts and longer-term psychological effects. So, even though a great deal is now known about the psychosocial challenges posed by environmental contamination situations, current plans for managing such disasters usually do not reflect this knowledge.

The same is true with regard to training. The emergency management community is now quite good at practicing various technical aspects of hazardous materials accident management. Likewise, health care professionals are becoming quite adept at creating exercises to improve the medical response to a contamination incident. These efforts are vital. Unfortunately, however, social and psychological issues are not generally incorporated in a way that fully reflects their importance in actual large-scale hazardous materials accidents. Again, this is particularly true with respect to social impacts and longer-term psychological effects.

Thus, it will be important in the coming years to better incorporate social and psychological considerations into preparedness and response mechanisms for dealing with hazardous materials transportation accidents. Given what is now known about such accidents, it would be useful for such mechanisms to include not only immediate response issues but longer-term effects as well. In addition, it would be valuable for training exercises to include more attention to psychosocial issues and more realistic social-behavioral assumptions.

Based on experience from past accidents, it is evident that social stigma is a serious problem after chemical and radiological accidents. It is a problem in and of itself, and it also complicates efforts to deliver services and rehabilitate communities. It would be beneficial, therefore, for strategies to prevent and mitigate stigma to be developed and integrated into large-scale contamination incident plans. Likewise, strategies to mitigate other social impacts (e.g., social division) would be useful.

In addition, there is a need for special materials and interventions for high-risk populations. In natural disaster situations, there are coloring books for children that help them to understand what has happened. Few such materials are available for chemical and radiological accidents. Clearly, the development of appropriate materials, as well as tailored interventions for high-risk populations, should be a priority, too.

Finally, there is the issue of information. In considering ways to reduce the community impacts of major hazardous materials transport accidents, information stands out as a crucial factor. Research suggests that an early lack of accurate information can contribute to both anger and fear (Bowler, *et al*. 1994a). Such a situation may increase long-term psychological morbidity, undermine trust, and damage public confidence, all greatly hindering individual and community recovery after a major accident.

In an analysis of the Dunsmuir train derailment, for example, Bowler, *et al*. (1994b) concluded that the inability of authorities to provide residents with accurate and early information on the possible adverse health effects of the spilled chemical (metam sodium) "was reported overwhelmingly as a contributing cause of fears and worries." According to the researchers, "this early lack of information contributed to a lingering anger at the authorities and heightened fear of future illness."

If information is a vital factor in reducing community impacts after a hazardous-materials accident, it is also crucial beforehand as well. Long before an accident occurs, members of the public need to be aware of the particular hazards in their community and of how to respond in an emergency situation. Furthermore, prior familiarity with, and understanding of, hazards may also help to reduce psychological morbidity should a major accident actually occur.

At the present time, mechanisms for *post-accident* communication are relatively well established. Public safety, emergency management, environmental, public health and other officials have amassed considerable experience with television, radio and other means of information transmission that would be utilized after a major transportation-related accident. However, in Alabama, there are still potential problems with post-accident communication during the immediate-response phase. One comment made by the Department of Public Safety was that the use of several different communications systems within the Department often prevented direct contact among personnel with incompatible equipment. In terms of *pre-accident* communication, the picture is more mixed. Unfortunately, at the present time, only a small number of local emergency planning committees in Alabama have the resources they need to communicate with the public on a regular basis. For example, Title III (Emergency Planning and Community Right-to-Know) newsletters are rare. Likewise, only a few LEPCs in the state have websites.

While a number of Alabama LEPCs are making valiant efforts, LEPC communication activities are clearly hampered by a lack of funding. A comprehensive analysis prepared by the National Governors' Association found that in contrast to many other states, the State of Alabama provides no funding for LEPC activities (Finegold 1997). The lack of resources for newsletters, and especially for websites, means that pre-accident communication with the public remains limited. As part of overall efforts to improve preparedness for major transportation accidents involving hazardous materials, it would be advantageous for funds to be allocated to Alabama's local emergency planning committees.

Internet Sources of Information

The federal Office of Pipeline Safety

http://ops.dot.gov

The National Transportation Safety Board (NTSB)

http://www.ntsb.gov

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