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Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances

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Accidents involving chemicals or radioactive materials represent a significant threat to the environment, public health and safety, and community well-being. In an increasingly complex and interconnected world, no community is immune from the threat posed by environmental accidents and contamination. Even communities far removed from industrial production or storage facilities can still be at risk from accidents associated with the transport of hazardous materials. While a variety of studies have been conducted on aspects of major transportation accidents, few have attempted to examine both environmental and community aspects of the problem. In contrast, this report takes an integrated approach to hazardous transportation accidents by considering environmental, safety, economic, and psychosocial issues. The purpose of the project is to (1) quantify transportation-related accidents involving hazardous materials in the state, and (2) identify key longer-term environmental health, public safety, and social impacts that are often overlooked after major transportation-related hazardous materials accidents.</td></tr>
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Executive Summary

Accidents involving chemicals or radioactive materials represent a significant threat to the environment, public health and safety, and community well-being. In an increasingly complex and interconnected world, no community is immune from the threat posed by environmental accidents and contamination. Even communities far removed from industrial production or storage facilities can still be at risk from accidents associated with the transport of hazardous materials. While a variety of studies have been conducted on aspects of major transportation accidents, few have attempted to examine both environmental and community aspects of the problem. In contrast, this report takes an integrated approach to hazardous transportation accidents by considering environmental, safety, economic, and psychosocial issues. The purpose of the project is to (1) quantify transportation-related accidents involving hazardous materials in the state, and (2) identify key longer-term environmental health, public safety, and social impacts that are often overlooked after major transportation-related hazardous materials accidents.

The project had four main tasks: consultation with key stakeholders; summary and analysis of representative transportation-related accidents involving hazardous materials that have occurred in Alabama since 1990; presentation of simplified chemical transport and fate models; and presentation of information for anticipating important social, psychological and related community impacts that can occur after transportation-related hazardous materials accidents.

Three case studies of transportation accidents involving hazardous materials are presented. The first, which took place near Dunsmuir, CA 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 is of a massive gasoline pipeline break and resulting explosion that occurred in 1999 in Bellingham, WA. All three of these case studies present extensive discussions of community impacts, along with descriptions of the physical problems that occurred during the accidents.

Alabama hazardous material transportation-related accident information has been collected and analyzed using data from the National Response Center. The purpose of this task was to identify the most common hazardous materials lost, where the accidents occurred, and which medium (water, land, air) was affected. This information was used to present procedures that can be used to predict the movement and dispersion of the lost material. More than 1,700 transportation-related accidents involving hazardous materials occurred in Alabama during the past ten years, involving a large variety of different materials. The petroleum hydrocarbons were the most common hazardous material lost. Of the 226 reported accidents in 1998, there were 20 deaths and 27 injuries. In addition, four accidents caused property damage, two accidents resulted in evacuations, and nine accidents resulted in road closures. During the 1990s, the locations with the most frequent spills were the historical *USS Alabama* Battleship museum site and the hazardous waste landfill at Emelle, probably due to diligent reporting by the site operators. Additional locations of frequent spills include several sites where chemicals are transferred from marine craft to land vehicles, such as trains and trucks.

The report presents several procedures to predict the fate and transport of spilled hazardous materials. The initial discussion is a general procedure that stresses downwind toxic and explosive hazards, summarized from a recent EPA manual, and is applicable for a wide range of hazardous materials. Two examples are also presented describing problems associated with spills of petroleum hydrocarbons (the most common material involved in Alabama transportation accidents) and losses of ammonia (a toxic gas).

Major transportation accidents involving hazardous materials have been shown to produce profound economic, social, and psychological impacts in affected communities. These impacts can be both widespread and long lasting. The Bellingham pipeline explosion is used to illustrate some of these effects. The case study is then followed by a more general discussion of the economic, social, and psychological effects of hazardous transportation accidents. Current scientific research is reviewed, examples are provided, and implications are considered.

Recommendations and conclusions are presented to illustrate the types of community impacts that can occur and steps that can be taken to enhance preparedness and response capabilities. The report also contains extensive appendices that present detailed information of Alabama accidents for the past ten years, and properties of hazardous materials that are needed for the calculation of expected exposure conditions.

"Workers transfer drums of hazardous material from the overturned truck into a van" (July 24, 1998).
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Section 1. Introduction

Project Rationale

Accidents involving chemicals or radioactive materials represent a significant threat to the environment, public health and safety, and community well-being. In an increasingly complex and interconnected world, no community is immune from the threat posed by environmental accidents and contamination. Even communities far removed from industrial production or storage facilities can still be at risk from accidents associated with the transport of hazardous materials. In the U.S., a staggering 4 billion tons of hazardous materials are moved each year via highways, railroads and other transportation routes (Lillibridge 1997; Quarantelli 1993).

Fortunately, the majority of transportation accidents involving hazardous materials are small and relatively easily managed. However, when major transportation accidents involving hazardous materials do occur, serious environmental health, safety and social problems can result. Indeed, depending on the nature and circumstances of an accident, some impacts can be both widespread and long-lasting.

While a variety of studies have been conducted on aspects of major transportation accidents, few have attempted to examine both environmental and community aspects of the problem. In contrast, this report takes an integrated approach to hazardous transportation accidents by considering environmental, safety, economic, and psychosocial issues. The approach combines the insights and experience of several disciplines, including civil and environmental engineering, public health, and social and behavioral science.

Rather than addressing the already well-explored topic of immediate emergency response and cleanup activities, this project deals with issues specifically related to contingency planning and post-emergency response. Therefore, this project focuses on the medium and longer-term impacts of transportation-related accidents involving hazardous materials. More specifically, the purpose of the project is to (1) quantify transportation-related accidents involving hazardous materials in Alabama, and (2) identify key longer-term environmental health, public safety, and social impacts that are often overlooked after major transportation-related hazardous materials accidents.

The project addresses the University Transportation Center for Alabama's (UTCA) priority on safety issues. Furthermore, the high priority topic of technology transfer is also addressed because an upper division/graduate class is being developed on environmental modeling for contingency planning utilizing the material presented in this research report. This class will be one of four graduate-level classes related to disaster management at UAB. The others are Natural Disaster Policy, Complex Disasters (in the School of Public Health) and an interdisciplinary course on Environmental Disasters (Becker 2000). In addition, information from this report will also be used in Environmental Management classes at UAB. Finally, material from the project can also be presented in a condensed format as a short course as part of other technology transfer projects funded by UTCA.

Methodology

The project was comprised of four main tasks: consultation with key stakeholders; summary and analysis of representative transportation-related accidents involving hazardous materials that have occurred in Alabama since 1990; presentation of simplified chemical transport and fate models; and presentation of information to identify and mitigate potential long-term adverse community impacts.

Stakeholder Meetings: Formal stakeholder meetings were held with staff from a variety of agencies and organizations that have a role to play planning for, or responding to, accidental hazardous releases. This included the Alabama Department of Transportation, the Alabama Department of Environmental Management, the Alabama Department of Public Safety, and others. In addition, informal discussions were held with personnel from the Alabama Department of Public Health, the Red Cross, and local emergency responders. Information from the stakeholder meetings was used to identify issues needing coverage in the report.

Diversity, Frequency, and Magnitude of Transportation Accidents Involving Hazardous Materials: For this task, the reported transportation-related accidents involving hazardous materials in Alabama were quantified and described. The primary source of information was the National Response Center's (NRC) nation-wide database on oil and hazardous materials spills. From this database, all transportation accident information for Alabama since 1990 was summarized. Data analyses were conducted to measure frequency of accidents by severity (volume of chemical spilled and number of accidents involving a particular chemical) and by location. Public records of several newspapers in the state were also reviewed (especially the *Birmingham News* and *Post Herald*, the *Huntsville Times*, the *Anniston Star*, the *Mobile Register*, the *Montgomery Advertiser*, plus the Gadsden and Dothan newspapers) to compile case histories of several representative transportation-related accidents. However, because many of these accidents were only reported in one issue of the paper, a complete case study for Alabama was only prepared for one transportation-related accident, the acrylonitrile spill on Interstate 65 in 1994. Additional case studies were also prepared for several notable national and international transportation accidents (a gasoline pipeline explosion in Bellingham, Washington; and a train derailment in Dunsmuir, California). These accidents were examined to provide additional information about local response scenarios and potential long-term social impacts of major transportation-related accidents that involved hazardous materials.

Simplified Chemical Transport and Fate Models: Hazardous materials that may be involved in transportation-related accidents are highly varied in their characteristics and potential amounts that may be lost during an accident. In addition, site conditions where an accident occurs can have significant effects on the behavior of the released materials. The results of the database analysis were used to determine the categories of potentially problem-causing chemicals frequently spilled in the state (such as petroleum hydrocarbons, ammonia, and chlorine).

Transport and fate estimation procedures for several classes of chemical compounds, using methods given by EPA (1999), Thomann and Mueller (1987), and Turner (1993) were used to produce generic (and some specific) exposure procedures in this report. This approach has frequently been used during the preparation of contingency plans (as required for the Coast Guard National Response Center and Federal Regional Contingency Plan regulations) for complex chemical facilities where numerous chemicals may be involved. In fact, several examples taken from oil spill and ammonia contingency plans and environmental impact reports, are included as case studies. These general procedures, in addition to the specific procedures for petroleum hydrocarbons and ammonia, should cover the majority of accident conditions that would be predicted in the state (based on past accident reports).

The steps involved in predicting potential exposures to hazardous materials involved in transportation-related accidents are generally as follows:

1. Identify materials lost, location (land or water), amount lost, and loss rate (and volume).
2. Predict likely combinations of materials that may be involved in individual accidents that may increase the seriousness of the incident.
3. Predict the fate of the spilled material (air or water media)
4. Estimate downwind atmospheric and downstream water concentrations.

Identification of Potential Longer-Term Community Impacts of Major Transportation Accidents: Firefighters, police officers and other first responders have accumulated considerable experience in identifying and managing the *immediate* effects of transportation-related hazardous material incidents. Established protocols are in use, and training is conducted on a regular basis. However, because there is far less experience dealing with *longer-term impacts*, these effects can easily be overlooked. The project's fourth task, therefore, was to provide information to help anticipate important social, psychological and related community impacts that can occur after major transportation-related hazardous materials accidents. To do so, this report drew upon information from the three above-noted tasks, plus recent social science and public health studies. The two-fold aim was to enhance university-based training related to transportation accidents in the state and contribute to the state's planning, preparedness and response process.

Section 2. Transportation Accidents Involving Hazardous Materials: Two Case Studies

In this section, two 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.

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. (as discussed in Section Five.)

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 2-1. “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*).

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.

Section 3. Analysis of Transportation-Related Chemical Spill Data for Alabama

This section summarizes the information collected and analyzed from the National Response Center involving transportation-related accidents occurring in Alabama. The purpose of this task was to identify the most common hazardous materials lost, where the accidents occurred, and which medium (land, air water) was affected. This information was used to select materials for study in Section 4, which describes methodologies that can be used to predict the movement and dispersion of the lost material. This database includes all spills and accidents reported to local authorities and to the Coast Guard. It therefore incorporates many accidents that are of no interest to this project (such as sewage overflows and offshore marine operations). This project task included the following activities: separating the Alabama records from those of the rest of the nation, purging reports of non-applicable events, sorting by transportation mode and location, sorting by material type, and sorting by volume of material lost.

Major features of the state's transportation network include the following:

- five major interstate highways and an extensive network of surface highways,
- the second longest inland waterway system in the nation and a deep-water port that is the nation's 12th busiest,
- five Class I railroads,
- eight commercial airports and 91 general aviation facilities,
- almost 95,000 miles of roadways with motorists traveling approximately 50 billion miles on them every year,
- the Port of Mobile which serves 1,100 vessels annually, generating 66,000 truck movements and 119,000 train movements to and from the facility, and
- over 5,200 miles of railroad track mileage in Alabama, with Birmingham being a major Southeastern hub.

With the large amount of transportation activity in the state, it is not surprising that more than 1,700 transportation-related accidents involving hazardous materials occurred in Alabama during the past ten years. These accidents have involved a large number of different materials, with petroleum hydrocarbon compounds being the most frequently lost hazardous material.

Methodology

This phase consisted of collecting information on hazardous-materials-related transportation accidents in Alabama from the databases available from the National Response Center (NRC). The NRC's "primary function is to serve as the national point of contact for reporting all oil, chemical, radiological, biological, and etiological discharges into the environment anywhere in the United States and its territories" (http://www.nrc.uscg.mil/nrcback.html, December 20, 2000). The NRC forwards these reports to the appropriate federal agencies, including the Department of Transportation, the Department of the Interior, the Department of Defense, the Department of Health and Human Services, the Federal Emergency Management Agency, the Environmental Protection Agency, the Nuclear Regulatory Commission, and the Federal Railroad Administration. The NRC is operated by the U.S. Coast Guard as part of the National Oil and Hazardous Substances Pollution Contingency Plan. Although the main intention of this database is to record losses of hazardous materials, many other materials have also been reported and included in the database by local law enforcement officials, environmental regulators, and shipping companies.

The database maintained by the NRC is accessible through the website http://www.nrc.uscg.mil/. At the time of the this project, the databases covered the years 1990 through 1999. The NRC makes the information available in four files per calendar year. The first file describes the incident itself; the second, a description of the material(s) involved; the third, information on any trains involved in the incident; and the fourth, information on any derailed railroad cars. For this project, the four files for each year were combined, using the NRC Incident Report Number, into a single spreadsheet for all accidents that occurred in the state of Alabama during the years of interest. These spreadsheets were then culled for transportation-related incidents, and finally combined into one spreadsheet that describes the incidents reported for the decade of interest. This spreadsheet is presented in Appendix A of this report.

Results

Table 3-1 shows some of the hazardous materials that have been lost during transportation-related accidents in Alabama from 1990 – 1999. By far, the most common (and the largest) materials spilled are petroleum oils and fuels (fuel oil, crude oil, kerosene, gasoline and diesel fuel). Ammonia spills were also common. Spills of numerous other toxicants and hazardous materials were also reported. Table 3-2 lists the locations of the 226 reported 1998 Alabama transportation-related accidents and the media directly affected. Of course, many of the land-based accidents affected other media through evaporation (to air) and runoff (to water). In the past 10 years, more than 1,700 transportation-related accidents have occurred in Alabama involving hazardous materials.

Table 3-1. Partial List of Materials Reported Spilled During Recent Alabama Transportation-Related Accidents

Ammonium Hydroxide	Ammonia, Anhydrous	Ammonium Nitrate Solution	Arsenic	Butadiene	Chlorine	Caustic Soda Solution	Ethylene Glycol
Gasoline	Hydrogen Peroxide	Kerosene	Methyl Mercaptan	Yellow Paint	Asbestos	Mercury	Lindane
Sewage	Oil: Diesel	Oil, Fuel: No. 5	Hydraulic Oil	Oil: Crude	Oil, Fuel: No. 2-D	Oil, Transformer	Refrigerant Gases
Sulfuric Acid	Sulfur Dioxide	Sodium Hydroxide	Sulfur Oxide	Triethylene Glycol	Toluene	Turpentine	P-Xylene

Table 3-2. Locations of Reported 1998 Alabama Transportation-Related Accidents

Location and Media Directly Affected	Percentage of 1998 Alabama Transportation-Related Accidents
Highways	27
Railroads	30
Pipelines	1
Marine terminals	43
Land	33
Water	52
Air	2
Unknown	14

The reported 1998 Alabama transportation-related accidents also resulted in immediate problems to people and property, and disruptions to the transportation systems. Of the 226 reported accidents in 1998, there were 20 deaths and 27 injuries. In addition, four accidents caused property damage, two accidents resulted in evacuations, and nine accidents resulted in road closures. However, longer-term problems are not addressed by these accident statistics.

Of special interest to this project was the frequency of accidents, the quantity of the different materials spilled, the hazards of the spilled chemicals, and the accident locations. The spreadsheets generated in this part of the project (Appendix A) are organized according to the format of the NRC reports. This information includes the following:

- date and time of the accident,
- the location of the incident,
- the suspected responsible party (including contact information),
- the cause of the accident,
- a description of the accident
- a description of the environmental medium affected,
- numbers of deaths, injuries and evacuation,
- a description (including volumes) of the chemicals spilled, and
- information on any train cars that derailed in the accident.

In some cases, the volume of chemical spilled was not known at the time of the report. The NRC information lists this lack of information as a “0” volume under the “Quantity Spilled” column. When conducting the additional analyses of the database, these ‘potentially-unknown’ quantities were retained, as these accidents, especially those involving petroleum products, are a significant fraction of the number of transportation-related accidents in Alabama. The information that was not retained in the additional analyses were the oil-sheen entries because the volume of oil spilled was obviously small.

Table 3-3 is a summary of the largest quantities of hazardous material lost for each mode of transportation considered. The accidents listed as occurring at “fixed” locations are generally loading operations and are not associated with building or storage tank disasters. The marine operations include shipping accidents and leaks, and underwater pipeline leaks and breaks that occurred on inland waterways. The off-shore locations are mostly associated with accidents at drilling and well platforms. These data clearly show that the most frequently spilled chemicals in

Alabama are the petroleum products. In addition to these, ethylene glycol (antifreeze) is also commonly lost to the environment. This would be expected in an accident in which the radiator and/or engine of a vehicle is damaged. These data also emphasize the variety of transportation modes (marine, highway, etc.) where these spills occur. Many different hazardous substances can be lost during transportation accidents, in addition to the most common oil and fuel spills. Fortunately, many of the most hazardous substances were associated with only one or a very few incidents in the ten years of study, and only relatively small quantities of material were lost. Highly-hazardous ammonium nitrate, ammonia, molten aluminum, sodium hydroxide, and different acids were all released to the environment in Alabama during their transport during the period of study.

Table 3-3. Largest Spill Quantities Lost for each Major Transportation Mode Examined (1990 – 1999 Alabama Transportation Accidents)

Transportation Mode	Most Common (by volume lost)	2nd Ranked	3rd Ranked	4th Ranked
Aircraft accidents	Jet fuel (1330 gals/13 incidents)	Malathion (404 gals/13 incidents)		
Fixed locations	Hydrocarbons (fuel oil, gasoline, crude oil, diesel oil, hydraulic oil, kerosene, asphalt, transformer oil, and creosote) (82,901 gals/250 incidents)	Chromic acid/phosphoric acid (24,000 gal/1 incident)	Coal (12,000 lbs/1 incident)	Sodium hydroxide (5,000 lbs/2 incidents)
Highway accidents	Hydrocarbons (diesel oil, road tar, gasoline, fuel oil, asphalt, LPG, jet fuel, hydraulic oil, and creosote) (184,281 gals/225 incidents)	Poultry fat (49,720 lbs/2 incidents)	Ammonium nitrate and fuel oil (30,000 lbs/1 incident)	Molten aluminum (20,000 lbs/1 incident)
Marine operations	Hydrocarbons (crude oil, diesel oil, fuel oil, asphalt, motor oil, lubricating oil, waste oil, hydraulic oil, gasoline, jet fuel, and lubricating mud) (2,024,569 gals/584 incidents)	Sodium hydroxide (1,000 lbs/1 incident)	Bromine (900 lbs/1 incident)	Adiponitrile (640 lbs/1 incident)
Off-shore locations	Hydrocarbons (lubricating mud, drilling mud, diesel oil, hydraulic oil, crude oil, motor oil, fuel oil) (1188 gals/62 incidents)			
Pipelines	Hydrocarbons (fuel oil, crude oil, diesel oil, and gasoline) (14,166 gals/26 incidents)	Paraxylene (1,000 gals/1 incident)	Salt water (60 gals/1 incident)	Triethylene glycol (35 gals/1 incident)
Railroad and highway crossings	Hydrocarbons (diesel oil, fuel oil, and motor oil) (8,558 gals/13 incidents)	Formaldehyde solution (1 gal/1 incident)		
Railroad accidents	Coal (934,800 lbs/10 incidents)	Plastic pellets (262,500 lbs/2 incidents)	Hydrocarbons (petroleum oil, asphalt, diesel oil, creosote, lubricating oil, and hydraulic oil) (72,959 gals/108 incidents)	Limestone (3,000 lbs/2 incidents)
Unknown locations	Hydrocarbons (gasoline, fuel oil, diesel oil, hydraulic oil, and asphalt) (2,861 gals/191 incidents)	Sodium hydroxide (5 gals/1 incident)	Ethylene glycol (5 gals/1 incident)	

Tables 3-4 through 3-12 are separated by location of the accidents (highways, railroads, pipelines, etc.) and also includes information, where available, from the National Fire Protection Association (NFPA) regarding the hazards associated with the particular chemical. The hazard information is primarily available for organic chemicals. The mode of transport with the fewest overall number of accidents is the air, i.e., airplane crashes. However, large quantities of pesticides (especially malathion) was lost to the environment during 13 crashes of crop-dusting planes during this ten-year period. The largest single accident was a crude oil spill of about 2,000,000 gallons at a marine terminal (the *T/V R. Hal Dean* ran aground in the Pensagoula Ship Channel on Jan 2, 1991, releasing 2,000,000 gallons of crude oil). The largest spills are associated with marine operations (ship casualties by far being the largest), followed by highway and railroad accidents, and then pipeline accidents. For many substances, just a few accidents accounted for the majority of the spill volume.

The tables in Appendix B show the locations of the most frequent accidents. The locations with the most frequent spills are the historical *USS Alabama* Battleship museum and the hazardous waste landfill at Emelle, likely because of diligent reporting by the site operators. Additional locations of frequent spills include several sites where chemicals are transferred from marine craft to land vehicles such as trains and trucks. At many of these sites, the quantities spilled per incident are small. However, it may be anticipated that frequent spills in one area may cause longer-lasting environmental impacts.

Table 3-4. Summary of Chemicals Spilled by Transportation Mode (aircraft accidents)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
JET FUEL: JP-4	3	700	gal	3-692	gal	5	gal	1	3	0	
MALATHION	13	404	gal	9-62	gal	30	gal				
JET FUEL: JP-8	2	225	gal	25-200	gal	113	gal				
JET FUEL: JP-5 (KEROSENE, HEAVY)	4	205	gal	0-100	gal	53	gal	0	2	0	
JET FUEL	1	100	gal	100	gal	100	gal	0	2	0	
JET A FUEL	1	70	gal	70	gal	70	gal	0	2	0	
AVGAS	1	30	gal	30	gal	30	gal	1	3	0	
DIMILIN 2F	1	15	gal	15	gal	15	gal				
BRAVO	1	0	gal	0	gal	0	gal				

Table 3-5. Summary of Chemicals Spilled by Transportation Mode (“fixed” locations, usually transfer stations)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
CHROMIC ACID/PHOSPHORIC ACID	1	24000	gal	24000	gal	24000	gal	3	0	1	OX
OIL, FUEL: NO. 6	10	19363	gal	0-12000	gal	5	gal	0	2	0	
JET FUEL: JP-8	3	16075	gal	75-9000	gal	7000	gal				
OIL: CRUDE	1	15277	gal	0-12000	gal	20	gal	0	2	0	
COAL	1	12000	lbs	12000	lbs	12000	lbs				
PRODUCED WATER	1	12000	gal	12000	gal	12000	gal				
OIL: DIESEL	63	9636	gal	0-2500	gal	5	gal	0	2	0	
COAL TAR PITCH	1	8000	gal	8000	gal	8000	gal	0	1	0	
GASOLINE: AUTOMOTIVE (UNLEADED)	18	6346	gal	0-4697	gal	28	gal	1	3	0	
PARAXYLENE	1	6000	gal	6000	gal	6000	gal	2	3	0	
SODIUM HYDROXIDE	2	5000	lbs	0-5000	lbs	2600	lbs	3	0	1	
ALUMINUM SULFATE	1	4725	gal	4725	gal	4725	gal				
GASOLINE: AUTOMOTIVE (4.23 G Pb/GAL)	17	4433	gal	0-2000	gal	5	gal	1	3	0	
POTASSIUM HYDROXIDE	4	3700	gal	0-1500	gal	1100	gal	3	0	1	
WAX EMULSION	1	3568	lbs	3568	lbs	3568	lbs				
HYDROXYL AMMONIUM SULFATE SOLUTION (30%)	1	3500	gal	3500	gal	3500	gal	3	0	0	
NAPHTHA: VM & P (75% NAPHTHA)	1	3400	gal	3400	gal	3400	gal	1	3	0	
CHROMATED COPPER ARSENATE	1	3200	gal	200-3000	gal	1600	gal				
NITRIC ACID	1	3000	gal	3000	gal	3000	gal	3	0	0	OX
METHYL MERCAPTAN	4	2566	lbs	145-1510	lbs	456	lbs	4	4	0	
SULFURIC ACID	12	2119	gal	0-800	gal	8	gal	3	0	2	Water
OIL, MISC: MOTOR	28	2028	gal	0-1000	gal	0	gal	0	2	0	
INCINERATOR ASH	1	2000	lbs	2000	lbs	2000	lbs				
TENNECO T500-100	1	1500	lbs	1500	lbs	1500	lbs				
OIL, FUEL: NO. 2-D	23	1460	gal	0-400	gal	0.5	gal	0	2	0	
METHYLENE CHLORIDE	1	1391	gal	1391	gal	1391	gal	2	1	0	
HYDRAULIC OIL	33	1381	gal	0-600	gal	1	gal	0	2	0	
ETHYL ACETATE	1	1332	gal	1332	gal	1332	gal	1	3	0	

Table 3-5. Summary of Chemicals Spilled by Transportation Mode ("fixed" locations, usually transfer stations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL, FUEL: NO. 2	9	1225	gal	0-700	gal	2	gal	0	2	0	
UNKNOWN FUEL OIL	1	1000	gal	1000	gal	1000	gal	0	2	0	
WASH WATER WITH A TRACE OF OIL	1	1000	gal	1000	gal	1000	gal				
OIL, MISC: LUBRICATING	19	840	gal	0-500	gal	0.25	gal	0	2	0	
HYDROGEN SULFIDE	2	811	lbs	0-811	lbs	406	lbs	4	4	0	
WASTE SLUDGE	1	750	lbs	750	lbs	750	lbs				
KEROSENE	2	705	gal	5-700	gal	353	gal	0	2	0	
JET-A	1	400	gal	400	gal	400	gal	0	2	0	
ORTHOXYLENE	1	360	gal	0	gal	0	gal	2	3	0	
WATER BASE YELLOW INK	1	300	gal	300	gal	300	gal				
JET A FUEL	2	275	gal	100-175	gal	138	gal	0	2	0	
DIMETHYL SULFIDE	4	211	gal	0.5-146	gal	32	gal	1	4	0	
STYRENE/BUTADIENE LATEX	1	200	gal	200	gal	200	gal	2	3	2	
WATER BASED ASPHALT	1	200	gal	200	gal	200	gal				
AMMONIA, ANHYDROUS	4	200	lbs	0-200	lbs	100	lbs	3	1	0	
JET FUEL: JP-4	7	200	gal	0-100	gal	20	gal	1	3	0	
FINISH	1	170	gal	170	gal	170	gal				
OIL, MISC: TRANSFORMER	6	162	gal	0-50	gal	35	gal	0	2	0	
MIXTURE OF CRUDE OIL AND DIESEL	1	160	gal	160	gal	160	gal				
OIL, MISC: MINERAL	3	135	gal	10-125	gal	25	gal	0	2	0	
ETHANOL, 2-2-BUTOXYETHOXY	1	133	gal	133	gal	133	gal	1	2	0	
MERCAPTAN	1	120	lbs	120	lbs	120	lbs				
CREOSOTE, COAL TAR	1	100	gal	100	gal	100	gal	2	2	0	
PROPIONITRILE	1	100	lbs	100	lbs	100	lbs	4	3	1	
HAZARDOUS WASTE SOLID/NOS/F006	1	100	lbs	100	lbs	100	lbs				
PROPANOL	1	100	gal	100	gal	100	gal				
SLUDGE	1	100	gal	100	gal	100	gal				
NITRIC ACID	1	92	gal	92	gal	92	gal	3	0	0	OX

Table 3-5. Summary of Chemicals Spilled by Transportation Mode (“fixed” locations, usually transfer stations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OTHER OIL (UNKNOWN)	7	81	gal	0-80	gal	0	gal	0	2	0	
WASTE OIL	19	67	gal	0-40	gal	0	gal	0	2	0	
N-BUTYL MERCAPTAN	1	50	gal	50	gal	50	gal				
WASH WATER MIXED WITH HYDROGEN SULFITE	1	50	gal	50	gal	50	gal				
WASTE OIL/LUBRICANTS - POSS. CON	6	50	gal	0-20	gal	8	gal	0	2	0	
LEAN AMINE (CAS 105599)	1	45	gal	45	gal	45	gal				
EPOXY CURE	1	42	gal	42	gal	42	gal				
OTHER OIL (REFINERY SLUDGE)	1	40	gal	40	gal	40	gal	0	2	0	
BOILER FLY ASH	1	40	lbs	40	lbs	40	lbs				
CORROSION INHIBITOR OIL	1	40	gal	40	gal	40	gal				
CUTTERS STOCK	1	40	gal	40	gal	40	gal				
ASPHALT	2	40	gal	5-35	gal	20	gal	0	1	0	
BENZO(A)PYRENE	1	30	gal	30	gal	30	gal				
DRILLING FLUID	1	20	gal	20	gal	20	gal				
TINUVIN TARS	1	15	lbs	15	lbs	15	lbs				
ST20	1	13	gal	13	gal	13	gal				
JET FUEL: JP-5 (KEROSENE, HEAVY)	1	10	gal	10	gal	10	gal	0	2	0	
OTHER OIL(LIGHT FUEL OIL)	1	10	gal	10	gal	10	gal	0	2	0	
ROOFING TAR	1	10	gal	10	gal	10	gal	1	2	0	
NITROGEN DIOXIDE	1	10	lbs	10	lbs	10	lbs	3	0	0	OX
CACODYLIC ACID	1	10	gal	10	gal	10	gal				
CONTAMINATED GROUND WATER	1	10	gal	10	gal	10	gal				
WASTE SOLID NOS 9 AND NA3077	1	10	gal	10	gal	10	gal				
BENZENE	2	8.7	gal	0-8.7	gal	4	gal	2	3	0	
MINERAL SPIRITS	2	8	gal	0-8	gal	4	gal	0	2	0	
OIL, EDIBLE: SOYA BEAN	2	8	gal	3-5	gal	4	gal	0	1	0	
ASPHALT/DIESEL FUEL MIXTURE	1	6	gal	6	gal	6	gal	0	3	0	

Table 3-5. Summary of Chemicals Spilled by Transportation Mode (“fixed” locations, usually transfer stations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL:DIESEL (FUEL OIL NO. 5)	3	6	gal	1-5	gal	3	gal	0	2	0	
UNKNOWN OIL	34	6	gal	0-6	gal	0	gal	0	2	0	
AMMONIUM NITRATE	1	5	gal	5	gal	5	gal	0	0	3	OX
HYDRO TREATED GAS OIL	1	5	gal	5	gal	5	gal	0	2	0	
REFINED CHEMICAL OIL	1	5	gal	5	gal	5	gal	0	2	0	
FUEL WASTE	1	5	gal	5	gal	5	gal				
CHLOROFORM	1	3.2	gal	3.2	gal	3.2	gal	2	0	0	
OIL:DIESEL (BUNKER C)	1	3	gal	3	gal	3	gal	0	2	0	
D008	1	3	gal	3	gal	3	gal				
LEACHATE (F039 WASTE CODE)	1	3	gal	3	gal	3	gal				
PENTACHLOROPHENOL	2	3	gal	0-3	gal	2	gal	3	0	0	
GASOLINE: CASINGHEAD	1	2.5	gal	2.5	gal	2.5	gal	1	4	0	
CHLORINE	2	2.3	gal	0-2.3	gal	1.2	gal	4	0	0	OX
OTHER OIL, ROLLING OIL	1	2	gal	2	gal	2	gal	0	2	0	
BILGE SLOPS	1	2	gal	2	gal	2	gal				
CHEMICAL WASTE PRODUCTS	1	2	gal	2	gal	2	gal				
FO32 HAZARDOUS WASTE	1	2	gal	2	gal	2	gal				
NOS 9 MA3077	1	2	gal	2	gal	2	gal				
PROPIONIC ACID	1	2	gal	2	gal	2	gal				
ASPHALT	1	1	gal	1	gal	1	gal	0	1	0	
FEED STOCK OIL	1	1	gal	1	gal	1	gal	0	2	0	
WASTE OIL SLUDGE	1	1	gal	1	gal	1	gal	0	2	0	
M-XYLENE	1	1	gal	1	gal	1	gal	2	3	0	
XYLENE (O-, M-, P-, & MIXTURES)	1	1	gal	1	gal	1	gal	2	3	0	
CREOSOTE	1	0.94	gal	0.94	gal	0.94	gal	2	2	0	
ETHYLENE GLYCOL	16	0.83	gal	0-0.83	gal	0.05	gal	1	1	0	
NO 6 OIL WITH DIESEL MIXED IN	1	0.25	gal	0.25	gal	0.25	gal	0	2	0	

Table 3-5. Summary of Chemicals Spilled by Transportation Mode (“fixed” locations, usually transfer stations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
ASPHALT (PRIMER)	1	0	gal	0	gal	0	gal	0	1	0	
HEAT TRANSFER OIL	1	0	gal	0	gal	0	gal	0	2	0	
LUBE GREASE	1	0	gal	0	gal	0	gal	0	1	0	
MARINE DIESEL	1	0	gal	0	gal	0	gal	0	2	0	
OIL BASED PAINT	1	0	gal	0	gal	0	gal	0	2	0	
POLYPROPYLENE	1	0	gal	0	gal	0	gal	0	1	0	
TRANSMISSION FLUID	1	0	gal	0	gal	0	gal	0	2	0	
ACETONE	1	0	gal	0	gal	0	gal	1	3	0	
ANTIFREEZE	1	0	gal	0	gal	0	gal	1	1	0	
METHYL ALCOHOL	1	0	gal	0	gal	0	gal	1	3	0	
PROPANE	1	0	gal	0	gal	0	gal	1	4	0	
CAUSTIC SODA SOLUTION	1	0	gal	0	gal	0	gal	3	0	1	
SULFUR DIOXIDE	1	0	gal	0	gal	0	gal	3	0	0	
ACRYLONITRILE	1	0	gal	0	gal	0	gal	4	3	2	
ASBESTOS	1	0	gal	0	gal	0	gal				
COBALT BROMIDE (OUS)	1	0	gal	0	gal	0	gal				
CONTAMINATED SOIL	1	0	gal	0	gal	0	gal				
LATEX	1	0	gal	0	gal	0	gal				
LEAD	1	0	gal	0	gal	0	gal				
LIQUOR, BLACK	1	0	gal	0	gal	0	gal				
MALATHION	1	0	gal	0	gal	0	gal				
MATERIAL OUT OF TANK TRUCK	1	0	gal	0	gal	0	gal				
MTBE	1	0	gal	0	gal	0	gal				
PAINT REMOVER	1	0	gal	0	gal	0	gal				
PAINT THINNER	1	0	gal	0	gal	0	gal				
POISON	1	0	gal	0	gal	0	gal				

Table 3-5. Summary of Chemicals Spilled by Transportation Mode ("fixed" locations, usually transfer stations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
REFRIGERANT GASES	1	0	gal	0	gal	0	gal				
SUBSTANCE FROM INSIDE THE DYNAMITE STICK	1	0	gal	0	gal	0	gal				
TIRES	1	0	gal	0	gal	0	gal				
TIRES, ASBESTOS, PAINT CANS, ETC.	1	0	gal	0	gal	0	gal				
TIRES, SHINGLES, SHEET ROCK	1	0	gal	0	gal	0	gal				
TRANSMISSION FLUID	1	0	gal	0	gal	0	gal				
UNKNOWN MATERIAL	1	0	gal	0	gal	0	gal				
UNKNOWN TYPE CORROSIVE	1	0	gal	0	gal	0	gal				
WASH WATER	1	0	gal	0	gal	0	gal				
WASTE PAINT	1	0	gal	0	gal	0	gal				
BURNED TIRES	2	0	gal	0	gal	0	gal				
PAINT	3	0	gal	0	gal	0	gal				
BATTERY ACID	4	0	gal	0	gal	0	gal	3	0	2	Water
FREON	7	0	gal	0	gal	0	gal				

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL: DIESEL	93	88260	gal	0-78000	gal	50	gal	0	2	0	
TAR (ROAD)	1	55560	lbs	55560	lbs	55560	lbs	1	2	0	
POULTRY FAT	2	49720	lbs	0-49720	lbs	24860	lbs				
PGP	1	42000	lbs	42000	lbs	42000	lbs				
AMMONIUM NITRATE & 6% FUEL OIL	1	30000	lbs	30000	lbs	30000	lbs	0	0	3	OX
HAZARDOUS WASTE SOLID	1	30000	lbs	30000	lbs	30000	lbs				
ANIMAL FAT	1	22000	lbs	22000	lbs	22000	lbs				
MOLTEN ALUMINUM	1	20000	lbs	20000	lbs	20000	lbs				
GASOLINE: AUTOMOTIVE (UNLEADED)	17	13906	gal	0-8000	gal	15	gal	1	3	0	
PRODUCED WATER	1	10000	gal	10000	gal	10000	gal				
PROPIONIC ACID	1	10000	lbs	10000	lbs	10000	lbs				
OIL, FUEL: NO. 2-D	53	6647	gal	0-2500	gal	60	gal	0	2	0	
HYDROCHLORIC ACID	10	5529	gal	0-4200	gal	50	gal				
COAL TAR PITCH	1	5000	lbs	5000	lbs	5000	lbs	0	1	0	
POULTRY BLOOD	1	5000	gal	5000	gal	5000	gal				
GASOLINE: AUTOMOTIVE (4.23 G Pb/GAL)	13	4926	gal	0-3500	gal	100	gal	1	3	0	
POLYCHLORINATED BIPHENYLS	5	4542	gal	0-4536	gal	0.09	gal	2	1	0	
FERROUS CHLORIDE	1	4500	gal	4500	gal	4500	gal				
ASPHALT	3	4030	gal	0-4000	gal	30	gal	0	1	0	
20-0-20 FERTILIZER; GRANULAR	1	4000	lbs	4000	lbs	4000	lbs				
SODIUM HYPOCHLORITE	4	3800	gal	0-3800	gal	0	gal				
WATERPROOFING RESIN - E-Z-REZ #710	1	3275	lbs	3275	lbs	3275	lbs				
ANILINE	2	2897	gal	150-2347	gal	1448	gal	3	2	0	
METHYL ETHYL KETONE	1	2500	gal	2500	gal	2500	gal	1	3	0	
FERRIC SULFATE	1	2500	gal	2500	gal	2500	gal				
BATTERY RECYCLING WASTE	1	2300	lbs	2300	lbs	2300	lbs	3	0	2	Water
OIL, FUEL: NO. 2	5	2120	gal	0-2000	gal	30	gal	0	2	0	
LIQUEFIED PETROLEUM GAS	2	1600	gal	0-1600	gal	800	gal	1	4	0	

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
KARMEX (DIURON SOLID NOS)	1	1500	gal	1500	gal	1500	gal				
JET FUEL: JP-4	4	1395	gal	15-1000	gal	190	gal	1	3	0	
MONOCHLOROACETIC ACID	1	1320	gal	1320	gal	1320	gal				
OIL, MISC: MOTOR	36	1138	gal	0-1000	gal	0	gal	0	2	0	
CARBON DIOXIDE	1	1000	lbs	1000	lbs	1000	lbs				
AMMONIA, ANHYDROUS	3	1000	gal	0-1000	gal	0	gal	3	1	0	
JET FUEL: JP-5 (KEROSENE, HEAVY)	2	850	gal	400-450	gal	425	gal	0	2	0	
FERTILIZER	1	800	gal	800	gal	800	gal				
SULFUR	2	800	gal	100-700	gal	400	gal	2	1	0	
SODIUM HYDROSULFIDE SOLUTION	1	600	gal	600	gal	600	gal				
STYRENE (35%)	1	510	gal	510	gal	510	gal	2	3	2	
PCB (CONTAMINATED SOIL)	1	500	lbs	500	lbs	500	lbs	2	1	0	
D006 HAZARDOUS WASTE SOLID	1	500	lbs	500	lbs	500	lbs				
COPPER CHLORIDE DIHYDRATE	1	496	lbs	496	lbs	496	lbs				
HYDRAULIC OIL	19	477	gal	0-200	gal	5	gal	0	2	0	
HAZARDOUS WASTE	2	415	gal	15-400	gal	208	gal				
AMMONIUM NITRATE	1	300	gal	300	gal	300	gal	0	0	3	OX
SULFUR (MOLTEN)	1	300	gal	300	gal	300	gal	2	1	0	
PAINT	2	300	gal	0-300	gal	150	gal				
CREOSOTE	3	204	gal	30-104	gal	70	gal	2	2	0	
SULFURIC ACID	5	201	gal	0-186	gal	4	gal	3	0	2	Water
OIL, MISC: COAL TAR & WATER	1	200	gal	200	gal	200	gal	0	2	0	
NTX (75% METHYLENE CHLORIDE, FORMIC ACID	1	200	gal	200	gal	200	gal	2	1	0	
HAZ WASTE SOLID NOS(CONTAINS LEAD OXIDE)	1	200	lbs	200	lbs	200	lbs				
LIQUID ALLUM	1	200	gal	200	gal	200	gal				
JET FUEL: JP-8	4	193	gal	33-60	gal	50	gal				

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
AMMONIUM NITRATE SOLUTION	2	143	gal	17-125	gal	71	gal	0	0	3	OX
OIL, MISC: LUBRICATING	6	108	gal	0-100	gal	1.5	gal	0	2	0	
OIL, FUEL: NO. 1-D	1	100	gal	100	gal	100	gal	0	2	0	
J2 FUEL	1	100	gal	100	gal	100	gal	1	3	0	
PERCHLOROETHYLENE	1	100	gal	100	gal	100	gal	2	0	0	
CAUSTIC ALKALI LIQUID NOS	1	100	gal	100	gal	100	gal				
THIOPHENOL RESIDUE	1	100	gal	100	gal	100	gal				
CHLOROFORM	3	85	lbs	0-68	lbs	17	lbs	2	0	0	
WASTE FLAMABLE LIQUID	2	70	gal	20-50	gal	35	gal				
NAPHTHA: SOLVENT	2	56	gal	6-56	gal	31	gal	1	3	0	
FLAMMABLE LIQUID - ALIPHATIC HYDROCARBON	1	55	gal	55	gal	55	gal				
D001 FLAMABLE LIQUID	1	50	gal	50	gal	50	gal				
MERCURY CONTAMINATED WASTE WATER	1	50	gal	50	gal	50	gal				
NITRIC ACID	2	50	gal	0-50	gal	25	gal	3	0	0	OX
BATTERY PLANT TRASH	1	40	lbs	40	lbs	40	lbs	3	0	2	Water
BENZENE	2	33	gal	30-Mar	gal	17	gal	2	3	0	
FLAMMABLE WASTE LIQUID(NOS)	1	30	gal	30	gal	30	gal				
ORGANOPHOSPHOROUS PESTICIDES	1	30	lbs	30	lbs	30	lbs				
PROPANE GAS	1	25	gal	25	gal	25	gal	1	4	0	
METHYLENE CHLORIDE	1	25	gal	25	gal	25	gal	2	1	0	
ALKALINE CORROSIVE MATERIAL	1	25	gal	25	gal	25	gal				
BARIUM (FILTER CAKE)	1	25	gal	25	gal	25	gal	3	0	3	OX
FUEL WASTE	1	25	gal	25	gal	25	gal				
TOLUENE	1	22	gal	22	gal	22	gal	2	3	0	
ACETONITRILE	1	20	gal	20	gal	20	gal	2	3	0	
CONTAMINATED GROUND WATER	1	20	gal	20	gal	20	gal				

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
K0088: PIPELINE DEBRIS/OTHER EQUIPMENT PARTS	1	20	gal	20	gal	20	gal				
METHYLENE BISTHIOCYANATE	1	20	gal	20	gal	20	gal				
MIXED/WASTE SOLVENTS - POSS. CON	1	20	gal	20	gal	20	gal				
WASTE WATER TREATMENT SLUDGE	1	20	gal	20	gal	20	gal				
ETHYLENE GLYCOL	23	18.4	gal	0-3	gal	0.11	gal	1	1	0	
FUELS WASTE	1	15	gal	15	gal	15	gal				
WASTE CODE FO39 (LEACHATE)	1	15	gal	15	gal	15	gal				
OIL, MISC: MINERAL	3	15	gal	0-15	gal	0	gal	0	2	0	
BUTADIENE	1	13	gal	13	gal	13	gal	2	4	2	
OIL, MISC: RESIN	1	10	gal	10	gal	10	gal	0	2	0	
DIMETHYL-N-BUTYLAMINE	1	10	gal	10	gal	10	gal	2	3	0	
CREOSOTE CONTAMINATED SOIL AND DEBRIS	1	10	gal	10	gal	10	gal				
HAZARDOUS LIQUID WASTES(FO34)	1	10	lbs	10	lbs	10	lbs				
LEAD BATTERY LIQUID	1	10	gal	10	gal	10	gal				
LINDANE	1	10	gal	10	gal	10	gal				
SWEEPER TRASH (D007)	1	10	gal	10	gal	10	gal				
WASTE MATERIAL DOO1, DOO4 F001, F004	1	10	gal	10	gal	10	gal				
MINERAL SPIRITS	2	5.5	gal	0.5-5	gal	2.75	gal	0	2	0	
INCINERATOR DEBRIS	2	5.5	gal	0.5-5	gal	2.75	gal				
MINERAL SPIRITS	1	5	gal	5	gal	5	gal	0	2	0	
TRANSMISSION OIL	1	5	gal	5	gal	5	gal	0	2	0	
D004	1	5	gal	5	gal	5	gal				
D006, D007, D009, D018	1	5	gal	5	gal	5	gal				
F039 LEACHATE	1	5	gal	5	gal	5	gal				
LEACHATE F039	1	5	gal	5	gal	5	gal				

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
LEACHATE/F039, F001, F004, F005, U051, U076, U159	1	5	gal	5	gal	5	gal				
RCRA INCINERATOR ASH	1	5	gal	5	gal	5	gal				
WASTE ALKALINE	1	5	gal	5	gal	5	gal				
POLYOXYPROPYLENEDIAMINE	1	4.5	gal	4.5	gal	4.5	gal				
INCINERATOR ASH	1	4	gal	4	gal	4	gal				
WASTE DERIVED FUELS	1	3	gal	3	gal	3	gal	0	2	0	
DOO8 HAZARDOUS SOLID WASTE	1	3	gal	3	gal	3	gal				
DOO8, FOO6	1	3	gal	3	gal	3	gal				
INCINERATOR ASH	1	3	lbs	3	lbs	3	lbs				
OIL, MISC: TRANSFORMER	2	3	gal	0-3	gal	1.5	gal	0	2	0	
D008 RCRA WASTE (LEAD)	2	3	gal	1-2	gal	1.5	gal				
TRANSMISSION FLUID	2	2.5	gal	0.5-2	gal	1.25	gal	0	2	0	
ANTI-FREEZE	1	2	gal	2	gal	2	gal	1	1	0	
CREOSOTE, COAL TAR	1	2	gal	2	gal	2	gal	2	2	0	
BLAST FURNACE SLAG	1	2	gal	2	gal	2	gal				
LEAD, UNKNOWN TYPE	1	2	gal	2	gal	2	gal				
LIQUID LEAD	1	2	gal	2	gal	2	gal				
MILADHON-D	1	2	gal	2	gal	2	gal				
POLYALKYLAMINE	1	2	gal	2	gal	2	gal				
WASTE LIQUID	1	2	gal	2	gal	2	gal				
WATER CONTAINING FLY ASH	1	1.2	gal	1.2	gal	1.2	gal				
PETROLEUM NAPHTHA	1	1	gal	1	gal	1	gal	1	3	0	
80 % PHOSPHORIC ACID	1	1	gal	1	gal	1	gal	3	0	0	
ARSENIC (RQ OF 1LB)	1	1	lbs	1	lbs	1	lbs	3	0	0	
2-BUTOXY ETHANOL; GLYCOL ETHERS	1	1	gal	1	gal	1	gal	2	2	1	
BAG HOUSE DUST, D006,D008	1	1	gal	1	gal	1	gal				
D007(PAINT FILTERS)	1	1	gal	1	gal	1	gal				

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
DOO8 WASTE FUEL	1	1	gal	1	gal	1	gal				
HAZARDOUS WASTE: D001, F003, F005, U056	1	1	gal	1	gal	1	gal				
HAZARDOUS WASTE: U120, U156, U188	1	1	gal	1	gal	1	gal				
SULFUR TRIOXIDE	1	1	lbs	1	lbs	1	lbs				
COPPER CHROMIUM ARSENIC	1	0.75	gal	0.75	gal	0.75	gal				
HEXACHLOROBUTADIENE	1	0.5	gal	0.5	gal	0.5	gal	2	1	1	
D008 HAZARDOUS WASTE	1	0.5	gal	0.5	gal	0.5	gal				
WASTE D008	1	0.5	gal	0.5	gal	0.5	gal				
OTHER OIL	3	0.38	gal	0-0.25	gal	0.13	gal	0	2	0	
DOO4, DOO8, D009, D0011, D0019	1	0.25	lbs	0.25	lbs	0.25	lbs				
FREON	3	0.14	gal	0-0.14	gal	0	gal				
ETHYL ACRYLATE	1	0.13	gal	0.13	gal	0.13	gal	2	3	2	
OIL BASED PAINT	1	0	gal	0	gal	0	gal	0	2	0	
ENGINE STARTING FLUID	1	0	gal	0	gal	0	gal	1	3	0	
ETHYL ETHER	1	0	gal	0	gal	0	gal	1	4	1	
GASOLINE ADDITIVE	1	0	gal	0	gal	0	gal	1	3	0	
METHYL ALCOHOL	1	0	gal	0	gal	0	gal	1	3	0	
TAR BASE	1	0	gal	0	gal	0	gal	1	3	0	
CUMENE	1	0	gal	0	gal	0	gal	2	3	1	
DICHLOROMETHANE	1	0	gal	0	gal	0	gal	2	1	0	
BATTERY ACID	1	0	gal	0	gal	0	gal	3	0	2	Water
NITRIC ACID (70% OR LESS)	1	0	gal	0	gal	0	gal	3	0	0	OX
PENTACHLOROPHENOL	1	0	gal	0	gal	0	gal	3	0	0	
SULFUR DIOXIDE	1	0	gal	0	gal	0	gal	3	0	0	
ACRYLONITRILE	1	0	gal	0	gal	0	gal	4	3	2	
ALUMINUM PHOSPHIDE PESTICIDE	1	0	gal	0	gal	0	gal	4	4	2	Water
ALCOHOL	1	0	gal	0	gal	0	gal				

Table 3-6. Summary of Chemicals Spilled by Transportation Mode (highway locations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
ALUMINUM SULFATE	1	0	gal	0	gal	0	gal				
BIOWASTES	1	0	gal	0	gal	0	gal				
BUTANOL	1	0	gal	0	gal	0	gal	2	3	1	
CADMIUM	1	0	gal	0	gal	0	gal				
CHROMIUM	1	0	gal	0	gal	0	gal				
COAL	1	0	gal	0	gal	0	gal				
DURSBAN	1	0	gal	0	gal	0	gal				
FERROUS OXIDE	1	0	gal	0	gal	0	gal				
GRANULAR FERTILIZER	1	0	gal	0	gal	0	gal				
GRANULAR NITROGEN	1	0	gal	0	gal	0	gal				
LEAD	1	0	gal	0	gal	0	gal				
RADIOACTIVE MATERIAL	1	0	gal	0	gal	0	gal				
RADIOACTIVE MATERIAL NOS	1	0	gal	0	gal	0	gal				
REFRIGERANT GASES	1	0	gal	0	gal	0	gal				
STRONTIUM CHROMATE	1	0	gal	0	gal	0	gal				
UNKNOWN HERBICIDES	1	0	gal	0	gal	0	gal				
CHLORINE	2	0	gal	0	gal	0	gal	4	0	0	OX
BLACK LIQUOR	2	0	gal	0	gal	0	gal				
GREEN LIQUOR (CORROSIVE)	2	0	gal	0	gal	0	gal				
RAW SEWAGE	2	0	gal	0	gal	0	gal				
WASTE OIL	5	0	gal	0	gal	0	gal	0	2	0	
UNKNOWN OIL	6	0	gal	0	gal	0	gal	0	2	0	

Table 3-7. Summary of Chemicals Spilled by Transportation Mode (marine operations)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL: CRUDE	22	2007824	gal	0-2000000	gal	6	gal	0	2	0	
OIL:DIESEL	161	6458	gal	0-2000	gal	1	gal	0	2	0	
SODIUM HYPOCHLORITE (15% OR LESS)	1	3500	gal	3500	gal	3500	gal				
OIL, FUEL: NO. 2-D	67	2385	gal	0-500	gal	5	gal	0	2	0	
OIL, FUEL: NO. 6	39	1768	gal	0-1200	gal	0.8	gal	0	2	0	
ASPHALT	8	1104	gal	0-400	gal	50	gal	0	1	0	
OIL, MISC: MOTOR	18	1012	gal	0-605	gal	2	gal	0	2	0	
SODIUM HYDROXIDE	1	1000	lbs	1000	lbs	1000	lbs	3	0	1	
BROMINE	1	900	lbs	900	lbs	900	lbs	3	0	0	OX
ADIPONITRILE	1	640	lbs	640	lbs	640	lbs	2	2	1	
OIL, MISC: LUBRICATING	30	575	gal	0-200	gal	2.4	gal	0	2	0	
WASTE OIL AND WATER MIXTURE	16	533	gal	0-500	gal	1	gal	0	2	0	
WASTE OIL	2	502	gal	2-500	gal	251	gal	0	2	0	
HYDRAULIC OIL	54	480	gal	0-100	gal	2.25	gal	0	2	0	
BILGE SLOPS	7	380	gal	0-300	gal	0.13	gal				
OTHER OIL(IFO 180 FUEL OIL)	2	205	gal	80-125	gal	103	gal	0	2	0	
HYDRAULIC FLUID (BIO-DEGRADABLE)	1	200	gal	200	gal	200	gal	0	2	0	
IFO380 (BLEND OF DIESEL AND NO. 6 OIL)	1	200	gal	200	gal	200	gal				
UNKNOWN OIL	73	194	gal	0-55	gal	0	gal	0	2	0	
GASOLINE: AUTOMOTIVE (4.23 G Pb/GAL)	16	193	gal	0-40	gal	2	gal	1	3	0	
WASTE OIL	19	185	gal	0-30	gal	1.5	gal	0	2	0	
AFFF FOAM	1	180	gal	180	gal	180	gal				
GASOLINE: AUTOMOTIVE (UNLEADED)	10	170	gal	0-120	gal	0.06	gal	1	3	0	
OIL, FUEL: NO. 2	9	164	gal	0-150	gal	0.5	gal	0	2	0	
JET FUEL: JP-8	12	142	gal	0-40	gal	5	gal				
UNKNOWN OIL(DRILLING MUD)	1	100	gal	100	gal	100	gal	0	2	0	
OTHER OIL	16	93	gal	0-45	gal	1.5	gal	0	2	0	
OIL:DIESEL (BUNKER C)	7	82	gal	0.13-80	gal	0.5	gal	0	2	0	

Table 3-7. Summary of Chemicals Spilled by Transportation Mode (marine operations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
MINERAL BASED DRILLING MUD	1	80	gal	80	gal	80	gal				
DE-GUMMED SOYBEAN OIL	1	75	gal	75	gal	75	gal	0	1	0	
OIL, FUEL: NO. 5	38	67	gal	0-50	gal	0.13	gal	0	2	0	
BUNKER-C/NO. 5 FUEL OIL	1	50	gal	50	gal	50	gal	0	2	0	
OTHER OIL-WASTE AND DIESEL	1	50	gal	50	gal	50	gal	0	2	0	
FUEL OIL	2	50	gal	50	gal	50	gal	0	2	0	
BILGE MATERIAL	2	45	gal	5-40	gal	23	gal				
OTHER OIL THERMAL OIL	1	40	gal	40	gal	40	gal	0	2	0	
HEAVY OLEFIN FEED	2	35	gal	0-35	gal	17.5	gal				
THERMAL HEATING OIL (VEGETABLE BASED)	1	25	gal	25	gal	25	gal	0	1	0	
NAPHTHA: SOLVENT	1	25	gal	25	gal	25	gal	1	3	0	
PAINT	2	21	gal	1-20	gal	10.5	gal				
OIL:DIESEL (BUNKER C, FUEL OIL 5)	4	21	gal	0-20	gal	0.25	gal	0	2	0	
OILY WASTE	1	20	gal	20	gal	20	gal	0	2	0	
BILGE OIL	1	20	gal	20	gal	20	gal				
ENGINE OIL	2	20	gal	0-20	gal	10	gal	0	2	0	
UNSPECIFIED JET FUEL	2	20	gal	5-15	gal	10	gal	0	2	0	
EMULSIFIED OIL	1	15	gal	15	gal	15	gal	0	2	0	
BENZYL CHLORIDE	1	15	gal	15	gal	15	gal	3	2	1	
CARBON MONOXIDE	1	12.3	lbs	12.3	lbs	12.3	lbs	3	4	0	
OIL, MISC: COAL TAR	1	10	gal	10	gal	10	gal	0	2	0	
OTHER OIL:ASPHAULT	1	10	gal	10	gal	10	gal	0	2	0	
STYRENE	1	10	gal	10	gal	10	gal	2	3	2	
SULFURIC ACID	1	10	gal	10	gal	10	gal	3	0	2	Water
FERRIC CHLORIDE	1	10	gal	10	gal	10	gal				
OIL-BASED MUD	1	3	gal	3	gal	3	gal	0	2	0	
PACKIKG OIL RESIDUE	1	3	gal	3	gal	3	gal	0	2	0	

Table 3-7. Summary of Chemicals Spilled by Transportation Mode (marine operations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
ACRYLONITRATE	1	3	gal	3	gal	3	gal				
HEAVY AROMATIC HYDROCARBINS	1	3	gal	3	gal	3	gal				
ETHYLENE GLYCOL	1	2.3	gal	2.3	gal	2.3	gal	1	1	0	
VACUUM GAS OIL	1	2	gal	2	gal	2	gal	0	2	0	
VIRGIN GAS OIL	1	2	gal	2	gal	2	gal	0	2	0	
OIL, MISC: TRANSMISSION	1	1.1	gal	1.1	gal	1.1	gal	0	2	0	
CRUDE SOYBEAN OIL	1	1	gal	1	gal	1	gal				
MIXTURE OF HYDROCARBONS	1	1	gal	1	gal	1	gal				
MIXTURE OF ODS AND OSX	1	1	gal	1	gal	1	gal				
OIL, FUEL: NO. 1-D	1	0.5	gal	0.5	gal	0.5	gal	0	2	0	
GEAR OIL	1	0.25	gal	0.25	gal	0.25	gal	0	2	0	
OIL, MISC: NEATSFOOT	1	0.13	gal	0.13	gal	0.13	gal	0	2	0	
CHEMICAL AND DIESEL COMBINATION	1	0.11	gal	0.11	gal	0.11	gal				
PETROLEUM BASED PAINT	1	0.04	gal	0.04	gal	0.04	gal	0	2	0	
OIL, 90% FUEL: NO. 6,10% DIESEL FUEL	1	0	gal	0	gal	0	gal	0	2	0	
OIL: DIESEL AND BILGE SLOPE	1	0	gal	0	gal	0	gal	0	2	0	
OTHER OIL BILGE OIL	1	0	gal	0	gal	0	gal	0	2	0	
OTHER OIL GAS OIL	1	0	gal	0	gal	0	gal	0	2	0	
REFINED CORN OIL	1	0	gal	0	gal	0	gal	0	1	0	
UNKNOWN OIL (VACUUM GAS OIL)	1	0	gal	0	gal	0	gal	0	2	0	
VARIOUS KINDS OF OILS	1	0	gal	0	gal	0	gal	0	2	0	
METHYL ETHYL KETONE	1	0	gal	0	gal	0	gal	1	3	0	
NATURAL GAS	1	0	gal	0	gal	0	gal	1	4	0	
AMMONIA, ANHYDROUS	1	0	gal	0	gal	0	gal	3	1	0	
NITROGEN OXIDE	1	0	gal	0	gal	0	gal	3	0	0	OX
LEAD BASED PAINT	1	0	gal	0	gal	0	gal				
SEWAGE	1	0	gal	0	gal	0	gal				

Table 3-7. Summary of Chemicals Spilled by Transportation Mode (marine operations) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
STRONG SMELL OF OIL: DIESEL	1	0	gal	0	gal	0	gal				
VINYL PAINT	1	0	gal	0	gal	0	gal				
WASTE PAINT	1	0	gal	0	gal	0	gal				
ASPHALT BLENDING STOCKS: ROOFERS	2	0	gal	0	gal	0	gal	0	3	0	
KEROSENE	2	0	gal	0	gal	0	gal	0	2	0	
UNKNOWN MATERIAL	2	0	gal	0	gal	0	gal				
WASTE AND SEWAGE WATER	1	55	gal	55	gal	55	gal				
UNKNOWN OIL	1	0	gal	0	gal	0	gal	0	2	0	
UNKNOWN MATERIAL	2	0	gal	0	gal	0	gal				

Table 3-8. Summary of Chemicals Spilled by Transportation Mode (off-shore locations)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
SHELL SOL 71 OIL	1	400	gal	400	gal	400	gal	0	2	0	
OIL BASED LIQUID MUD	4	326	gal	20-126	gal	90	gal	0	2	0	
OIL, MISC: LUBRICATING	2	150	gal	0.5-150	gal	75	gal	0	2	0	
OIL BASED MUD	1	120	gal	120	gal	120	gal	0	2	0	
OIL: DIESEL	10	101	gal	0-55	gal	0.2	gal	0	2	0	
HYDRAULIC OIL	10	72.5	gal	0-20	gal	1	gal	0	2	0	
CRUDE OIL	3	14	gal	1-12	gal	1	gal				
OIL, MISC: MOTOR	3	2.5	gal	0.5-0.99	gal	0.99	gal	0	2	0	
OIL, FUEL: NO. 2-D	3	0.59	gal	0-0.59	gal	0	gal	0	2	0	
UNKNOWN OIL	24	0.58	gal	0-0.5	gal	0	gal	0	2	0	
WASTE OIL	1	0.1	gal	0.1	gal	0.1	gal	0	2	0	

Table 3-9. Summary of Chemicals Spilled by Transportation Mode (pipelines)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL, FUEL: NO. 2-D	4	9101	gal	0-9000	gal	51	gal	0	2	0	
CRUDE OIL	9	4750	gal	0-1680	gal	200	gal				
PARAXYLENE	1	1000	gal	1000	gal	1000	gal	2	3	0	
OIL: DIESEL	2	150	gal	0-150	gal	75	gal	0	2	0	
GASOLINE: AUTOMOTIVE	3	150	gal	0-100	gal	75	gal	1	3	0	
SALT WATER	1	60	gal	60	gal	60	gal				
TRIETHYLENE GLYCOL	1	35	gal	35	gal	35	gal	0	1	0	
OIL:DIESEL (BUNKER FUEL)	1	15	gal	15	gal	15	gal	0	2	0	
PROPANE	1	0	gal	0	gal	0	gal	1	4	0	
NATURAL GAS	6	0	gal	0	gal	0	gal	1	4	0	

Table 3-10. Summary of Chemicals Spilled by Transportation Mode (railroad and highway crossings)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL: DIESEL	8	7321	gal	0-4000	gal	160	gal	0	2	0	
OIL, FUEL: NO. 2-D	4	1112	gal	2-1000	gal	55	gal	0	2	0	
OIL, MISC: MOTOR	1	125	gal	125	gal	125	gal	0	2	0	
FORMALDEHYDE SOLUTION	1	1	gal	1	gal	1	gal	2	2	0	

Table 3-11. Summary of Chemicals Spilled by Transportation Mode (railroads)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
COAL	10	934800	lbs	0-640000	lbs	10000	lbs				
PLASTIC PELLETS	2	262500	lbs	500-262000	lbs	131000	lbs				
PETROLEUM OIL	1	23000	gal	23000	gal	23000	gal	1	3	0	
ASPHALT	3	20000	gal	0-20000	gal	0	gal	0	1	0	
OIL: DIESEL	43	18103	gal	0-2600	gal	30	gal	0	2	0	
SULFURIC ACID	0	15490	gal	0-10000	gal	1.5	gal	3	0	2	Water
OIL, FUEL: NO. 2-D	23	9534	gal	1-3000	gal	60	gal	0	2	0	
LIMESTONE	2	3000	lbs	1000-2000	lbs	1500	lbs				
AMMONIA, ANHYDROUS	8	2125	lbs	0-1500	lbs	63	lbs	3	1	0	
ETHYL PHOSPHONOTHIOIC DICHLORIDE	1	2000	lbs	2000	lbs	2000	lbs				
CHLOROFORM	1	1250	lbs	1250	lbs	1250	lbs	2	0	0	
CHARCOAL	1	1000	lbs	1000	lbs	1000	lbs				
PHOSPHORIC ACID	6	986	gal	0.1-983	gal	0.38	gal	3	0	0	
PENTANE	1	700	gal	700	gal	700	gal	1	4	0	
CREOSOTE	3	604	gal	4-500	gal	100	gal	2	2	0	
HYDROCHLORIC ACID	11	346	gal	0-330	gal	0.5	gal				
OIL, MISC: LUBRICATING	20	335	gal	0.25-50	gal	4	gal	0	2	0	
OTHER OIL: PARAFIN SOLVENT	1	300	gal	300	gal	300	gal	0	2	0	
ETHYLENE GLYCOL	3	215	gal	0-215	gal	15	gal	1	1	0	
HOMINY FEED	1	200	lbs	200	lbs	200	lbs				
HYDRAULIC OIL	9	176.3	gal	0-50	gal	20	gal	0	2	0	
TURPENTINE	3	151	gal	0.06-149	gal	1.5	gal	1	3	0	
OLEUM	1	150	gal	150	gal	150	gal				
BENZENE	2	132	gal	42-90	gal	66	gal	2	3	0	
TURPENTINE METHYL MERCAPTAN	2	130	gal	30-100	gal	65	gal				
SPENT POT LINER FROM ALUMINUM REDUCTION	1	100	lbs	100	lbs	100	lbs				
AMMONIUM NITRATE	1	65	gal	65	gal	65	gal	0	0	3	OX
XYLENE (O-, M-, P-, & MIXTURES)	1	55	gal	55	gal	55	gal	2	3	0	

Table 3-11. Summary of Chemicals Spilled by Transportation Mode (railroads) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
OIL, FUEL: NO. 2	2	50	gal	0-50	gal	25	gal	0	2	0	
NITROGEN FERTILIZER SOLUTION	4	43	gal	0.25-40	gal	1.5	gal				
CHLORINE	8	41.1	lbs	0-33	lbs	0	lbs	4	0	0	OX
COTTONSEED OIL, FATTY ACID	1	40	gal	40	gal	40	gal	0	1	0	
STYRENE	2	31	gal	1-31	gal	16	gal	2	3	2	
SODIUM HYDROXIDE	8	25.6	gal	0-10	gal	1.5	gal	3	0	1	
TRIMETHYL HEXAMETHYLENE DIAMINE	1	25	gal	25	gal	25	gal				
JET FUEL: JP-4	1	20	gal	20	gal	20	gal	1	3	0	
UNKNOWN OIL	3	20	gal	0-20	gal	0	gal	0	2	0	
BIPHENYL	1	14	gal	14	gal	14	gal	2	1	0	
CALCINIDE ALUMINUM ORE	1	10	gal	10	gal	10	gal	0	1	1	
DIPHENYL OXIDE	1	10	gal	10	gal	10	gal	1	1	0	
BLAZE MASTER POWDER	1	10	lbs	10	lbs	10	lbs				
ACRYLONITRILE PROPIONITIRICRMENRAL	1	6	gal	6	gal	6	gal	4	3	2	
TEREPHTHALIC ACID	2	5.2	gal	0.2-5	gal	2.6	gal	0	1	0	
CARBON DIOXIDE	5	5.13	gal	0-5	gal	0	gal				
CARALUMINA CALCINED	1	5	gal	5	gal	5	gal	0	1	1	
LIQUIFIED PETROLEUM GAS	1	5	gal	5	gal	5	gal	1	4	0	
ARSENIC ACID SOLUTION (95-97% WATER)	1	5	gal	5	gal	5	gal	3	0	0	
POLYCHLORINATE	1	5	gal	5	gal	5	gal				
P-XYLENE	2	5	gal	0-5	gal	2.5	gal	2	3	0	
OCTYL MERCAPTAN	2	4	gal	1-3	gal	2	gal				
BUTADIENE	2	3.87	gal	3.87	gal	3.87	gal	2	4	2	
POTASSIUM HYDROXIDE	3	3.1	gal	0.06-2	gal	1	gal	3	0	1	
OIL, EDIBLE: SOYA BEAN	1	3	gal	3	gal	3	gal	0	1	0	
OXANONE (OSB-OIL STRIPPER)	1	3	gal	3	gal	3	gal	0	2	0	

Table 3-11. Summary of Chemicals Spilled by Transportation Mode (railroads) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
FLAMMABLE LIQUID (VITROPYLAMINE)	1	3	gal	3	gal	3	gal				
GLYCOL ETHER	1	3	gal	3	gal	3	gal				
HAZARDOUS WASTE SOLIDS	1	3	lbs	3	lbs	3	lbs				
OILY WATER MIXTURE	1	2	gal	2	gal	2	gal	0	2	0	
BUTYL ACETATE	1	2	gal	2	gal	2	gal	1	3	0	
GASOLINE: AUTOMOTIVE (UNLEADED)	1	2	gal	1	gal	1	gal	1	3	0	
POLYVINYL CHLORIDE	1	2	lbs	2	lbs	2	lbs				
OCTYL MERCAPTAS	1	1.5	gal	1.5	gal	1.5	gal				
OIL: CRUDE	3	1.25	gal	0.12-1	gal	0.13	gal	0	2	0	
ACETIC ACID, GLACIAL	2	1.13	gal	0.13-1	gal	0.57	gal	3	2	0	
ISOPROPYLAMINE	2	1.12	gal	0.12-1	gal	0.56	gal	3	4	0	
AMMONIUM NITRATE, LIQUID	1	1	gal	1	gal	1	gal	0	0	3	OX
OTHER OIL	1	1	gal	1	gal	1	gal	0	2	0	
LIQUIFIED PETROLEUM GAS	1	1	gal	1	gal	1	gal	1	4	0	
CAUSTIC POTASH SOLUTION	1	1	gal	1	gal	1	gal	3	0	1	
POTASSIUM HYDROXIDE	1	1	gal	1	gal	1	gal	3	0	1	
SULFUR DIOXIDE	1	1	lbs	1	lbs	1	lbs	3	0	0	
CRUDE SULFATE TURPENTINE	1	1	gal	1	gal	1	gal				
FERRIC SULFATE	1	1	gal	1	gal	1	gal				
METHYLENE DIPHENYL DIISOCYANATE	1	1	gal	1	gal	1	gal				
PULPMILL LIQUIDS	1	1	gal	1	gal	1	gal				
TOLUENE 2,4-DIISOCYANATE	1	0.99	gal	0.99	gal	0.99	gal	3	1	3	Water
PROPIONITRILE	1	0.99	lbs	0.99	lbs	0.99	lbs	4	3	1	
OTHER OIL (LUBE OIL)	1	0.5	gal	0.5	gal	0.5	gal	0	2	0	
OTHER OIL (TRANSMISSION OIL)	1	0.5	gal	0.5	gal	0.5	gal	0	2	0	
PETROLEUM NAPHTHA	1	0.5	gal	0.5	gal	0.5	gal	1	3	0	
HEXANETHYLENEDIAMINE	1	0.5	gal	0.5	gal	0.5	gal				

Table 3-11. Summary of Chemicals Spilled by Transportation Mode (railroads) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
WASTE FLAMMABLE LIQUID	1	0.5	gal	0.5	gal	0.5	gal				
CAUSTIC SODA SOLUTION	4	0.38	gal	0-0.25	gal	0.06	gal	3	0	1	
OTHER OIL (CONDENSATE)	1	0.25	gal	0.25	gal	0.25	gal	0	2	0	
SODIUM CHLORATE	1	0.25	gal	0.25	gal	0.25	gal	1	0	2	OX
DIISOBUTYLAMINE	1	0.25	gal	0.25	gal	0.25	gal	3	3	0	
SODIUM CHLORITE	1	0.13	gal	0.13	gal	0.13	gal	1	0	1	OX
BATTERY ACID	1	0.13	gal	0.13	gal	0.13	gal	3	0	2	Water
FLAMMABLE ALCOHOL	1	0.13	gal	0.13	gal	0.13	gal				
OIL, MISC: MOTOR	2	0.13	gal	0-0.13	gal	0.06	gal	0	2	0	
ISO-BUTYRALDEHYDE	1	0.1	gal	0.1	gal	0.1	gal	3	3	2	
CYCLOATXANOL	1	0.01	gal	0.01	gal	0.01	gal				
WASTE OIL	1	0	gal	0	gal	0	gal	0	2	0	
ACETONE	1	0	gal	0	gal	0	gal	1	3	0	
CYCLOHEXANONE	1	0	gal	0	gal	0	gal	1	2	0	
LIQUEFIED PETROLEUM GAS	1	0	gal	0	gal	0	gal	1	4	0	
METHYL ACETOACETATE	1	0	gal	0	gal	0	gal	2	2	0	
PARACYMENE XLYENE	1	0	gal	0	gal	0	gal	2	3	0	
SULFUR	1	0	gal	0	gal	0	gal	2	1	0	
VINYL CHLORIDE	1	0	gal	0	gal	0	gal	2	4	2	
ETHYLENEDIAMINE	1	0	gal	0	gal	0	gal	3	2	0	
PHENOL	1	0	gal	0	gal	0	gal	4	2	0	
AMMONIA FERTILIZER SOLUTION	1	0	gal	0	gal	0	gal				
CARBON BLACK	1	0	gal	0	gal	0	gal				
CARBUTADIENES, INHIBITED	1	0	gal	0	gal	0	gal				
COPPER CHLORIDE (IC) (10%)	1	0	gal	0	gal	0	gal				
FLUOROSULFONIC ACID	1	0	gal	0	gal	0	gal				

Table 3-11. Summary of Chemicals Spilled by Transportation Mode (railroads) (continued)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
HEXAFLOUROPROPYLENE	1	0	gal	0	gal	0	gal				
HYDROFLUOSILICIC ACID	1	0	gal	0	gal	0	gal				
SEWAGE	1	0	gal	0	gal	0	gal				
TALLOW	1	0	gal	0	gal	0	gal				
UNKNOWN MATERIAL	1	0	gal	0	gal	0	gal				

Table 3-12. Summary of Chemicals Spilled by Transportation Mode (unknown locations)

Name of Material	Number of Incidents	Total Quantity Spilled	Unit of Measure	Range of Quantity Spilled	Unit of Measure	Median Quantity Spilled	Unit of Measure	Health	Flammability	Reactivity	Special
GASOLINE: AUTOMOTIVE (UNLEADED)	5	2500	gal	0-2500	gal	0	gal	1	3	0	
UNKNOWN OIL	142	255	gal	0-100	gal	0	gal	0	2	0	
OIL, FUEL: NO. 2-D	5	40	gal	0-40	gal	0	gal	0	2	0	
OIL: DIESEL	25	40	gal	0-40	gal	0	gal	0	2	0	
HYDRAULIC OIL	1	20	gal	20	gal	20	gal	0	2	0	
ASPHALT	1	6	gal	6	gal	6	gal	0	1	0	
SODIUM HYDROXIDE	1	5	gal	5	gal	5	gal	3	0	1	
ETHYLENE GLYCOL	3	5	gal	0-5	gal	0	gal	1	1	0	
OIL, MISC: TRANSFORMER	1	0	gal	0	gal	0	gal	0	2	0	
OIL: CRUDE	1	0	gal	0	gal	0	gal	0	2	0	
OTHER OIL (TAR BALLS)	1	0	gal	0	gal	0	gal	0	2	0	
TURBINE OIL	1	0	gal	0	gal	0	gal	0	2	0	
UNKNOWN SHEEN	1	0	gal	0	gal	0	gal	0	2	0	
GASOLINE: AUTOMOTIVE (4.23 G Pb/GAL)	1	0	gal	0	gal	0	gal	1	3	0	
BENZENE	1	0	gal	0	gal	0	gal	2	3	0	
A MIXTURE OF DIFFERENT COLOR PAINT	1	0	gal	0	gal	0	gal				
INSECTICIDE	1	0	gal	0	gal	0	gal				
RED PAINT LIKE MATERIAL	1	0	gal	0	gal	0	gal				
WASTE OIL	2	0	gal	0	gal	0	gal	0	2	0	
YELLOW LATEX PAINT	2	0	gal	0	gal	0	gal				
OIL, MISC: MOTOR	4	0	gal	0	gal	0	gal	0	2	0	

Section 4. Environmental Fate and Transport Modeling

This section presents several procedures to predict the fate and transport of spilled hazardous materials. The initial discussion is general and it stresses downwind toxic and explosive hazards. These procedures, summarized from a recent EPA manual, are applicable for a wide range of hazardous materials. Specific characteristics for all regulated hazardous materials are also included in the appendices to enable the efficient use of these procedures. A discussion is also provided that considers mixtures of materials and how these mixtures may be more hazardous than individual material losses.

Based on the information presented previously in Section 3, two detailed examples are presented describing problems associated with spills of petroleum hydrocarbons, by far the most common material lost in Alabama transportation accidents, and ammonia, a very toxic gaseous material. Specific procedures are given for calculating the spread and transport of oil slicks, and a numerical example is shown. In addition, a detailed example is presented for predicting both air and water problems associated with ammonia spills. These examples represent procedures for toxic and buoyant materials for which specific methods have been developed (based on actual field studies). These procedures enable the calculation of the magnitude of potential exposures to these hazardous materials.

Evaluation of Toxic and Explosive Atmospheric Conditions Associated with Transportation Accidents involving Hazardous Materials

Much of the material in this report section is summarized from the recent EPA (1999) guidance document *Risk Management Program Guidance for Offsite Consequence Analysis*. This referenced EPA report provides guidance on how to conduct the offsite-consequence analyses for Risk Management Programs required under the Clean Air Act, Section 112(r)(7). This Act directed the EPA to issue regulations requiring facilities that handle, manufacture, store, or use large quantities of very hazardous chemicals to prepare and implement programs to prevent the accidental release of those chemicals. These facilities also must be prepared to mitigate the consequences of any releases that do occur. EPA issued 40 CFR 68 on June 20, 1996. This regulation requires these facilities to prepare a risk management system, including analyses of potential toxic and explosive conditions if such material is lost to the environment. The summarized material presented in this section refers to the worst-case scenario procedures included in the guidance document. This summary is not a substitute for the complete report for regulated facilities, of course, but is presented here as a currently accepted evaluation procedure that is suitable for evaluating transportation accidents involving hazardous materials. The results obtained using these methods are expected to be conservative (i.e., they will generally, but not always, overestimate the distance to toxic and explosive endpoints).

Steps for Performing Analyses

Worst-Case Analysis for Toxic Gases

To conduct worst-case analyses for toxic gases, including toxic gases liquefied by pressurization:

Step 1: *Determine worst-case scenario*. Identify the toxic gas, quantity, and worst-case release scenario.

Step 2: *Determine release rate*. Estimate the release rate for the toxic gas.

Step 3: *Determine distance to endpoint*. Estimate the worst-case consequence distance based on the release rate and toxic endpoint. Select the appropriate table based on the density of the released substance, the topography of the site (urban or rural), and the duration of the release.

Worst-Case Analysis for Toxic Liquids

To conduct worst-case analyses for toxic substances that are liquids at ambient conditions or for toxic gases that are liquefied by refrigeration alone:

Step 1: *Determine worst-case scenario*. Identify the toxic liquid, quantity, and worst-case release scenario.

Step 2: *Determine release rate*. Estimate the volatilization rate for the toxic liquid and the duration of the release.

Step 3: *Determine distance to endpoint*. Estimate the worst-case consequence distance based on the release rate and toxic endpoint. Select the appropriate reference table based on the density of the released substance, the topography of the site (rural or urban), and the duration of the release. Estimate distance to the endpoint from the appropriate table.

Worst-Case Analysis for Flammable Substances

To conduct worst-case analyses for all regulated flammable substances (i.e., gases and liquids):

Step 1: *Determine worst-case scenario*. Identify the appropriate flammable substance, quantity, and worst-case scenario.

Step 2: *Determine distance to endpoint*. Estimate the distance to the required overpressure endpoint of 1 psi for a vapor cloud explosion of the flammable substance. Estimate the distance to the endpoint from the quantity released.

Determining Worst-Case Scenarios

A worst-case release is defined as:

- The release of the largest quantity of a substance from a vessel or process line failure, and

- The release that results in the greatest distance to the endpoint for the regulated toxic or flammable substance.

This procedure assumes meteorological conditions for the worst-case scenario of atmospheric stability class F (stable atmosphere) and wind speed 1.5 meters per second (3.4 miles per hour). Ambient air temperature is assumed to be 25 °C (77 °F).

The procedure provides two choices for topography, urban and rural. EPA (40 CFR 68.22(e)) has defined urban as many obstacles in the immediate area, where obstacles include buildings or trees. Rural, by EPA's definition, means there are no buildings in the immediate area, and the terrain is generally flat and unobstructed. Thus, if the site is located in an area with few buildings or other obstructions (e.g., hills, trees), open (rural) conditions should be assumed. If the site is in an area with many obstructions, even if it is in a remote location that would not usually be considered urban, urban conditions should be assumed.

Toxic gases include all regulated toxic substances that are gases at ambient temperature (25 °C, 77 °F), with the exception of gases liquefied by refrigeration under atmospheric pressure and released into diked areas. For the worst-case consequence analysis, it is assumed that a gaseous release of the total quantity occurs in 10 minutes. Gases liquefied by refrigeration alone that would form a pool one centimeter or less in depth upon release must be modeled as gases. (Modeling indicates that pools one centimeter deep or less formed by gases liquefied by refrigeration would completely evaporate in 10 minutes or less, thus giving a release rate that is equal to or greater than the worst-case release rate for a gas. Therefore, it is appropriate to treat these substances as gases for the worst-case analysis in this case). Table C-1 lists the endpoint for each toxic gas. These endpoints are used for air dispersion modeling to estimate the consequence distance and are considered critical levels of the contaminants.

For toxic liquids, it is assumed that the total quantity in a vessel is spilled. This procedure also assumes that the spill takes place onto a flat, non-absorbing surface. For toxic liquids carried in pipelines, the quantity potentially released from the pipeline is assumed to form a pool. The total quantity spilled is assumed to spread instantaneously to a depth of one centimeter (0.033 foot or 0.39 inch). The release rate to air is estimated as the rate of evaporation from the pool. Table C-2 lists the endpoint for air dispersion modeling for each regulated toxic liquid (the endpoints are specified in 40 CFR part 68, Appendix A, and are considered to be critical levels of the contaminants).

For all regulated flammable substances, it is assumed that the worst-case release results in a vapor cloud containing the total quantity of the substance that could be released from a vessel or pipeline. This procedure assumes that the vapor cloud detonates using a TNT-equivalent method (assumes a 10-percent yield factor). The procedure uses an endpoint for a vapor cloud explosion as an overpressure of 1 pound per square inch (psi). This endpoint is the threshold for potentially serious injuries to people as a result of property damage caused by an explosion (e.g., injuries from flying glass from shattered windows or falling debris from damaged houses).

Release Rates for Toxic Substances

The following describes simple methods for estimating release rates for toxic substances for the worst-case scenario. Simple release-rate equations are provided, and the factors to be used in these equations are given for each substance (in Tables C-1, C-2, and C-3). These estimated release rates are used in the next part of this section to predict dispersion distances to the toxic endpoint for regulated hazardous gases and liquids.

Release Rates for Toxic Gases

Hazardous substances that are gases at ambient temperature (25 °C, 77 °F) should be considered gases for these analyses, with the exception of gases liquefied by refrigeration at atmospheric pressure. Gases liquefied under pressure should be treated as gases. Gases liquefied by refrigeration that would form a pool one centimeter (0.033 foot) or less in depth should also be treated as gases. The evaporation rate from such a pool would be equal to or greater than the rate for a toxic gas, which is assumed to be released over 10 minutes. Therefore, treating liquefied refrigerated gases as gases rather than liquids in such cases is reasonable.

Unmitigated Releases of Toxic Gas. If no passive mitigation system is in place (dikes or other containments), which should be expected for most transportation accidents, the release rate is simply the largest amount of material that would be lost divided by a 10-minute period.

As an example, if a tank contains 2,500 pounds of diborane gas, the release rate (QR) is:

QR = 2,500 pounds/10 minutes = 250 pounds per minute

Releases of Liquefied Refrigerated Toxic Gas in Diked Area. If a toxic gas that is liquefied by refrigeration alone is released into an area where it will be contained by dikes to form a pool more than one centimeter (0.033 foot) in depth, the worst-case analysis assumes evaporation from the pool at the boiling point of the liquid. If the gas liquefied by refrigeration would form a pool one centimeter (0.033 foot) or less in depth, the previous 10 minute assumption for complete evaporation is used. If the material would be released in a diked area, first compare the diked area to the maximum area of the pool that could be formed to see if the pool depth is less or greater than one centimeter.

The following equation can be used to estimate the maximum size of the pool:

$$A = QS \times DF \qquad \text{Equation 1}$$

where: A = Maximum pool area (ft^2), for a depth of one cm

QS = Quantity released (lbs)

DF = Density factor (as shown in Tables C-1 and C-2)

If the pool formed by the released liquid would be smaller than the diked area, assume a 10-minute gaseous release, and estimate the release rate as described previously. If the dikes prevent the liquid from spreading out to form a pool of maximum size (one centimeter in depth), use the following equation:

$$QR = 1.4 \times LFB \times A \qquad \text{Equation 2}$$

where: *QR* = Release rate (lbs/min)

LFB = Liquid Factor Boiling for hazardous gases liquefied by refrigeration alone, or use LFA, Liquid Factor Ambient, for hazardous liquids at ambient temperature (Tables C-1 and C-2)

A = Diked area (ft^2)

1.4 = Wind speed factor = $(1.5)^{0.78}$, where 1.5 meters per second (3.4 miles per hour) is the wind speed for the worst case

After the release rate is estimated, estimate the duration of the vapor release from the pool in the diked area (the time it will take for the pool to evaporate completely) by dividing the total quantity spilled by the release rate. The duration of a chlorine or sulfur-dioxide release, liquefied by refrigeration alone, is not needed for the analyses for critical distances.

<u>Example for Mitigated Release of Gases Liquefied by Refrigeration (Chlorine)</u>

A refrigerated tank contains 50,000 pounds of liquid chlorine at ambient pressure. A diked area around the chlorine tank is 275 ft^2 and is sufficient to hold all of the spilled liquid chlorine. Once the liquid spills into the dike, it is then assumed to evaporate at its boiling point (-29 °F). The evaporation rate at the boiling point is determined from equation 2. For this calculation, the wind speed is assumed to be 1.5 meters per second and the wind speed factor is 1.4, LFB for chlorine (from Table C-1) is 0.19, and A is 275 ft^2. The release rate is:

QR = 1.4 x 0.19 x 275 = 73 pounds per minute

The duration of the release does not need to be considered for chlorine.

<u>Release Rates for Toxic Liquids</u>

For the worst-case analysis, the release rate to air for toxic liquids is assumed to be the rate of evaporation from the pool formed by the released liquid. Assume the total quantity in a vessel or the maximum quantity from ruptured pipes is released into the pool. Passive mitigation measures (e.g., dikes) may be considered in determining the area of the pool and the release rate. To estimate the critical distance using this method, the evaporation duration (the duration of the release) and the release rate must be known.

The calculation methods presented here apply to substances that are liquids under ambient conditions or gases liquefied by refrigeration alone. It is assumed that these liquids form pools deeper than one centimeter upon release. Gases liquefied under other conditions (under pressure or a combination of pressure and refrigeration) or gases liquefied by refrigeration alone that would form pools one centimeter or less in depth upon release are treated as gas releases, rather than liquid releases. The procedures above are used for those releases.

Releases of Toxic Liquids from Pipes. When considering a liquid release from a broken pipe, the maximum quantity that could be released assuming that the pipe is full must be estimated. The time needed to stop pumping the liquid also needs to be calculated as part of the release. The quantity in the pipe (in pounds) is the volume released divided by the Density Factor (DF) times 0.033. (DF values are listed in Table C-2. Density in pounds per cubic foot is equal to 1/(DF times 0.033).) Assume the estimated quantity (in pounds) is released into a pool and use the method and equations described below to determine the evaporation rate of the liquid from the pool.

Unmitigated Releases of Toxic Liquids. If no passive mitigation measures are in place, the liquid is assumed to form a pool one centimeter (0.39 inch or 0.033 foot) deep instantaneously. The release rate to air from the pool (the evaporation rate) is calculated as discussed below for releases at ambient or elevated temperature.

If the liquid is always at ambient temperature, find the Liquid Factor Ambient (LFA) and the Density Factor (DF) in Table C-2. The LFA and DF apply to liquids at 25 °C. Calculate the release rate of the liquid at 25 °C from the following equation:

$$QR = QS \times 1.4 \times LFA \times DF \qquad \text{Equation 3}$$

where:
- *QR* = Release rate (pounds per minute)
- *QS* = Quantity released (pounds)
- 1.4 = Wind speed factor = $(1.5)^{0.78}$, where 1.5 meters per second (3.4 miles per hour) is the wind speed for the worst case
- *LFA* = Liquid Factor Ambient
- *DF* = Density Factor

Example for an Unmitigated Liquid Release at Ambient Temperature (Acrylonitrile)

A tank contains 20,000 pounds of acrylonitrile at ambient temperature. The total quantity in the tank is spilled onto the ground in an undiked area, forming a pool. Assume the pool spreads out to a depth of one centimeter. The release rate from the pool (QR) is calculated from Equation 3. For the calculation, the wind speed is assumed to be 1.5 meters per second and the wind speed factor is 1.4. From Table C-2, the LFA for acrylonitrile is 0.018 and DF is 0.61. Then:

$$QR = 20{,}000 \text{ X } 1.4 \times 0.018 \times 0.61 = 307 \text{ pounds per minute}$$

The duration of the release would therefore be:

$$t = 20{,}000 \text{ pounds}/307 \text{ pounds per minute} = 65 \text{ minutes}$$

If the liquid is at an elevated temperature (above 50 °C or at or close to the boiling point), find the Liquid Factor Boiling (LFB) and the Density Factor (DF) in Table C-2. If the temperature is elevated, calculate the release rate of the liquid from the following equation:

$QR = QS \times 1.4 \times LFB \times DF$ Equation 4

where: *QR* = Release rate (pounds per minute)
QS = Quantity released (pounds)
1.4 = Wind speed factor = $(1.5)^{0.78}$, where 1.5 meters per second (3.4 miles per hour) is the wind speed for the worst case
LFB = Liquid Factor Boiling
DF = Density Factor

Example of an Unmitigated Release at Elevated Temperature (Acrylonitrile)
A tank contains 20,000 pounds of acrylonitrile at an elevated temperature. The total quantity in the tank is spilled onto the ground in an undiked area, forming a pool. Assume the pool spreads out to a depth of one centimeter. The release rate from the pool is calculated from Equation 4. For the calculation, the wind speed factor for 1.5 meters per second is 1.4. From Table C-2, the LFB for acrylonitrile is 0.11 and the DF is 0.61. Then:

QR = 20,000 x 1.4 x 0.11 x 0.61 = 1,880 pounds per minute

The duration of the release would therefore be:

t = 20,000 pounds/1880 pounds per minute = 11 minutes

Mixtures Containing Toxic Liquids. If the partial pressure of the hazardous substance in the mixture is known, it is possible to estimate an evaporation rate. In this case, estimate a pool size for the entire quantity of the mixture, assuming an unmitigated release. If the density of the mixture is known, use it in estimating the pool size. Otherwise, assume the density is the same as the pure regulated substance (in most cases, this assumption is unlikely to have a large effect on the results).

Example of a Mixture Containing Toxic Liquid (Acrylonitrile)
A tank contains 50,000 pounds of a mixture of acrylonitrile (a hazardous substance) and N,Ndimethylformamide (not regulated). The weight of each of the components of the mixture is known (acrylonitrile = 20,000 pounds; N,N-dimethylformamide = 30,000 pounds). The molecular weight of acrylonitrile, from Table C-2, is 53.06, and the molecular weight of N,N-dimethylformamide is 73.09. Using Equation 5, calculate the mole fraction of acrylonitrile in the solution as follows:

$$X_r = \frac{\left(\frac{W_r}{MW_r}\right)}{\sum_{i=1}^{n}\left(\frac{W_i}{MW_i}\right)}$$ Equation 5

where:

X_r	=	Mole fraction of the hazardous substance
W_r	=	Weight of the hazardous substance
MW_r	=	Molecular weight of the hazardous substance
W_i	=	Weight of each component of the mixture
MW_i	=	Molecular weight of each component of the mixture
n	=	Number of components of the mixture

$$X_r = \frac{(20{,}000/53.06)}{(20{,}000/53.06) + (30{,}000/73.09)}$$

$$X_r = \frac{377}{377 + 410}$$

$$X_r = 0.48$$

Estimate the partial vapor pressure of acrylonitrile as follows (using the vapor pressure of acrylonitrile in pure form at 25 ° C, 108 mm Hg, from Table C-2):

VP_m = 0.48 x 108 = 51.8 mm Hg

Before calculating the evaporation rate for acrylonitrile in the mixture, the surface area of the pool formed by the entire quantity of the mixture is needed. The quantity released is 50,000 pounds and the Density Factor for acrylonitrile is 0.61 in Table C-2; therefore:

A = 50,000 lbs x 0.61 = 30,500 square feet

Now calculate the evaporation rate for acrylonitrile in the mixture from Equation 6 using the VP_m and A calculated above:

$$QR = \frac{0.0035 \times U^{0.78} \times MW^{2/3} \times A \times VP}{T} \qquad \text{Equation 6}$$

where:

QR	=	Evaporation rate (lbs/min)
U	=	Wind speed (m/sec)
MW	=	Molecular weight (Table C-2)
A	=	Surface area of pool formed by the entire quantity of the mixture (ft^2)
VP	=	Vapor pressure (mm Hg) (VP_m)
T	=	Temperature (^oK), ^oC plus 273 (298 for 25^oC)

$$QR = \frac{0.0035 \times 1.0 \times (53.06)^{2/3} \times 30{,}500 \times 51.8}{298}$$

QR = 262 pounds per minute

Release Rates for Common Water Solutions of Toxic Substances and for Oleum

The following discussion presents a simple method of estimating the release rate from spills of water solutions of several substances. Oleum (a solution of sulfur trioxide in sulfuric acid) also is discussed.

The vapor pressure and evaporation rate of a substance in a solution depends on its concentration in the solution. If a concentrated water solution containing a volatile toxic substance is spilled, the toxic substance initially will evaporate more quickly than water from the spilled solution. The vapor pressure and evaporation rate will decrease as the concentration of the toxic substance in the solution decreases. At the much lower concentrations, water may evaporate more quickly than the toxic substance. There does exist one concentration at which the composition of the solution does not change as evaporation occurs. However, for most situations of interest, the actual concentration exceeds this concentration, and the toxic substance evaporates more quickly than water.

For estimating release rates from solutions, this procedure uses liquid factors (ambient) for several common water solutions at several concentrations. These factors take into account the decrease in evaporation rate with decreasing concentration. Table C-3 provides LFA and DF values for several concentrations of ammonia, formaldehyde, hydrochloric acid, hydrofluoric acid, and nitric acid in water solution. Factors for oleum are also included in this table. These factors may be used to estimate an average release rate for the hazardous substances from a pool formed by a spill of solution. Liquid factors are provided for two different wind speeds since the wind speed affects the rate of evaporation.

For the worst-case scenario, the factor for a wind speed of 1.5 meters per second (3.4 miles per hour) should be used. When estimating the critical distance for the release of solutions under ambient conditions, consider only the first 10 minutes of the release, as the toxic component in a solution evaporates fastest during the first few minutes of a spill (when its concentration is highest). Although the toxic substance will continue to evaporate from the pool after 10 minutes, the rate of evaporation is so much lower that it can safely be ignored in estimating the critical distance. Release rates are estimated as follows.

Ambient Temperature. If the solution is at ambient temperature, the LFA at 1.5 meters per second (3.4 miles per hour) and DF for the solution are obtained from Table C-3. To estimate the release of the hazardous substance in solution, follow the instructions for liquids. For the calculation of the release rate, use the total quantity of the solution as the quantity released (QS).

Example for Calculating the Evaporation Rate for a Water Solution of Hydrochloric Acid at Ambient Temperature

A tank contains 50,000 pounds of 37 percent hydrochloric acid solution, at ambient temperature. For the worst-case analysis, assume the entire contents of the tank are released, forming a pool. The release occurs in a diked area of 9,000 square feet. From Table C-3, the Density Factor (DF) for 37 percent hydrochloric acid is 0.42. From Equation 1, the maximum area of the pool would be 50,000 lbs times 0.42, or 21,000 square feet.

The diked area is smaller; therefore, the diked area should be used in the evaporation rate (release rate) calculation, using Equation 2. For the calculation, the pool area (9,000 square feet) and the Liquid Factor Ambient (LFA) for 37 percent hydrochloric acid are needed; also assume a wind speed of 1.5 meters per second, so the wind speed factor is 1.4. From Table C-3, the LFA is 0.0085. From Equation 2, the release rate (QR) of hydrogen chloride from the pool is:

$$QR = 1.4 \times 9{,}000 \times 0.0085 = 107 \text{ pounds per minute}$$

Estimation of Worst-Case Distance to Toxic Endpoint

This procedure provides graphs (Figures 4-1 to 4-8) giving worst-case distances for neutrally buoyant gases and vapors and for dense gases and vapors for both rural (open) and urban (obstructed) areas. Neutrally buoyant gases and vapors have approximately the same density as air, and dense gases and vapors are heavier than air. Neutrally buoyant and dense gases are dispersed in different ways when they are released. These generic figures can be used to estimate distances using the specified toxic endpoint for each substance and the estimated release rate to air. In addition to the generic figures, chemical-specific figures are provided for ammonia, chlorine, and sulfur dioxide. These chemical-specific figures were developed based on modeling carried out for industry-specific guidance documents. All the figures were developed assuming a wind speed of 1.5 meters per second (3.4 miles per hour) and F stability. To use the figures, the worst-case release rates estimated as described in the previous sections are needed. For liquid pool evaporation, the duration of the release is also needed. In addition, the appropriate toxic endpoint and whether the gas or vapor is neutrally buoyant or dense is also needed (Tables C-1, C-2 and C-3).

Regulated Toxic Substances Other than Ammonia, Chlorine, and Sulfur Dioxide

- Find the toxic endpoint for the substance in Table C-1 for toxic gases or Table C-2 for toxic liquids.
- Determine whether the figure for neutrally buoyant or dense gases and vapors is appropriate from Appendix Table C-1 for toxic gases or Table C-2 for toxic liquids. A toxic gas that is lighter than air may behave as a dense gas upon release if it is liquefied under pressure, because the released gas may be mixed with liquid droplets, or it may be cold.
- Determine whether the figure for rural or urban conditions is appropriate.
  - Use the rural figure if the site is in an open area with few obstructions.
  - Use the urban figure if the site is in an urban or obstructed area. The urban figures are appropriate if there are many obstructions in the area, even if it is in a remote location, not in a city.

- Determine whether the 10-minute figure or the 60-minute figure is appropriate.
  - Always use the 10-minute figure for worst-case releases of toxic gases.
  - Always use the 10-minute figure for worst-case releases of common water solutions and oleum from evaporating pools, for both ambient and elevated temperatures.
  - If the estimated release duration for an evaporating toxic liquid pool is 10 minutes or less, use the 10-minute figure.
  - If the estimated release duration for an evaporating toxic liquid pool is more than 10 minutes, use the 60-minute figure.

Neutrally Buoyant Gases or Vapors. If Tables C-1 or C-2 indicate the gas or vapor should be considered neutrally buoyant, and other factors would not cause the gas or vapor to behave as a dense gas, divide the estimated release rate (pounds per minute) by the toxic endpoint (milligrams per liter). Find the calculated release rate/toxic endpoint ratio on the x-axis of the figures (Figures 4-1, 4-2, 4-3, or 4-4), then find the corresponding distance to the y-axis (see example below).

Example for a Gas Release of Diborane
The estimated release rate for diborane gas is 250 pounds per minute. From Table C-1, the toxic endpoint for diborane is 0.0011 mg/L, and it is a neutrally buoyant gas. The facility and the surrounding area have many buildings, pieces of equipment, and other obstructions; therefore, assume urban conditions. The appropriate data is therefore shown on Figure 4-3 (a 10-minute release of a neutrally buoyant gas in an urban area).

The release rate divided by toxic endpoint for this example is (250 lb/min)/(0.0011 mg/L) = 230,000 [(lb/min)/(mg/L)].

From Figure 4-3, this value corresponds to a critical distance of about 8 miles.

Dense Gases or Vapors. If Table C-1 or C-2 or other relevant factors indicates that the substance should be considered a dense gas or vapor (heavier than air), find the critical distance from the appropriate figure (Figure 4-5, 4-6, 4-7, or 4-8) as follows;

- Select the curve on the figure that is closest to the toxic endpoint of the substance.
- Find the release rate closest to the release rate estimated for the substance on the x-axis of the figure.
- Determine the corresponding critical distance on the y-axis.

Example for a Release of Ethylene Oxide, a Dense Gas
A tank contains 10,000 pounds of ethylene oxide, which is a gas under ambient conditions. Assuming the total quantity in the tank is released over a 10-minute period, the release rate (QR) is:

QR = 10,000 pounds/10 minutes = 1,000 pounds per minute

From Table C-1, the toxic endpoint for ethylene oxide is 0.09 mg/L, and the appropriate figure is for a dense gas. The facility is in an open, rural area with few obstructions; therefore, use the figure for rural areas.

Using Figure 4-5 for 10-minute releases of dense gases in rural areas, the toxic endpoint of 0.09 mg/L is closer to 0.1 than 0.075 mg/L. For a release rate of 1,000 pounds per minute, the distance to 0.1 mg/L is about 3.5 miles.

<u>Example for Liquid Evaporation from a Pool of Acrylonitrile</u>
The estimated evaporation rate is 307 pounds per minute for acrylonitrile from a pool formed by the release of 20,000 pounds into an undiked area. The estimated time for evaporation of the pool as 65 minutes. From Table C-2, the toxic endpoint for acrylonitrile is 0.076 mg/L, and the appropriate figure for a worst-case release of acrylonitrile is the dense gas figure. The facility is in an urban area, so Figure 4-8 is used for a 60-minute release of a dense gas in an urban area.

From Figure 4-8, the toxic endpoint closest to 0.076 mg/L is 0.075 mg/L. The worst-case critical distance, corresponding to the release rate of 307 pounds per minute, is therefore about 3 miles.

<u>Ammonia, Chlorine, or Sulfur Dioxide</u>. Use the appropriate chemical-specific figure for the substance (Figures 4-9 through 4-12). If ammonia is liquefied by refrigeration alone, use Figure 4-10, even if the duration of the release is greater than 10 minutes. If chlorine or sulfur dioxide is liquefied by refrigeration alone, use the chemical-specific reference figure, even if the duration of the release is greater than 10 minutes. Use the rural curve on the figure if the site is in an open area with few obstructions, otherwise use the urban curve if the site is in an urban or obstructed area. The urban curve is appropriate if there are many obstructions in the area, even if it is in a remote location and not in a city.

Estimation of Distance to Overpressure Endpoint for Flammable Substances
For the worst-case scenario involving releases of flammable gases and/of volatile flammable liquids, assume that the total quantity of the flammable substance forms a vapor cloud within the upper and lower flammability limits and the cloud detonates. As a conservative worst-case assumption, this procedure assumes that 10 percent of the flammable vapor in the cloud participates in the explosion. This procedure estimates the distance to an overpressure level of 1 pound per square inch (psi) resulting from the explosion of the vapor cloud. An overpressure of 1 psi may cause partial demolition of houses, which can result in serious injuries to people, and shattering of glass windows, which may cause skin laceration from flying glass. This section presents a simple method for estimating the area (distance from the explosion) potentially affected by a vapor cloud explosion of a hazardous substance. This procedure is based on a TNT-equivalent model.

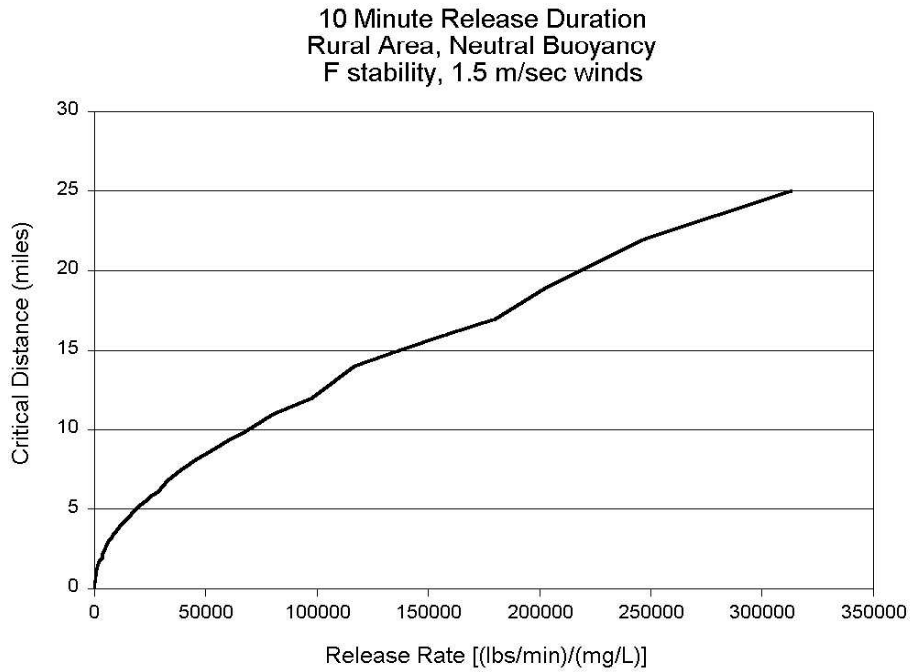

Figure 4-1. Neutrally buoyant gas in rural area, 10 minute release.

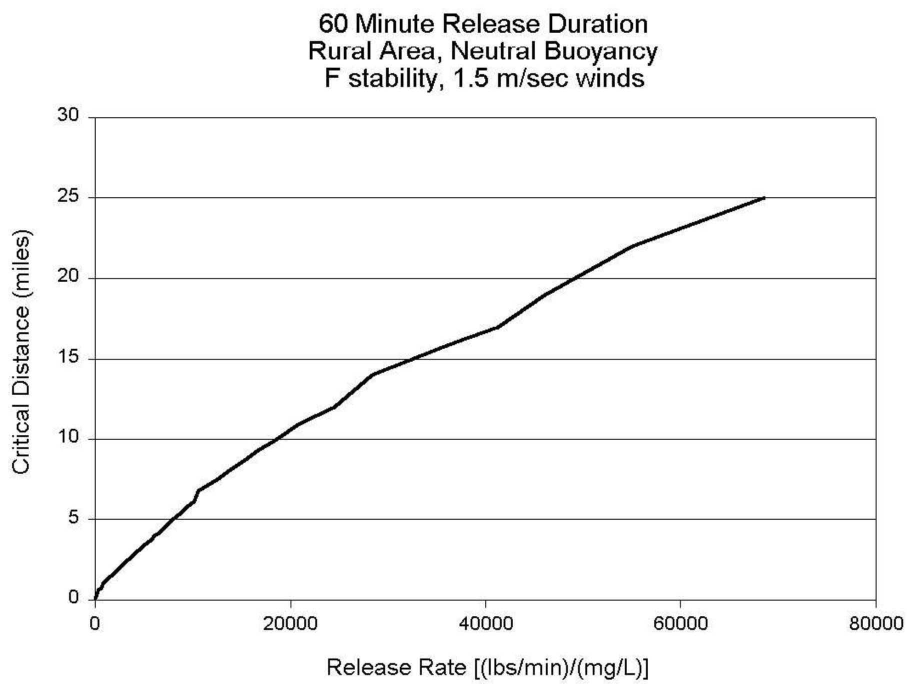

Figure 4-2. Neutrally buoyant gas in rural area, 60 minute release.

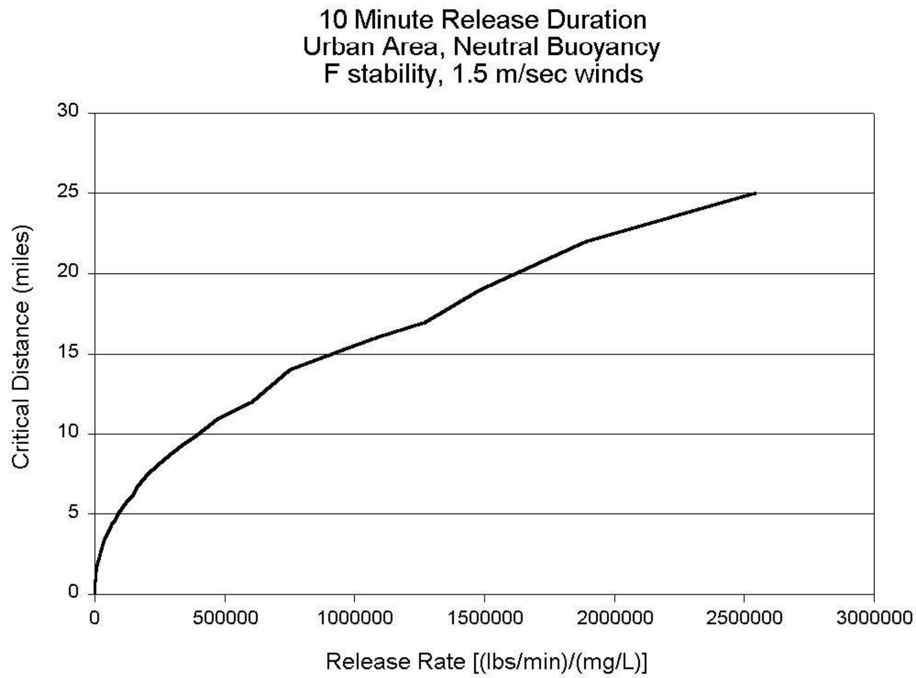

Figure 4-3. Neutrally buoyant gas in urban area, 10 minute release.

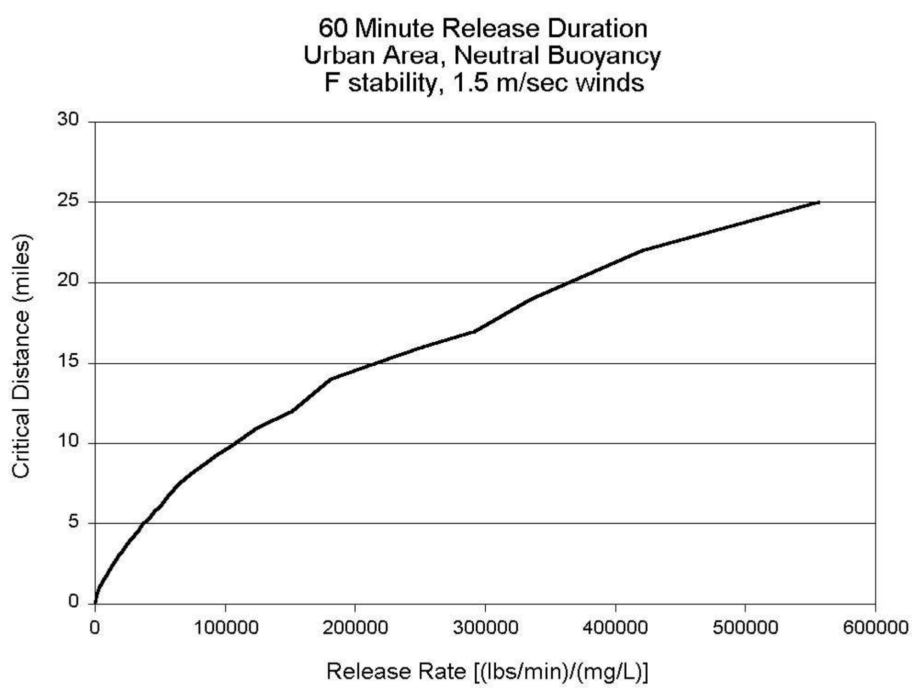

Figure 4-4. Neutrally buoyant gas in urban area, 60 minute release.

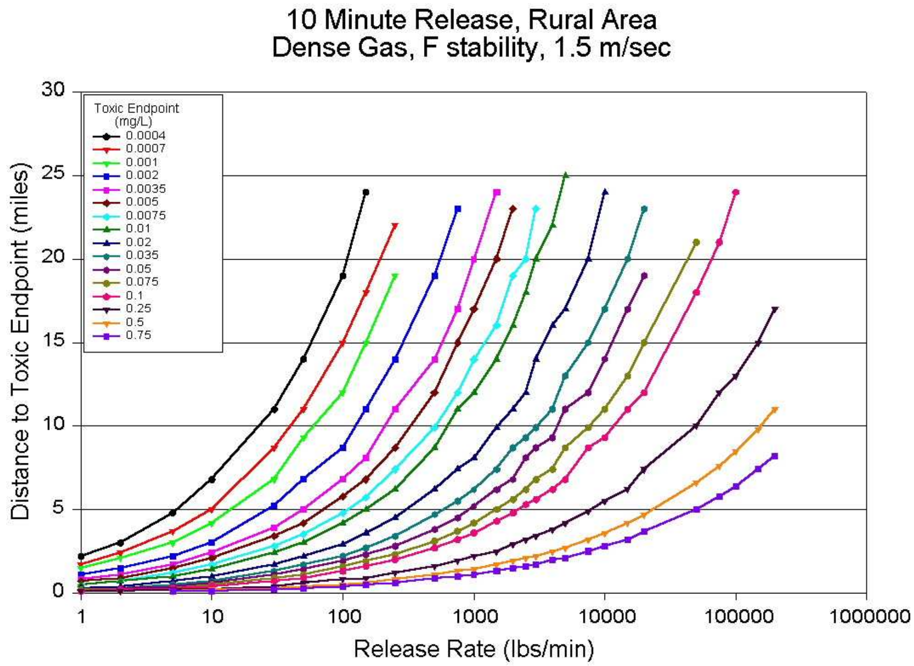

Figure 4-5. Dense gas in rural area, 10 minute release.

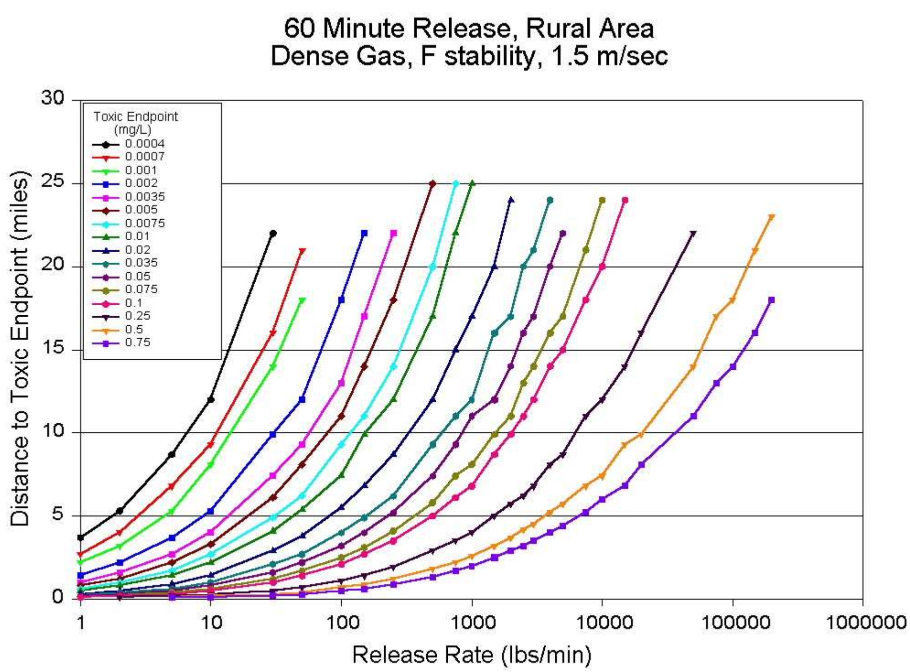

Figure 4-6. Dense gas in rural area, 60 minute release.

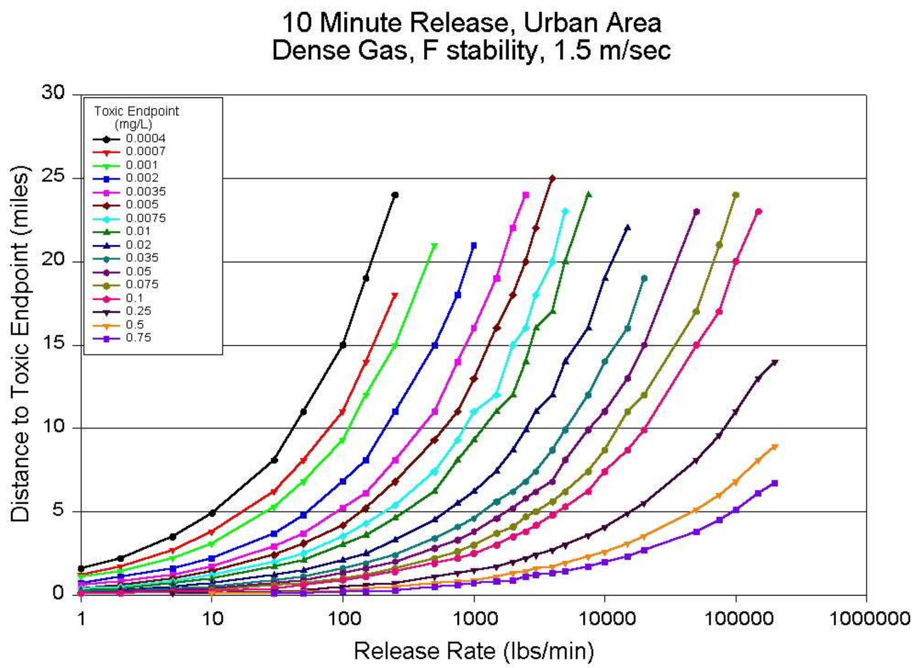

Figure 4-7. Dense gas in urban area, 10 minute release.

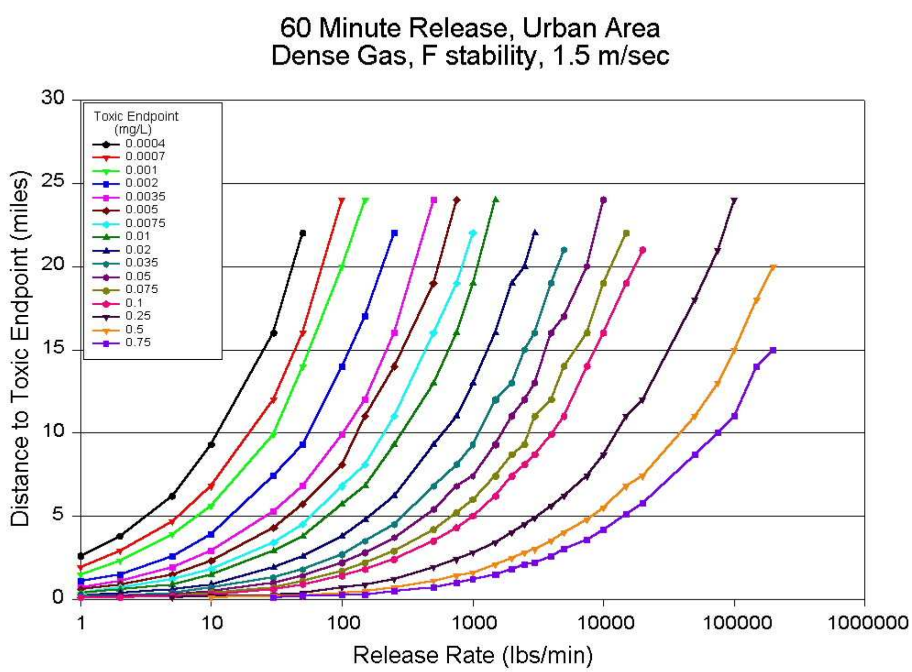

Figure 4-8. Dense gas in urban area, 60 minute release.

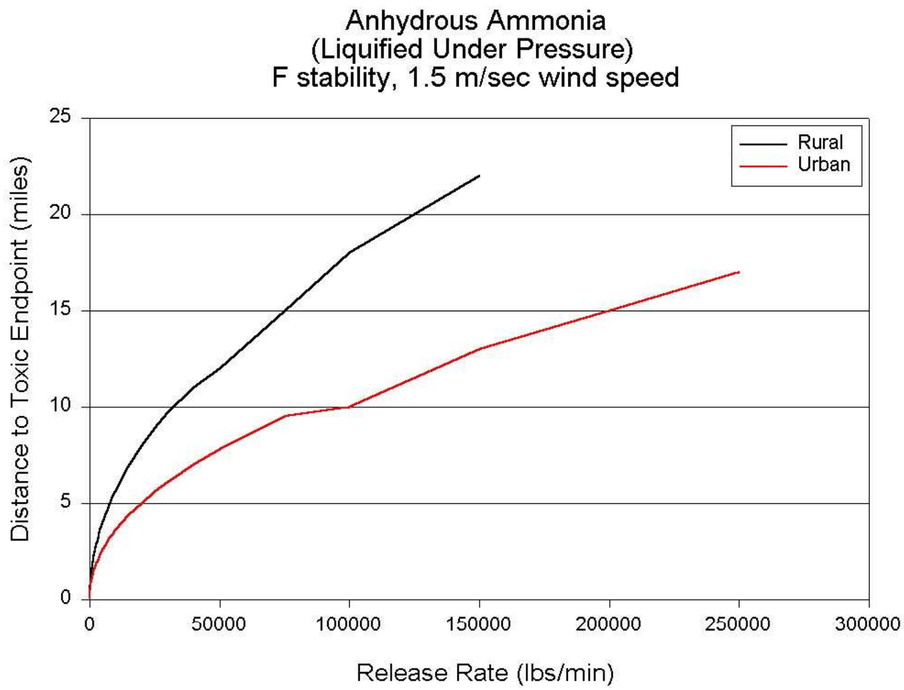

Figure 4-9. Anhydrous ammonia (liquefied under pressure) release.

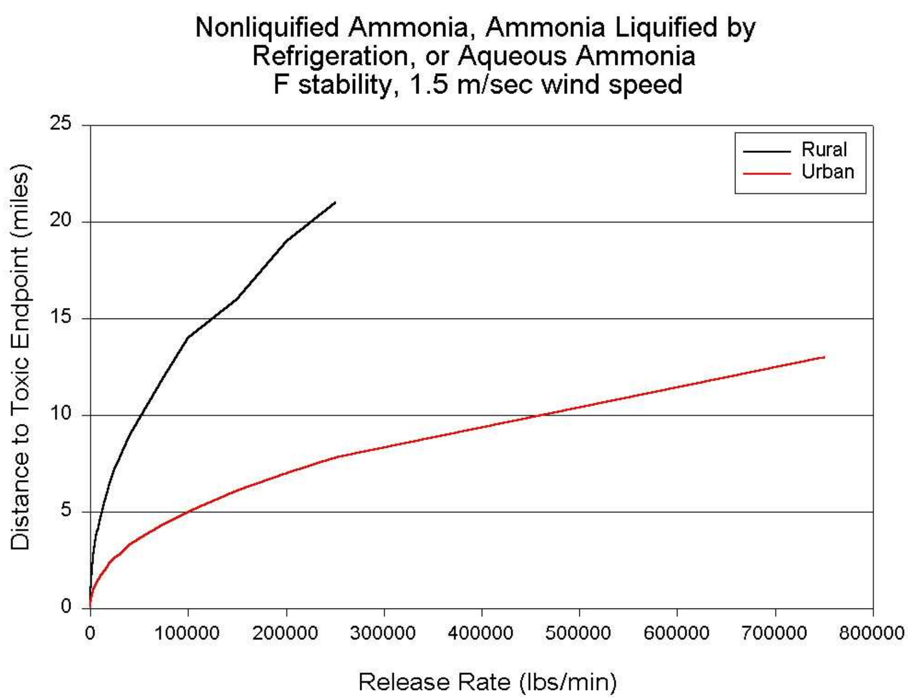

Figure 4-10. Anhydrous ammonia (non-liquefied, or liquefied by refrigeration, or aqueous ammonia) release.

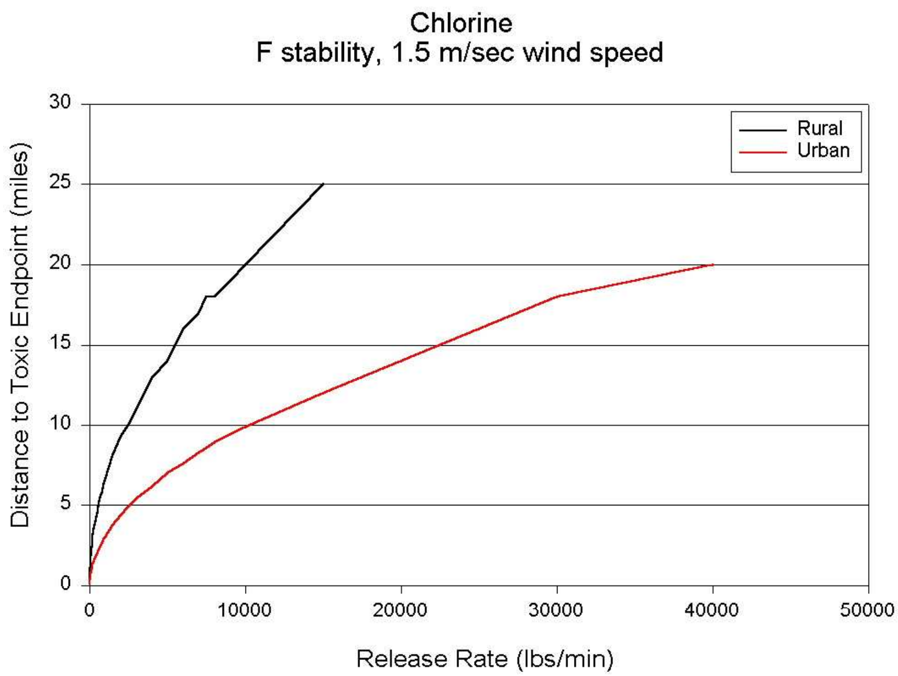

Figure 4-11. Chlorine release.

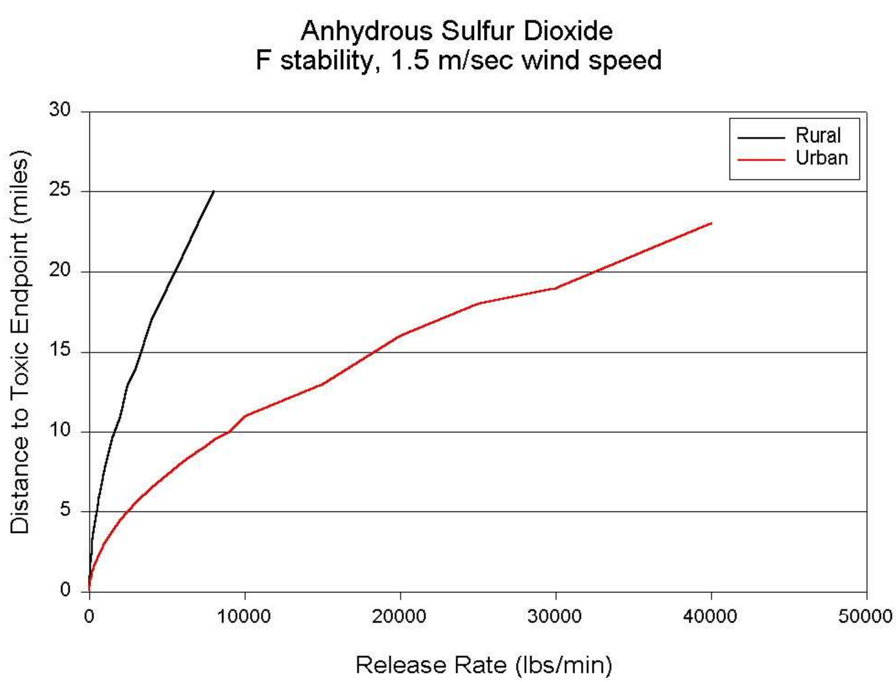

Figure 4-12. Anhydrous sulfur dioxide release.

Flammable Substances Not in Mixtures

For the worst-case analysis of a flammable substance that is not in a mixture with other substances, estimate the consequence distance for a given quantity of a regulated flammable substance using Table 4-1. This table provides distances to 1 psi overpressure for vapor cloud explosions of quantities from 500 to 2,000,000 pounds. An alternative is to calculate the worst-case distance for flammable substances using the heat of combustion of the flammable substance and the following equations.

Critical distances to an overpressure level of 1 pound per square inch (psi) may be determined using the following equation, which is based on the TNT-equivalency method:

$$D_{mi} = 0.0081 \times \left(0.1 \times W_{lb} \times \frac{HC_f}{HC_{TNT}} \right)^{1/3} \qquad \text{Equation 7}$$

where:

D_{mi} = Distance to overpressure of 1 psi (miles)

W_{lb} = Weight of flammable substance (pounds)

HC_f = Heat of combustion of flammable substance (kilojoules per kilogram), from Table D-1

HC_{TNT} = Heat of explosion of trinitrotoluene (TNT) (4,680 kilojoules per kilogram)

Example for a Vapor Cloud Explosion of Propane

A tank contains 50,000 pounds of propane. From Table 4-1, the critical distance to 1 psi overpressure is 0.3 miles for this quantity of propane. Alternatively, it is possible to directly calculate the distance to 1 psi using Equation 7:

$$D = 0.0081 \text{ x } [0.1 \text{ x } 50{,}000 \text{ x } (46{,}333/4{,}680)\ ]^{1/3}$$

$$D = 0.3 \text{ miles}$$

Flammable Mixtures

For a mixture of flammable substances, it is possible to estimate the heat of combustion of the mixture from the heats of combustion of the components of the mixture using Equation 8 and then use Equation 7 to determine the vapor cloud explosion distance. The heat of combustion of the mixture may be estimated as follows:

$$HC_m = \frac{W_x}{W_m} \times HC_x + \frac{W_y}{W_m} \times HC_y \qquad \text{Equation 8}$$

where:

HC_m	=	Heat of combustion of mixture (kilojoules per kilogram)
W_x	=	Weight of component “X” in mixture (kilograms or pounds/2.2)
W_m	=	Total weight of mixture (kilograms or pounds/2.2)
HC_x	=	Heat of combustion of component “X” (kilojoules per kilogram), from Table D-1
W_y	=	Weight of component “Y” in mixture (kilograms or pounds/2.2)
HC_y	=	Heat of combustion of component “Y” (kilojoules per kilogram)

Example for Calculating Heat of Combustion of Mixture for Vapor Cloud Explosion Analysis

A mixture contains 8,000 pounds of ethylene (the reactant) and 2,000 pounds of isobutane (a catalyst carrier). To carry out the worst-case analysis, estimate the heat of combustion of the mixture from the heats of combustion of the components of the mixture (ethylene heat of combustion = 47,145 kilojoules per kilogram; isobutane heat of combustion = 45,576). Using Equation 8:

$$HC_m = \frac{[(8{,}000/2.2)\times 47{,}145]}{(10{,}000/2.2)} + \frac{[(2{,}000/2.2)\times 45{,}576]}{(10{,}000/2.2)}$$

$$HC_m = (37{,}716) + (9{,}115)$$

HC_m = 46,831 kilojoules per kilogram

Now use the calculated heat of combustion for the mixture in Equation 7 to calculate the distance to 1 psi overpressure for vapor cloud explosion.

D = 0.0081 x [0.1 x 10,000 x (46,831/4,680)]$^{1/3}$

D = 0.2 miles

Table 4-1. Distance (miles) to Overpressure of 1.0 psi for Vapor Cloud Explosions of 500 - 2,000,000 Pounds of Regulated Flammable Substances Based on TNT Equivalent Method, 10 Percent Yield Factor (EPA 1999)

Quantity in Cloud (pounds)		500	2,000	5,000	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000
CAS No.	**Chemical Name**	**Distance (miles) to 1 psi Overpressure**										
75-07-0	Acetaldehyde	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
74-86-2	Acetylene	0.07	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0
598-73-2	Bromotrifluoroethylene	0.02	0.04	0.05	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4
106-99-0	1,3-Butadiene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
106-97-8	Butane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
25167-67-3	Butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
590-18-1	2-Butene-cis	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
624-64-6	2-Butene-trans	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
106-98-9	1-Butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
107-01-7	2-Butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
463-58-1	Carbon oxysulfide	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
7791-21-1	Chlorine monoxide	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.1	0.2	0.2	0.3
590-21-6	1-Chloropropylene	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
557-98-2	2-Chloropropylene	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
460-19-5	Cyanogen	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
75-19-4	Cyclopropane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
4109-96-0	Dichlorosilane	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
75-37-6	Difluoroethane	0.04	0.06	0.09	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
124-40-3	Dimethylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
463-82-1	2 2-Dimethylpropane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
74-84-0	Ethane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
107-00-6	Ethyl acetylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
75-04-7	Ethylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-00-3	Ethyl chloride	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
74-85-1	Ethylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	I.0
60-29-7	Ethyl ether	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-08-1	Ethyl mercaptan	0.05	0.09	0.1	0.2	0.2	0.2	0.3	0.4	0.5	0.7	0.9
109-95-5	Ethyl nitrite	0.05	0.07	0.1	0.1	0.2	0.2	0.3	0.3	0.5	0.6	0.7
1333-74-0	Hydrogen	0.09	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.9	1.1	1.4
75-28-5	Isobutane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
78-78-4	Isopentane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
78-79-5	Isoprene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
75-31-0	Isopropylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-29-6	Isopropyl chloride	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
74-82-8	Methane	0.07	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0
74-89-5	Methylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
563-45-1	3-Methyl-1-butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
563-46-2	2-Methyl-1-butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
115-10-6	Methyl ether	0.05	0.09	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.7	0.9

Table 4-1. Distance to Overpressure of 1.0 psi for Vapor Cloud Explosions of 500 - 2,000,000 Pounds of Regulated Flammable Substances Based on TNT Equivalent Method, 10 Percent Yield Factor (EPA 1999) (continued)

Quantity in Cloud (pounds)		500	2,000	5,000	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000
CAS No.	**Chemical Name**	**Distance (miles) to 1 psi Overpressure**										
107-31-3	Methyl formate	0.04	0.07	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7
115-11-7	2-Methylpropene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
504-60-9	1 3-Pentadiene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
109-66-0	Pentane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
109-67-1	1-Pentene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
646-04-8	2-Pentene, (E)-	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
627-20-3	2-Pentene, (Z)-	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
463-49-0	Propadiene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
74-98-6	Propane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
115-07-1	Propylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
74-99-7	Propyne	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
7803-62-5	Silane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
116-14-3	Tetrafluoroethylene	0.02	0.03	0.04	0.05	0.07	0.09	0.1	0.1	0.2	0.2	0.3
75-76-3	Tetramethylsilane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
10025-78-2	Trichlorosilane	0.03	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.4
79-38-9	Trifluorochloroethylene	0.02	0.03	0.05	0.06	0.07	0.1	0.1	0.2	0.2	0.3	0.3
75-50-3	Trimethylamine	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.6	0.8	1.0
689-97-4	Vinyl acetylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
75-01-4	Vinyl chloride	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
109-92-2	Vinyl ethyl ether	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-02-5	Vinyl fluoride	0.02	0.04	0.05	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4
75-35-4	Vinylidene chloride	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
75-38-7	Vinylidene fluoride	0.04	0.06	0.09	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
107-25-5	Vinyl methyl ether	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9

Spills of Mixtures of Hazardous Chemicals During Transportation Accidents

Spills involving more than one type of chemical are possible during some transportation accidents, especially when the accidents involve railroads. Most other transportation modes (chemical tank trucks and pipelines) are more likely to involve only one hazardous material. However, some trucks may be carrying several different materials. Under certain conditions, multi-component spills may be dangerously reactive or generate hazardous by-products. The following discussion is an example evaluation for binary mixtures of some materials.

An example list of chemicals is shown in Table 4-2 by reactivity group. Table 4-3 displays these groups in the form of a matrix in order to indicate the potential for unsafe conditions if chemicals from any two groups may mix. Extreme caution would need to be taken to prevent accidental mixing of chemicals belonging to groups for which an "X" appears. Regulations restrict the transportation of large amounts of chemicals that may mix forming extremely hazardous conditions, but errors do occur. The accidental mixing of reactive groups could, in certain instances, result in violent and hazardous chemical reactions. The generation of toxic gases, the heating, overflow and rupture of storage tanks, and fire and explosion are possible consequences of such reactions.

The following discussion also gives a general overview of what products and conditions could be produced by the reaction of any potentially hazardous combinations of chemicals from two different groups. An extensive variety of combinations are possible when considering the reactions of broad groups of chemicals. Even though combinations of certain groups can be considered potentially hazardous, there may exist individual combinations which do not produce unsafe conditions. Conversely, some chemical-group combinations which are generally not considered hazardous as a mix might very well be if unusual circumstances occur. Combinations of more than two groups would be much more complex to evaluate. As a rule, if the mixture contains one or more reactive groups, it should be assumed that hazardous conditions would likely develop.

Table 4-2. Reactivity Groups for Selected Chemicals

<u>Inorganic Acids</u>	<u>Petroleum Oils</u>	<u>Ammonia</u>
Boric acid	Diesel fuel	Ammonia (Anhydrous)
Chromic acid*		Ammonium hydroxide
Fluoboric acid	<u>Halogenated Compounds</u>	
Hydrochloric acid	Transformer oils	<u>Sulfur, Molten</u>
Hydrofluoric acid (Anhydrous)	Silicon tetrafluoride	Sulfur liquid
Hydrofluoric acid (Aqueous)		
Nitric acid*	<u>Inorganic Salts</u>	<u>Metals</u>
Sulfur dioxide (Anhydrous)	Alum	Arsenic precipitate
Phosphoric acid	Ammonium fluoride	Bauxite
Sulfuric acid* (Oleum)	Calcium sulfate	Metal oxides
Sulfur trioxide (Anhydrous)	Fluorospar	
<u>Organic acids</u>	<u>Caustics</u>	<u>Strong Oxidants</u>
Acetic acids	Sodium hydroxide	Hydrogen peroxide
	Soda ash	Potassium dichromate
		Potassium permanganate
		Sodium bichromate

*Compound may also be considered a strong oxidant.

Table 4-3. Chemical Compatibility

1	Inorganic Acids	1									
2	Organic Acids	X	2								
3	Caustics	X	X	3							
4	Halogenated Compounds	X		X	4						
5	Petroleum Oils					5					
6	Ammonia	X	X				6				
7	Sulfur, Molten					X		7			
8	Inorganic Salt								8		
9	Strong Oxidant		X			X				9	
10	Metal Oxides	X									10
11	Metals	X		X							

"X" represents a potentially hazardous combination.

<u>Reaction Products of Combinations of Potentially Hazardous Reactivity Groups</u>

Inorganic Acids + Organic Acids

1. Vapor Products in the Presence of Water
    - Depending on the heat generated by the reaction, fumes from the component acids may be given off. The reaction may form volatiles – giving off ketones, aldehydes, and esters.
2. Solid or Liquid Products in the Presence of Water
    - Possible formation of precipitates.
3. Vapor Products Without Water
    - Same as with the presence of water.
4. Solid or Liquid Products Without Water
    - Char or charcoal products may form depending on the circumstances.

Inorganic Acids + Caustics

1. Vapor Products in the Presence of Water
    - The main products of this reaction are heat and salts. Component acid fumes may be given as a result of the heat involved.
2. Solid or Liquid Products in the Presence of Water
    - No significant products are expected to occur from this reaction.
3. Vapor Products Without Water
    - Water vapor, carbon dioxide, and possibly acid fumes will be produced.
4. Solid or Liquid Products Without Water
    - A crusty mass of salt precipitates is expected to form with the possibility of acid and precipitate splatter.

Inorganic Acids + Halogenated Compounds

1. Vapor Products in the Presence of Water

- Water vapor and carbon dioxide will be produced along with the possible emission of halogens and nitrous oxides.

2. Solid or Liquid Products in the Presence of Water
   - This reaction could produce either or both solid and liquid products depending on the components.
3. Vapor Products without Water
   - This reaction produces basically the same products as those formed in the presence of water, only in larger quantities
4. Solid or Liquid Products Without Water
   - Miscellaneous tars are expected to result from this reaction.

Inorganic Acids + Ammonia

1. Vapor Products in the Presence of Water
   - Vapor emissions from components only are expected; no vapor reaction products.
2. Solid or Liquid Products in the Presence of Water
   - Depending on the concentrations of the components, ammonia salt precipitates are likely to occur.
3. Vapor Products Without Water
   - No significant vapor products are expected to occur in this reaction.
4. Solid or Liquid Products Without Water
   - Particulates of ammonium halides would be generated from this reaction.

Inorganic Acids + Metal Oxides

1. The same products as listed in the "Inorganic Acids + Caustics" reaction are expected to form in this reaction, but the reaction will be less violent.

Inorganic Acids + Metals

1. Vapor Products in the Presence of Water
   - Hydrogen and water vapors will be produced from this reaction, violent splattering may also occur.
2. Solid or Liquid Products in the Presence of Water
   - Various solids are likely to be precipitated out depending on the acid involved.
3. Vapor Products Without Water
   - Highly toxic arsines and stybines would result from arsenic precipitate combining with inorganic acids.
4. Solid or Liquid Products Without Water
   - Same as with water except that larger quantities of solids will be produced.

Organic Acids + Caustics

1. Vapor Products in the Presence of Water
   - Vapor products from this reaction will be primarily odors resulting from the formation of soaps. Phenol derivatives might also occur as vapors.
2. Solid of Liquid Products in the Presence of Water
   - Solid products will occur in the form of various, insoluble materials and soaps.
3. Vapor Products Without Water
   - Mainly soap vapors and gases will be produced.

4. Solid or Liquid Products Without Water
    - Same products as with water.

Organic Acids + Ammonia

1. Vapor Products in the Presence of Water
    - These would be vapors from both the components and the various reaction products.
2. Solid or Liquid Products in the Presence of Water
    - The components are soluble with little or no precipitates.
3. Vapor Products Without Water
    - Vapors are the same as those with water except in larger quantities.
4. Solid or Liquid Products Without Water
    - Ammonium acetate and salts are present in a gum-like substance.

Organic Acids + Oxidants

1. Vapor Products in the Presence of Water
    - This reaction will produce a myriad of vapor products which could include gases such as formaldehyde and methane.
2. Liquid or Solid Products in the Presence of Water
    - Possibly some solid products will form.
3. Vapor Products Without Water
    - This reaction will produce more vapor products than if water was present. Water vapor would be given off explosively along with carbon dioxide.
4. Liquid or Solid Products Without Water
    - Possible formation of solids, more so than with water.

Caustics + Halogenated Compounds

1. Vapor Products in the Presence of Water
    - Vaporous halogens can be expected to be given off by this reaction.
2. Solid or Liquid Products in the Presence of Water
    - Very little, if any, solids are likely to be produced in this reaction.
3. Vapor Products Without Water
    - Possible toxic halogens and halogenated compounds would be emitted as vapors.
4. Solid or Liquid Products Without. Water
    - Some solids are expected to be produced.

Caustics + Metals

1. Vapor Products in the Presence of Water
    - The reaction products are basically the same as those of acids and metals which yield hydrogen and water vapors.
2. Solid of Liquid Products in the Presence of Water
    - Reaction will form arsenic products in solid form.
3. Vapor Products Without Water
    - Products are basically the same as those of acids and metals, except that arsine will probably not be given off.
4. Solid or Liquid Products Without Water

- Same as with water except in larger quantities.

Petroleum Oils + Caustics

1. Vapor Products in the Presence of Water
   - Many vaporous products will be given off from this violent reaction.
2. Solid or Liquid Products in the Presence of Water
   - Some solids can be expected to be produced.
3. Vapor Products Without Water
   - Probably an explosive, flaring reaction with much particulate matter being released.
4. Solid or Liquid Products Without Water
   - Products would be in the form of a crusty mass of precipitates or a gummy tar.

Petroleum Oils + Molten Sulfur

1. Vapor Products in the Presence of Water
   - Possibly explosive reaction accompanied by fire. Sulfur dioxide and maybe sulfur trioxide would be emitted. Carbon particulates and sulfur combinations of petroleum products will also be given off.
2. Solid or Liquid Products in the Presence of Water
   - Solid sulfur and possibly some tars would result.
3. Vapor Products Without Water
   - The reaction would be violent yielding larger quantities of products and a high probability of fire.
4. Solid or Liquid Products Without Water
   - Solid sulfur and probably tars would result.

<u>Stakeholder Comments on Hazardous Materials Involved in Transportation Accidents</u>

Interviews with stakeholders raised several concerns relating to the types of chemicals that may be involved in a hazardous-materials transportation accidents. According to the stakeholders, the chemical groups that responders generally were not prepared and equipped to deal with were water-reactive chemicals, corrosives, elevated temperature materials, regulated medical waste, and precursor chemicals for clandestine laboratories. The typical response of a local fire department in a highway accident would be to put water on the chemical and wash it off the roadway. However, in the case of water-reactive chemicals, this may make a small problem a significantly larger one. When dealing with elevated-temperature materials, the departments do not have the appropriate gear, i.e., their rubber suits are not acceptable for working near a 250^{o}C fire. One example of a commonly-transported elevated temperature material was liquid asphalt. Regulated medical waste is a concern because of the variety of vehicles in which it can be transported and because of the lack of information that may be available about the exact nature of the waste. The last chemical group is the precursor chemicals for clandestine laboratories. These shipments are not placarded and there is no paperwork on what a truck contains. In many cases, these are rental trucks. Therefore, personnel responding to an accident likely do not know that they are entering a chemical hazard area, and therefore, they are not properly protected.

Hazards of Accidental Releases of Ammonia during Transportation Operations

This discussion presents the results of a detailed site-specific evaluation of potential ammonia spills associated with transportation accidents. These accidents may range from complete loss of the cargo from specialized ammonia transport ships, losses during transfer operations, and losses during trucking of ammonia. Both water and air quality problems associated with these various spill conditions are addressed in this discussion. This discussion also considers a typical range of site meteorological conditions, not just worst-case conditions as described earlier (using the methods from the *Offsite Consequence Analysis* (EPA 1999) procedure).

Properties of Ammonia

Ammonia is a colorless gas at atmospheric pressure and normal temperature. It is alkaline and possesses a characteristic penetrating odor. On compression and cooling, ammonia gas condenses to a liquid about 60 percent as heavy as water. The liquid has a high vapor pressure at ordinary temperature, and commercial shipment requires pressure containers unless the liquid is refrigerated. Ammonia is readily absorbed in water to make ammonium hydroxide (NH_4OH). Considerable heat evolves during the solution of ammonia gas in water (1 lb NH_3 gas produces 937 Btu when dissolved in water).

Ammonia does not support ordinary combustion, but it does burn with a yellowish flame in an atmosphere of air or oxygen. The ignition temperature of ammonia-air mixtures is 780^{o}C, and the products of combustion are mainly nitrogen and water. Under certain conditions, mixtures of ammonia and air will explode when ignited. The explosive range for dry ammonia-air mixtures is about 16 to 25 percent ammonia. Admixtures with other combustible gases such as hydrogen, admixtures where oxygen replaces air, and/or higher than atmospheric temperatures and pressures will broaden the explosive range. Because this range is restrictive, the explosion hazard is usually ignored as being highly unlikely, and ammonia is generally treated as a nonflammable compressed gas. However, ammonia explosions have occurred associated with transportation accidents.

The major hazards associated with ammonia are from the toxic effects on breathing and caustic burns caused by vapor, liquid, or solutions. Also, the cryogenic properties of refrigerated liquid ammonia can present some unique hazards because of the extreme cold. The concentrations of ammonia vapor in the air that will cause various physiological responses in humans are given in Table 4-4. The toxic endpoint of ammonia, as defined in Appendix A to 40 CFR part 68, is 200 ppm (equivalent to 0.14 mg/L). This is the concentration used by EPA (1999) for offsite consequence analyses.

Table 4-4. Physiological Response to Various Concentrations of Ammonia (Kirk and Othmer)

Physiological Response	Approximate Ammonia Concentration in Air (ppm)
Least detectable odor	50
Maximum concentration allowable for prolonged exposure	100
Maximum concentration allowable for short exposure (1/2-1 hr)	300-500
Least amount causing immediate irritation to throat	400
Least amount causing immediate irritation to eyes	700
Compulsive coughing and possible death	1700
Dangerous for even short exposure (1/2 hr)	2500-4500

Potential Sources of Accidental Releases

Most leaks and spills of ammonia are caused by failure of equipment or mishandling by personnel. There are many sources for these releases. The most serious and probable of these sources are discussed below. The amounts of release are estimated for typical design conditions.

Vessels

1. A catastrophic accident, such as a collision involving a vessel could release a potential maximum of about 12,000 tons of liquid ammonia.
2. The refrigeration system on a vessel could develop a leak from a broken pipe or fitting. During a transfer operation, the loss during a 5-minute shutdown period could amount to about 125 lb, while without a transfer, the loss could be about 42 lb.
3. Spills could occur at a terminal during off-loading of a vessel. Because of automatic emergency equipment, the losses would be limited to line drainage between the automatic valves and the break. This loss could be about 7 tons.

Trucks and Rail Cars

1. Trucks and rail cars could be involved in accidents with subsequent leaks or spills. If there is a tank rupture, the entire ammonia cargo of up to about 20 tons/truck and 80 tons/rail car could be spilled almost instantaneously. A lesser amount could be lost through a tank crack or a broken fitting.

2. During the normal loading of a tank truck at a storage terminal, approximately 1 ounce of ammonia vapor may be released to the atmosphere through a vent stack usually 20 ft high.

Venting

Various pieces of equipment have relief valves that vent ammonia vapor if the pressure builds up to a prespecified level (usually caused by a rise in temperature from loss of refrigeration or from a fire.) This venting occurs in a controlled fashion as described below.

1. The relief valves on ammonia-carrying vessels can begin to vent after several days without refrigeration. These losses can amount to 200 to 500 lb/hr. .
2. Large refrigerated storage tanks can vent after about 4 hours without refrigeration. The maximum vent rate can be about 750 lb/hr per tank. This would require an extremely long time to completely vent a tank. Backup electrical generators are typically used to supply electricity to the refrigeration equipment in case of prolonged power outages (the most probable cause of refrigeration failures).
3. The tanks on trucks and rail cars likely will vent only if involved in a fire. In a fire, a full truck tank would empty in about 4.5 hours, and a full rail car would empty in about 18 hours.

Water Quality Effects

The following discussion pertains to the hazards of spilling anhydrous ammonia during shipping and transfer operations at a facility located on a narrow ship channel. The discussion uses the ammonia (anhydrous)-specific, far-field prediction models provided in Raj, *et al.* (1974).

Anhydrous ammonia is a cryogenic liquid (-28^{o}F) at normal atmospheric pressure. It floats on the water surface, rapidly dissolving within the water body into ammonium hydroxide (NH_4OH), while at the same time boiling into the atmosphere as gaseous ammonia (NH_3). The partition ratio (the quantity of ammonia that dissolves into the receiving water divided by the total quantity spilled) is normally between 0.5 and 0.8 for surface spills and somewhat higher for underwater spills. For simplicity, the partition ratio for these analyses is assumed to be 0.6 for all spills. Furthermore, all spills are considered to be instantaneous.

If the water body near the site is of a generally one-dimensional nature and lacks advective currents, the spill would be distributed evenly over the cross section of the channel. Furthermore, it is expected that the length of channel affected by the spill would be roughly proportional to the length of time elapsed after the spill. If one further assumes that the concentration is constant longitudinally behind the advancing pollution front, then a single concentration value can be calculated to represent the entire contaminated prism as a function of increasing channel length for a given spill quantity. These functions are plotted on Figure 4-13, which assumes a constant cross-sectional area of 10,000 ft^2 within a ship channel and a speed of the pollution-front advance of approximately 0.2 ft/sec (if the actual cross-sectional area is larger than 10,000 ft^2, the resulting concentrations would be correspondingly smaller; if the actual water velocities were greater than 0.2 ft/sec, the times for the indicated concentrations to reach a specific point would be correspondingly sooner).

In reality, a well-mixed pollutant diffuses along a one-dimensional channel. It is not concentrated evenly along the polluted channel length. The actual concentrations are inversely proportion to the distance from the spill point**.** It can be assumed that the single concentration values obtained for a given spill value and channel length (Figure 4-13) best represent those concentration values expected to be measured approximately midway between the spill point and the limit of the channel length affected. The actual values will be greater by a factor of between 1 and 2 than those shown near the spill point, and will be less than the plotted concentrations down-channel from the midpoint.

The downstream length before complete mixing across the channel occurs can be estimated using an equation presented by Thomann and Mueller (1987):

$$L_m = \frac{2.6UB^2}{H} \qquad \text{Equation 9}$$

where: U is the stream velocity in ft/second
B is the average stream width in feet, and
H is average stream depth in feet

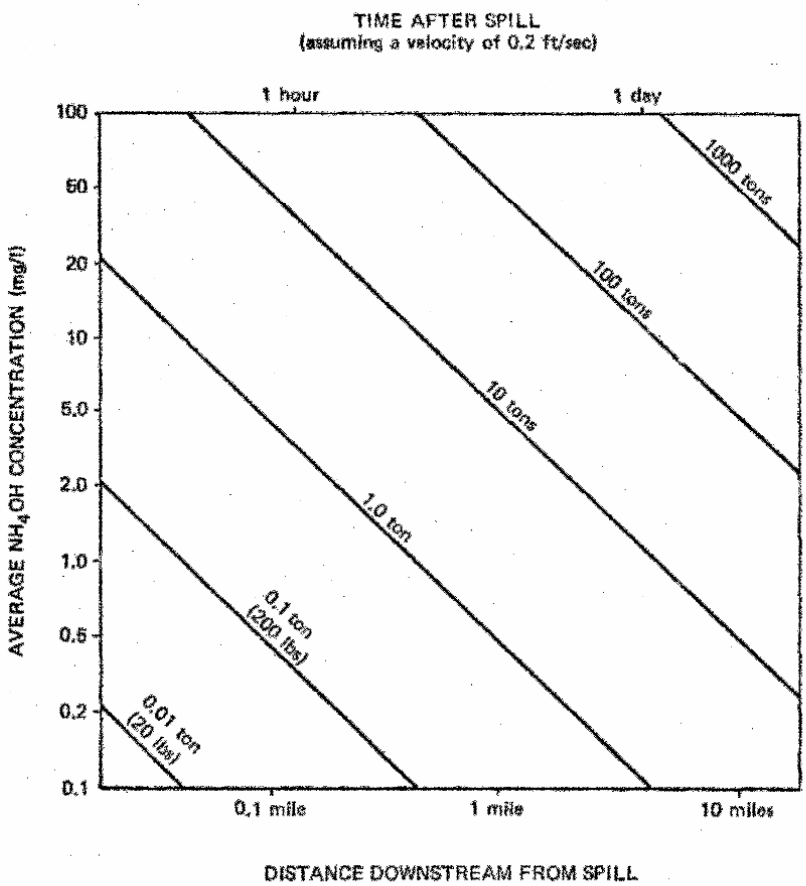

Figure 4-13. Mean ammonium hydroxide concentrations in estuarine prisms for various ammonia spill quantities.

For illustration, consider the following conditions approximating the above example:

U = 0.2 ft/sec
B = 285 ft
H = 35 ft

In this case, the "complete mixing" length would be about 1200 feet (0.22 mile). About half of this distance would be needed if the discharge location is located at the centerline of the channel. These are relatively short lengths for most of the spills represented in Figure 4-13, and would occur between one and two hours after the ammonia is released.

Air Quality Effects

The physical processes governing atmospheric dispersion when large quantities (over 1000 tons) of liquid ammonia (LNH_3) are spilled instantaneously on or under water are not well understood. However, laboratory, swimming pool, and lake tests provide some insight into the dispersion behavior. These results offer tentative models for estimating potential atmospheric concentrations from spills.

The important parameters needed for analysis of instantaneous ammonia spills are the following:

- The amount of LNH_3 released;
- The actual ratio of LNH_3 that evaporates into the atmosphere when the accident happens on or under the water (one minus the partition ratio); and
- The estimated rate of rise of the NH_3 vapor cloud.

The partition ratio of 0.6 (from estimates developed by Raj, *et al.* 1974) has been applied in estimating ambient concentrations from spills. Raj and his associates also developed a plume rise model that seemed to agree well with observed cloud center heights and was considered conservative. During the same studies, well-defined Gaussian distributions of concentrations in the horizontal direction were observed. Therefore, Gaussian dispersion models (presented by Turner 1970), using Pasquill-Gifford stability classes, are applied in the following discussion for estimating the air quality impacts of hypothesized spills on both land and water.

<u>Tank Ruptures on Vessels</u>

Expected ambient concentrations were calculated for distances of 0.2 to 10 miles downwind from a hypothetical vessel accident in which an entire cargo of liquid ammonia (12,000 tons) was spilled into the water instantaneously. It was assumed that (1) the entire spill would spread over a circular area with a radius of about 800 ft and (2) 40 percent of the LNH_3 would evaporate in several minutes (based on projections from Raj, *et al*. 1974).

Since the density of NH_3 is only 60% of the density of air at the same temperature and pressure, atmospheric stability will have very little effect on the rate of rise of the NH_3. Because the rate of rise of the NH_3 is not controlled by atmospheric stability, the only way any part of the plume can reach the ground at a point downwind is through turbulent atmospheric transport. Stability classes A, B, and C are the unstable atmospheric classes, and by definition atmospheric instability fosters turbulent action. Stability class D is called the neutral class, but it embraces both stable and unstable conditions. For such a fast-rising gas (NH_3), it seems doubtful that the plume can return to the ground, even with unstable conditions. Since stable classes E and F have low levels of turbulence, calculations were made only for classes A, B, C, and D. Even with these unstable conditions, applying the Pasquill-Gifford equation is considered to be a conservative practice, yielding an overestimation of expected ambient concentrations.

Downwind distances to points at which selected concentrations were calculated to occur are summarized in Table 4-5. It should be noted that 0.2 mile is just outside the assumed spill area. It was assumed that concentrations within the spill area would be at least 5000 ppm (and quickly lethal).

The maximum durations of exposure for the various concentrations will be along the dispersion centerline in the horizontal plane at the ground and in the direct downwind direction. Away from this centerline, durations of similar concentrations will be shorter. These estimated, downwind duration values are summarized in Table 4-6. The durations are calculated for an instantaneous spill and will increase if the ammonia vapor is released over a longer period; however, concentrations will be correspondingly lower.

Table 4-5. Estimated Downwind Distances of Four Concentrations of NH_3 - Total Vessel Spill Of 12,000 Tons

Atmospheric Stability Class	Wind Speed (mph)	Downwind Distances (miles) for: 50 ppm	300 ppm	1700 ppm	5000 ppm
A	5	2.0	0.7	<0.2	<0.2
B	11	4.4	1.9	0.8	0.4
C	15	1.2	0.9	0.6	0.4
	25	9.0	3.5	1.6	1.0
D	≤15	<0.2	<0.2	<0.2	<0.2
	25	0.6	0.5	0.4	0.3
	35	1.1	0.9	0.7	0.5
	45	2.0	1.5	1.1	0.8

Table 4-6. Estimated Durations Of Various Concentrations at Several Distances Directly Downwind of an Instantaneous Total Vessel Spill

Atmospheric Stability Class	Wind Speed (mph)	Estimated Duration (minutes) for: ≥50 ppm	≥300 ppm	≥1700 ppm	≥5000 ppm
		At a distance of 0.5 mile			
A	5	19	8	0	0
B	11	9	7	4	0
C	15	4	3	1	0
	25	3	3	2	1
D	≤15	0	0	0	0
	25	<1	0	0	0
	35	1	1	<1	<0.5
	45	1	1	<1	<0.5
		At a distance of 1.0 mile			
A	5	18	0	0	0
B	11	9	6	0	0
C	15	3	0	0	0
	25	3	3	1	0
D	≤15	0	0	0	0
	25	0	0	0	0
	35	<1	0	0	0
	45	1	<1	<1/2	0
		At a distance of 5.0 miles			
A	5	0	0	0	0
B	11	5	0	0	0
C	15	0	0	0	0
	25	4	0	0	0
D	≤15	0	0	0	0
	25	0	0	0	0
	35	0	0	0	0
	45	0	0	0	0

The values in Tables 4-5 and 4-6 indicate that:

- For atmospheric stability classes A and B, which involve only low wind speeds, ambient concentrations at a given distance are relatively low, but exposure durations are longer.
- For stability classes C and D, which generally involve higher wind speeds, ambient concentrations at a given distance are relatively high, but exposure durations are relatively short.

The ammonia cloud is not expected to touch the ground surface within 10 miles for stability classes E and F, because of the small dispersion coefficients and rapid rise of the NH_3 cloud. For all atmospheric stability classes, under certain terrain conditions, ambient concentrations higher than those calculated may occur, depending upon relative altitude and distance from the spill. As an example, a rising plume may strike the ground in an area of extreme topography or if high buildings are nearby.

In fog or low cloud conditions, some spilled NH_3 would react with the water vapor, becoming NH_4OH. This reaction would cause lower ambient concentrations and longer durations than those shown in Tables 4-5 and 4-6. In fog or a low stratus cloud layer, the lateral spread is expected to be small. In cumulus clouds, there would be greater lateral and vertical spreading. Since an NH_4OH molecule is about twice as heavy as a water molecule, it is expected that fallout would occur, primarily near the scene of the accident.

<u>Other Malfunctions</u>

Transfer Sills

Transfer spills could occur during the loading or off-loading of a vessel, truck or rail car. When modeling a potential spill in this category, it is assumed that the LNH_3 from a transfer spill would spread evenly on the land and completely evaporate in one hour or, for a spill duration of greater than one hour, for the duration of the spill. It also would be assumed that none of the ammonia would run off into the water. The spill would then act as a continuous source, allowing use of the Gaussian dispersion model for a continuous point ground-level source to predict concentrations downwind. Other malfunctions, such as venting from relief valves on vessels, storage tanks, trucks, and rail cars, can be described by the same model, with the only variation being the rate of venting or evaporation.

The highest concentrations would be estimated for stability class D, as discussed previously. For planning purposes, the calculations should be based on a wind speed of 10 mph because this value represents the most turbulent conditions expected to occur in class D.

Venting Leaks

With loss of refrigeration, LNH_3 will begin to boil (vaporize). As heat is absorbed from the surroundings, the temperature and pressure inside the tank will rise. Because of the heavy insulation of large LNH_3 storage tanks, about 4 hours without refrigeration can elapse before the relief valves begin to vent. Even higher pressure settings on relief valves on vessels means that several days without refrigeration would be required before the internal pressure would build to the point where venting begins. Maximum venting rates are expected to be about 200 to 500 lb/hr for vessel tanks.

Trucks and trains are designed to transport liquid ammonia under pressure at ambient temperatures. A fire in or near a truck or rail car could cause relief valves to open. The rate capacity of the relief valves is about 4.5 tons/hr of NH_3. The heat from a fire, in addition to causing the ammonia to boil, would create a strong updraft which likely would cause the ammonia vapors to quickly rise. A fire could also incinerate some of the ammonia vapors. Both of these conditions would combine to reduce ground-level concentrations to below those predicted here.

Tank Ruptures
Trucks and trains are susceptible to accidents which could create more serious hazard conditions than venting. The worst accident situation would be one in which the tank ruptured and instantaneously spilled 20 tons of LNH_3 (truck) or 80 tons of LNH_3 (rail car) onto the ground without a fire. Without the additional heat from a fire, no special supporting updraft would be created, and the ammonia cloud, though rising, would stay closer to the ground for a greater distance downwind, especially if foggy or rainy. It typically is assumed that the entire cargo would spread out to a uniform depth of about 3 inches (EPA 1999 assumes a pool depth of 1 cm and the corresponding pool would therefore be about 7.5 times larger. The total evaporation rate would be similarly larger, but for a shorter duration). Ammonia pools of 3 inches in depth are expected to evaporate in approximately 2 hours. The evaporation rate would be 40 ton/hr (rail car) and 10 tons/hr (truck). If the LNH_3 is contained in a smaller area, if a smaller total amount spills, or if the atmosphere is in a condition other than class D and/or has higher wind speeds, ammonia concentrations downwind are expected to be less. Similarly, if the pool was 1 cm deep (as assumed by the EPA 1999 method), the ammonia would evaporate in about 15 minutes. The evaporation rate would be about 300 ton/hr (rail car) and 75 tons/hr (truck), and the corresponding downwind concentrations would be about 7.5 times larger than if a 3 inch pool was formed.

Summary of Effects on the Living Environment
Table 4-7 summarizes expected downwind distances and durations of ammonia concentrations for different spill conditions. The following discussion summarizes the expected impacts on living organisms associated with these spills.

Table 4-7. Estimated Downwind Distances of Concentrations of NH_3 for Various Transportation Accidents

Malfunction	Assumed Evaporation Rate (lb/hr)	Maximum Downwind Distance[a] (miles) for: 50 ppm	300 ppm	1700 ppm	5000 ppm	Assumed Duration
Vessel venting on loss of refrigeration	500	0.05	0.05	<0.01	<0.01	Until refrigeration is re-established and the NH_3 is cooled sufficiently
Truck or rail car transfer line accident	8,000	0.33	0.10	0.03	0.02	1 hr[b]
Truck or rail car venting in a fire	9,000	0.36	0.11	0.04	0.02	1 hr[b]
Vessel transfer line accident	14,000	0.48	0.15	0.05	0.02	1 hr[b]
Truck tank rupture	20,000	0.60	0.19	0.06	0.03	2 hr[b]
Rail car tank rupture	80,000	1.40	0.46	0.15	0.12	2 hr[b]

[a] Assumed wind speed, 10 mph; stability class D.
[b] If the durations are shorter (pool depths shallower) the concentrations will be greater; similarly, if the durations are longer, the concentrations will be less.

Human Population

Human physiological responses to various concentrations of ammonia were presented in Table 4-4. Depending on specific atmospheric conditions, it can be expected that people several miles downwind likely will have to be treated for ammonia inhalation effects for a vessel disaster. However, no deaths are likely to occur, except possibly very close to a loss site. Durations of exposure will increase if the ammonia vapor is released over a longer period of time (not instantaneously), but the concentrations at any given location will be correspondingly lower. The other types of accidents could generate downwind concentrations sufficient to cause noticeable odors up to 1.5 miles away. Evacuation might be required for up to 0.5 miles downwind, depending upon the type of accident. Because of ammonia's characteristic odor at relatively low concentrations, people will likely respond by leaving an affected area before official warnings are issued.

Marine and Aquatic Organisms

In the event of a spill during the loading or off-loading of a vessel, ammonia could be leaked directly into the water. Assuming a line draining directly into the water, 7 tons of liquid ammonia could be lost. With a partition ratio of 0.6, 4 tons of NH_3 would go into solution as ammonium hydroxide, while the remainder would vaporize into the air. The toxicity of an ammonia solution in water is directly proportional to the concentration of nonionized NH_3 present. The amount of nonionized NH_3 is dependent on pH, temperature, and salinity. With a pH of 8.0, a temperature of 15^oC, and zero salinity, the percentage of nonionized NH_3 would be 5.7 percent. At a pH of 9.0, nonionized NH_3 would be 37.7 percent of the total ammonia concentration. This information then can be used to calculate the concentration of nonionized NH_3 in the water, as shown in the example below. A concentration of nonionized NH_3 greater than 1.25 ppm can be toxic to some freshwater fish.

With the pH range described above, assuming complete mixing within a channel having a 10,000 ft^2 cross-section, a 7-ton spill would produce toxic conditions for fish for a distance of about 1 mile along the channel. There would be a severe fish kill in the immediate vicinity of the spill where the concentrations of NH_3 would be highest. It can also be assumed that planktonic and benthic organism mortality would also occur in the vicinity of the spill.

A spill of lesser magnitude could occur if the refrigeration equipment on a vessel were to develop a leak from a broken pipe or fitting. Such a leak could release from 42 to 125 1b of NH_3 in 5 minutes. The effect of such a release probably would be confined to the local area. However, the possibility of a fish kill within the immediate area is likely.

In the unlikely event that a catastrophic accident were to occur causing the release of an entire vessel's contents, approximately 12,000 tons of NH_3 could be released into the water. Such a spill could ultimately cause toxic concentrations of NH_3 throughout a large area. The size of the affected area would change as the contaminated water moves downstream. There would be massive mortalities of fish, plankton, shellfish, and other benthic organisms.

A long-term result of any ammonia spill would be increased eutrophication of the receiving waters, depending on the presence of other needed nutrients. The additional nutrient levels could stimulate noxious blooms of algae, which would cause continuous water quality degradation.

Terrestrial Biology

In sufficiently high concentrations, ammonia is toxic to living organisms (Miner 1969, and Levine 1968). Large amounts of this chemical would be released into the environment in the event of a large leak or spill, such as a total vessel spill. Regardless of where a vessel ruptured along an inland route, high concentrations of ammonium hydroxide would likely reach shore. If this chemical floated into any of the wetlands bordering the shipping route, much of the vegetation would be killed, potentially causing destruction of important habitat for waterfowl, shorebirds, and other shore species.

Waterfowl and shorebirds present in the wetlands at the time the ammonium hydroxide came into shore could be directly affected. A large number of birds could be killed by ingestion of the chemical. The ammonium hydroxide could also strip protective oils from the feathers of waterfowl, causing the loss of the birds' natural water repellency. In this case, birds would die either from drowning or from infections contracted as a result of getting wet.

The ammonia which would escape into the atmosphere would form a plume with a concentration of several thousand ppm at its center. Concentrations of 1700 ppm or more of ammonia would occur for several minutes at sea level for a distance of several miles downwind from the location of a vessel accident or for longer periods but over a smaller area if the ship leaked slowly. It is likely that any bird or animal exposed to these high concentrations of ammonia would be injured or rapidly killed. Birds in the vicinity of the accident could possibly become disoriented in their attempts to escape the odor and might fly into the lethal part of the plume. If the vessel broke up near shore, animal and birds could be killed for several miles inland.

Severe damage to vegetation would also be expected to occur. The extent of this damage would depend upon the resistance of individual plant species to ammonia and the time of year the spill occurred. Plant species differ in their sensitivity to ammonia (Miner 1969). It is possible that some species may be able to withstand high concentrations of the gas for several minutes. In the spring or summer, a concentrated ammonia plume would probably severely damage most vegetation that it contacts. Perennial species in the natural flora would be most affected by ammonia in the summer and early fall when they are under the greatest physiological stress because of low soil moisture. Since seeds are most resistant to ammonia, annual species in the natural flora would not be greatly affected during summer months. These species would be hardest hit in the spring or fall.

Potential Movement and Effects Associated with Oil Spills

The following discussion is a summary of oil spill analysis and impact reports prepared by Woodward Clyde Consultants for numerous clients for submission to regulatory agencies. The following discussions are excerpts and summaries from these reports and indicate how impacts associated from oil spills can be evaluated, especially in regards to spill movement and dispersion. The fate and effects of oil spills on the environment, based on selected historical oil spill incidents, are also described.

Parameters Affecting Oil Spill Movement
The movements, and other characteristics, of a spill of petroleum hydrocarbons lost on water are controlled by weather conditions (wind, temperature, and rainfall), ocean conditions (tides and currents), and physical parameters of the materials which could be spilled. The important physical parameters of the various petroleum hydrocarbons include the following:

- Specific gravity (or density);
- Evaporation rate;
- Boiling range;
- Viscosity;
- Pour point;
- Emulsification ability; and
- Water solubility.

Some of these factors are related. For example, the evaporation rate is dependent on weather conditions (especially wind) and the boiling range of the material. Similarly, the spread rate depends on weather, viscosity, and the pour point. Emulsification is a very complex parameter since both oil-in-water and water-in-oil emulsions can be involved and wind and wave conditions are usually controlling. The solubility of most of the materials is very limited (below 0.01 g/100g). Table 4-8 gives the significant physical parameters of greatest interest, along with typical values for residual fuel oils. These values will be used in a later example.

Table 4-8. Characteristics of Typical Residual Fuel Oils used in Example

Parameter	Residual Fuel Oils
Specific Gravity (@ 60°F)	0.904 – 1.02
API Gravity (@ 60°F)	7 – 25
Viscosity (Saybolt Universal sec @ 100°F)	45 – 18,0 00
Flash Point (°F)	150 – 250
Pour Point (°F)Sulfur Content (% by weight)	0.5 or less

<u>Potential Oil Spills</u>

Submarine Pipelines
The design and installation of modern submarine pipeline facilities for marine terminals include a number of safety features to prevent oil leakage. In addition, extensive provisions are made to minimize the volume of oil released in the event of a leak, including:

- Additional steel wall thickness on product transfer lines.
- Cathodic protection.
- Somastic coatings (or coal tar wrap).
- Concrete weight coating over somastic coatings to increase stability and provide negative buoyancy for empty lines.
- Burial of lines in surf zone.
- Pressure safety valves.
- Submarine hoses of strength several times the operating pressures.

Even when these precautions are taken, there is still the possibility of damage to the submarine hoses by improper handling, or to the pipeline by man-caused events (dropped material, i.e., anchor or chain, of sufficient weight to cut lines) or natural occurrences. The speed of the curtailment of oil released to the sea is dependent upon the rapidity with which the ship's or shore pumps are stopped, the vacuum pumps started, and the valves closed. The rate at which petroleum products or crude oil could be released would vary depending upon the extent of the pipeline incident. The magnitude of a spill could range from a few gallons (resulting from a minor leak in the pipeline system) to many barrels (resulting from a major pipeline fracture). The quantity released would also depend upon pipeline operating conditions at the time of the incident, *i.e.*, pumps on line or on standby. The potential spillage magnitude would also vary with the location of the pipeline incident. In submarine installations, the sea water (being of higher specific gravity than fuel oil) would seal off the oil in the sector of pipeline above (upslope) the leak. In the sector of the line below (downslope) the leak, water would slowly enter the pipe, displacing the crude oil or product. Potential spills volumes for offshore spills are categorized by the National Oil Spill Contingency Plan as follows:

> Minor Spill - a discharge of oil less than 10,000 gals (238 bbl*);
> Moderate Spill - a discharge of oil of 10,000 to 100,000 gals (238 to 2,380 bbl); and
> Major Spill - a discharge of oil of more than 100,000 gals (2,380 bbl).
> *Based on 42 gal/bbl

Pipelines are by far the most common method of transporting crude oil and petroleum products in the United States. The possibility of a crude oil and/or petroleum product spillage could occur at any point along submarine pipelines. An analysis by the National Petroleum Council (1972) of spill incidents from pipeline systems in the United States indicate that approximately 2.8 bbl/mi/yr were lost.

Tanker Operations
Tankers can contribute to oil pollution of the marine environment through five principal sources:

- Cargo tank cleaning operations;
- Discharges from bilge pumping;
- Hull leakage;
- Spills during cargo handling operations; and
- Vessel casualties.

There are three principal causes of unintentional discharges of oil during tanker-terminal operations, namely (1) mechanical failures, (2) design failures, or (3) human error. Incident reports of spills during tanker-terminal operations show that human error is the predominant cause and is the most difficult to remedy. Mechanical failures include cargo transfer hose bursts, and piping, fittings, or flange failures, either on shore or on the tankers. Mechanical failure could also be due to an inherent design fault including the incompatibility of a tanker with a given marine terminal, i.e., improper manifold connections, inadequate mooring facilities, and shoreside loading pumps with excess pumping capacity.

Oil spills that occur during the loading or unloading of crude oil or petroleum products are more often associated with leaky connections, failure to drain cargo hoses, improper mooring, improper valve or manifold alignment, or overfill during loading operations.

Prediction of the Movement of Oil Spills

The fate of an oil spill in the marine environment depends on the spreading motion of the oil and the translation of the slick by the winds and currents in the surface waters. Both of these mechanisms are understood well enough that oil spill movement predictions can be made, providing adequate input data are available. These required data for the oil spreading equations include surface wind speed and direction, tidal currents, and knowledge of the general circulation of the waters of interest.

Fay (1971) developed a prediction equation for the spread of an oil slick considering gravity, inertia, viscous and surface tension forces. This analytical approach, coupled to experimentally determined constants, is considered in some detail by Premack and Brown (1973). Based on this historic research, simplified estimates of the spread of oil on water can be made using the following equations:

$$A_{max} = 1.65 \times 10^8 \times V^{3/4} \qquad \text{Equation 10}$$

$$r_{max} = 72.5 \times V^{3/8} \qquad \text{Equation 11}$$

$$t = \frac{34}{u^{2/3}} \times V^{1/2} \qquad \text{Equation 12}$$

where:

A_{max}	=	maximum area of spread (ft^2)
r_{max}	=	maximum radius of a circular slick (ft)
t	=	time to reach maximum radius (minutes)
V	=	spill volume (gallons)
u	=	spreading coefficient (dynes/cm) (11 dynes/cm for No. 6 fuel oil and 35 dynes/cm for waxy sweet crude)

Ichiye (see James, *et al*. 1972) and Murray (1972) also considered the impact of oceanic turbulent diffusive processes on the fate of an oil slick. Murray compared Fay's approach and turbulent diffusion theory to observations of slick growth from the Chevron spill of 1970 in the Gulf of Mexico. He concluded that eddy diffusion is a major driving force which cannot be neglected in oil slick growth. Ichiye developed a mathematical model for oil slick expansion and presented theoretical arguments and data comparisons with the theory to support the need for applying turbulent forces in the equation for determining oil dispersion at sea. Ichiye also pointed out the significance of wind speed on the spreading rate of a slick. Ichiye's thorough treatment of the subject added a new dimension to oil slick prediction techniques and is considered in the example analysis that follows is this section. However, it should be pointed out that for discontinuous spills under light wind conditions, the two models are in agreement with each other during the time to maximum expansion, as defined by Fay. The consideration of eddy diffusion as a driving force becomes most important at later times and during moderate to high winds.

The transport of oil in an oceanic environment depends upon a number of variables. After spreading to its maximum radius, the translation of an oil slick in most near-shore waters will be dominated by wind forces and tidal currents. The direction of the oil slick movement, as influenced by the wind, should be taken as that of the wind (as discussed by Murray (1970)). The speed of the wind-driven component of the slick movement is generally considered to be about 3 percent of the wind speed. Oil slick translation is thus calculated as the vector sum of the tidal currents and the wind stress on the slick. In addition to the translation of the surface slick, one must consider the possibility of the oil aging and mixing vertically with the water column. This requires knowledge of the properties of the oil in question. For example, crude oil in a slick can lose its volatile fraction by evaporation in a matter of hours causing a shift in oil density toward that of sea water. Movement of neutrally buoyant oil globules in deeper waters will be influenced by potentially complex and unknown subsurface circulation patterns.

Estimates of initial spill volume and a spreading equation are required to determine the spreading radius of a hypothetical spill as a function of time. Wind speed and direction, local tidal currents, and the general circulation along the coast are required to determine the trajectory of the slick, and estimates of the general circulation of the water body are needed to predict the fate of that fraction of the spill which may mix downward into the water column. The following discussion presents an example analysis of oil spill movement, based on typical offshore oil spill losses, and hypothetical environmental conditions.

Spill Volume and Resulting Spill Dimensions

In this example, the potential volume of oil that could be released to the environment as a result of a break in a submarine pipeline varies from a minimum of about 500 barrels to a maximum of about 10,000 barrels. A hypothetical oil spill of 500 tons (3750 bbl) is assumed in this example. This volume would be classified as a major spill.

Figures 4-14 and 4-15 describe the oil slick dimensions as a function of time for a 500 ton spill for various wind speeds. It should be noted that the predicted elliptical area defines the envelope in which the oil is found. At later times, and especially under high wind conditions, the slick will have broken up and some fraction will have evaporated and some fraction will have mixed with subsurface waters.

Calculation of Oil Slick Movement Under Various Selected Wind and Current Conditions

The following example assumes an instantaneous oil spill of 500 tons that will grow radially according to the theory of Ichiye. Figures 4-14 and 4-15 are plots of this spill growth. The slick movement was determined by the vector sum of tidal or coastal currents and wind-driven currents. Tidal currents had an assumed northerly current paralleling the shore during rising tides and southerly current paralleling the shore during falling tides; an average speed of 0.3 knots over a period of 4 hours for flood and ebb was used. No tidal component is applied during assumed 2-hour periods of slack tides. Wind-driven currents were assumed to have the same direction as the wind and a speed of 3 percent of the wind speed. Figures 4-16 through 4-18 are examples of the predicted fate of this spill occurring at a tanker berth as a result of a ruptured submarine pipeline or a tanker casualty.

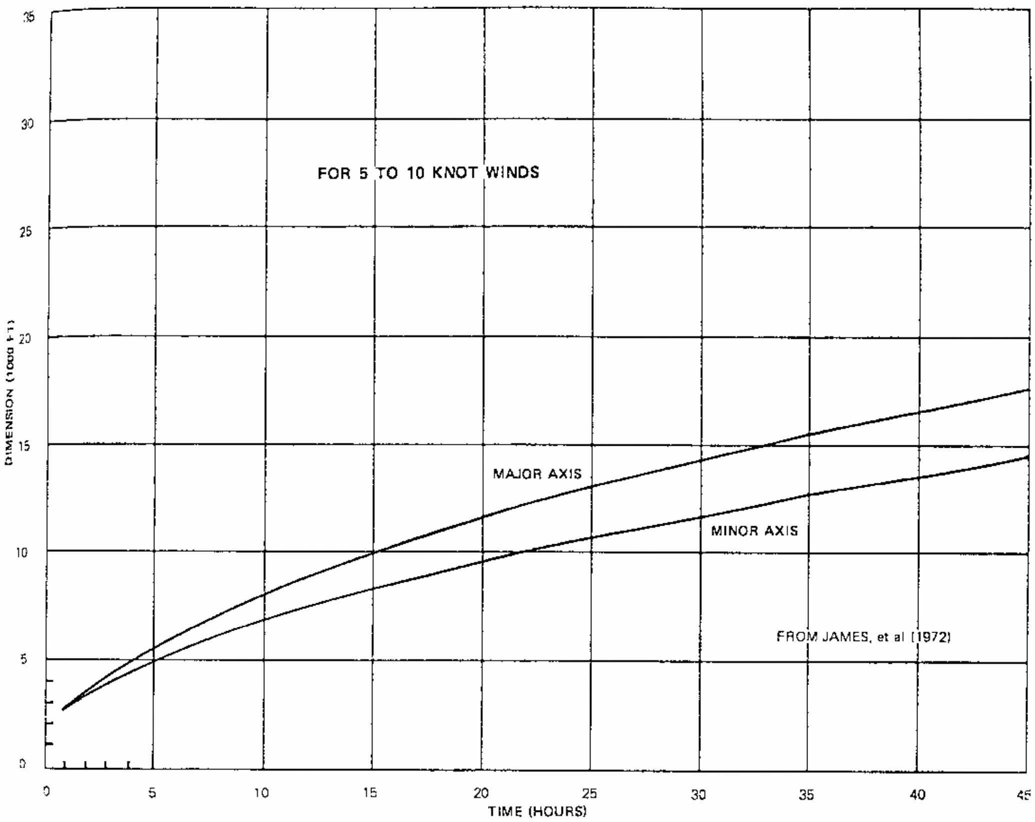

Figure 4-14. Growth of a 500 ton oil spill during five to ten knot winds.

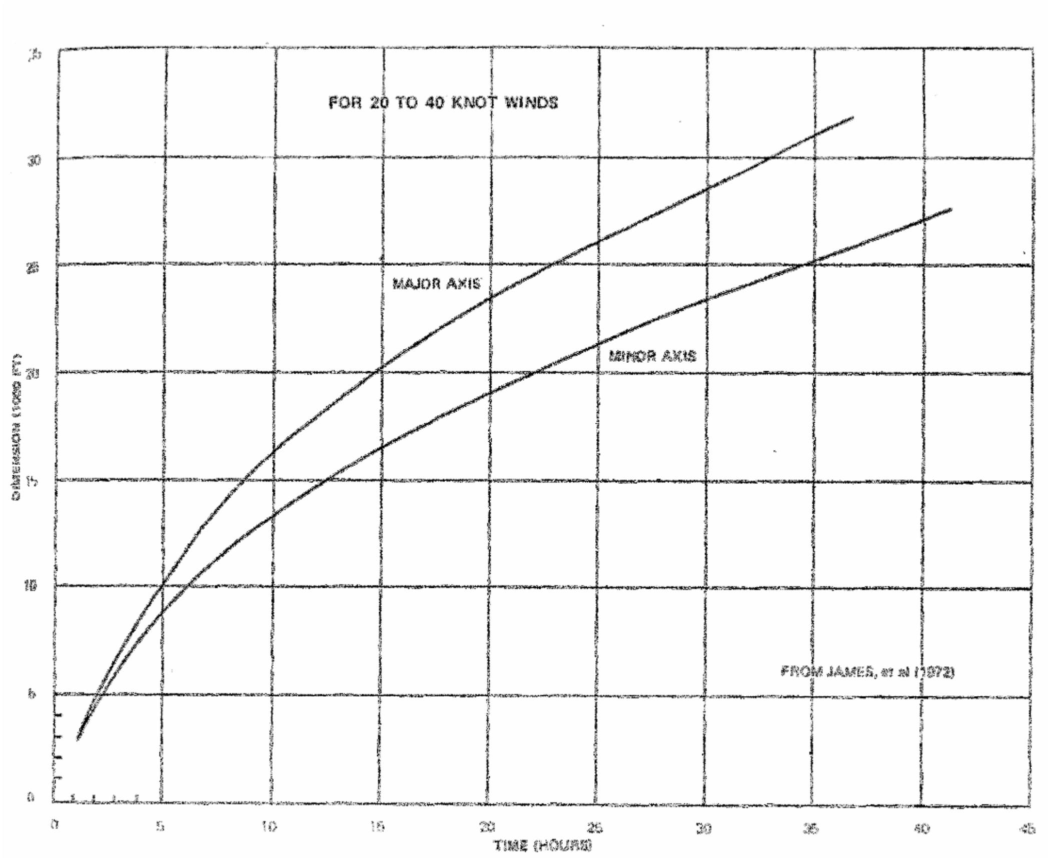

Figure 4-15. Growth of a 500 ton oil spill during twenty to forty knot winds.

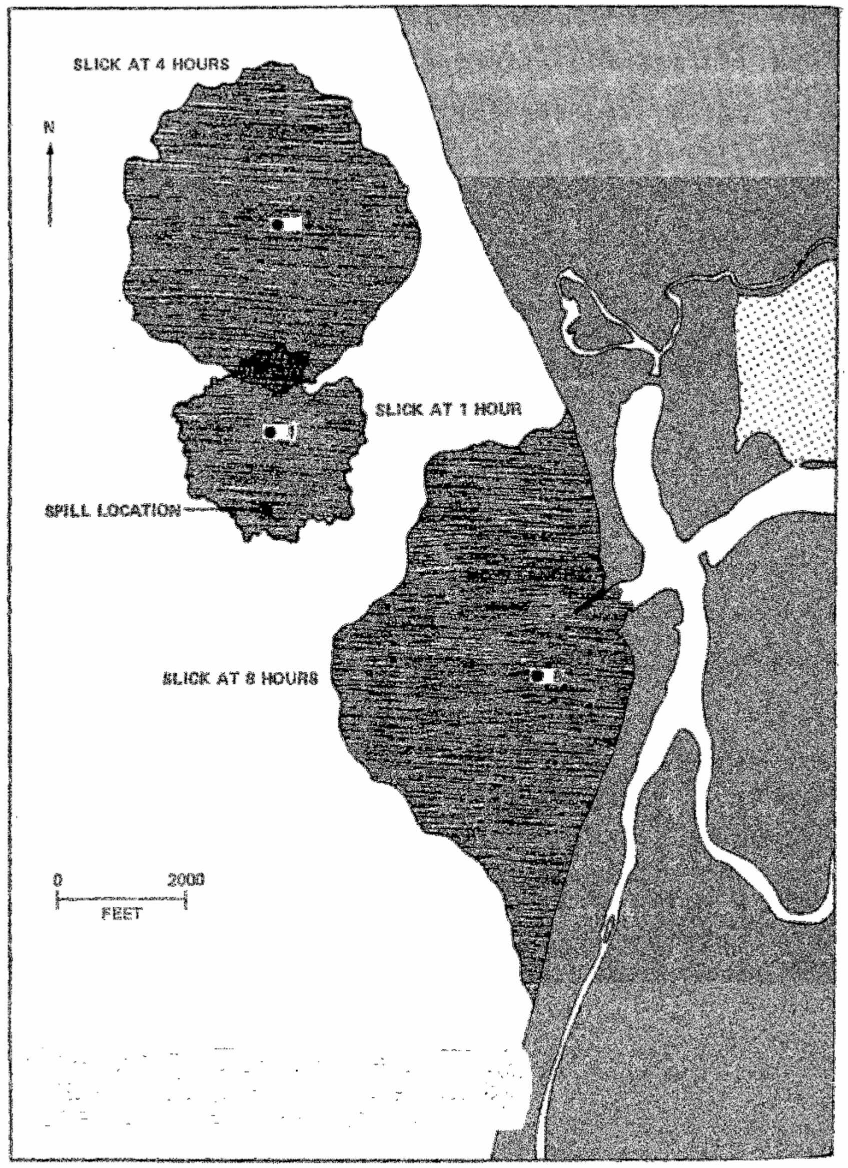

Figure 4-16. Predicted behavior of a 500 ton oil spill under the influence of a 5 knot NW wind and 0.3 knot tidal current (spill initiated at slack water before flooding tide).

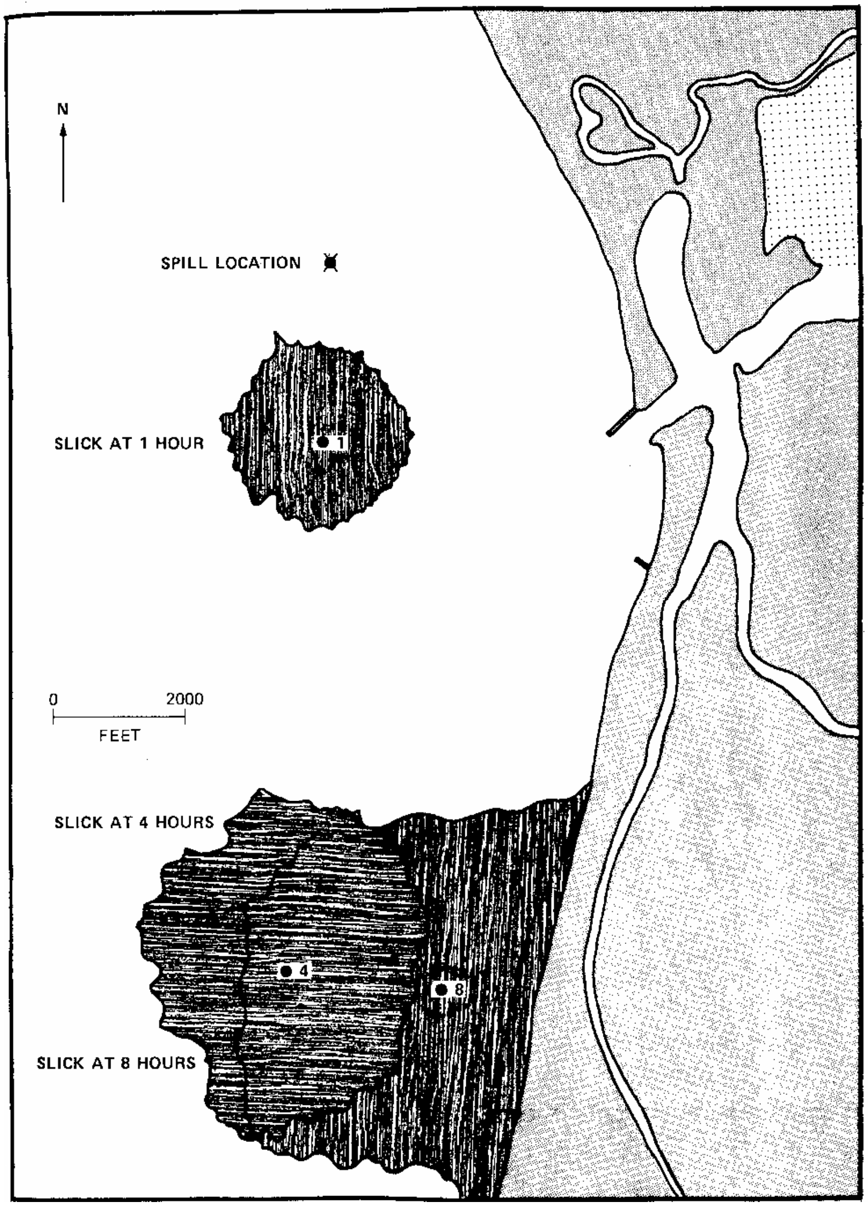

Figure 4-17. Predicted behavior of a 500 ton oil spill under the influence of a 5 knot NW wind and 0.3 knot tidal current (spill initiated at slack water before ebbing tide).

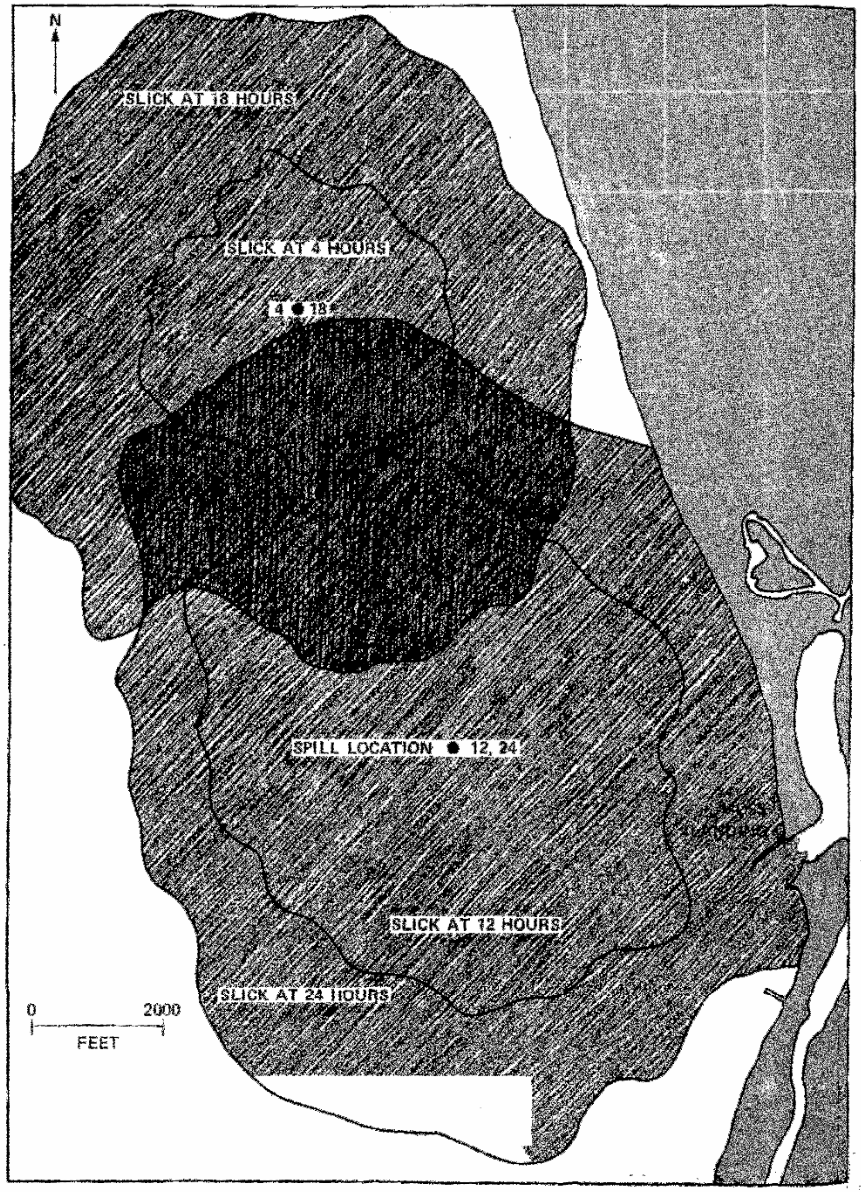

Figure 4-18. Predicted behavior of a 500 ton oil spill under calm winds and a 0.3 knot tidal current (spill initiated at slack water before flood tide).

Analysis of the Environmental Impact of an Offshore Oil Spill

Fate of Oil

The impact of an oil spill will depend upon the volume of spill, duration, type of petroleum product, and physical factors such as wind, wave, and current conditions under which the spill occurs. The fate of oil in an oil spill depends on a complex interaction between the several arbitrarily defined categories, as shown in Figure 4-19, plus a host of other less well-defined variables. Some of the lighter fractions of oil will evaporate very rapidly (evaporation), others are sensitive to sunlight and oxidize to innocuous or inert compounds (photo-oxidation), and still other fractions will either dissolve (dissolution), emulsify (emulsification), or adsorb to sediment

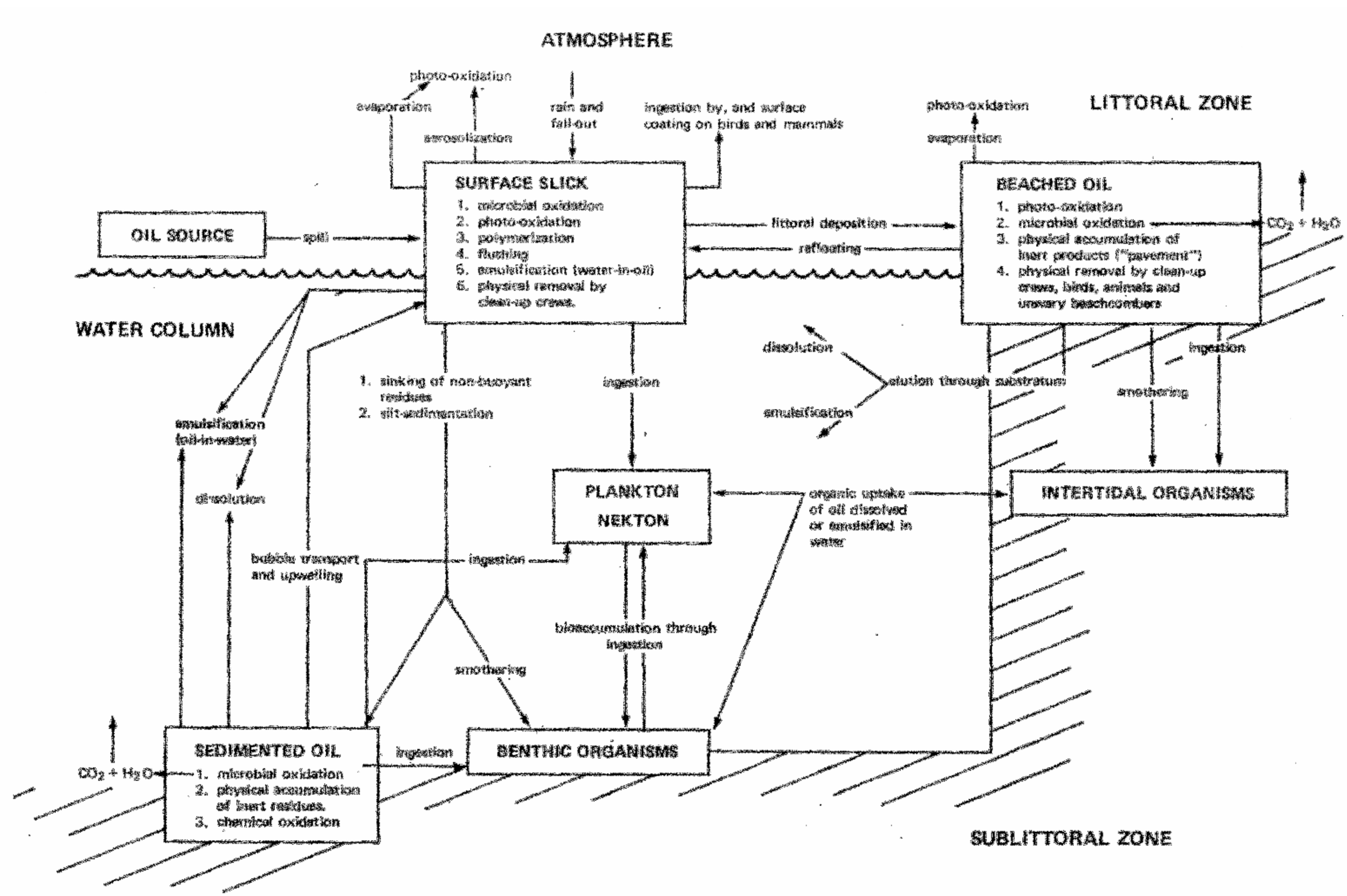

Figure 4-19. Fate of an oil spill in the marine environment.

particles (sedimentation), depending on their physical properties. The physical fate or dispersion of oil can occur by several methods: littoral deposition, physical removal, dissolution, flushing, elution, sedimentation, microbial oxidation, organic uptake. These are discussed in more detail below.

In an oil spill the relative importance of each of the categories in the fate of an oil spill diagram (Figure 4-19) is influenced by several physical and chemical parameters and other events, including:

- Type of petroleum product (Bunker “C”, diesel fuel, naphtha, and others);
- Volume of spill;
- Distance from shore;
- Sea and weather conditions (air and water temperature, wind direction and speed, wave height, etc.);
- Oceanographic conditions (currents, tide, salinity, etc.);
- Shoreline and bottom topography (sand or rock beaches, relief, degree of exposure to surf, etc.);
- Season of year, especially with reference to biological activities such as breeding, migration patterns, feeding habits, etc.; and
- Cleanup and restoration procedures.

The type of oil spilled will have a dramatic effect on the resulting effect of the spill. Bunker “C” fuel, for instance, although aesthetically unpleasant, is initially less destructive to marine life than is the more toxic diesel fuel. Oil from a spill occurring when oceanographic and/or meteorological conditions result in rough seas is likely to be more widely dispersed through the water column and along the shore by emulsification, dissolution, wind drift, etc., than one occurring in calm seas. However, the latter can be much more readily contained and/or picked up by mechanical devices such as booms, oil skimmers, and the like.

Composition of Petroleum

In order to consider the properties/behavior of oil in aqueous environments, it is necessary to know the composition of the oil. Crude oil and several heavy fuel oil fractions are a complex mixture of hydrocarbon and non-hydrocarbon molecules, encompassing a wide range of molecular weights.

Crude oils and most of their distillation products are extremely complex mixtures of organic chemicals with hydrocarbons being the most numerous and abundant (comprising more than 75 percent of most crude and fuel oils). Over 200 hydrocarbons, 90 sulfur-containing organic compounds, and 33 nitrogen-containing organic compounds are present in crude oils. In addition, there are porphyrins, sulfur, trace metals, and residues called asphaltenes in many crude oils. Crude oils and most crude oil products contain a series of n-alkanes with chain lengths of carbon atoms numbering between 1 and 60. The ratio of abundance of odd chain lengths to even chain lengths is approximately 1.0. A series of branched alkanes are also present including isoprenoid alkanes such as pristane, farnesane, and phytane, naphthenes (cyclic alkanes with or without side chains), aromatic hydrocarbons (ranging from alkyl substituted benzenes and naphthalenes to polynuclear aromatic structures), and naphthenoaromatics (naphthenes joined with aromatic ring systems). Alkenes (olefins) are not usually present in crude oils but they are formed in some refining processes and are present in some refined products.

There are three properties/behaviors of oil in sea water which are important with respect to the impacts of oil on the marine environment. They are: evaporation, emulsification and, to a much lesser degree, dissolution (solubility). Other properties such as density, boiling point, pour point, viscosity, etc., are less important or manifest themselves in the three prime properties listed. The lighter fraction of crude and heavy fuel oil and other volatile fractions (i.e., those of lower molecular weight) will evaporate to the air at a rate primarily dependent on vapor pressure of the oil. However, evaporation will be enhanced by high winds and rough sea conditions, which favor formation of aerosols and increased surface area; the faster and farther the oil spreads, the faster it evaporates. Cobet and Guard (1973) found that as much as 13 percent of the Bunker C fuel lost in the San Francisco Bay spill could have evaporated within 3 months and, depending on atmospheric conditions at the time, possibly even more would have evaporated. Fuel oil, lubricating oil, and similar components have few or no volatile components and thus will not readily evaporate. On the other hand, diesel fuel and other light "cutting" stocks are comprised primarily of components which evaporate rapidly. In general, the more toxic fractions are those which evaporate fastest, leaving a less toxic, more viscous, and more dense residue in the surface slick.

Oil-in-water and water-in-oil emulsifications do form and considerable quantities of oil may be bound up in this manner. In general, the lighter fractions will go into an oil-in-water emulsification more easily than heavier fractions but vigorous agitation and/or solvent-emulsifier mixtures are usually required. As the hydrocarbon molecular weight increases, the emulsions become water-in-oil. These water-in-oil emulsions tend to form naturally and easily, especially with some wind and wave agitation. They are quite stable.

For a given class of hydrocarbons, dissolution (solubility) in water decreases with increasing molecular weight (carbon number). For the various classes of hydrocarbons, solubility increases in the following order: alkanes, cycloalkanes, olefins, and aromatics, with corresponding solubilities as shown below.

	mg hydrocarbon/liter of water
Alkanes	
ethane (C_2)	60
dodecane (C_{12})	0.003
Cycloalkanes	
cyclopentane (C_5)	156
dimethylhexane (C_8)	6
Olefins	
propene (C_3)	200
1-octene (C_8)	3
Aromatics	
benzene (C_6)	1780
isopropylbenzene (C_9)	50

Sea water solubilities are approximately 70 percent of those cited for fresh water. Hydrocarbon solutions in sea water are only temporary because dissolved hydrocarbons volatilize and evaporate rather rapidly. Because there is no discernible reservoir of hydrocarbons in the atmosphere, with the exception of methane, the equilibrium favors the transfer of hydrocarbons from the liquid phase (sea water) to the gas phase (air), particularly under turbulent conditions of wind, current, and wave action. Even under the best conditions, relatively little oil is dispersed by dissolution when compared to the amounts dispersed by evaporation, emulsification and physical dispersion.

Effects of Oil on Marine Water Quality

The most obvious effect on water quality associated with an oil spill would be the physical presence of floating oil slicks which would deter boaters, bathers, divers, and others from using the affected area. Also, oil coming ashore would be aesthetically objectionable and would interfere with shoreline recreational activities such as picnicking, sunbathing, beachcombing, clam digging, and surf fishing. Depending on the specific oil material, dissolved hydrocarbon concentrations in the water column also could significantly increase, especially for a material containing large amounts of soluble components (as mentioned previously).

Observations by the U.S. Fish and Wildlife Service during the Santa Barbara oil spill showed small dissolved oxygen (DO) reductions even under thin slicks as compared with associated uncontaminated water. The largest decreases in DO were detected in the upper 30 meters under an oil slick. These reductions were insufficient to cause any significant biological damage. The resultant oxygen levels generally remained above the level considered by the State Water Resources Control Board to be necessary for life (5.0 mg/L) and that the affected area was relatively small. Most observations of DO during oil spills have shown little effect of the spill on dissolved oxygen levels in sea water-petroleum mixtures.

Typical values of BOD_5 for petroleum products in sea water generally range from 2.5 to 5.4 mg BOD_5/mg hydrocarbon. These BOD_5 values can be high, but the biological activity is generally limited to surface waters where oxygen levels are maintained at high levels due to aeration and photosynthesis. The amount of oxygen required to completely oxidize one gallon of crude oil is equivalent to the entire oxygen content of 320,000 gal of typical sea water, assuming no replenishment from the atmosphere or photosynthetic activity. In general, the BOD_5 requirement of oil products would be spread over several days and over a relatively large area. Both the requirement and the effects would be concentrated in the upper layers of water.

Experimental data has shown that an oily odor is imparted to sea water at relatively low petroleum concentrations (0.05 to 1.0 mg/L). The odor persistence is very much a function of whether or not a slick persists. As the temperature increases, the rapidity with which the odor disappears increases. Odor persistence can range from 1 to 3 days in the absence of a slick, to 1 to 25 days with oil films. Following the *Torrey Canyon* spill, fish and shellfish were tainted by oil.

Dispersion of Oil in the Marine Environment

Physical Dispersion

Crude oil and refined products are physically dispersed to different parts of the marine environment by several mechanisms. The primary forces determining the fate of an oil slick are advective processes such as currents and the wind stress on the slick which determine its trajectory, and diffusive processes which are important in determining the growth of the slick after the oil has stopped spreading by inertial and viscous forces (discussed above).

Low-viscosity, high-API-gravity crude oils, and refined products generally break up and dissolve or emulsify in sea water. Individual oil droplets become attached to sediment particles either by adsorption or adherence, particularly in the intertidal-shallow sublittoral or surf zones, and disperse with these suspended particles. By this mechanism, oil becomes diluted and may finally become incorporated in sediments, animals, and plants. On the other hand, high-viscosity, low-API-gravity crude oils and refined products such as Bunker “C” fuel behave like soft asphalt. When lower molecular weight hydrocarbons evaporate or dissolve, the remaining portion of these oils may become more dense than seawater and sink. This will be particularly true if they form water-in-oil emulsions which can also then pick up suspended silt particles and become heavier than water. The sunken oil may reside on the bottom in sediments as relatively inert material or it may undergo further chemical and biological degradation, converting the residues to lighter molecular weight materials which rise to the surface and repeat the original chain of reactions until most of the oil is consumed. Some of these lighter fractions may also dissolve or emulsify on the way back to the surface. These dense oils can form water-in-oil emulsions which may sink or be cast up on the beach.

With typical on-shore winds and currents, those fractions of oil, especially of crude and fuel oil, which are not weathered or lost (evaporation, emulsification, dissolution, sedimentation, or organic uptake while on the water surface or in the water column), are deposited in the littoral or intertidal zone (littoral deposition) by waves and/or receding tides. Diesel fuel and other light fractions evaporate rapidly from rocky beaches, but may penetrate several inches into sand beaches and remain there. They will work their way back to the surface over a long period of time, or work their way through the sand to come out in the shallow sublittoral zone (elution). Crude oil and other heavy fractions are deposited on the beaches in the form of “asphalt” or tar. On rock beaches, this asphalt coats the rocks, weathers, and becomes a semi-permanent substratum. On sand beaches, the asphalt may mix with and become buried under several inches of sand to form a subsurface “pavement” layer. This situation was observed in both the *Torrey Canyon* and Santa Barbara spills. In both cases the “pavement” layer was exposed and covered several times during winter months.

Biological Dispersion

Hydrocarbons are not foreign to the marine environment; they are synthesized by most, if not all, living organisms. The conditions under which microbial attack occurs and the rate of biodegradation are a function of such diverse factors as the type and number of bacteria in the given marine environment, the quantity and type of oil spilled, the spill concentration, water temperature, salinity, oxygen concentration, nutrients, and pH. Some reported values for marine biodegradation of oils vary from 35 to 55 percent of oxidizable crude oil degraded within 60 hr, to between 26 and 98 percent of oil degraded by mixed cultures within 30 days at 77°F.

Early studies have found an abundance of oil-oxidizing bacteria in coastal waters and muds near natural oil seeps. As an example, along the California coast, oil-oxidizing bacteria concentrations range from zero (none detected) to greater than 10 per milliliter of mud, with the largest populations being found in San Pedro Bay and Long Beach Harbor. Microbial degradation appears to be most efficient in removing relatively low concentrations of oil such as thin films. However, oil oxidizing bacteria are sensitive to toxic constituents of oils such as toluene and xylene, as well as phenol and small quantities of nitrogenous, oxygenated, and/or organic sulfur compounds. Therefore, the concentration and composition of oil in a given area affects both the overall biodegradability and the rate of microbial activity.

Many oleophilic microbes become nutrient limited, i.e., they use up all of the nitrogen or phosphorus or both, which are essential for maintaining life and growth. Both sea water and petroleum have low concentrations of nitrates and phosphates. Once the nitrates and phosphates are depleted, or at least reach very low levels, the microbe populations will be reduced in species diversity and abundance even though a considerable quantity of oil remains. Recent oil spill cleanup activities have therefore included adding substantial amounts of nutrients to affected areas to encourage natural microbial oxidation of residual oils.

Effects of Oil on Marine Ecosystems

The effect of petroleum products ranging from gasoline to crude oil on one or more components of marine ecosystems has been the topic of numerous symposia, scientific papers, formal and informal lectures, and newspaper articles. Ecological effects are presently receiving close attention by industrial and academic groups under the auspices of the American Petroleum Institute (API), Environmental Protection Agency (EPA), and other industrial, private, state, and Federal agencies. A review of the literature and interviews with these several sources indicate that three kinds of effects (and the resultant biotic responses) exist. These effects are arbitrarily divided into three categories.

FIRST ORDER EFFECTS include the direct effect of petroleum products on the biota. These effects may be toxic physically (such as suffocation), or physiologically (such as internal disturbances following ingestion). All of these may result in immediate mortality, torpidity, or poor health. These are generally short-term effects which usually affect all species to some degree and show up within hours or days.

SECOND ORDER EFFECTS include changes in populations of each species with respect to size-frequency and age structure, productivity, standing crop, reproductive abilities, etc. These are generally intermediate-term effects which show up in weeks, months, and for some long-lived species, years.

THIRD ORDER EFFECTS include changes at the community or ecosystem level with respect to relationships within or between trophic levels, species composition and/or abundance, and other aspects of community dynamics. These changes are often the result of subtle, sub-lethal effects which may not show up for months or years.

First order effects have been documented in some detail in several instances. Second and third order effects are generally less well documented, except for a few large spills such as *Torrey Canyon*, *Tampico Maru*, West Falmouth, and Santa Barbara. Even in these cases, the data interpretation may be open to criticism.

Clearly, there are significant impacts on the marine environment from most oil spills. This impact may vary from an aesthetic problem of several days' duration resulting from visible oil slicks and beaches contaminated with oil, to a severe kill of marine organisms and water fowl, and severe disruption of commercial and recreational activities. Long-term effects might occur for several years before ecosystem recovery. The spill may even bring about a permanent change in the ecosystem as evidenced by new and different species of flora and fauna becoming dominant in terms of space or ecological importance.

The severity of both short-term and long-term effects is predicated on certain conditions. The following generally increase the severity of an oil spill:

1. A massive oil spill relative to the size of the receiving and affected area.
2. A spill of primarily refined oil.
3. The spill being confined naturally or artificially to a limited area of relatively shallow water for a prolonged period.
4. The presence of sea bird and/or mammal rookeries in the affected area.
5. The absence of oil-oxidizing bacteria in the marine environment.
6. The presence of other pollutants, such as industrial and municipal wastes in the affected area.
7. The application of detergents and/or dispersants as part of the cleaning action.

Biological Effects of Recorded Spills

The general aspects of some recent major oil spills are presented in Table 4-9. Of these spills, only four have shown extensive kill of much of the areas' marine life. Three of these, West Falmouth, the *Tampico Maru* incident off Baja California, and the Wake Island spill shared the common factor of a large amount of product being discharged to a small, partially enclosed body of water. The *Torrey Canyon* spill occurred in open waters. In most other spill studies, organism kill was most common in the intertidal zone. A brief description of several major historical spills follows.

Table 4-9. Summary of Recorded Historical Major Oil Spills

Spill	Date	Quantity Spilled (1000 gal)	Product Type	Detergents Used in Cleanup	Time to Recovery (General Estimate)
Louisiana	1956		Crude	No	several months
Tampico Maru	1957	2,500	Diesel fuel (#2 fuel oil)	No	1 - 10 years
Fawley, England	1960	52	Fuel Oil	Yes	> 2 years
Torrey Canyon	1967	29,400	Crude	Yes	> 2 years
Milford Haven	1968	70 - 150	Crude	Yes	Several months
Santa Barbara	1969	4,200	Crude	Yes	Several months
West Falmouth	1969	175	Diesel fuel (#2 fuel oil)	No	< 2 years
Tampa Bay	1970	10	Bunker "C"	Yes	Days to weeks
Nova Scotia	1970	3,800	Bunker "C"	No	Months to years
Platform Charlie, LA	1970	42[a]	Crude	Yes	Days
Wake Island	1970	6,000	Bunker "C"[b]	--	--
San Francisco	1971	840	Bunker "C"	No	10 months +

[a]Daily discharge estimated to be 42,000 gal for a three-week period.
[b]Also included aviation gasoline and jet fuel, aviation turbine fuel and diesel oil.

Unfortunately, there have been numerous other major oil spills in the last 30 years, notably the March 1989 Exxon Valdez oil spill when the tanker ran aground on a reef, spilling 258,000 barrels of crude oil into Alaska's Prince William Sound.

Louisiana Spill. On November 17, 1956, an oil well caught fire and spilled oil for a period of about two weeks into the marshes of Louisiana. Although the original slick covered over 50 square miles, by December the oil had disappeared from the surface except for a light film within Barataria Bay. There was still considerable oil along the shoreline of the Freeport Sulfur Canal. As late as February 5, 1957, oil could still be stirred from the bottom of areas such as Billet Bay, indicating that considerable oil still covered the bottom. There was no way to determine how much oil escaped from the well. All light fractions likely burned when the well was on fire, and much more evaporated. Thus, most of the lost oil was artificially "weathered." The exception was the oil lost in the short period (several hours) after the fire was extinguished and during which the oil flowed unhindered.

Examination of the impact of the spilled oil on oysters was of prime concern. Data from polluted and nonpolluted areas clearly showed that contact with oil for an extended period had no effect as far as the survival and growth of oysters was concerned. Mortalities of oysters in the area were primarily associated with the incidence of infection of a fungus disease typical of Louisiana and were not related to the distance from the well. Oily taste in the oyster meats could not be identified after two months.

A cursory examination of the organisms associated with oyster reefs showed that control and experimental stations did not differ significantly. Normal reproduction and growth of populations took place during the entire period of study. The oysters themselves spawned normally, and heavy sets of young oysters occurred at some experimental stations. Normal reproduction and growth of populations took place during the entire period of study. The oysters themselves spawned normally, and heavy sets of young oysters occurred at some experimental stations. These young oysters grew rapidly with relatively low mortality, while at the same time large numbers of older oysters died of an epidemic disease probably unrelated to the spill. Growth of the surviving oysters was excellent, as was their condition. Thus, survival, reproduction, growth, and size of oyster meats were not affected by the oil.

Tampico Maru Spill. During the spring of 1957, the oil tanker *Tampico Maru* went aground off the coast of Baja California. The ship formed a breakwater across a small cove while 60,000 bbl of diesel fuel began leaking from its hull. Damage to the benthic fauna and flora of the cove was extensive, and the shore was littered with dead and dying animals. A month after the accident, a thick viscous sludge of water, oil, and small particles covered most of the bottom of the cove and the tide pools. The sea plants did not seem to be as seriously damaged as the animals. Many plants remained attached and living, although some deterioration was noted. Few animal species survived. Among those that did were the small gastropod, *Littorina planaxis*, and large green anemones, *Anthopleura xanthogrammica*.

By summer, three months after the spill, the cove began to appear fresh and clean; eight months after, no oil was observed, though small quantities may have persisted. Motile animals, such as large fish, sea lions, and lobsters were seen. Smaller organisms, such as bryozoans, began to colonize the barren zones. By far the greatest change was the appearance of a dense and luxurious growth of seaweed.

The No. 2 fuel oil was confined to a small cove by the position of the tanker. This, in turn, reduced the oxygenation of the waters from the breaking waves, resulting in a massive kill among both the fauna and flora. Oil was the primary factor causing the destruction of the organisms. Seaweeds appeared to be more tolerant than the animals. Most of the plant species re-established themselves within a few months, but the animal species reappeared more gradually over a period of 7 years. Seven years afterward, the populations of certain organisms such as grazing sea urchins, abalones, and filter-feeding mussels, were still considerably reduced, and some species present before the shipwreck have not been seen since. Several organisms which are believed to be very tolerant of oil pollution were observed after the spill.

Fawley (England) Spill. The effects of this 1960 spill of fuel oil were seen on common intertidal organisms, such as the polychaete worms *Cirriforma tentaculata* and *Cirratulus cirratus*, but it was not certain that fuel oil alone was responsible for mortality. Where oil dispersants were employed, studies indicated a sharp decline in adult numbers. Two years after the spill, the numbers of adults of *Cirriforma tentaculata* had still not recovered.

Torrey Canyon Spill. The biological effects of the *Torrey Canyon* spill can be divided into two main categories: (1) those caused by, or directly related to, the crude oil itself and (2) those related to the cleanup procedures, especially the application of detergents. It was recognized from the onset of the *Torrey Canon* operations that oil, although it killed several thousand sea birds, was a pollutant mainly destructive to the amenities of shores and beaches, whereas detergents, on the other hand, were known to be destructive to life. Assessment of the biologic damage and recovery in the affected areas was examined in regard to either the presence of crude oil or the presence of crude oil in combination with detergents. Phytoplankton surveys of the channel areas, when compared with past surveys, contained samples having plant populations of the type normally found in a channel in early spring. Both diatoms and dinoflagellates appeared to be healthy at all stations. The overall result of later surveys showed that there were deaths among the smallest flagellates, often after a period of only a few days, in all samples taken from areas of thin or thick oil cover, whereas there were no deaths at stations in uncontaminated water. This indicated that these small flagellates were sensitive to very low concentrations of toxic substances.

Other phytoplankton, such as diatoms and dinoflagellates, appeared to be little affected. Further, most of the colorless dinoflagellates were unaffected, and some of those studied in laboratory cultures grew better in oily sea water than in uncontaminated water. Zooplankton, mainly copepod crustaceans, appeared to be of normal abundance, and all seemed healthy when examined immediately after they were captured. Fish also appeared to be healthy. Some oil was found by divers and fishermen on the sea floor, but there were no external signs of oil contamination on the fish and only a few visible traces of oil within the gut.

Along the rocky shore, heavy oil alone rarely seemed to have any ill effects during the first few days. In some cases, such as Cape Cornwall, moribund limpets were observed under the oil. It is possible that they had been smothered by thick coatings of oil, or that the oil which enveloped them contained the detergent sprayed at sea. The survival of mussels under heavy oil was seen at Booby's Bay in the first few days of pollution. In the absence of heavy detergent treatments, these mussels survived. Furthermore, at Portreath, mussels were found alive and behaving normally, even in pools which had an oil film.

In the Hayle Estuary, oil contamination occurred on March 28 – 29. 1967. No detergents were used within the estuary. When examined on April 10, the rich worm fauna of the sandy flats seemed unharmed. Although the black oily rim was still visible on the vertical walls around the estuary and harbor in mid-August, weathering had reduced it considerably. In places, an orange lichen *Xanthoria* was growing through the oil. Perennial salt marsh plants and grasses had grown through the oily layer and were spreading over the oil residue. The normal drift-line fauna of small amphipods and wood lice were common under stones. These are good examples of recovery by natural means in the absence of the use of any detergent.

Milford Haven Spill. Crude oil was spilled in Milford Haven along the shore at Hazel Beach on November 1, 1968. No evidence of biological damage was observed before cleaning operations commenced, although the rock area was covered with a thick black film of crude oil. Mollusks were attached to rocks and were apparently healthy. Following these observations, the shore was washed twice with an emulsifier applied with a water jet. The most obvious change was the growth of seaweeds in the mid-shore during March, July, and August. By late September, these plants were about 6-in. long, forming a patchy cover on the shore. Following cleaning (three weeks after the initial spill), the gastropods showed considerable decrease in numbers, but when the next survey was made on January 23, the population had largely recovered its previous abundance. In Milford Haven, it is difficult to distinguish between the effects of small, chronic spills and large, rare spills.

Santa Barbara Spill. Oil released from the offshore well in the Santa Barbara Channel eventually affected most of the mainland beaches in the channel and some areas of the Channel Islands. Slicks initially covered large areas of the channel and tended to accumulate on the beaches in the upper littoral zone. Phytoplankton studies in the Santa Barbara Channel showed no conclusive evidence of any major effect which could be directly attributed to the spilled oil. These studies were based on 11 stations which were resampled 12 times from 1969 to 1970. The data showed higher productivity occurring inshore, seasonal variations in productivity, and the presence of a phytoplankton bloom in August 1969. No low productivity values resulting from the presence of oil on the surface of the water were found. There was a reduction in the reproduction in *Pollicipes polymerus*, a barnacle. The breeding in *Mytilus californianus*, a mussel, was probably reduced as a result of oil pollution.

The major damage to the marine invertebrates following the Santa Barbara spill resulted principally from the oil-removal operations along the mainland shore. The steam cleaning of rocks to remove the oil killed all sessile invertebrates that were attached to them. Further, cleaning the beaches with skip loaders to remove the oily straw and debris undoubtedly took its toll on some of the invertebrates inhabiting those beaches.

No permanent damage to marine plants was observed by California Department of Fish and Game divers during repeated surveys in 1969. On Santa Cruz Island, the algae *Hespherophycus harveyanus*, originally heavily coated by oil in February, was clean by August. In addition, numerous young plants were found to be present. The surf grass *Phyllospadix torreyi* was heavily coated by oil and suffered high mortalities but the beds had come back by the time of the later surveys. Most of the other plants and algae surveyed on the islands and the mainland appeared relatively unaffected by the oil pollution.

California Department of Fish and Game trawls obtained 14,070 fishes representing 59 species. They failed to show damage directly related to oil pollution or starvation. U.S. Bureau of Commercial Fisheries personnel found no gross evidence of dead or deformed larvae of fish eggs nor gross changes in the composition of the ichthyoplankton in the channel during February 1969.

<u>West Falmouth Oil Spill</u>. The West Falmouth oil spill of September 16, 1969, involving No. 2 diesel fuel, has been investigated by scientists at the Woods Hole Oceanographic Institute. These controversial studies indicated that a massive kill of benthic invertebrates occurred even before the application of detergents. In addition, wherever fuel oil was detected in the sediments, there was a reported kill. In areas containing the most oil, the kill was almost complete. The reports state that the kill was caused directly or indirectly by the fuel oil. Affected areas were said to not be repopulated 9 months after the spill, resulting in marshes being eroded because of decreased stability following the kill. Up to two years after the spill, fuel oil is still detectable in the sediments.

<u>Nova Scotia Spill</u>. Five months (i.e., July, 1970) after the destruction of the oil tanker *S.S. Arrow*, carrying Bunker C fuel oil, the marine fauna and flora below the tide levels were healthy, and fishing and lobstering were normal. Background levels of hydrocarbons from the spill had decreased significantly by January 1971. As expected, the intertidal zone was the most severely affected, but only where oiling was exceptionally heavy. An estimated 25 percent of the clams (*Mya arenaria*) were killed in the early part of the season. Algae, primarily *Fucus spiralis*, was oiled and became more easily torn loose in storms. Other species appear to have been little affected. Salt marsh cord grass (*Spartina alterniflora*) suffered high mortality. The lobster season had gotten underway on schedule in early May and the lobsters were in hibernation when the oil was spilled, which helped to protect them. Other subtidal organisms appear not to have suffered. Zooplankton in early March were normal. Copepods were observed with oil in their digestive tracts, which generally passed through unaltered and without harm to the animal. Local fisheries were found to be unaffected in the following season.

<u>Gulf Coast Spill.</u> On February 10, 1970, a blowout fire occurred on offshore Platform 2 in Main Pass Block 41 field, 11 miles east of the Mississippi River Delta. The fire burned until March 10 when it was extinguished by explosives. Over the next three-week period, crude oil escaped at an estimated rate of 1000 bbl/day before the last well was capped. Oil came onshore only briefly at Breton Island. Investigations revealed no apparent damage to marine organisms. The benthic community consisted of large numbers of species and showed no measurable effect from the discharged oil. Numerous samples showed large numbers of species of fish and normal size and

numbers of shrimp. The shrimp data indicated a normal reproductive cycle, with no effect of oil on reproduction and juvenile stages. The normal attachment of oysters just following the spill further indicated no effect of oil on oyster reproduction or ,juvenile stages.

Wake Island Spill. The Wake Island spill resulted in an estimated kill of 2500 kg of inshore reef fishes plus an unknown number of invertebrates and other fish. There was no evidence of damage to sea birds.

San Francisco Spill. The discharge of 20,000 bbl of Bunker C oil near the Golden Gate Bridge in San Francisco Bay in January 1971 caused extensive coverage of the intertidal zones within portions of the bay and seaward as far north as Bolinas and to a lesser extent south of Half Moon Bay.

An investigation on the effect of the spill on Duxbury Reef, a marine reserve, indicated that heavy oil deposits on the reef area caused kills by smothering certain species such as acorn barnacles and limpets. The same effects were noted at Sausalito. Marine snails suffered less mortality than did the sessile barnacles and other sedentary animals. The normally large population of striped shore crabs (*Pachygrapsus crassipes*) was missing from the rocky crevices. The condition of Duxbury Reef in December 1971 was one of apparent good health; the recruitment of some marine animals appeared to be approaching normal levels and the oil had disappeared from much of the reef surfaces and was barely discernible in the most heavily deluged areas.

Summary of Documented Spills

The following is a summary of the effects of the historical oil spills, and is based on field investigations. The results of the different studies often have quite varied conclusions (likely due to a combination of factors including spill and material characteristics, and environmental conditions, plus differences in the experimental designs and sampling procedures), but the following is a list of generally accepted conclusions concerning the effects of oil spills.

1. The principal damage from oil spills is to birds. The literature is remarkably unanimous on this point. The data are conclusive and can be taken without reservation. While no bird damage has resulted from some spills, it is believed that this resulted from accidental circumstances, and the danger to birds is present wherever a spill occurs.

2. The effects in the intertidal zones, beaches, marshes, and rocky shores are sometimes of significant severity. The intertidal zone is subject to heavy concentrations of oil, and damage may be expected if concentrations reach a critical level. Usually the damage to biotic communities from the oil itself is quite small even when heavy concentrations reach the shore. Humans are among the most affected when beaches are made uninhabitable.

3. Little documentation has shown any significant damage to marine bottom communities in deep or shallow water. There appears to be an intermediate zone between the intertidal area and “deep” water in which some relatively small damage occurs under adverse circumstances (such as heavy wave action in surf zones).

4. Damage to fisheries appears to be confined to those cases where animals (such as the mussel *Mytilus*, oysters, or clams) live in intertidal zones. Any fishery animal can become tainted with oily taste and smell. Considerable losses to the industry may occur when such contamination affects any significant part of the populations.

5. Recovery from damage caused by oil spills is usually rapid and complete so far as the marine communities are concerned, and in some cases these communities may be stimulated to higher productivity by the process.

6. No significant damage to plankton has been observed in oil spills.

Use of Models to Predict Areas of Significant Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Materials

The procedures and examples in this section have illustrated various modeling techniques that can be used to predict areas of possible impact associated with hazardous material accidents. It has been possible for many years to identify the possible areas that should be used as buffer zones near locations that may have serious accidents. These procedures have been used to locate transfer facilities and chemical manufactures away from sensitive receptors, especially schools and hospitals. When addressing highway and railroad systems, however, it is much more difficult to separate these areas because of their natural close proximity to high density urban areas, and the inability to precisely predict the likely locations of accidents. In addition, cities cannot restrict the legal shipments of these materials near their communities. The material presented in this section is therefore most useful for planning purposes and for training local emergency response responders, for locating sensitive receptors in the community, and for selecting local routes of hazardous materials. It can also be used to better predict the possible long-term effects that potential accidents that occur on nearby transportation corridors may have on their community.

An associated UTCA project (Panwhar, *et al.* 2000) illustrated how this information can be used for the optimization of local hazardous material transportation routes within a community. The project developed and prepared a simple demonstration of a geographic information system (GIS) based hazardous waste transport system. This system, the Hazardous Waste Transportation System (HWTS) is intended to reduce the impact of potential incidents regarding hazardous waste shipments through an urban area by optimizing the transportation routes. The methodology used a probabilistic risk assessment framework which takes into account the probability of accidents for each road segment and the consequences of an accident as route selection parameters. The facilities most vulnerable to the impact of accidents (which should be avoided), such as schools, hospitals, and day care centers, are considered. The demonstrated model can utilize the accident rates for each road segment and the locations of these vulnerable facilities. Vulnerability of the facilities is calculated as a function of the distance of the facilities from the transportation routes and the population of the vulnerable facility. A route is then selected to minimize the potential impacts by routing the hazardous waste shipments away from these vulnerable areas.

In the demonstration phase of their project, Panwhar, *et al.* (2000) used ArcView GIS to store roadway data and other socio-economic information for Jefferson county, Alabama, identifying sensitive locations as well as to integrate them and develop the safest route. The routing analysis uses a combination of roadway length, length of time in transit, population exposure and proximity to sensitive areas, such as schools, day care centers, retirement homes, and hospitals. It also considers the timing of the day for the specific facilities as the exposure greatly varies with time. For example, most of the schools will be at highest risk during 7:00 am to 3:00 pm, whereas at off-peak hours and holidays, the risk associated with these facilities will be minimal.

GIS was used in the HWTS to calculate risk values for all roadway segments. Figure 4-20 shows buffer areas around the various schools. The shortest route intersected numerous school zones of influence, with potential serious consequences in cases of accidents. Using the combined roadway distance and risk scores, a new route was developed that minimized potential impact associated for a hazardous waste shipment. This new route is shown in Figure 4-20. The shortest path had a distance of 10.5 miles compared to the shown minimized impact route of 11.7 miles.

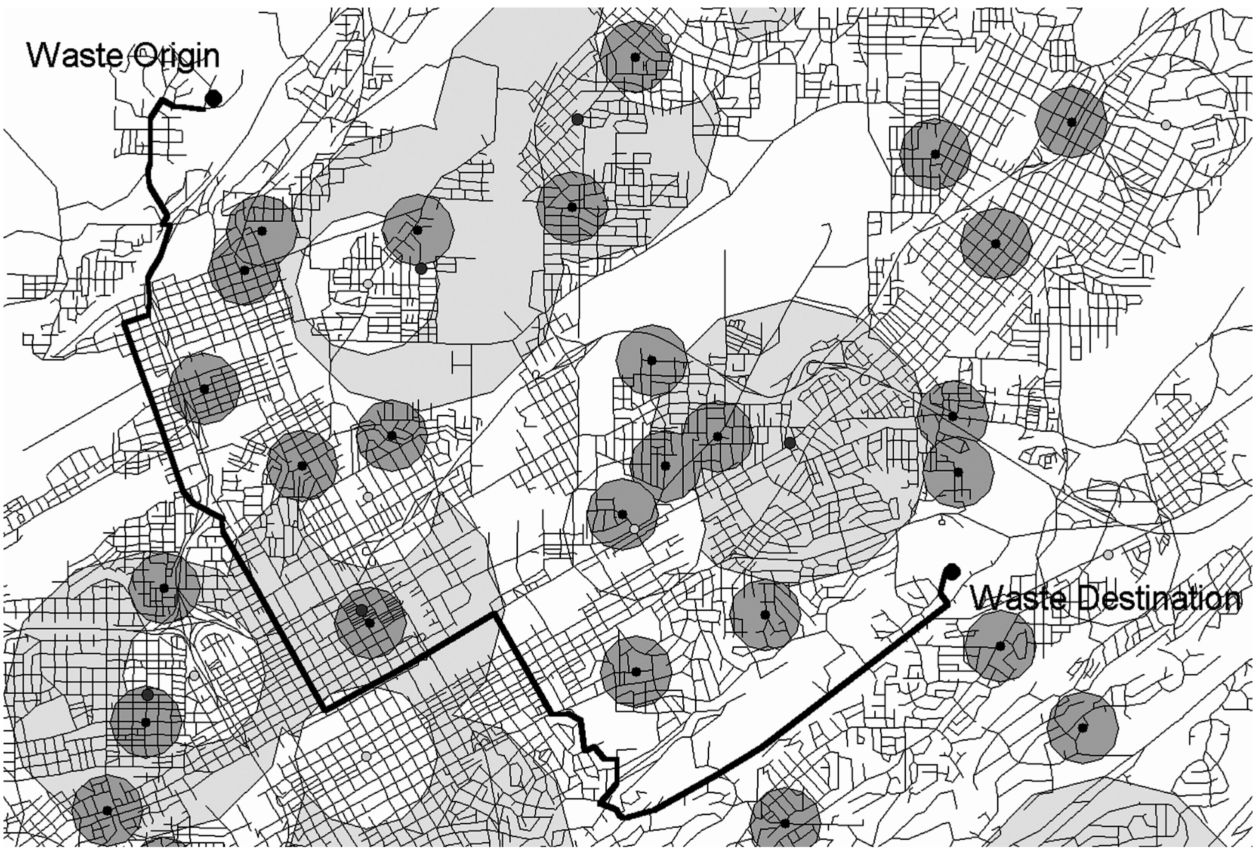

Figure 4-20. Best route minimizing intersections with critical zones around schools (Panwhar, *et al.* 2000).

The demonstration program can be extended to include all pertinent socio-economic characteristics desired by the community, including other features to avoid during the routing of hazardous materials (including the general population). The most important expansion of this transportation system would be the incorporation of better predictions of possible community impacts using the procedures presented in this report section.

Section 5. Community Impacts of Major Transportation Accidents Involving Hazardous Materials

Major transportation accidents involving hazardous materials can produce profound economic, social and psychological impacts in affected communities. These impacts can be both widespread and long lasting. This section discusses the community impacts of hazardous-materials transportation accidents. As in previous parts of this report, the section begins with a brief illustrative case study. The case study examines a June 1999 pipeline explosion in Bellingham, Washington that killed a man and two children and had a profound effect on the community. Following the discussion of the Bellingham case, the section continues with a more general review of the economic, social, and psychological effects of hazardous materials transportation accidents. Here, current scientific research is reviewed, examples are provided, and implications are considered.

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

Accident Description

Olympic Pipe Line Company owns and operates a 400-mile system of pipes that carry 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 is 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).

Impacts of the Bellingham Pipeline Explosion

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 5-1. Aerial photo of explosion scene (copyright *Bellingham Herald* June 11, 1999, *Reprinted with permission*).

Figure 5-2. 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 5-3. Fire fighters from Tosco Refinery spray foam on hot spots along Woburn St. (copyright June 10, 1999 *Bellingham Herald*, *Reprinted with permission*).

Figure 5-4. 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 5-5. 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 5-6. 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: 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.

Section 6. Conclusions and Recommendations

Project Overview and Conclusions

The purpose of the project was to (1) quantify transportation-related accidents involving hazardous materials in the state and (2) identify key longer-term environmental health, public safety, and social impacts that are often overlooked after major transportation-related hazardous materials accidents. In an increasingly complex and interconnected world, no community is immune from the threat posed by environmental accidents and contamination. Even communities far removed from industrial production or storage facilities can still be at risk from accidents associated with the transport of hazardous materials. While a variety of studies have been conducted on aspects of major transportation accidents, few have attempted to examine both environmental and community aspects of the problem. In contrast, this report takes an integrated approach to hazardous transportation accidents by considering environmental, safety, economic, and psychosocial issues.

The project was comprised of four main tasks: consultation with key stakeholders; summary and analysis of representative transportation-related hazardous materials accidents that have occurred in Alabama since 1990; presentation of simplified chemical transport and fate models; and presentation of information to help anticipate important social, psychological and related community impacts that can occur after major transportation-related hazardous materials accidents.

Section 2 of this report utilizes two case studies – Dunsmuir, CA, and Warrior, AL, -- to highlight the problems encountered in transportation accidents. The first accident, which took place near Dunsmuir, CA in 1991, involved a train derailment that spilled a large quantity of the pesticide metam sodium. The Dunsmuir case showed the massive ecological-scale effects that can result from a major transportation accident involving hazardous materials. In the Upper Sacramento River, fish, algae, plankton and insects were killed immediately and, in effect, the stream was sterilized. The airborne plume killed much of the streambank vegetation.

The second case study, a truck accident involving acrylonitrile on Interstate-65, near Warrior, 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. In addition, the fact that a barge with 100 times more acrylonitrile ran aground a year after the I-65 accident indicates that there is the potential for large-scale transportation accidents to occur in Alabama.

If the Dunsmuir and I-65 accidents both illustrated the need for improvements in training and preparedness, the point was further emphasized in the stakeholder discussions conducted in connection with this report. Several of the larger fire departments (Birmingham, Tuscaloosa, Montgomery, Mobile, and Huntsville) have hazardous materials responders who have had the required emergency response training. Fort Rucker also has its own hazmat unit. However, much of the state is served by volunteer/semi-volunteer fire departments. Interviews with stakeholders highlighted several concerns. 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 spent on a response. Second, stakeholders are concerned that 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, said stakeholders, there are three communications systems, which can cause coordination problems. Third, there is a concern about responders, especially local departments, not having the knowledge to respond to incidents involving ‘unusual’ chemicals, i.e., those chemicals that are not encountered frequently during a traffic accident. A fourth concern that was raised was the lack of alternate routes for detours and evacuations. The closure of I-65 resulted in large volumes of traffic passing through the town of Warrior on a roadway that was ill-equipped to deal with the volume of cars and trucks. Finally, concern was expressed that responders and residents are not always informed in a timely manner about potential hazards resulting from spills.

Section 3 of the report reviews information about Alabama’s transportation system and about the hazardous-materials transportation accidents that have occurred in the state in the 1990s. Major features of Alabama’s transportation network include the following:

- Five major interstate highways and an extensive network of surface highways;
- The second longest inland waterway system in the nation and a deep-water port in Mobile (the nation’s 12^{th} busiest);
- Five Class I railroads;
- Eight commercial airports and 91 general aviation facilities;
- Almost 95,000 miles of roadways with motorists travelling approximately 50 billion miles on them per year;
- The Port of Mobile which serves 1,100 vessels annually (generating 66,000 truck movements and 119,000 train movements to and from the facility); and
- Over 5,200 miles of railroad track miles, with Birmingham being a major Southeastern hub.

Information on hazardous material transportation accidents in Alabama was collected and analyzed using data from the National Response Center. More than 1,700 transportation-related hazardous materials accidents involving a large number of materials occurred in the State over the past ten years. Petroleum hydrocarbons were the most common hazardous material lost. A review of the data showed that of the 226 reported accidents in 1998, there were 20 deaths and 27 injuries. In addition, four accidents caused property damage, two accidents resulted in evacuations, and nine accidents resulted in road closures. The locations with the most frequent reported spills were the historical *USS Alabama* Battleship museum and the hazardous waste landfill at Emelle, probably due in part to diligent reporting by the site operators. Additional locations of frequent spills include several sites where chemicals are transferred from marine craft to land vehicles such as trains and trucks.

A review of the data in the tables in Section 3 and Appendix A shows that transportation accidents involving hazardous materials can vary considerably in magnitude. Fortunately, most of the accidents are small. Many of these releases occur during transfer operations (i.e., between trains or trucks and ships or other loading facilities). The mode of transport with the fewest accidents was air, but air accidents tended to involve the loss of large quantities of pesticides (accidents involving crop-dusting planes). Another frequent type of accident involves ships. These losses may be due to a ship running aground, and accidents often involve the release of the ship's fuel.

Stakeholders raised several issues related to potential future transportation accidents in Alabama. Concern was raised about the routing of hazardous materials in the state, particularly in relation to the tunnel in Mobile. Also at issue was the transport of transuranic waste from Oak Ridge and Savannah River. This waste has been scheduled to pass through downtown Birmingham on I-59/I-20. Public safety personnel were concerned that they would not be informed of the schedule for the waste transport.

Section 4 presents several procedures to predict the fate and transport of spilled hazardous materials. The initial discussion is a general procedure that stresses downwind toxic and explosive hazards, summarized from a recent EPA manual, and is applicable for a wide range of hazardous materials. An overview of potential reactions of mixtures of hazardous materials is also presented in this section. Two detailed examples are also presented describing problems associated with spills of petroleum hydrocarbons (the most common material lost in Alabama transportation accidents), and releases of ammonia (a toxic gas). A review of the literature on several major historical oil spills produced the following general conclusions:

1. The principal damage from oil spills is to birds.
2. The effects in the intertidal zones, beaches, marshes, and rocky shores are sometimes of significant severity.
3. Little documentation is available that shows any significant damage to marine bottom communities in either deep or shallow water.
4. Damage to fisheries appears to be confined to those cases where animals live in intertidal zones.
5. Recovery from oil-spill damage is usually rapid and complete so far as marine communities are concerned.
6. No significant damage to plankton has been observed in the referenced incidents.

The interviews with stakeholders showed that there are fears about the types of chemicals that may be encountered during a transportation accident. The chemical groups that responders generally were not prepared and equipped to deal with were water-reactive chemicals, corrosives, elevated temperature materials, regulated medical waste, and precursor chemicals for clandestine laboratories. The typical response of a local fire department would be to put water on the chemical and wash it off the roadway. However, in the case of water-reactive chemicals, this may make a small problem much worse. When dealing with elevated temperature materials, the departments often do not have the appropriate gear. (Rubber suits are clearly unsuitable near a 250^{o}C fire.) One example of a commonly transported elevated temperature material was liquid asphalt. Regulated medical waste is another concern because of the variety of vehicles in which it can be transported and because of the lack of information that may be available about the exact nature of the waste. The last chemical group is the precursor chemicals for clandestine laboratories. These shipments are not placarded and there is no paperwork on what the truck contains. In many cases, these are rental trucks. Therefore, personnel responding to an accident likely do not know that they are entering a chemical hazard area, and they are not appropriately protected. The procedures presented in Section 4 can be used to address many of these concerns. It is possible to locate sensitive receptors (schools and hospitals, for example) at safe distances from potential accident locations, by hazardous waste responders to better understand the magnitude of possible accident problems, and by transportation planners to better select routes of especially hazardous materials.

As Section 5 demonstrates, major transportation accidents involving hazardous materials can produce profound economic, social and psychological impacts in affected communities. People in Bellingham, Washington, for example, viewed the pipeline explosion as “the most devastating thing that we’ve ever had happen to this community. This has shaken the community’s sense of security to the core.” Furthermore, as both the scientific literature and the case studies presented in the report illustrate, the impacts of hazardous materials incidents can be traumatic, widespread and long lasting. “It comes as a shock to me how much suffering remains in this community because of this,” a Bellingham doctor noted. And as a Dunsmuir resident made clear, the lingering effects of a contamination accident make getting “back to normal” difficult. “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.”

Some of the most immediate effects of toxic transportation emergencies can result when an accident forces people to evacuate. Evacuations are highly disruptive, affecting businesses, schools and every aspect of community life. The economic effects of toxic emergencies can also be considerable. Response and clean-up operations are expensive, and contamination, or even the *perception* of contamination, can lower property values and seriously damage industries such as farming, fishing and tourism.

Less apparent than immediate disruption and economic effects – but potentially more problematic and complex to address – are the psychological effects of accidents involving hazardous materials. Concerned about their health and the health of loved ones, victims of chemical or radiological accidents live in what Erikson (1995) characterizes as a “permanent state of alarm and anxiety.” Studies suggest that people who have suffered through transportation accidents involving hazardous materials are at increased risk of a range of psychological problems. “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” (Vyner 1988). Furthermore, just as hazardous materials accidents can have substantial and long-lasting mental health effects, so too can they leave profound social impacts in their wake. Loss of trust, social conflict and division are common, as are social stigma and a sense of a reduced quality of life in affected communities.

During the stakeholder discussions, concern was expressed over the limited resources available both to responder agencies and local emergency planning committees (LEPCs) in Alabama. Mandated under the Emergency Planning 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.

Recommendations

Many local fire departments are not adequately prepared to assist in a hazardous materials incident. In order to address this situation, several volunteer fire departments have begun cooperating with each other 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. Greater support for such efforts is needed so that small fire departments can obtain needed training and equipment.

As has been clearly demonstrated, 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. To enhance our ability to prevent and mitigate community impacts, it will be crucial 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. In addition, it would be valuable for training exercises to include more attention to psychosocial issues and more realistic social-behavioral assumptions. It would also be beneficial, 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 very useful. The development of appropriate materials, as well as tailored interventions for high-risk populations, needs to 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. It is vital in reducing community impacts *after* a chemical or radiological accident, and it is also crucial *beforehand*. 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.

While mechanisms for *post-accident* communication are relatively well established, the situation with respect to *pre-accident* communication remains 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, 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 the fact that, in contrast to many other states, the State of Alabama provides no funding for LEPCs. 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.

Section 7. References

Section 1. Introduction

Becker, S.M. Environmental Disaster Education at the University Level: An Integrative Approach. *Safety Science.* 35, 95-104. 2000.

Lillibridge, S.R. Industrial disasters. In: *The Public Health Consequences of Disasters* (Eric K. Noji, ed.). New York: Oxford University Press. 1997.

Quarantelli, E.L. The Environmental Disasters of the Future Will Be More and Worse but the Prospect Is Not Hopeless. *Disaster Prevention and Management*. 2, 11-25. 1993.

Thomann, R.V. and J.A. Mueller. *Principles of Surface Water Quality Modeling and Control*. Harper and Row Publishers. Cambridge. 1987.

Section 2. Transportation Accidents Involving Hazardous Materials

-------- Interview with an unidentified firefighter who was one of the first responders to the accident. December 1, 2000.

-------- Interview with Fire Chief Tommy Hale. December 1, 2000.

Committee on Government Operations. 1992. *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, DC: U.S. Government Printing Office.

Davis, J. "Blood tests indicate chemical affected ill firefighters." *The Birmingham News*. February 11, 1994.

Davis, J. "I-65 toxic spill creates a miles-long traffic jam." *The Birmingham News*. February 8, 1994.

Davis, J. "No contamination reported at spill site." *The Birmingham News*. February 9, 1994.

Davis, J. "Soil removed from site of I-65 tanker spill." *The Birmingham News*. February 15, 1994.

Davis, J. "Troopers say truck driver fell asleep." *The Birmingham News*. February 23, 1994.

Davis, J. "Warrior readies new claim for loss city suffered in I-65 chemical spill." *The Birmingham News*. March 17, 1994.

Green, J. "Warrior waits for settlement following tanker truck spill." *The Birmingham News*. January 16, 1995.

Powell, D. and G. Short. "Tanker topples on I-65." *The Birmingham Post-Herald*. February 8, 1994. (a).

Short, G. "Spill creates pandemonium for usually quiet Warrior area." *The Birmingham Post-Herald*. February 8, 1994 (b).

The Birmingham News. "Chemical barge aground on Tenn-Tom." March 13, 1995.

The Birmingham News. "Warrior fire chief fears suits contaminated." February 10, 1994.

Wilstach, N. and J. Davis. "Toxic spill on I-65 leads to evacuations." *The Birmingham News*. February 7, 1994.

Section 4. Environmental Fate and Transport Modeling

Center for Process Safety of the American Institute of Chemical Engineers (AIChE). *Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs.* New York: AIChE. 1994.

Center for Process Safety of the American Institute of Chemical Engineers (AIChE). *Guidelines for Use of Vapor Cloud Dispersion Models,* Second Ed. New York: AIChE. 1996.

Center for Process Safety of the American Institute of Chemical Engineers (AIChE). *International Conference and Workshop on Modeling and Mitigating the Consequences of Accidental Releases of Hazardous Materials,* September 26-29, 1995. New York: AIChE. 1995.

Cobet, A. and H. Guard. Effect of a Bunker Fuel on the Beach Bacterial Flora. *Proceedings of Conference in Prevention and Control of Oil Spills,* American Petroleum Institute, Washington, D.C. 1973.

Fay, J.A. Physical Processes in the Spread of Oil on a Water Surface. *Proceedings of Joint Conference on Prevention and Control of Oil Spills,* sponsored by American Petroleum Industry, Environmental Protection Agency, and United States Coast Guard. 1971.

Federal Emergency Management Agency, U.S. Department of Transportation, U.S. Environmental Protection Agency. *Handbook of Chemical Hazard Analysis Procedures.* 1989.

James, W.P., *et al. Environmental Aspects of a Supertanker Port on the Texas Gulf*, Texas A and M University, (prepared for Sea Grant NOAA) 1972.

Kirk and Othmer. *Encyclopedia of Chemical Technology,* 2nd ed., Vol. 2. New York: Interscience Publishing Company.

Levine, B. S. USSR Literature on Air Pollution and Related Occupational Diseases. *The Biological Effects and Hygienic Importance of Atmospheric Pollutants.* Vol. 17. 1968.

Madsen, W.W. and R.C. Wagner. An Accurate Methodology for Modeling the Characteristics of Explosion Effects. *Process Safety Progress.* 13, 171-175. 1994.

Mercx, W.P.M., D.M. Johnson, and J. Puttock. Validation of Scaling Techniques for Experimental Vapor Cloud Explosion Investigations. *Process Safety Progress.* 14, 120. 1995.

Mercx, W.P.M., R.M.M. van Wees, and G. Opschoor. Current Research at TNO on Vapor Cloud Explosion Modelling. *Process Safety Progress.* 12, 222. 1993.

Miner, S. *Air Pollution Aspects of Ammonia*. Bethesda, Md.: Litton Systems, Inc., Environmental Systems Division. 1969.

Murray, S.P. Turbulent Diffusion of Oil in the Ocean. *J. Limnology and Oceanography*. Vol. 17, No. 5. 1972.

Murray, S.P., *et al. Oceanographic Observations and Theoretical Analysis of Oil Slicks during the Chevron Spill, March, 1970,* Report No. 87, Louisiana State University, Coastal Studies Institute. 1970.

National Petroleum Council, Committee on Environmental Conservation. *Environmental Conservation: The Oil and Gas Industries.* Vol. 2. 1972.

Panwhar, S.T., R. Pitt and M.D. Anderson. *Development of a GIS-Based Hazardous Materials Transportation Management System – A Demonstration Project*. UTCA Report 99244. The University Transportation Center for Alabama. Tuscaloosa, AL. Dec. 2000.

Premack, J. and G. A. Brown. Predictions of Oil Slick Motions in Narragansett Bay. *Proceedings of Joint Conference on Prevention and Control of Oil Spills, 13-15 Mar 1973,* Washington

D.C., sponsored by American Petroleum Industry, Environmental Protection Agency, and United States Coast Guard. 1973.

Prugh, R.W. Quantitative Evaluation of Fireball Hazards. *Process Safety Progress.* 13, 83-91. 1994.

Raj, P. K., J. Hagopian, and A. S. Kalelkar. *Prediction of Hazards of Spills of Anhydrous Ammonia on water.* NTIS Report No. CG-D-74-4, sponsored by U.S. Coast Guard. Springfield, VA. 1974.

Scheuermann, K.P. Studies About the Influence of Turbulence on the Course of Explosions. *Process Safety Progress.*, 13, 219. 1994.

Thomann, R.V. and J.A. Mueller. *Principles of Surface Water Quality Modeling and Control*. Harper and Row Publishers. Cambridge. 1987.

TNO Bureau for Industrial Safety, Netherlands Organization for Applied Scientific Research. *Methods for the Calculation of the Physical Effects of the Escape of Dangerous Material (Liquids and Gases).* Voorburg, the Netherlands: TNO (Commissioned by Directorate-General of Labour). 1980.

TNO Bureau for Industrial Safety, Netherlands Organization for Applied Scientific Research. *Methods for the Calculation of the Physical Effects Resulting from Releases of Hazardous Materials.* Rijswijk, the Netherlands: TNO (Commissioned by Directorate-General of Labour). 1992.

TNO Bureau for Industrial Safety, Netherlands Organization for Applied Scientific Research. *Methods for the Determination of Possible Damage to People and Objects Resulting from Releases of Hazardous Materials.* Rijswijk, the Netherlands: TNO (Commissioned by Directorate-General of Labour). 1992.

TNO Bureau for Industrial Safety, Netherlands Organization for Applied Scientific Research. *Methods for the Calculation of the Physical Effects.* The Hague, the Netherlands: Committee for the Prevention of Disasters. 1997.

Touma, Jawad S., *et al.* Performance Evaluation of Dense Gas Dispersion Models. *J. Applied Meteorology.* 34, 603-615. 1995.

Turner, B. D. *Workbook of Atmospheric Dispersion Estimates.* Washington, D.C.: U.S. Environmental Protection Agency. 1970.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. *Guidance on the Application of Refined Dispersion Models for Hazardous/Toxic Air Release.* EPA-454/R-93-002. May 1993.

U.S. Environmental Protection Agency. *Risk Management Program Guidance for Offsite Consequence Analysis*. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response, Chemical Emergency Preparedness and Prevention Office. EPA 550-B-99-009. 1999.

U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. *Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants.* EPA-450/4-88-009. September 1988.

U.S. Environmental Protection Agency, Federal Emergency Management Agency, U.S. Department of Transportation. *Technical Guidance for Hazards Analysis, Emergency Planning for Extremely Hazardous Substances.* December 1987.

U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxic Substances. *Flammable Gases and Liquids and Their Hazards.* EPA 744-R-94-002. February 1994.

Section 5. Community Impacts of Major Transportation Accidents Involving Hazardous Materials

Books, Scientific Reports and Journal Articles

Aaronen, E., and E.J. Mikkelsen. The psychological impacts of technological disasters. *Journal of SocialBehavior and Personality*. 8, 335-352. 1993.

Baum, A., R. Fleming, and L.M. Davidson. Natural disaster and technological catastrophe. *Environment and Behavior*. 15, 333-354. 1983a.

Baum, A. Toxins, technology, disasters. In *Cataclysms, Crises and Catastrophes: Psychology in Action* (G.R. VandenBos and B.K. Bryant, eds.). Washington, DC: American Psychological Association. 1987.

Baum, A., R. Fleming, and J.E. Singer. Coping with victimization by technological disaster. *Journal of Social Issues*, 39, 117-138. 1983a.

Becker, S.M. Psychosocial assistance after environmental accidents: A policy perspective. *Environmental Health Perspectives* (National Insitutes of Health). 105(S6), 1557-1563. 1997.

Becker, S.M. Environmental disaster education at the university level: An integrative approach. *Safety Science*. 35, 95-104. 2000.

Becker, S.M. Psychosocial effects of radiation accidents. In: *Medical Management of Radiation Accidents*, 2nd edition (F.A. Mettler, Jr., ed.). Boca Raton: CRC Press. 2001.

Bowler, R.M., D. Mergler, G. Huel, and J.E. Cone. Psychological, psychosocial, and psychophysiological seqeulae in a community affected by a railroad chemical disaster. *Journal of Traumatic Stress*. 7(4):601-624. 1994a.

Bowler, R.M., D. Mergler, G. Huel, and J.E. Cone. Aftermath of a chemical spill: Psychological and physiological sequelae. *NeuroToxicology*, 15, 723-730. 1994b.

Breton, J.-J., J.-P. Valla and J. Lambert. Industrial disaster and mental health of children and their parents. *Journal of the American Academy of Adolescent and Child Psychiatry*. 32, 438-445. 1993.

Brown, P., and E.J. Mikkelsen. *No Safe Place: Toxic Waste, Leukemia, and Community Action*. Berkeley: University of California Press. 1990.

Collins, D.L., and A.B. de Carvalho. Chronic Stress From the Goiania Cs-137 Radiation Accident. *Behavioral Medicine*. 18, 149-157. 1993.

Committee on Government Operations. *Train Derailments and Toxic Spills*. Hearing before the Government Activities and Transportation Subcommittee of the Committee on Government Operations. U.S. House of Representatives. One Hundred Second Congress, First Session, October 3, 1991. Washington, D.C.: U.S. Governmet Printing Office. 1992.

Couch, S.R. and J.S. Kroll-Smith. The chronic technological disaster: Toward a social scientific perspective. *Social Science Quarterly*. 66, 564-575. 1985.

Cuthbertson, B.H., and J.M. Nigg. Technological disaster and the non-therapeutic community: A question of true victimization. *Environment and Behavior*. 19, 462-483. 1987.

Davis, N.Y. The Exxon Valdez oil spill, Alaska. In *The Long Road to Recovery: Community Responses to Industrial Disaster* (J.K. Mitchell, ed.). Tokyo: United Nations University Press. 1996.

Dyer, C.L., D.A. Gill and J.S. Picou. Social disruption and the Valdez oil spill: Alaskan natives in a natural resource community. *Sociological Spectrum*. 12, 105-126. 1992.

Edelstein, M.R. *Contaminated Communities: The Social and Psychosocial Impacts of Residential Toxic Exposure*. Boulder, Co: Westview. 1988.

Edelstein, M.R., and A. Wandersman. Community dynamics in coping with toxic contaminants. In: *Neighborhood and Community Environments* (I. Altman and A. Wandersman, eds.). New York: Plenum, pp. 69-112. 1987.
Erikson, K. *A New Species of Trouble: The Human Experience of Modern Disasters*. New York: W.W. Norton. 1995.
Erikson, K. *Everything in its Path: Destruction of Community in the Buffalo Creek Flood*. New York: Simon & Schuster. 1976.
Erikson, K. The view from East Swallow. In: *Research in Social Problems and Public Policy*, Vol. 5 (W.R. Freudenberg and T.I.K Youn, eds.). Greenwich, CT: JAI Press. 1993.
Fullerton, C.S., and R.J. Ursano. The other side of chaos: Understanding the patterns of posttraumatic responses. In *Posttraumatic Stress Disorder: Acute and Long-Term Responses to Trauma and Disaster* (C.S. Fullerton & R.J. Ursano, eds.). Washington, DC: American Psychiatric Press. 1997.
Gill, D.A., and J.S. Picou. Technological disaster and chronic community stress. *Society & Natural Resources*. 11, 795-815. 1998.
Kasperson, R.E., and J.X. Kasperson. The social amplification and attenuation of risk. *The Annals of the American Academy of Political and Social Science*. 545, 95-105. 1996.
Kroll-Smith, J.S., and S.R. Couch. Technological hazards: Social responses as traumatic stressors. In: *The International Handbook of Traumatic Stress Syndromes* (J.P. Wilson and B. Raphael, eds.). New York: Plenum Press. 1993.
Landesman, L.Y., J. Malilay, R. Bissell, S.M. Becker, L. Roberts, and M.S. Ascher. Roles and Responsibilities of Public Health in Disaster Preparedness and Response. In: *Public Health Administration* (Lloyd F. Novick, ed.,). Aspen Publishers. 2000.
Levine, A.G. *Love Canal: Science, Politics, and People*. Lexington, MA: Lexington Books. 1982.
Levine, A.G. Psychosocial impacts of toxic chemical waste dumps. *Environmental Health Perspectives*. 48, 15-17. 1983.
Lillibridge, S.R. Industrial disasters. In: *The Public Health Consequences of Disasters* (E.K. Noji, ed.). New York: Oxford University Press. 1997.
Finegold, A.F. *Emergency Planning and Community Right to Know: State Profiles*, 1997. Washington, DC: Center for Best Practices, National Governors' Association. 1997.
Palinkas, L.A., M.A. Downs, J.S. Petterson, and J. Russell. Social, cultural, and psychological impacts of the Exxon Valdez oil spill. *Human Organization*. 52, 1-13. 1993.
Picou, J.S., D.A. Gill, C.L. Dyer, and E.W. Curry. Disruption and stress in an Alaskan fishing community: Initial and continuing impacts of the Exxon Valdez oil spill. *Industrial Crisis Quarterly*. 6, 235-257. 1992.
Reko, H. K. *Not an Act of God: The Story of Times Beach*. St. Louis: Ecumenical Dioxin Response Task Force. 1984a.
Reko, H. K. The psychosocial impact of environmental disasters. *Bulletin of Environmental Contamination and Toxicology*. 33, 661. 1984b.
Scanlon, T.J. Toxic chemicals and emergency management: The evacuation of Missasauga, Ontario, Canada. In *Coping with Crises: The Management of Disasters, Riots and Terrorism* (U. Rosenthal, M.T. Charles and P.T. Hart, eds.). Springfield, Illinois: Charles C. Thomas Publishers. 1989.
Taylor, A.J.W. *Disasters and Disaster Stress*. New York: AMS Press. 1989.

Taylor, A.J.W. Socioticism: One of the trinity of adversaries. In: *Human Stress: Current Selected Research, Volume 1* (J. Humphrey, ed.). New York: AMS Press. 1986.
Thompson, J. Psychological impact. In *Major Chemical Disasters - Medical Aspects of Management* (Virginia Murray, ed.). London: Royal Society of Medicine Service Ltd. 1990.
Ursano, R.J., B.G. McCaughey, and C.S. Fullerton. The structure of human chaos. In: *Individual and Community Responses to Trauma and Disaster: The Structure of Human Chaos* (R.J. Ursano, B.G. McCaughey and C.S. Fullerton, eds.). Cambridge: Cambridge University Press. 1994.
Vyner, H.M. *Invisible Trauma: The Psychological Effects of Invisible Contaminants*. Lexington, MA: Lexington Books. 1988.
Weisaeth, L. Psychological and psychiatric aspects of technological disasters. In *Individual and Community Responses to Trauma and Disaster: The Structure of Human Chaos* (R.J. Ursano, B.G. McCaughey & C.S. Fullerton, eds.). Cambridge: Cambridge University Press. 1994.

Newspaper and Magazine Articles

Acohido, B. and E. Sorensen. "Olympic inspection raised questions." *The Seattle Times*. June 12, 1999.
Associated Press. "Explosion still taking human toll, team is told." *The Seattle Times*, November 17, 1999.
Barker, K. "A 'river of gasoline,' then panic in Bellingham." *The Seattle Times*. June 13, 1999a.
Brunner, J. "In search of answers, parents of boys killed in pipeline burst sue." *The Seattle Times*. July 28, 1999.
Brunner, J. "Legislation would increase pipeline inspections in attempt to boost safety." *The Seattle Times*. February 1, 2000.
Brunner, J. "Punitive damages for pipeline deaths? Maybe." *The Seattle Times*. September 25, 1999a.
Brunner, J. "Residents ask: Why in a residential area?" *The Seattle Times*. June 13 1999b.
Davila, F. "Bellingham park making a comeback after pipeline blast." *The Seattle Times*. August 10, 1999.
Dudley, B. "Bellingham agrees to let Olympic rebuild pipeline." *The Seattle Times*. September 07, 1999.
Dudley, B. "Congress to hold hearing on Bellingham pipeline leak." *The Seattle Times*. October 8, 1999.
Dudley, B. "More tests sought before pipe reopened." *The Seattle Times*. January 19, 2000.
Dudley, B. "Numerous markings suggest pipe damage from construction work." *The Seattle Times*. July 1, 1999.
Dudley, B. "Olympic Pipe Line hit with record fine." *The Seattle Times*, June 3, 2000c.
Dudley, B. "Olympic Pipe Line records show valve shutdown was not the first." *The Seattle Times*. September 25, 1999b.
Dudley, B. "Public adamant in call to improve pipeline safety." *The Seattle Times*. September 9, 1999.
Dudley, B. "Will impact of pipeline burst hit home values?" *The Seattle Times*. September 19, 1999a.
Dudley, B. and S. Miletich. "Blast probe focuses on valve as pipeline operators refuse to talk." *The Seattle Times*. June 24, 1999.
Grimaldi, J.V. "NTSB ties rupture to water-line project." *The Seattle Times*. October 27, 1999.

Grimaldi, J.V. “Pipeline inquiry hits snag as feds complain of suspended tests, wary witnesses.” *The Seattle Times*. October 28, 1999.

Grimaldi, J.V. “Pipeline-blast investigators examine past excavation work.” *The Seattle Times*. June 18, 1999.

Harris, J. and C. Logg. “Gas pipeline explodes.” *Bellingham Herald*. June 11, 1999.

Hendren, J. “Agency to be target at pipeline hearing.” *The Seattle Times.* March 12, 2000.

Logg, C.A. “Pipeline possibly split below operating pressure.” *Bellingham Herald*. October 2, 1999.

Miletich, S. “Olympic Pipe Line blames construction firm for deadly rupture.” *The Seattle Times*. February 11, 2000.

Miletich, S. “Pipeline chief tries to delay testimony.” *The Seattle Times*. December 4, 1999.

Morris, K., J. Burkitt, J. Brunner, and J. Broom. “3 die, including 2 boys, when fireball erupts in Bellingham gas-line explosion.” *The Seattle Times*. Friday, June 11, 1999.

Nelson, R.T., J. Brunner and S. Miletich. “Lighter ignited fire; bigger disaster averted.” *The Seattle Times*. June 17, 1999.

Porter, M. “Residents edgy after blast.” *Bellingham Herald*. June 16, 1999.

Seattle Times “Memorial march planned to mark Bellingham events.”, June 4, 2000b.

Seattle Times, “Blast-related Web sites.” June 4, 2000a.

Seattle Times. “Bellingham pipeline ruptures during test.” September 19, 1999b.

Seattle Times. “Cities want stricter pipeline rules.”, January 21, 2000.

Seattle Times. “Event leading to the 1999 Olympic pipeline rupture.” June 3, 2000b.

Seattle Times. “Three lives lost to leaking pipeline.” June 3, 2000a.

Solomon, C. “Eastside pipeline forum yields few answers.” *The Seattle Times*. March 17, 2000.

Appendix A. Alabama Transportation Accidents Involving Hazardous Materials

NRC Report No	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
870	1/12/90	Std Report	1/12/90 13:30	Fixed	Dock 12	Mobile			International Paper Company	Paper Mill Rd, Mobile, AL 36653
959	1/14/90	Std Report	1/13/90 16:00	Fixed	Building 3267	Mobile			International Paper Company	Paper Mill Rd, Mobile, AL 36653
959	1/14/90	Std Report	1/13/90 16:00	Fixed	Building 3267	Mobile			International Paper Company	Paper Mill Rd, Mobile, AL 36653
1073	1/16/90	Std Report	1/13/90 15:30	Pipeline	2101 E Pacific Coast Hwy	Mobile	Citronelle		Douglas Oil Co.	POB 305, Citronelle, AL 36522
1161	1/17/90	Std Report	1/13/90 15:00	Fixed	Galveston Terminal Docks	Mobile			International Paper Company	Paper Mill Rd, Mobile, AL 36653
1161	1/17/90	Std Report	1/13/90 15:00	Fixed	Galveston Terminal Docks	Mobile			International Paper Company	Paper Mill Rd, Mobile, AL 36653
1161	1/17/90	Std Report	1/13/90 15:00	Fixed	Galveston Terminal Docks	Mobile			International Paper Company	Paper Mill Rd, Mobile, AL 36653
1299	1/18/90	Std Report	1/18/90 14:30	Railroad	Block 32 29-33-29N 89-19-31W	Colbert	Sheffield		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
1351	1/19/90	Std Report	1/19/90 12:15	Fixed	Section 20, 4 S, 3 W	Cullman			292 Truckstop	Hwy 65 N at Hwy 91, AL
1439	1/20/90	Std Report	1/20/90 15:00	Marine	Block 32 29-33-29N 89-19-31W	Baldwin	Magnolia Springs		Unknown	
1630	1/23/90	Std Report	1/23/90 15:30	Pipeline	Great Salt Lake, 8 mi W O	Colbert	Sheffield		Reynolds Metals Aluminum Reclamation	POB 120, Sheffield, AL 35660
1791	1/25/90	Std Report	1/25/90 7:30	Highway		Sumter			Chemical Waste Management	POB 55, Emelle, AL 35459
1812	1/25/90	Std Report	1/25/90 11:00	Offshore	Hwy 146 & Texas Av	Marion	Offshore		Mobil Oil Co	1250 Poydras St. New Orleans, LA 70013
6576	2/1/90	Std Report	2/1/90 10:00	Highway	2725 N Wood Rd	Jefferson	Fultondale	35207	Bunt Construction Co	PO Box 321035, Birmingham, AL 35232
6950	2/5/90	Std Report	2/1/90 12:00	Fixed	Hwy 75 N	Marshall	Albertville	35950	Unnamed Used Parts Shop	Hwy 75 N, Albertville, AL
6977	2/5/90	Std Report	2/5/90 4:00	Highway	I-20/59 & I-65	Jefferson	Birmingham		Builder's Transport, Inc.	POB 7005, Camden, SC 29020
7216	2/6/90	Std Report	2/6/90 9:00	Fixed	Paper Mill Rd	Mobile	Mobile	36692	International Paper Company	PO Box 2448, Mobile, AL 36692
7216	2/6/90	Std Report	2/6/90 9:00	Fixed	Paper Mill Rd	Mobile	Mobile	36694	International Paper Company	
7216	2/6/90	Std Report	2/6/90 9:00	Fixed	Paper Mill Rd	Mobile	Mobile	36693	International Paper Company	

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
870	Unknown	M/V Constitution/ Unknown	Air	Air	0		0 No	No		
959	Unknown	Tank Truck/ Fuel Hose Ruptured During Transfer	Air	Air	0		0 No	No		
959	Unknown	Tank Truck/ Fuel Hose Ruptured During Transfer	Air	Air	0		0 No	No		
1073	Unknown	80,000 BBL aboveground storage tank	Land	Land	0		0 No	No		
1161	Unknown	Barge HM 101/Tankerman Error	Atmosphere	Air	0		0 No	No		
1161	Unknown	Barge HM 101/Tankerman Error	Atmosphere	Air	0		0 No	No		
1161	Unknown	Barge HM 101/Tankerman error	Atmosphere	Air	0		0 No	No		
1299	Unknown	Produced water discharge	Soil	Land	0		0 No	No		
1351	Unknown	Pipeline pinhole leak	Storm sewer	Water	0		0 No	No		
1439	Unknown	Overboard produced water discharge equipment not functioning	Fish River	Water	0		0 No	No		
1630	Unknown	F4 Aircraft jettisoned fuel tanks in emergency	Subsurface soil	Subsurface	0		0 No	No		
1791	Unknown	Rail car repair dumping material	Land	Land	0		0 No	No		
1812	Unknown	Aboveground tank line leak	Gulf of Mexico	Water	0		0 No	No		
6576	Operator Error	Fuel delivery truck overfilled storage tank	Ground	Land			No	No		
6950	Dumping	Company allows oil from used cars to runoff after rain	Unknown Creek	Water			No	No		
6977	Equipment Failure	Truck fuel line ruptured	Storm sewer	Water			No	No		
7216	Equipment Failure	Material released during replacement of fan bearings		Air			No	No		
7216										
7216										

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
870			DSL	Dimethyl sulfide	6	lbs	0	non			
959			MMC	Methyl mercaptan	541	lbs	0	non			
959			DSL	Dimethyl sulfide	580	lbs	0	non			
1073			OIL	Oil: crude	120	gal	0	non			
1161			HDS	Hydrogen sulfide	811	lbs	0	non			
1161			MMC	Methyl mercaptan	1510	lbs	0	non			
1161			DSL	Dimethyl sulfide	1621	lbs	0	non			
1299			HCL	Hydrochloric acid	0	gal	0	non			
1351			GAT	Gasoline	0	unk	0	unk			
1439			ODS	Oil: diesel	0	unk	0	unk			
1630			OTW	Oil, fuel: no. 2	9000	gal	0	non			
1791			NCC	Fly ash with water	10	lbs	0	non			
1812			OIL	Oil: crude	1	gal	1	gal			
6576			OTW	Oil, fuel: no. 2	30	gal	0	non			
6950			OMT	Oil, misc: motor	0	unk	0	unk			
6977			ODS	Oil: diesel	250	gal	15	gal			
7216			OIL	Oil: crude	0.1	gal	0.1	gal			
7216			NCC	Mercaptan	120	lbs	0	non			
7216			DSL	Dimethyl sulfide	130	lbs	0	unk			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
7560	2/8/90	Std Report	2/7/90 12:00	Fixed	3551 Greensboro Av	Tuscaloosa	Tuscaloosa		Mr. Transmission	3551 Greensboro Av, Tuscaloosa, AL 35401
7950	2/12/90	Std Report	2/12/90 5:00	Fixed	Industrial Blvd	St. Clair	Ragland	35131	Chemco Metals Inc.	Industrial Blvd, Ragland, AL 35131
8419	2/15/90	Std Report	2/14/90 23:50	Fixed	Beneath Franklin St at RR tracks	Lowndes	Burkville	36752	General Electric	1 Plastics Dr, Burkville, AL 36752
8593	2/16/90	Std Report	2/16/90 1:15	Fixed	Riverfront Park 106 1st Av	Talladega	Coosa Pines	35044	Kimberly Clark Corp.	Hwy235, Coosa Pines, AL 35044
8671	2/16/90	Std Report	2/16/90 13:50	Marine	7778 Dauphin Island Pkwy	Mobile	Theodore	36582	Conoco	7778 Dauphin Island Pkwy, Theodore Industrial Canal, Mobile, AL 36652
9166	2/21/90	Std Report	2/20/90 17 00	Unknown	29295 US Hwy 98, PO Box 130 Hwy 1406	Baldwin	Daphne	36527		
9580	2/23/90	Std Report	2/23/90 13.20	Marine	400 Pinto Island	Mobile	Mobile	36633	Gulf Offshore Platforms	400 Pinto Island, Mobile, AL 36633
11803	3/11/90	Std Report	3/11/90 10:05	Highway	Pine Products Rd, Tennessee River MP 386	Jackson	Scottsboro		Redwing Carriers, Inc.	
11804	3/11/90	Std Report	3/11/90 5:00	Highway	1020 Grand Concourse at B.B. Comer Bridge	Jackson	Scottsboro		Redwing Carriers, Inc.	1715 E Willow St, Scottsboro, AL 35768
12023	3/12/90	Std Report	3/9/90 19:30	Fixed	Stolthaven Terminal Hwy 431 S	Chambers	Lafayette	36862	Alabama-Georgia Wood Preserving Co.	PO Drawer 9, Lafayette, AL 36862
12050	3/12/90	Std Report	3/12/90 15:55	Highway	I-65 & US 82, Union 76 Truck Stop	Montgomery	Montgomery		Tri-State Motor Transit	POB 113, Joplin, MO 64802
12185	3/13/90	Std Report	3/13/90 9:30	Highway	Cliss Rd POB 98 MP 163	Sumter	Emelle	35459	Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
12341	3/14/90	Std Report	3/14/90 8:00	Marine	5673 F-41	Mobile	Mobile		USCG Fire and Safety	C/O USCG Fire and Safety Bldg S-108 Brooklyn Com, Mobile, AL 36615
12824	3/16/90	Std Report	3/16/90 11:00	Fixed	Builders Transport Inc., 2150 Michigan Av	Mobile	Mobile		Builder's Transport, Inc	POB 7005, Camden, SC 29020

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
7560	Dumping	Caller says Mr. Transmission suspected of dumping oil	Unknown Creek	Water			No	No		
7950	Operator Error	Transformer hit by forklift	Concrete	Land			No	No		
8419	Equipment Failure	Open valve on tank/unknown why valve open/Trash on an embankment near tracks/036550 MD License Plate	Cement sump	Land			No	No		
8593	Equipment Failure	Transfer pump flange came loose	Land	Land			No	No		
8671	Operator Error	Fuel tank overflow	Theodore Ship Channel	Water			No	No		
9166	Unknown	Oil discovered on water	Mobile Bay	Water			No	No		
9580	Equipment Failure	M/V Glomar Pacific hose busted while pumping waste oil into container	Mobile River	Water			No	No		
11803	Unknown	Tractor trailer struck by train/Truck cargo (125 automobile batteries) spilled	Tennessee River	Water			No	No		
11804	Transport Accident	Tank truck driven off road and rolled over	Ground	Water			1 No	No		
12023	Operator Error	Material spilled during offloading of material from vessel	Concrete pad & pit	Land			No	No		
12050	Equipment Failure	Barrel on flatbed truck leaking	Truck bed	Unknown/ Other			No	No		
12185	Operator Error	Dump truck tailgate open	Ground	Land			No	No		
12341	Operator Error	Caller reported RP dumping oil on field behind his garage	Mobile Bay	Water			No	No		
12824	Other	Someone tied back fuel triggers at two terminal pumps	Concrete sumps	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
7560			OUN	Oil, unknown	0	unk	0	unk			
7950			PCB	Polychlorinated biphenyls	10	gal	0	non			
8419			DCM	Dichloromethane	15393	lbs	0	non			
8593			SFA	Sulfuric acid	9900	lbs	0	non			
8671			ODS	Oil: diesel	70	gal	60	gal			
9166			OUN	Oil, unknown	0	unk	0	unk			
9580			OWA	Waste oil	2	gal	2	gal			
11803			NCC	Black liquor	0	unk	0	unk			
11804			NCC	Black liquor	0	unk	0	unk			
12023			NCC	Copper chromium arsenic compound	3000	gal	0	non			
12050			NCC	Flammable liquid, waste	20	gal	0	non			
12185			NCC	Battery plant trash	40	lbs	0	non			
12341			OIL	Oil: crude	3000	gal	3000	gal			
12824			ODS	Oil: diesel	293	gal	0	unk			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
14254	3/25/90	Std Report	3/25/90 16:00	Highway	100 New Dutch Ln	Russell	Phenix City	36867		1282 Briarwood Av, Phenix City, AL 36867
14525	3/27/90	Std Report	3/26/90 22:30	Highway	County Rd 700 N & 292	Blount	Blount Springs			
14525	3/27/90	Std Report	3/26/90 22:30	Highway	County Rd 700 N & 292	Blount	Blount Springs			
15064	3/30/90	Std Report	3/29/90 23:45	Marine	Hess Facility	Mobile	Mobile		Higman Towing Company	PO Box 908, Orange, TX 77630
15410	4/2/90	Std Report	3/31/90 9:45	Fixed	Widow's Creek	Jackson	Bridgeport		Tennessee Valley Authority	101 Market St 3 S 153 F Lookout Place, Chattanooga, TN 37402
15437	4/2/90	Std Report	4/2/90 12:35	Highway	AL Hwy 17 at MM 163	Sumter	Emelle		Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
15459	4/2/90	Std Report	4/2/90 14:15	Highway	AL Hwy 17 at MM 163	Sumter	Livingston		Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
15536	4/3/90	Std Report	4/2/90 20:00	Highway	AL Hwy 17 at MM 163	Sumter	Emelle		Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
15653	4/3/90	Std Report	4/3/90 5:00	Highway	I-85 S MP 56	Lee	Auburn		Schwerman Trucking Co	PO Box 1601, Milwaukee, WI 56021
15949	4/5/90	Std Report	4/5/90 7:00	Highway	14 14th St N	Jefferson	Birmingham		Drug Transport, Inc.	1939 Forge St, Tucker, GA 30084
16002	4/5/90	Std Report	4/5/90 16:00	Fixed	2513 Leroy Stevens Rd	Mobile	Mobile		Jackson Oil Products	2513 Leroy Stevens Rd, Mobile, AL 36693
16206	4/6/90	Std Report	4/6/90 12:00	Fixed	E bank of Murder Creek	Escambia	Brewerton		Delta Mart Co.	105 Forest Av, Brewton, AL 36426
16461	4/9/90	Std Report	4/6/90 15:30	Marine	Destin Dome Block 56	Mobile			Seacor Marine	PO Box 2291, Morgan City, LA 70381
16552	4/10/90	Std Report	4/10/90 7:20	Railroad	Norfolk Southern yard MP 149MB	Mobile	Mobile		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
16797	4/11/90	Std Report	4/11/90 13:25	Fixed	Magazine Point	Mobile	Mobile	36610	Douglas Oil Co.	Magazine Point, Mobile, AL 36610

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
14254	Operator Error	Vehicle transmission busted open when driver ran over curb	Ground	Land			No	No		
14525	Unknown	Caller states major road accident spilled gravel contaminated with old RR ballast	Topsoil & Asphalt	Land			No	No		
14525										
15064	Equipment Failure	T/B S-2511 crack above waterline leaking	Mobile River	Water			No	No		
15410	Equipment Failure	Tent enclosure/Equipment failure	Sump > Ash pond	Water			No	No		
15437	Equipment Failure	Dump truck tailgate leaked due to rainwater infiltration	Company scales	Land			No	No		
15459	Equipment Failure	Dump trailer leaked	Asphalt	Land			No	No		
15536	Equipment Failure	Dump truck tailgate leaking	Pavement	Land			No	No		
15653	Transport Accident	Tractor trailer overturned on highway	Highway	Land			No	No		
15949	Operator Error	Case of material dropped during loading	Concrete	Land			No	No		
16002	Operator Error	Multiple oil spills at fuel tank storage area, saturating area's soil	Soil	Land	0	0	No	No		
16206	Natural Phenomenon	Storage tank overturned during March 17 flooding	Murder Creek	Water			No	No		
16461	Equipment Failure	M/V Nicor Texas hose leaked while transferring material to platform	Gulf of Mexico	Water			No	No		
16552	Equipment Failure	Tank car RC RX 1296 dome leaking	Tank car side	Unknown/ Other			No	No		
16797	Unknown	Tank overflowed due to unknown cause	Mobile River	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
14254			OTH	Transmission fluid	5	gal	0	gal			
14525			EGL	Ethylene glycol	0	unk	0	unk			
14525			SHD	Sodium hydroxide	0	unk	0	unk			
15064			OIL	Oil: crude	1	gal	1	gal			
15410			NCC	Asbestos	0	unk	0	unk			
15437			NCC	RCRA waste runoff, D008 (lead)	1	gal	1	gal			
15459			NCC	Waste lead, D008	2	gal	0	non			
15536			NCC	Blast furnace slag	2	gal	0	non			
15653			PAC	Phosphoric acid (80 %)	1	gal	0	non			
15949			CRF	Chloroform	17	lbs	0	non			
16002			OMT	Oil, misc: motor	1000	gal	0	unk			
16206			ODS	Oil: diesel	0	unk	0	unk			
16461			ODS	Oil: diesel	15	gal	15	gal			
16552			HCL	Hydrochloric acid	2	gal	0	non			
16797			GCS	Gasoline: casinghead	2.5	gal	2.5	gal			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
17115	4/13/90	Std Report	4/13/90 11:30	Railroad	Seibert rail yard	Mobile	Mobile		CSX Transportation	4900 Osborn Rd, Richmond, VA 23231
17184	4/14/90	Std Report	4/13/90 22:00	Marine	Alabama State Docks Pier 7	Mobile	Mobile		Total Tankering	103 Dauphin St Suite 501, Mobile, AL 36602
17387	4/16/90	Std Report	4/16/90 10:30	Marine	Vessel moored at LL&E terminal	Mobile	Mobile			
18732	4/24/90	Std Report	4/24/90 4:00	Marine	Mobile Harbor Coastal Fuels & Marketing S dock	Mobile	Mobile		Coastal Tug & Barge, Inc.	POB 11526, Chickasaw, AL 36611
18798	4/24/90	Std Report	4/24/90 9:00	Fixed	Widow's Creek Fossil Plant Hwy 72 MP 407	Jackson	Stevenson		Tennessee Valley Authority	1101 Market St 3F Blue Ridge Place, Chattanooga, TN 37402
18808	4/24/90	Std Report	4/24/90 12:20	Railroad	Norris Yard MP 791	Jefferson	Birmingham		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
19483	4/27/90	Std Report	4/27/90 20:30	Highway	1 mi S of Rte 1 Box 171	Tuscaloosa	Buhl		Oil Fields Services	
19620	4/28/90	Std Report	4/28/90 16:00	Marine	Weeks Bay	Mobile	Mobile		National Marine, Inc.	PO Box 2386, Mobile, AL 36652
19753	4/30/90	Std Report	4/30/90 8:30	Fixed	Fuel point at base	Calhoun	Fort McClellan	36205	US Army Fort McClellan	ATZN-FEE, Fort McClennan, AL 36205
19898	5/1/90	Std Report	4/29/90 20:00	Fixed	1104 Hunter Loop Rd	Montgomery	Montgomery		Marathon Oil Co.	PO Box 29, Powder Springs, GA 30073
19964	5/1/90	Std Report	4/30/90 22:30	Fixed	AL Hwy 17 at MM 163	Sumter	Emelle	35459	Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
20332	5/3/90	Std Report	5/2/90 17:00	Fixed	Ross Clark Cir NW (next to 3771)	Houston	Dothan	36304	Swifty Oil Lube	Ross Clark Cir NW (next to 3771), Dothan, AL
20566	5/4/90	Std Report	5/4/90 12:00	Marine	Mobile River MP 1	Mobile	Mobile			
20694	5/6/90	Std Report	5/6/90 12:30	Marine	Blakeley Island at Coastal Fuel Dock	Mobile	Mobile			
20792	5/7/90	Std Report	5/6/90 8:30	Marine	Tennessee River MP 304.1 LDB	Morgan	Decatur		Decatur Transport Inc	POB 1784, Decatur, AL 35602
21062	5/9/90	Std Report	5/8/90 23:30	Railroad	Selma railyard MP 193N	Dallas	Selma		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
21212	5/9/90	Std Report	5/9/90 15:45	Fixed	Alabama State Docks Berth North B2	Mobile	Mobile		Bender Ship Building and Repair	POB 482, Mobile, AL 36601

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
17115	Equipment Failure	Tank car fitting loose	Land	Land			No	No		
17184	Equipment Failure	Blown gasket on barge belcher 36	Mobile River	Water			No	No		
17387	Operator Error	Vessel Hogeh Foam	Mobile Harbor	Water			No	No		
18732	Operator Error	Barge drip pan overflowed during onloading	Mobile Harbor	Water			No	No		
18798	Operator Error	Fuel tank overflowed	Tennessee River	Water			No	No		
18808	Unknown	Material released from container loaded on flatbed car	Gravel	Land			No	No		
19483	Dumping	2 Oil Fields Svcs. semi trucks dumping material into creek at bridge	Unnamed creek	Water			No	No		
19620	Operator Error	M/V Rebel Hustler sunk in bad weather	Mobile Bay	Water			No	No		
19753	Operator Error	Valve on truck left open while filling fuel pod on truck	Soil	Land			No	No		
19898	Operator Error	Tank overfilled	Ground	Land			No	No		
19964	Operator Error	Golf cart transporting glass jar/Jar fell	Asphalt surface	Land			No	No		
20332	Dumping	Company dumped oil into dumpster which leaked	Soil	Land			No	No		
20566	Operator Error	M/V Glomar Conception tank leaking due to hatch being cut away	Mobile River	Water			No	No		
20694	Operator Error	Lube oil on vessel deck washed overboard	Mobile Bay	Water			No	No		
20792	Equipment Failure	Coal tar got into steam line of barge AO 36/Steam line released material	Tennessee River	Water			No	No		
21062	Unknown	Rail tank car (GATX46844) dome leaking only when moving	Tank car side	Air			No	No		
21212	Equipment Failure	Rig NN1 catchbasin overflowed	Mobile River	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
17115			XLP	p-Xylene	5	gal	0	gal			
17184			OSX	Oil, fuel: no. 6	0.99	gal	0.99	gal			
17387			ODS	Oil: diesel	6	gal	6	gal			
18732			OSX	Oil, fuel: no. 6	0.99	gal	0.99	gal			
18798			ODS	Oil: diesel	2500	gal	0	unk			
18808			NCC	Hazardous waste solid	3	lbs	0	non			
19483			UNK	Unknown Material	0	unk	0	unk			
19620			ODS	Oil: diesel	2000	gal	2000	gal			
19753			GAT	Gasoline: automotive (4.23 g Pb/gal)	70	gal	0	non			
19898			GAT	Gasoline: automotive (4.23 g Pb/gal)	239	gal	0	non			
19964			OTH	Waste oil sludge	1	gal	0	non			
20332			WTO	Waste oil/lubricants	0	unk	0	unk			
20566			OWA	Waste oil	500	gal	500	gal			
20694			OLB	Oil, misc: lubricating	3	gal	3	gal			
20792			OCT	Oil, misc: coal tar	10	gal	10	gal			
21062			SFA	Sulfuric acid	0.25	gal	0	non			
21212			OMT	Oil, misc: motor	1.5	gal	1.5	gal			

NRC Report No	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
21386	5/10/90	Std Report	5/9/90 12:00	Marine	Alabama State Dock South C3	Mobile	Mobile		Lott Ship Agency	POB 1802, Mobile, AL 36602
21757	5/14/90	Std Report	5/14/90 6:40	Marine	In front of Wheeler Hydro Plant, Rte 2	Lawrence	Town Creek	35672	Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
21757	5/14/90	Std Report	5/14/90 6:40	Marine	In front of Wheeler Hydro Plant, Rte 2	Lawrence	Town Creek	35672	Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
21757	5/14/90	Std Report	5/14/90 6:40	Marine	In front of Wheeler Hydro Plant, Rte 2	Lawrence	Town Creek	35672	Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
21757	5/14/90	Std Report	5/14/90 6:40	Marine	In front of Wheeler Hydro Plant, Rte 2	Lawrence	Town Creek	35672	Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
21757	5/14/90	Std Report	5/14/90 6:40	Marine	In front of Wheeler Hydro Plant, Rte 2	Lawrence	Town Creek	35672	Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
22183	5/16/90	Std Report	5/16/90 9:00	Highway	Hwy 216, 2 mi W of I-59	Tuscaloosa	Million Dollar Lake			
22553	5/18/90	Std Report	5/17/90 20:40	Marine	Mobile River MM 30	Mobile	Mobile		Coastal Refinery	POB 9037, Houma, LA 70360
22828	5/20/90	Std Report	5/19/90 20:30	Fixed	Wolf Creek Rd County Hwy 27	Franklin	Vandiver			Wolf Creek Rd, County Hwy 27, Vandiver, AL
23079	5/21/90	Std Report	5/21/90 15:30	Railroad	Norfolk Southern rail yard	Mobile	Mobile		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
23179	5/22/90	Std Report	5/22/90 8:35	Fixed	Alabama Power Co I-65	Lamar	Vernon		Heavi-Duty Electric	POB 268, Goldsboro, NC 27530
23928	5/26/90	Std Report	5/26/90 15:10	Marine	Mobile River MM 6	Mobile	Mobile		M/V Eagle One	
24143	5/29/90	Std Report	5/29/90 8:45	Unknown	Okatuppa Creek MP 123	Choctaw	Gilbertown			

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
21386	Equipment Failure	M/V Giant pumped bilge	Mobile River	Water			No	No		
21757	Unknown	Vesseloat sank at dam face	Wheeler Lake	Water			No	No		
21757	Unknown	Vesseloat sank at dam face	Wheeler Lake	Water			No	No		
21757	Unknown	Vesseloat sank at dam face	Wheeler Lake	Water			No	No		
21757	Unknown	Vesseloat sank at dam face	Wheeler Lake	Water			No	No		
21757	Unknown	Vesseloat sank at dam face	Wheeler Lake	Water			No	No		
22183	Transport Accident	Coal truck overturned during accident	Million Dollar Lake	Water			No	No		
22553	Equipment Failure	Tugboat hull crack leaking	Mobile River	Water			No	No		
22828	Dumping	Car battery residue dumped	Wolf Creek	Water			No	No		
23079	Equipment Failure	Rail car (DUPX 14633) top sloshed material while in motion	Railcar & ballast	Land			No	No		
23179	Equipment Failure	Transformer turned over in back of truck during offloading	Truck bed & concrete	Land			No	No		
23928	Equipment Failure	M/V Eagle One	Mobile River	Water			No	No		
24143	Unknown	Oil found in river	Okatuppa Creek	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
21386			OUN	Bilge oil	20	gal	20	gal			
21757			MEK	Methyl ethyl ketone	0	unk	0	unk			
21757			OMT	Oil, misc: motor	0	unk	0	unk			
21757			ODS	Oil: diesel	0	unk	0	unk			
21757			UNK	Vinyl paint	0	unk	0	unk			
21757			UNK	Waste paint	0	unk	0	unk			
22183			NCC	Coal	0	unk	0	unk			
22553			OSX	Oil. fuel: no. 6	1	gal	1	gal			
22828			UNK	Unknown Material	0	unk	0	unk			
23079			SFA	Sulfuric acid	0.5	gal	0	non			
23179			PCB	Polychlorinated biphenyls	8	gal	0	non			
23928			OUN	Oil, unknown	0	unk	0	unk			
24143			OUN	Oil, unknown	0	unk	0	unk			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
24341	5/29/90	Std Report	5/29/90 19:55	Railroad		Washington	McIntosh		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
24358	5/30/90	Std Report	5/25/90 3:30	Fixed	Hwys 161 & 180	Baldwin	Orange Beach		Baldwin County Electric	PO Box 220, Summerdale, AL 36580
24434	5/30/90	Std Report	5/30/90 12:30	Railroad	Allied Signal Fairfield Tar Plant 1327 Erie St	Jefferson	Birmingham	35224	Allied Signal, Inc.	Columbia Rd. & Park Av., PO Box 1053R, Morristown, NJ 07962
24738	5/31/90	Std Report	5/31/90 18:00	Unknown	Decatur Boat Harbor, N side of Railroad Bridge	Morgan	Decatur			
24896	6/1/90	Std Report	6/1/90 18:00	Unknown	I-10 bridge at Mobile Bay	Mobile	Mobile			
24958	6/2/90	Std Report	5/31/90 2:30	Highway	Hwy 80 W MM 113	Lowndes	Lowndesboro		ABC Trucking	307 Birmingham Hwy, Montgomery, AL
25107	6/4/90	Std Report	6/2/90 9:30	Fixed	Williamson Av	Lee	Opelika	36801	City of Opelika	PO Box 390, Opelika, AL 36801
25187	6/4/90	Std Report	6/4/90 12:00	Fixed	Greyhound Bus Station 201 Government St	Mobile	Mobile	36602	Greyhound	201 Government St, Mobile, AL 36602
25638	6/7/90	Std Report	6/6/90 14:55	Railroad	MP 210.1	Hale	Moundville		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
25843	6/8/90	Std Report	6/8/90 4:00	Railroad	Montgomery rail yard	Montgomery	Montgomery		CSX Transportation	4900 Osborn Rd, Richmond, VA 23231
26027	6/9/90	Std Report	6/9/90 9:30	Fixed	Odem Rd	Mobile	Citronelle			
26618	6/13/90	Std Report	6/13/90 2:00	Highway	AL Hwy 17 at MM 163	Sumter	Emelle	35459	Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
26692	6/13/90	Std Report	6/13/90 6:45	Highway	Hwy 17 & County Hwy 9	Lamar	Vernon		Terra First, Inc.	Vernon, AL 35592
26783	6/13/90	Std Report	6/13/90 19:52	Highway	Alberta & Main St	Coffee	Enterprise			
26901	6/14/90	Std Report	6/14/90 14:30	Marine	Tombigbee River MM 124, Osage Landing, 7 mi N of Coffeeville Lock & Dam	Clarke	Coffeeville		International Paper Company	6075 The Corners Pkwy Suite 108, Norcross, GA 30092
26946	6/14/90	Std Report	6/12/90 20:00	Highway	Hwy 17	Lamar	Vernon		Unknown Trucking Company	

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
24341	Equipment Failure	Tank car (UTLX 84328) faulty gasket leak	Atmosphere	Air			No	No		
24358	Transport Accident	Vehicle hit pole knocking down 2 transformers	Ground	Land			No	No		
24434	Other	Rail tank car leaked while being washed	Ground	Land			No	No		
24738	Unknown	Caller discovered leaking 55-gal drum next to railroad tracks	Tennessee River	Water			No	No		
24896	Unknown	Oil sheen sighting	Mobile Bay	Water			No	No		
24958	Operator Error	Tractor trailer ran off road	Unknown Creek	Water			No	No		
25107	Transport Accident	Transformer hit by truck	Ground	Land			No	No		
25187	Unknown	Greyhound facility	Roadway & drains	Water			No	No		
25638	Transport Accident	Train (28 cars) derailed when train truck tractor trailer truck	Land	Land		1	4 Yes	No		
25843	Equipment Failure	Locomotive derailment/Fuel tank leaked	Gravel & dirt	Land			No	No		
26027	Unknown	AV 257 tank battery leaking	Unnamed stream	Water			No	No		
26618	Equipment Failure	Rolloff box fell when truck hydraulic system failed	Ground	Land			No	No		
26692	Transport Accident	Truck accident	Roadway	Land			No	Yes		0
26783	Transport Accident	Truck with used motor oil in accident	Storm sewer	Water			No	No		
26901	Other	Oil in barge when barge full of water/Oil pumped out with water	Tombigbee River	Water			No	No		
26946	Equipment Failure	Tank truck leaking	Roadway & ditch	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
24341			EDA	Ethylenediamine	0	unk	0	non			
24358			PCB	Polychlorinated biphenyls (>50 ppm)	6	gal	0	non			
24434			CCT	Creosote	500	gal	0	non			
24738			UNK	Unknown Blue Material	0	unk	0	unk			
24896			OIL	Oil: crude	0	unk	0	unk			
24958			ODS	Oil: diesel	0	unk	0	unk			
25107			PCB	Polychlorinated biphenyls	500	gal	0	non			
25187			OTW	Oil, fuel: no. 2	0	unk	0	unk			
25638		500000	OTH	Petroleum oil	23000	gal	0	non			
25843			OTW	Oil, fuel: no. 2	50	gal	0	non			
26027			OIL	Oil: crude	3000	gal	0	unk			
26618			NCC	Sweeper trash, D007	10	gal	0	non			
26692			UNK	Unknown Material	0	unk	0	unk			
26783			OMT	Oil, misc: motor	0	unk	0	unk			
26901			OUN	Oil, unknown	55	gal	55	gal			
26946			UNK	Unknown red material	0	unk	0	non			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
27029	6/15/90	Std Report	6/15/90 8:00	Unknown	2204 Seminole Dr 2 blocks from this address	Madison	Huntsville	35805		
27367	6/18/90	Std Report	6/18/90 9:00	Highway	Safety Kleen Corp , 1002 Hoke Av	Jefferson	Dolomite		Chemical Leaman Tank Line	POB 579, Fairforest, SC 29336
27556	6/19/90	Std Report	5/14/90 6:30	Marine	Wheeler Hydro Plant Hwy 101	Lawrence	Town Creek		Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
27556	6/19/90	Std Report	5/14/90 6:30	Marine	Wheeler Hydro Plant Hwy 101	Lawrence	Town Creek		Tennessee Valley Authority	Lookout Place 3 S 155 FF-C, 1102 Market St., Chattanooga, TN 37402
27623	6/20/90	Std Report	6/19/90 17:00	Highway	US 231	Montgomery	Montgomery			MI License No. M200603429640
27952	6/22/90	Std Report	6/14/90 12:00	Fixed	Ogden-Martin Co. 5251 Triana Blvd	Madison	Huntsville	35005	Dunlop Tire and Chemicals	Madison, AL
28118	6/23/90	Std Report	6/23/90 13:55	Marine	Approx. 0.5 mi S of Dauphin Island	Mobile				
28400	6/26/90	Std Report	6/26/90 8:25	Marine	Coastal Fuel Docks, Blakeley Island	Mobile	Mobile	36633	Coastal Tug & Barge, Inc.	PO Box 025500, Miami, FL 33102
28460	6/26/90	Std Report	6/26/90 13:10	Marine	Olin Barge slip River Rd	Washington	McIntosh		Olin Chemical Corp.	POB 28, McIntosh, AL 36553
28753	6/28/90	Std Report	6/26/90 9:45	Marine	265 S Water St	Mobile	Mobile	36601	Bender Ship Building and Repair	265 S Water St, Mobile, AL 36601
28910	6/28/90	Std Report	6/26/90 9:45	Marine	265 S Water St	Mobile	Mobile	36601	Bender Ship Building and Repair	265 S Water St, Mobile, AL 36601
28997	6/30/90	Std Report	6/30/90 6:00	Marine	Walter Trent Marina, Hwy 180 E	Baldwin	Orange Beach	36561	Porkie's Restaurant	212 E 20th Av, Gulf Shores, AL
29308	7/3/90	Std Report	7/2/90 11:00	Fixed	Station AL506 Zippy Mart, 3326 Eutaw Hwy	Tuscaloosa	Tuscaloosa		Crown Central	11 W Oxmoor Rd, Homewood, AL 35209
29737	7/6/90	Std Report	7/6/90 8:45	Railroad	Ciba-Geigy Hwy 43	Washington	McIntosh		Ciba-Geigy Corp.	PO Box 113, McIntosh, AL 36533

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
27029	Unknown	Gasoline found on water	Pinhook Creek	Water			No	No		
27367	Operator Error	Tank truck overfilled	Unknown	Land			No	No		
27556	Other	M/V Frankie Lee sank	Tennessee River	Water			No	No		
27556	Other	M/V Frankie Lee sank	Tennessee River	Water			No	No		
27623	Operator Error	Van rear ended		Unknown/ Other		1	No	No		
27952	Dumping	Dunlop putting hazardous materials into trash/Caller had to separate hazmat so trash could be burned/Caller says he is contaminated	Garbage Pit	Land			No	No		
28118	Operator Error	P/C Soon Came pumping bilges	Gulf of Mexico	Water	0	0	No	No		
28400	Unknown	Oil bubbles coming from stern of barge assumed to have pinhole leaks/Barge capacity 12,000 BBLS	Mobile River	Water			No	No		
28460	Operator Error	Barge tank overfilled	Tombigbee River	Water			No	No		
28753	Other	Floating dry dock tank ruptured in explosion and fire	Mobile River	Water		3	No	No		
28910	Other	Floating dry dock tank ruptured in explosion and fire	Mobile River	Water		3	No	No		
28997	Unknown	M/V Porkies II	Terry Cove	Water			No	No		
29308	Other	Underground storage tank/Gas removed from tank and tank filled with water to do tank test	Subsurface soil	Subsurface			No	No		
29737	Equipment Failure	Rail car hose disconnected	Soil	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
27029			GAT	Gasoline: automotive (4.23 g Pb/gal)	0	unk	0	unk			
27367			NSV	Naphtha: solvent	50	gal	0	non			
27556			NCC	Paint	20	gal	20	gal			
27556			ODS	Oil: diesel	0	unk	0	unk			
27623											
27952			COB	Cobalt bromide (OUS)	0	unk	0	non			
28118			WTO	Waste oil/lubricants	0	unk	0	unk			
28400			OSX	Oil, fuel: no. 6	0.01	gal	0	gal			
28460			SHD	Sodium hydroxide	1000	lbs	1000	lbs			
28753			OWA	Waste oil and water mixture	500	gal	500	gal			
28910			GAT	Gasoline: automotive (4.23 g Pb/gal)	0	unk	0	non			
28997			ODS	Oil: diesel	0	unk	0	unk			
29308			GAT	Gasoline: automotive (4.23 g Pb/gal)	0	unk	0	unk			
29737			SFA	Sulfuric acid	5000	gal	0	non			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
29766	7/6/90	Std Report	7/6/90 9:30	Fixed	312 28th St N	Jefferson	Birmingham	35203	Penske Truck Leasing Co.	312 28th St N, Birmingham, AL 35203
30078	7/9/90	Std Report	7/9/90 10:00	Railroad	MM 149 MB N of rail yard	Mobile	Mobile		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
30138	7/9/90	Std Report	7/6/90 11:23	Marine	Mobile Bay near N Sand Island	Mobile	Mobile		Woodson Construction Co.	PO Box 80337, Lafayette, LA
30140	7/9/90	Std Report	7/7/90 16:30	Marine	Mobile Bay near N Sand Island	Mobile	Mobile		Woodson Construction Co.	PO Box 80337, Lafayette, LA
30141	7/9/90	Std Report	7/8/90 11:38	Fixed	Mobile Bay near N Sand Island	Mobile	Mobile		Woodson Construction Co.	PO Box 80337, Lafayette, LA
30197	7/10/90	Std Report	7/9/90 19:00	Unknown	Widow's Creek Fossil Plant Hwy 72 MP 407	Jackson	Bridgeport	37402	Tennessee Valley Authority	101 Market St 3 S 153 F Lookout Place, Chattanooga, TN 37402
30312	7/10/90	Std Report	7/8/90 0:00	Fixed	848 Seacliff Dr	Baldwin	Fairhope		Eastern Shore Marine	848 Seacliff Dr, Fairhope, AL
30334	7/11/90	Std Report	7/10/90 21:45	Highway	Hwy 17 & Hwy 28, 6 mi S of Emelle	Greene	Emelle		Jack Gray Transport, Inc.	4600 E 15th Av, Gary, IN 46403
30546	7/12/90	Std Report	7/11/90 0 00	Air	Over reservoir and nearby land (possibly Lake Martin)	Elmore	Opelika		USAF - Hurlburt Field	834 ABW/DEEV, Hurlburt Field, FL 32544
30702	7/13/90	Std Report	7/12/90 14:00	Marine	Fowl River Marina	Mobile	Mobile			7275 Congo Rd, Theodore, AL 36582
30901	7/14/90	Std Report	7/13/90 22.30	Marine	Hwy 43 N PO Box 1028, Tombigbee River MM 216.7	Marengo	Demopolis	36732	Bertucci Barge Line	POB 10563, Jefferson, LA 70181
31526	7/18/90	Std Report	7/18/90 10:45	Marine		Mobile			Mobil Oil Co	1250 Poydras St, New Orleans, LA 70013
31950	7/21/90	Std Report	7/20/90 5:30	Fixed	Pinto Island, S end	Mobile	Mobile	36633	S.A.F.E. Inc.	PO Box 1691, Mobile, AL 36633
33038	7/28/90	Std Report	7/28/90 9:30	Offshore	Orange Beach, S half of Wolf Bay, Hwys 180 & 161	Baldwin	Orange Beach			
33188	7/30/90	Std Report	7/29/90 23:10	Railroad	Boyles Railyard	Jefferson	Birmingham		CSX Transportation	500 Water St, Jacksonville, FL 32202
33342	7/30/90	Std Report	7/28/90 17:00	Marine	Mobile Bay	Mobile	Mobile		Woodson Construction Co.	PO Box 80337, Lafayette, LA
33567	8/1/90	Std Report	8/1/90 6:50	Fixed	MM 31	Mobile	Bucks		Alabama Power Co.	POB 70, Bucks, AL 36512

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
29766	Other	Underground pipe leading from underground tank ruptured when truck struck fuel pump	Subsurface soil	Subsurface			No	No		
30078	Equipment Failure	Rail car (VSCX143) bottom outlet valve leaking		Unknown/ Other			No	No		
30138	Unknown	Material washed off Woodson Lay barge no 1	Mobile Bay	Water			No	No		
30140	Unknown	Woodson Lay barge no. 1 gear box leaked	Mobile Bay	Water			No	No		
30141	Operator Error	Fuel system valve accidently left open after fueling welding machine	Mobile Bay	Water			No	No		
30197	Unknown	Oil discharged with source unknown	Tennessee River	Water			No	No		
30312	Equipment Failure	Leaking diesel pump	Mobile Bay	Water			No	No		
30334	Transport Accident	Tractor trailer in accident	Roadway	Land			No	No		
30546	Equipment Failure	H-53 Helicopter/Due to engine problems, had to jettison fuel in order to perform safe landing	Reservoir	Water			No	No		
30702	Unknown	Vessel sunk	Fowl River	Water			No	No		
30901	Equipment Failure	M/V Captain Anthony hose ruptured	Tennessee River	Water			No	No		
31526	Equipment Failure	Barge swivel leaking	Mobile Bay	Water			No	No		
31950	Operator Error	Bucket spilled while being moved by crane	Mobile Bay	Water			No	No		
33038	Unknown	Oil slick covering south half of Wolf Bay	Wolf Bay	Water			No	No		
33188	Transport Accident	Tank car developed hole when bumped into another car	Soil	Land			No	No		
33342	Equipment Failure	Engine problems released fuel from exhaust pipe of crewboat Miss Margie	Mobile Bay	Water			No	No		
33567	Unknown	Facility intake pipes bringing in oily sheen with cooling water from Mobile River	Mobile River	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
29766			OTW	Oil, fuel: no. 2	700	gal	0	non			
30078			NCC	Vitropylamine	3	gal	0	non			
30138			OTW	Oil, fuel: no. 2	0	unk	0	unk			
30140			OLB	Gear oil	0.25	gal	0.25	gal			
30141			OTW	Oil, fuel: no. 2	2	gal	2	gal			
30197			ODS	Oil: diesel	0	unk	0	unk			
30312			ODS	Oil: diesel	0	unk	0	unk			
30334			CUM	Cumene	0	unk	0	unk			
30546			JPF	Jet fuel: JP-4	5000	lbs	5000	lbs			
30702			GAT	Gasoline: automotive (4.23 g Pb/gal)	3	gal	3	gal			
30901			ODS	Oil: diesel	30	gal	30	gal			
31526			OLB	Oil, misc: lubricating	0.99	gal	0.99	gal			
31950			OTH	Drilling fluid	20	gal	0	unk			
33038			ODS	Oil: diesel	0	unk	0	unk			
33188			CSS	Caustic soda solution	0	unk	0	non			
33342			OTW	Oil, fuel: no. 2	0	unk	0	unk			
33567			ODS	Oil: diesel	0	unk	0	unk			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
33726	8/2/90	Std Report	8/2/90 9:00	Unknown	2407 Fraim Dr	St. Clair	Pell City	35125		
33899	8/3/90	Std Report	8/3/90 8:30	Railroad	MP 149MB	Mobile	Mobile		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
33909	8/3/90	Std Report	8/3/90 10:45	Fixed	Fowl River at Dauphin Island Pkwy at Quartering Barge	Mobile	Mobile		Offshore Pipelines, Inc.	PO Box 758, Dauphin Island, AL 36528
34032	8/4/90	Std Report	8/4/90 12:30	Fixed	ON HWY 21 TALLADEGA HWY, ROUTE 2	Talladega	Winterboro		Floyd and Beasley Transfer	Hwy 21 and Talladega Hwy, Rte 2, Winterboro, AL
34037	8/4/90	Std Report	8/4/90 12:20	Railroad	River Rd	Dallas	Selma	36702	Hammermill Paper	River Rd, Selma, AL 36702
34132	8/5/90	Std Report	8/5/90 15:00	Highway	Rte 4 Box 316	Tuscaloosa	Cottondale	35453		
34324	8/7/90	Std Report	8/7/90 4:30	Railroad	Brewton City Hall	Escambia	Brewton		CSX Transportation	PO Box 1030, Mobile, AL 36633
34966	8/11/90	Std Report	8/11/90 5:11	Marine	Blakeley Island	Mobile	Mobile		Coastal Fuel Marketing, Inc.	Blakeley Island, Mobile, AL
34967	8/11/90	Std Report	8/11/90 5:00	Fixed	Blakeley Island Terminal Hwy 98	Mobile	Mobile	36652	Belcher Oil/Coastal Oil	Blakeley Island Terminal, Hwy 98, Mobile, AL 36652
34979	8/11/90	Std Report	8/11/90 6:52	Railroad	MP 88.3	Walker	Jasper		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
35245	8/13/90	Std Report	8/13/90 11:30	Highway	I-65	Conecuh	Evergreen		W.P. Ballard	1200 2nd Av N, Birmingham, AL 35203
35692	8/16/90	Std Report	8/16/90 14:05	Marine	Bender Shipyard, I-10	Mobile	Mobile		USACE	Custom House, 2nd and Chestnut, Philadelphia, PA 19106
35956	8/18/90	Std Report	8/18/90 11:30	Fixed	Rte 1	Mobile	Creola	36525	GFS Seismograph	LA
35967	8/18/90	Std Report	8/18/90 10:55	Railroad	Norris Yard MP 791	Jefferson	Birmingham		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
35968	8/18/90	Std Report	8/17/90 16:00	Fixed	Seacliff Dr	Baldwin	Fairhope	36532	Eastern Shore Marine	Sea Cliff Dr, Fairhope, AL 36532
36149	8/20/90	Std Report	8/20/90 10:45	Railroad	Mobile Railyard MP 149	Mobile	Mobile		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
36185	8/20/90	Std Report	8/20/90 15:00	Fixed	1200 2nd Av N	Jefferson	Birmingham	35203	W.P. Ballard	1200 2nd Av N, Birmingham, AL 35203
36229	8/21/90	Std Report	8/21/90 6:00	Marine	Mobile Bay Channel at Mobil Oil Slip	Mobile	Theodore		M/V Nicor Sailor	

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
33726	Unknown	Construction site on water 200 yds from marina/Heavy equipment may be source	Logan Martin Lake	Water			No	No		
33899	Unknown	Railroad tank car vent valve leaking vapor	Atmosphere	Air			No	No		
33909	Equipment Failure	Fuel transfer hose from tug Miss Rachel to quartering barge Carolyn slipped	Fowl River	Water			No	No		
34032	Unknown	Tire fire		Air			No	No		
34037	Equipment Failure	RR car dome flange	Air	Air			No	No		
34132	Dumping	2 tanker trucks dumping loads on road in front of caller's property	Soil	Land			No	No		
34324	Equipment Failure	Pump stuck open, overfilling locomotive fuel tank	Roadway & ballast	Land			No	No		
34966	Equipment Failure	Leaking flange on barge IV1109	Mobile Bay	Water			No	No		
34967	Unknown	Fueling line	Mobile River	Water			No	No		
34979	Unknown	Tank car top dome leaking	Soil	Land			No	No		
35245	Equipment Failure	After blowout, truck tire severed pipe	Soil	Land			No	No		
35692	Unknown	USS McFarland leaking beneath vessel	Mobile River	Water			No	No		
35956	Dumping	Marsh buggy dumping	Dead Lake	Water			No	No		
35967	Equipment Failure	Rail tank car pressure valve leaking	Railcar	Land			No	No		
35968	Dumping	Foam sheeting used to protect paint dumped	Fly Creek	Water			No	No		
36149	Unknown	Rail tank car (UTLX66437) dome leaking only when moving	Ground	Land			No	No		
36185	Equipment Failure	Tank truck overflowed while pumping from storage tank due to meter malfunction on truck	Asphalt	Unknown/ Other			No	No		
36229	Operator Error	M/V Nicor Sailor receiving tank overfilled during internal fuel transfer	Mobile Bay	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
33726			ODS	Oil: diesel	0	unk	0	unk			
33899			CLX	Chlorine	0	unk	0	non			
33909			OTW	Oil, fuel: no. 2	2	gal	0.5	gal			
34032			NCC	Tires	0	unk	0	non			
34037			CLX	Chlorine	0	unk	0	non			
34132			UNK	Unknown	0	unk	0	non			
34324			ODS	Oil: diesel	200	gal	0	non			
34966			OSX	Oil, fuel: no. 6	8	gal	8	gal			
34967			OSX	Oil, fuel: no. 6	12000	gal	12000	gal			
34979			PAC	Phosphoric acid	0.5	gal	0	non			
35245			PER	Perchloroethylene	100	gal	0	non			
35692			OHY	Oil: hydraulic oil	0.99	gal	0.99	gal			
35956			OUN	Oil, unknown	0	unk	0	unk			
35967			TDI	Toluene 2,4-diisocyanate	0.99	gal	0	non			
35968			NCC	Foam sheeting (plastic)	0	unk	0	unk			
36149			SHD	Sodium hydroxide	0.5	gal	0	non			
36185			PER	Perchloroethylene	20	gal	0	non			
36229			OTW	Oil, fuel. no. 2	150	gal	150	gal			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
36272	8/21/90	Std Report	8/21/90 11:00	Marine	Coastal Fuel Docks, Blakeley Island	Mobile	Mobile		USNS Cape Flattery	Norfolk, VA
36485	8/22/90	Std Report	8/22/90 16:00	Highway	1002 Hoke Av	Jefferson	Dolomite	35061	Safety Kleen Corp	1002 Hoke Av, Dolomite, AL 35061
36628	8/23/90	Std Report	8/22/90 16:00	Highway	Safety Kleen Corp., 1002 Hoke Av	Jefferson	Dolomite		Montgomery Tank Lines	2250 E 15th St, Gary, IN 46402
36706	8/23/90	Std Report	8/23/90 18:15	Fixed	AL Hwy 17 at MM 163	Sumter	Emelle	35459	Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
36974	8/26/90	Std Report	8/26/90 3:00	Marine	LL&E on Mobile River, E bank	Mobile	Mobile		Page and Jones, Inc	52 N Jackson St, Mobile, AL 36602
37029	8/26/90	Std Report	8/26/90 15:30	Railroad	Norris Yard MP 791	Jefferson	Irondale		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
37037	8/26/90	Std Report	8/24/90 18:00	Fixed	7 mi E of Athens between MP 84 and MP 85 of Hwy 72	Limestone	Athens		Carriage Motor Company	7 Miles E of Athens btwn Mile 84 and 85 on Hwy 72, Athens, AL
37176	8/27/90	Std Report	8/27/90 14:40	Fixed	McDuffie Coal Terminal Port of Mobile	Mobile	Mobile		Lott Ship Agency	259 N Conception St, Mobile, AL 36603
37181	8/27/90	Std Report	8/27/90 14:50	Marine	McDuffie Coal Terminal, off Virginia St, Berth 2	Mobile	Mobile		Mid Stream Fuel Service	11 Government St, Mobile, AL 36652
37671	8/30/90	Std Report	8/29/90 16:00	Highway	Hwy 5 E of Hwy 82 on Don MacMillan Bridge	Bibb	Brant		Belcher Oil Company	
37891	9/2/90	Std Report	9/2/90 1:30	Highway	I-59 N MM 163	St. Clair	Gadsden		CTX Trucking	Geismor, GA
37898	9/2/90	Std Report	9/2/90 12:00	Marine	LL&E Terminal	Mobile	Mobile		Sabine Towing	PO Box 1528, Groves, TX 77619
37899	9/2/90	Std Report	9/2/90 12:15	Marine	Industrial Pkwy	Mobile	Saraland		LL and E	Industrial Pkwy, Saraland, AL
37932	9/3/90	Std Report	9/2/90 1:30	Highway	I-59 N MM 163	St. Clair	Ashville		Continental Transport Express	PO Box 228, Geismar, LA 70734
38083	9/4/90	Std Report	9/4/90 8:30	Fixed	McHugh Oil Field Services 1112 DeSoto Dr	Mobile	Dauphin Island		Offshore Pipelines, Inc.	PO Box 758, Dauphin Island, AL 36528
38083	9/4/90	Std Report	9/4/90 8:30	Fixed	McHugh Oil Field Services 1112 DeSoto Dr	Mobile	Dauphin Island		Offshore Pipelines, Inc.	PO Box 758, Dauphin Island, AL 36528

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
36272	Equipment Failure	USNS Cape Flattery starboard stern struct bearing possibly leaking	Mobile River	Water			No	No		
36485	Operator Error	Tanker truck release during transfer	Ground	Land			No	No		
36628	Equipment Failure	Tank truck fitting leaking	Soil	Land			No	No		
36706	Equipment Failure	MA Poliments/Liner in box broke during shipment	Asphalt	Land			No	No		
36974	Operator Error	Cargo tank overflowed during cargo transfer	Mobile River	Water			No	No		
37029	Equipment Failure	Rail tank car dome cap leaking during motion	Land	Land			No	No		
37037	Other	Burning used tires on open lot	Atmosphere	Air			No	No		
37176	Operator Error	Transfer hose from pier improperly connected	Mobile Bay	Water			No	No		
37181	Operator Error	Fuel released during transfer from T/B MF727 to M/V Lady Bird	Mobile River	Water			No	No		
37671	Dumping	Caller discovered gas truck dumping oil	Soil	Land			No	No		
37891	Transport Accident	Tanker truck overturned	Pavement & soil	Land	0	1	Unknown	Yes	300	
37898	Unknown	Pinhole leak in no. 2 tank of barge STCO 211	Intracoastal Waterway	Water			No	No		
37899	Equipment Failure	Pinhole leak in hull of barge STCO-211	Chickasaw Bogue	Water			No	No		
37932	Transport Accident	MC307 Cargo tank dome leak	Roadway	Land		1	No	Yes	300	
38083	Unknown	Crane fell in water while loading out on barge	Bay Aloe, Mississippi Sound	Water			No	No		
38083	Unknown	Crane fell in water while loading out on barge	Bay Aloe, Mississippi Sound	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
36272			OUN	Oil, unknown	0	unk	0	unk			
36485			MNS	Mineral spirits	5	gal	0	non			
36628			MNS	Mineral spirits	5	gal	0	non			
36706			NCC	D008	3	gal	0	non			
36974			JPF	Jet fuel: JP-4	0.5	gal	0.5	gal			
37029			STY	Styrene	1	gal	0	non			
37037			NCC	Burning tire smoke	0	unk	0	non			
37176			OTW	Oil, fuel: no. 2	0	unk	0	unk			
37181			OIL	Oil: crude	10	gal	10	gal			
37671			OUN	Oil, unknown	0	unk	0	non			
37891			ANL	Aniline	20000	lbs	0	non			
37898			OTW	Oil, fuel: no. 2	0.25	gal	0.25	gal			
37899			OTW	Oil, fuel: no. 2	0.25	gal	0.25	gal			
37932			ANL	Aniline	150	gal	0	non			
38083			OHY	Oil: hydraulic oil	2	gal	2	gal			
38083			NCC	Lube grease	0	unk	0	unk			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
39332	9/14/90	Std Report	9/14/90 10:40	Fixed	26619 Perdido Beach Blvd	Baldwin	Orange Beach		Zeke's Landing Marina	PO Box 1220, Orange Beach, AL 36561
39552	9/17/90	Std Report	9/16/90 20:50	Railroad	Norris Yard MP 791	Jefferson	Birmingham		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
39572	9/17/90	Std Report	9/17/90 8:45	Offshore		Mobile			Shell Oil Company	PO Box 1309, Kenner, LA 70063
39831	9/18/90	Std Report	9/18/90 17:15	Fixed	Widow's Creek Facility MP 415	Jackson	Bridgeport		Tennessee Valley Authority	Chattanooga TVA Office Complex, Chattanooga, TN
39930	9/19/90	Std Report	9/17/90 14:00	Marine	Marina on Dauphin Island Pkwy	Mobile	Mobile		Shrimp Boat Miss Dana	
40129	9/20/90	Std Report	9/20/90 13:20	Air	SW corner of county	Russell	Spring Hill		Shane Gardner Co.	Green Wood, FL
40400	9/21/90	Std Report	9/18/90 10:30	Highway	Kenny's Yamaha, 338 Douglas Av	Escambia	Brewton		Safety Kleen Corp	4800 S Old Peachtree Rd, Norcross, GA 30071
41972	10/2/90	Std Report	10/2/90 11:30	Fixed	Calhoun Disposal 1106 Old Gadsden Hwy	Calhoun	Anniston		Safety Kleen Corp	1002 Hoke Av, Dolomite, AL 35061
42596	10/6/90	Std Report	10/6/90 17.00	Air	Birmingham Municipal Airport Concourse B-2	Jefferson	Birmingham	35232	Northwest Airlines	Birmingham Municipal Airport, Birmingham, AL 35212
42679	10/8/90	Std Report	10/7/90 18:00	Marine	Black Warrior River MM 270	Greene	Akron		Tug Sibley and Barge	
42832	10/9/90	Std Report	10/9/90 8:30	Marine	1400 Market St NE	Morgan	Decatur		Bungee Corporation	POB 2248, Decatur, AL 35602
42882	10/9/90	Std Report	10/9/90 10:30	Highway	AL Hwy 17 at MM 163 PO Box 55	Sumter	Emelle	35459	Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
42918	10/9/90	Std Report	10/9/90 14.10	Railroad	Decatur Railyard MP 363A	Morgan	Decatur		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
42953	10/9/90	Std Report	10/9/90 20:44	Marine	Bendor Shipyard no. 9, 265 S Water St	Mobile	Mobile		US Navy	USNS Range Sentinel
42993	10/10/90	Std Report	10/10/90 7:30	Offshore		Mobile			Mobil Oil Co	1250 Poydras St, New Orleans, LA 70013
43207	10/11/90	Std Report	10/11/90 8:00	Fixed	3300 Ball St	Jefferson	Birmingham	35234	Ashland Chemical Co.	3300 Ball St, Birmingham, AL 35234

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
39332	Equipment Failure	Fuel pump hose nozzle leaking due to pressure buildup	Cotton Bayou	Water			No	No		
39552	Equipment Failure	Tank car GATX-26769 dome leaking	Atmosphere	Air			No	No		
39572	Equipment Failure	M/V New Venture cable hole	Gulf of Mexico	Water			No	No		
39831	Other	Stored oil filters seeped from storage area	Tennessee River	Water			No	No		
39930	Other	M/V Miss Dana sunk at dock	Fowl River	Water			No	No		
40129	Transport Accident	Crop duster crashed	Forested area	Land			No	No		
40400	Operator Error	16-gal drum damaged during unloading	Ground	Land			No	No		
41972	Transport Accident	16-gal drum tipped over	Concrete & gravel	Land			No	No		
42596	Operator Error	Left wing fuel tank of Boeing 727/Accidentally overfilled fuel tank	Concrete surface	Land			No	No		
42679	Unknown	Oil sheen observed around tug Sibley and barge	Black Warrior River	Water			No	No		
42832	Operator Error	Barge Uluage cargo compartment overfilled	Tennessee River	Water			No	No		
42882	Operator Error	Tank truck valve left open	Soil	Land			No	No		
42918	Equipment Failure	Tank car CELX1055 bottom valve faulty	Soil	Land			No	No		
42953	Equipment Failure	Transfer hose clamp came loose while taking on fuel from fuel barge	Mobile Bay	Water			No	No		
42993	Operator Error	Transfer hose release	Mobile Bay	Water			No	No		
43207	Equipment Failure	Operator hooked up wrong line while transferring material to storage tank	Soil	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
39332			ODS	Oil: diesel	0.99	gal	0.99	gal			
39552			BDI	Butadiene	0	unk	0	non			
39572			OTH	Shell sol 71 oil	400	gal	400	gal			
39831			OLB	Oil, misc: lubricating	0.99	gal	0.99	gal			
39930			ODS	Oil: diesel	0	unk	0	unk			
40129			MLT	Malathion	62	gal	0	non			
40400			NSV	Naphtha: solvent	6	gal	0	non			
41972			MNS	Mineral spirits	8	gal	0	non			
42596			OTH	Oil: Jet A Jet fuel	70	gal	0	non			
42679			OUN	Oil, unknown	0	unk	0	unk			
42832			OTH	Soybean oil: degummed	75	gal	50	gal			
42882			NCC	Waste material D001, D004, F001, F004	10	gal	10	gal			
42918			AAC	Acetic acid	1	gal	0	non			
42953			OSX	Oil, fuel: no. 6	80	gal	0	unk			
42993			OHY	Oil: hydraulic oil	0.99	gal	0.99	gal			
43207			NVM	Naphtha: VM & P (75% naphtha)	3400	gal	0	non			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
43469	10/13/90	Std Report	10/13/90 7:30	Marine	1 mi S of Dauphin Island at mouth of Mobile Bay	Mobile	Mobile		Woodson Engineering	Houston, TX
43477	10/13/90	Std Report	10/13/90 20:50	Marine	E end of Dauphin Island	Mobile	Dauphin Island		Radcliff Marine	PO Box 3064, Mobile, AL 36652
44298	10/19/90	Std Report	10/19/90 10:00	Fixed	Saturn 5 Blvd	Madison	Marshall Space Flight Center	35812	NASA	AB 44, Marshall Space Flight Center, Huntsville, AL 35812
44626	10/22/90	Std Report	10/22/90 16:30	Offshore		Mobile			Chevron USA	PO Box 646, Venice, LA 70038
44702	10/23/90	Std Report	10/8/90 23:00	Offshore	N of Sand Island	Mobile	Mobile		Woodson Construction Co.	POB 80337, Lafayette, LA 70598
44990	10/25/90	Std Report	10/25/90 7:45	Fixed	No. 3 Mobile Infirmary Cir	Mobile	Mobile	36607	Mobile Infirmary Medical Center	No. 3 Mobile Infirmary Cir, Mobile, AL 36607
45341	10/28/90	Std Report	10/28/90 3:00	Railroad	Norris Yard MP 791	Jefferson	Irondale		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
45660	10/30/90	Std Report	10/30/90 13:30	Marine	Across from McHugh's Dock on DeSoto St	Mobile	Dauphin Island			
45863	11/1/90	Std Report	11/1/90 1:00	Highway	Gulf Lumber Co., Conception St	Mobile	Mobile		Gulf Lumber Company	Conception St Rd, Mobile, AL 36602
45891	11/1/90	Std Report	11/1/90 0:33	Highway	Gulf Lumber Co on Conception Rd	Mobile	Mobile		Radcliff Marine	Box 3064, Mobile, AL 36652
46491	11/5/90	Std Report	11/5/90 13:30	Railroad	Norfolk Southern yard MP 363A	Morgan	Decatur		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
46559	11/6/90	Std Report	11/6/90 8:45	Marine	Amarada Hess Corp., Magazine Point	Mobile	Mobile		Lebeouf Brothers Towing Company	Houma, LA
46718	11/7/90	Std Report	11/7/90 1:45	Marine	Mobile Bay 3000 ft S of Mobil Platform 76 Aux	Mobile	Dauphin Island		Woodson Construction Co.	PO Box 340, Dauphin Island, AL 36528
46996	11/9/90	Std Report	11/9/90 2:30	Highway	I-65	Mobile	Mobile		Grace Transportation Svc.	PO Box 24999, Greenville, SC 29616
47025	11/9/90	Std Report	11/9/90 8:30	Highway	I-10 near exit 98, W of City, Mobile Bay	Baldwin	Mobile			
47342	11/12/90	Std Report	11/12/90 9:15	Highway	AL Hwy 17 at MM 163	Sumter	Emelle	35459	Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
43469	Unknown	Transfer hose from vessel to barge leaked	NW Gulf of Mexico	Water			No	No		
43477	Unknown	Barge leaked	NE Gulf of Mexico	Water			No	No		
44298	Equipment Failure	Gas pump/Ruptured fuel line	Concrete apron	Land			No	No		
44626	Equipment Failure	Transfer line gasket failed	Mobile Bay	Water			No	No		
44702	Equipment Failure	Hydraulic pump leaking	Mobile Bay	Water			No	No		
44990	Other	Transformer struck by automobile	Asphalt	Unknown/ Other			No	No		
45341	Equipment Failure	Rail tank car dome leaked	Atmosphere	Air			No	No		
45660	Unknown	Shrimp boat sank	Aloe Bay	Water			No	No		
45863	Equipment Failure	Transfer hose from tank truck ruptured	Ground	Water			No	No		
45891	Equipment Failure	Tanker truck transfer hose end split	Concrete	Land			No	No		
46491	Equipment Failure	Rail tank car valve blown	Soil	Land			No	No		
46559	Equipment Failure	Barge Leslie has hole in hull	Mobile River	Water			No	No		
46718	Equipment Failure	Barge Torch No. 1 boom's hydraulic hose ruptured	Mobile Bay	Water			No	No		
46996	Unknown	Tank truck shell cracked	Gravel parking lot	Land			No	No		
47025	Operator Error	Concrete truck accident	Mobile Bay	Water			No	No		
47342	Transport Accident	Dump truck tailgate leaking	Soil	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Detailed?
43469			OTW	Oil, fuel no. 2	5	gal	5	gal			
43477			OTW	Oil, fuel. no. 2	5	gal	5	gal			
44298			GAT	Gasoline: automotive (4.23 g Pb/gal)	15	gal	0	non			
44626			OTH	Oil-based mud	20	gal	20	gal			
44702			OHY	Oil: hydraulic oil	20	gal	20	gal			
44990			PCB	Polychlorinated biphenyls	20	gal	0	non			
45341			HCL	Hydrochloric acid	0.99	gal	0	non			
45660			OUN	Oil, unknown	0	unk	0	unk			
45863			GAT	Gasoline: automotive (4.23 g Pb/gal)	100	gal	100	gal			
45891			GAT	Gasoline: automotive (4.23 g Pb/gal)	100	gal	0	non			
46491			NCC	Octyl mercaptas	1.5	gal	0	non			
46559			ODS	Oil: diesel	2	gal	2	gal			
46718			OHY	Oil: hydraulic oil	1	gal	1	gal			
46996			HCL	Hydrochloric acid	50	gal	0	non			
47025			GAT	Gasoline: automotive (4.23 g Pb/gal)	0	unk	0	unk			
47342			NCC	Lead, unknown type	2	gal	0	non			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
47983	11/16/90	Std Report	11/16/90 18:15	Marine	Mobile Bay near Point Monluis Island, inlet of Fowl River	Mobile	Belle Fountain		Steiner Ship Yard	Bayou La Batre, AL
48035	11/17/90	Std Report	11/17/90 9:30	Marine	Mobile Bay 1/8 mi W of Mobile Platform auxiliary 76	Mobile	Mobile		Woodson Construction Co.	PO Box 340, Dauphin Island, AL 36528
48235	11/19/90	Std Report	11/1/90 15:00	Highway	AL Hwy 17 at MM 163	Sumter	Emelle		Matlack, Inc.	1413 Folk Rd, Wilmington, DE 19989
48597	11/23/90	Std Report	11/22/90 21:17	Marine	Pascagoula River	Jackson	Pascagoula			
48601	11/23/90	Std Report	11/23/90 7:55	Marine	Coastal Fuel Docks, Blakeley Island	Mobile	Mobile	36652		POB 190352, Mobile, AL 36619
48602	11/23/90	Std Report	11/23/90 7:55	Marine	Coastal Fuel Docks, Blakeley Island	Mobile	Mobile		Coastal Tug & Barge, Inc.	870 W Flagler, Miami, FL
48664	11/23/90	Std Report	11/23/90 14:23	Marine	W side of Dutch Harbor	Unknown				
48924	11/26/90	Std Report	11/26/90 14:30	Highway	Redstone Arsenal US Army Missile Command	Madison	Redstone Arsenal	35898	US Army Missile Command	US Army Missile Command ATTN: AMSMI-EQ, Redstone Arsenal, AL 35989
48999	11/27/90	Std Report	11/26/90 15:35	Offshore	Mobile Bay	Mobile			Mobil Oil Co	1250 Poydras St, New Orleans, LA 70013
49055	11/27/90	Std Report	11/27/90 10:35	Marine	Bayou La Batre Gulf City Fish Docks	Mobile				
49056	11/27/90	Std Report	11/27/90 13:17	Marine	Bayou La Batre International Oceanic Enterprises, Inc. Dock	Mobile				
49173	11/28/90	Std Report	11/27/90 16:00	Fixed	Metfuel Co Hwy 69 & Maxwell Crossing	Tuscaloosa	Tuscaloosa		McKenzie Tank Lines	POB 1200 122 Appleyard Dr, Tallahassee, FL 32304
49240	11/28/90	Std Report	11/28/90 16:50	Marine	Fairway Field	Mobile			Shell Offshore, Inc.	POB 4464, Houston, TX 77210
49250	11/28/90	Std Report	11/28/90 20:00	Highway	E Bank of Mobile River above Cochran Bridge site	Mobile	Mobile		Smith Trucking Co.	POB 226, Cleveland, SC 29635
49487	11/30/90	Std Report	11/30/90 12:30	Railroad	MP 804.2	Monroe	Fountain		Burlington Northern Railroad	3253 E Chestnut Expressway, Springfield, MO 65802

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
47983	Other	2 barges/Valve may have been opened	Mobile Bay	Water			No	No		
48035	Other	Work barge (8 ft by 42 ft) sank/Hydraulic unit leaked	Mobile Bay	Water			No	No		
48235	Transport Accident	55-gal drum punctured during transit	Trailer Insides	Unknown/ Other			No	No		
48597	Equipment Failure	F/S Two Fools bilge pump discharged overboard	Pascagoula River	Water			No	No		
48601	Equipment Failure	T/B Coastal barge 35 developed hole in hull	Mobile River	Water			No	No		
48602	Equipment Failure	T/B Coastal barge 35 developed hole in bottom	Mobile River	Water			No	No		
48664	Unknown	55-gal drum smashed between T/B Wayueh Jireh and F/V Alaska Ocean	Iliuliuk Bay	Water			No	No		
48924	Other	40-gal drum tipped over in back of parked delivery vehicle	Asphalt parking lot	Land		2	No	No		
48999	Other	Oil hose cap came off	Mobile Bay	Water			No	No		
49055	Other	M/V Amy Leshay sunk	Bayou La Batre	Water			No	No		
49056	Dumping	M/V Capt. Dawn pumping bilge	Bayou La Batre	Water			No	No		
49173	Equipment Failure	Tank fell over during loading		Land		1	No	No		
49240	Other	Containment dike around vent line on M/V Sage/Rough seas	Gulf of Mexico	Water			No	No		
49250	Transport Accident	Truck fuel tank caught on ferry ramp	Mobile River	Water			No	No		
49487	Transport Accident	5 tankcars and 1 flatcar (6 units total) derailed		Unknown/ Other			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
47983			OUN	Oil, unknown	0	unk	0	unk			
48035			OHY	Oil: hydraulic oil	0	unk	0	unk			
48235			NCC	Alkaline corrosive material	25	gal	0	non			
48597			WTO	Waste oil/lubricants	0	unk	0	unk			
48601			OSX	Oil, fuel: no. 6	1	gal	1	gal			
48602			OSX	Oil, fuel: no. 6	2	gal	2	gal			
48664			OUN	Oil, unknown	55	gal	55	gal			
48924			NCC	Polyoxypropylenediamine	4.5	gal	0	non			
48999			OMT	Oil, misc motor	0.99	gal	0.99	gal			
49055			OUN	Oil, unknown	0	unk	0	unk			
49056			OUN	Oil, unknown	0	unk	0	unk			
49173			PTH	Potassium hydroxide	1200	gal	0	non			
49240			ODS	Oil: diesel	0.99	gal	0.99	gal			
49250			ODS	Oil: diesel	50	gal	3	gal			
49487			CSS	Caustic soda solution	0	non	0	non			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
49487	11/30/90	Std Report	11/30/90 12:30	Railroad	MP 804.2	Monroe	Fountain		Burlington Northern Railroad	3253 E Chestnut Expressway, Springfield, MO 65802
49487	11/30/90	Std Report	11/30/90 12:30	Railroad	MP 804.2	Monroe	Fountain		Burlington Northern Railroad	3253 E Chestnut Expressway, Springfield, MO 65802
49737	12/3/90	Std Report	12/3/90 12:30	Highway	N Bypass GA/AL state line	Russell	Phenix City		Columbus Mills	4600 River Rd, Columbus, GA 21991
50651	12/11/90	Std Report	12/11/90 9:00	Highway	AL Hwy 17 at MM 163	Sumter	Emelle	35459	KW Plastics	POB 707, Troy, AL 36081
50730	12/11/90	Std Report	12/11/90 21:00	Marine	Hwy 98	Mobile	Mobile	36603	Coastal Fuel Marketing, Inc.	Hwy 98, Mobile, AL 36603
50887	12/13/90	Std Report	12/13/90 9:20	Offshore	2 mi S of Dauphin Island	Mobile			Shell Offshore, Inc.	POB 61122, New Orleans, LA 70161
50948	12/13/90	Std Report	12/12/90 20:15	Highway	AL Hwy 17 at MM 163	Sumter	Emelle		Chemical Waste Management	PO Box 55 Alabama Hwy 117 at MM 163, Emelle, AL 35459
51345	12/17/90	Std Report	12/16/90 9:30	Highway	Hwy 69 N	Tuscaloosa	Tuscaloosa		Western Co. NA	515 S Post Oak St, Houston, TX 77027
51437	12/17/90	Std Report	12/17/90 18:00	Marine	Tennessee River MP 405.2	Jackson	Stevenson		Ashland Oil Company	POB 391, Ashland, KY 41114
51936	12/21/90	Std Report	12/20/90 22:30	Marine	Chickasaw Creek at La Land Exploration Dock Hwy 158	Mobile	Saraland		Lebeouf Brothers Towing Company	New Orleans, LA
51969	12/21/90	Std Report	12/21/90 13:00	Marine	Battleship Park	Mobile	Mobile		USS Alabama Battleship	POB 65, Mobile, AL 36601
53224	1/2/91	Std Report	1/2/91 5:40	Marine	Coastal Marketing, Inc., Blakely Island	Mobile	Mobile	36603	Coastal Fuel Marketing, Inc.	Hwy 98, Mobile, AL 36603
53250	1/2/91	Std Report	1/2/91 8:40	Marine	Pascagoula Ship Channel	Unknown			T/V R. Hal Dean	
53894	1/7/91	Std Report	1/5/91 14:45	Marine		Mobile			Mobil Oil Co	1250 Poydras St, New Orleans, LA 70013
53901	1/7/91	Std Report	1/7/91 10:45	Railroad	Rail yard	Mobile	Mobile		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
53914	1/7/91	Std Report	1/7/91 10:41	Railroad	Norfolk Southern rail yard	Mobile	Mobile		Monsanto Chemical Company	POB 2204, Decatur, AL 35609

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
49487	Transport Accident	5 tankcars and 1 flatcar (6 units total) derailed		Unknown/ Other			No	No		
49487	Transport Accident	5 tankcars and 1 flatcar (6 units total) derailed		Unknown/ Other			No	No		
49737	Other	Tank truck overturned in accident	Storm sewer	Water			No	No		
50651	Other	Truck leaking bailed material	Asphalt parking lot	Land			No	No		
50730	Equipment Failure	Arm blew off barge during loading	Mobile River	Water			No	No		
50887	Operator Error	Transfer hose split during hose disconnection	Gulf of Mexico	Water			No	No		
50948	Equipment Failure	Dump truck faulty seal leak	Asphalt	Land			No	No		
51345	Transport Accident	Acid tank truck accident	Asphalt	Land			No	No		
51437	Equipment Failure	Transfer line from barge developed problem/Material discharged through valve during line inspection	Tennessee River	Water			No	No		
51936	Equipment Failure	Leaking valve on barge LBT 30	Chickasaw Creek	Water			No	No		
51969	Unknown	USN Sub Drum	Mobile Bay	Water			No	No		
53224	Unknown	Barge Coastal 36 - IFO 180 - 84,003 BBL	Mobile Canal	Water			No	No		
53250	Unknown	T/V R Hal Dean ran aground	Gulf of Mexico	Water			No	No		
53894	Operator Error	M/V Halliburton 222 tank valve left open	Mobile Bay	Water			No	No		
53901	Unknown	Rail tank car dome leaked	Soil	Land			No	No		
53914	Unknown	Tank car top vent leaking in railroad yard	Land	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
49487			CLX	Chlorine	0	non	0	non			
49487			SFA	Sulfuric acid	0	non	0	non			
49737			ODS	Oil: diesel	100	gal	20	gal			
50651			NCC	Hazardous Waste, D008	3	gal	0	non			
50730			ODS	Oil, diesel	0	unk	0	unk			
50887			OMT	Oil, misc: motor	0.99	gal	0.99	gal			
50948			NCC	Hazardous waste	15	gal	0	non			
51345			HCL	Hydrochloric acid (20%)	200	gal	0	non			
51437			OSX	Oil, fuel: no. 6	5	gal	5	gal			
51936			GAT	Gasoline: automotive (4.23 g Pb/gal)	40	gal	40	gal			
51969			ODS	Oil: diesel	0	unk	0	unk			
53224			OSX	Oil, 90% fuel no. 6, 10% diesel fuel	0	unk	0	unk			
53250			OIL	Oil: crude	2000000	gal	0	non			
53894			ODS	Oil: diesel	0.99	gal	0.99	gal			
53901			NCC	Acrylonitrile propionitric Rmenral	6	gal	0	non			
53914			PCN	Propionitrile	0.99	lbs	0	non			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
54105	1/8/91	Std Report	1/8/91 19:00	Marine	Chickasaw Port Authority	Mobile	Chickasaw		T/S Star	Chickasaw, AL
54151	1/9/91	Std Report	1/8/91 11:30	Fixed	Loran 3017.4 8744.4	Baldwin	Gulf Shores		Boat and Propeller Shop	
54188	1/9/91	Std Report	1/8/91 11:55	Marine	Midstream fuel dock MP 1.5	Mobile	Mobile		Mid Stream Fuel Service	11 Government St, Mobile, AL 36652
54780	1/13/91	Std Report	1/13/91 16:30	Marine	Theodore Industrial Canal, Ideal Cement Co.	Mobile	Theodore	36609		
54867	1/14/91	Std Report	1/14/91 8:40	Fixed	Paper Mill Rd	Mobile	Mobile	36692	International Paper Company	PO Box 2448 Paper Mill Rd, Mobile, AL 36692
55244	1/16/91	Std Report	1/15/91 14:30	Marine	Alabama State Dock Pier 5	Mobile	Mobile	36651	Bulk Shipping, Inc.	Sneeuwbeslaan 14, Antwerp, Netherlands
55443	1/17/91	Std Report	1/16/91 17:00	Fixed	AL Hwy 231 MP 48	Dale	Ozark	36361	Ozark Truck Stop, Inc.	PO Box 1669, Ozark, AL 36361
56112	1/22/91	Std Report	1/22/91 15:05	Railroad	Rail yard	Jefferson	Birmingham		Norfolk Southern Railroad	185 Spring St, Atlanta, GA 30303
56113	1/22/91	Std Report	1/22/91 17:00	Offshore	Alabama State Docks at foot of Water St.	Mobile	Mobile		US Navy	
56586	1/25/91	Std Report	1/25/91 15:00	Fixed	2429 N 19th St	Jefferson	Bessemer		Crown Central	11 W Oxmoor Rd, Homewood, AL 35209
56745	1/27/91	Std Report	1/27/91 11:30	Marine	1101 Ezre Trice Blvd Dock Facility	Mobile	Mobile	36603	Pacific Molasses Co.	1101 Ezra Trice Blvd, Mobile, AL 36603
56765	1/28/91	Std Report	1/28/91 0:01	Marine	Douglas Oil Co. at Mobile Harbor Pier	Mobile	Mobile		Barge Transport Co.	12941 I-45 N, Houston, TX 77060
56766	1/28/91	Std Report	1/28/91 0:40	Marine	Mobile Harbor	Mobile	Mobile		Barge Transport Co.	12941 I-45 N, Houston, TX 77060
59064	2/12/91	Std Report	2/11/91 16:00	Fixed	Alba Rd	Mobile	Coden	36523	Rodriguez Ship Builders	Alba Rd, Coden, AL 36523
59440	2/14/91	Std Report	2/14/91 0:15	Marine	Hwy 98, Blakeley Island Coastal Fuels pier	Mobile	Mobile			
60159	2/19/91	Std Report	2/19/91 7:00	Fixed	Hwy 20 W	Morgan	Decatur	35602	McPherson Oil Co.	Hwy 20 W, Decatur, Al 35602
60709	2/22/91	Std Report	2/22/91 8:45	Fixed	Hwy 98, Blakeley Island	Mobile	Mobile	36633	Coastal Fuel Marketing, Inc.	Hwy 98 Blakeley Island, Mobile, AL 36633

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
54105	Dumping	T/S Star pumping bilges 1 - 2 times weekly	Mobile River	Water			No	No		
54151	Unknown	Caller saw oil sheen behind facility		Water			No	No		
54188	Operator Error	1-gal sample container dropped overboard	Mobile River	Water			No	No		
54780	Unknown	Oil on deck of tank barge flowed into water	Theodore Industrial Canal	Water			No	No		
54867	Equipment Failure	Bearing in primary air fan failed and caused shutdown of system	Air	Air			No	No		
55244	Operator Error	Painting vessel hull spilling paint into water	Mobile River	Water			No	No		
55443	Operator Error	Flushing fuel tanks	Clay	Land			No	No		
56112	Equipment Failure	Tank car plug loose	Atmosphere	Air			No	No		
56113	Unknown	Caller reports sheen sighting near Sealift Command Naval Vessel	Mobile River	Water			No	No		
56586	Unknown	Service station gas pump	Concrete	Land			No	No		
56745	Equipment Failure	Leaking cargo hose on barge no PAVERSYT 302	Mobile Bay	Water			No	No		
56765	Equipment Failure	T/B Danielle pinhole leak below waterline	Mobile Harbor	Water			No	No		
56766	Unknown	Tank barge Danielle	Mobile River	Water			No	No		
59064	Other	Paint boat on water releasing paint into water	Coden Bayou	Water			No	No		
59440	Dumping	Barge Apex 3603 pumping void tank	Mobile River	Water			No	No		
60159	Natural Phenomenon	Heavy rain caused oil water separator to overflow	Bettye Rye Branch > Tennessee River	Water			No	No		
60709	Equipment Failure	Oil water separator storage tank pump failure	Storm drain	Water			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Derailed?
54105			WTO	Waste oil/lubricants	0	unk	0	unk			
54151			OUN	Oil, unknown	0	unk	0	unk			
54188			OSX	Oil, fuel: no. 6	0.99	gal	0.99	gal			
54780			OUN	Oil, unknown	0.99	gal	0.99	gal			
54867			MMC	Methyl mercaptan	370	lbs	0	non			
55244			NCC	Paint (oil-based	1	gal	1	gal			
55443			ODS	Oil: diesel	50	gal	0	non			
56112			LPG	Liquefied petroleum gas	0	unk	0	non			
56113			OLB	Oil, misc: lubricating	150	gal	150	gal			
56586			GAT	Gasoline: automotive (4.23 g Pb/gal)	0	unk	0	unk			
56745			OSX	Oil, fuel: no. 6	1200	gal	1200	gal			
56765			OIL	Oil: crude	2	gal	2	gal			
56766			OIL	Oil: crude	5	gal	5	gal			
59064			NCC	Paint	0	unk	0	unk			
59440			OSX	Oil, fuel: no. 6	0	unk	0	unk			
60159			OLB	Oil, misc: lubricating	100	gal	100	gal			
60709			WTO	Waste oil/lubricants	20	gal	20	gal			

NRC Report No.	Date Call Reported	Call Type	Incident Date and Time	Incident Type	Incident Location	County	City	Zip Code	Suspected Responsible Party	SRP Address
61107	2/25/91	Std Report	2/25/91 13:40	Marine		Baldwin				
61849	3/2/91	Std Report	3/2/91 15:00	Fixed	State Docks Rd	Russell	Phenix City	36868		
62208	3/5/91	Std Report	3/5/91 10:50	Marine	Kerr McGee Dock, Blakeley Island	Mobile	Mobile		Brown Marine Service, Inc.	POB 1415, Pensacola, FL 32956
62393	3/6/91	Std Report	3/6/91 5:05	Fixed	Hwy 10 E	Wilcox	Pine Hill		MacMillan Bloedel	POB 336, Pine Hill, AL 36769
62978	3/11/91	Std Report	3/11/91 10:43	Marine	Abba Av	Mobile	Coden	36523	Rodriguez Ship Builders	Abba Av, Coden, AL 36523
63372	3/13/91	Std Report	3/6/91 4:00	Highway	Hwy 134 & West Bypass	Coffee	Enterprise		Sikorsky Aircraft Services	6900 Main St, Stratford, CT 06601
63791	3/16/91	Std Report	3/16/91 12:45	Air	Airport Terminal Concourse C-2	Jefferson	Birmingham		Hanger One	4725 65th Pl N, Birmingham, AL 35206

NRC Report No.	Reported Cause	Incident Description	Medium Description	Medium Affected	Deaths Reported	Injuries Reported	Damages	Evacuations	Number Evacuated	Airway Closure
61107	Equipment Failure	M/V Ship Island transfer line leaked residue	Gulf of Mexico	Water			No	No		
61849	Unknown	Sheen sighted during transfer operation from T/B TB 2010	Chattahoochee River MM 153	Water			No	No		
62208	Unknown	Barge Brown 290	Mobile River	Water			No	No		
62393	Equipment Failure	Pipe leak due to corrosion	Air	Air			No	No		
62978	Dumping	M/V Valiant Lady pumping out bilge	Coden Bayou	Water			No	No		
63372	Transport Accident	Tank truck in accident	Soil & asphalt	Land		1	Yes	No		
63791	Operator Error	Aircraft Overfill	Tarmac	Land			No	No		

NRC Report No.	Road Closure	Reported Damages ($)	CHRIS Code	Name of Material	Quantity Spilled	Unit of Measure	Quantity in Water	Units of Measure	Name of Railroad	Train Number	Detailed?
61107			ODS	Oil: diesel	0.99	gal	0.99	gal			
61849			OTH	Oil: Feed stock oil	1	gal	1	gal			
62208			OUN	Oil, unknown	0	unk	0	unk			
62393			CLX	Chlorine	60	lbs	0	non			
62978			WTO	Waste oil/lubricants	0	unk	0	unk			
63372		100000	JPF	Jet fuel: JP-4	280	gal	0	non			
63791			JPV	Jet fuel: JP-5 (kerosene, heavy)	75	gal	0	unk			

Appendix B. Multiple Chemical Spills Sorted by Location (locations having greater than two incidents shown)

No. of Incidents	Incident Location	Incident 1 Chemicals	Incident 2 Chemicals	Incident 3 Chemicals	Incident 4 Chemicals	Incident 5 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel: no. 5 (0.07 gal)	Oil, fuel: no. 5 (0.06 gal)	Oil, fuel: no. 6 (0.13 gal)	Other oil (unknown)	Oil, fuel: no. 5 (0.03 gal)
64	Hwy 17 at MM 163, Boxelle, Sumter	Boiler fly ash (40 lbs)	D004, D008, D009, D0011, D0019 (0.25 lbs)	Waste alkaline (5 gal)	D004 (5 gal)	Paint filters, D007 (1 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Ammonia, anhydrous (unknown)	Butadiene (unknown)	Toluene 2,4-diisocyanate (0.99 gal)	Hazardous waste solid (3 lbs)	Liquefied petroleum gas (1 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil: diesel (0.25 gal)	Oil, fuel: no. 2-D (0.02 gal)	Gasoline: automotive (4.23 g Pb/gal) (3 gal)	Oil: diesel (0.5 gal)	Oil, fuel: no. 2-D (0.03 gal)
44	Alabama State Dock, Mobile, Mobile	Oil, misc: lubricating (2.6 gal)	Oil: misc: lubricating (3 gal)	Oil, fuel: no. 6 (5 gal)	Other oil (unknown)	Oil, unknown (unknown)
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert	Nitrogen, liquified fertilizer (40 gal)	Waste oil/lubricants (15 gal)	Oil, fuel: no. 2-D (400 gal)	Phosphoric acid (0.13 gal)	Oil: hydraulic oil (30 gal)
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile	Oil: crude (7 gal)	Waste oil (30 gal)	Oil: diesel (15 gal)	Oil: hydraulic oil (0.99 gal)	Oil: diesel (50 gal)
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile	Gasoline: automotive (4.23 g Pb/gal) (1 gal)	Waste oil (40 gal)	Jet fuel: JP-12 (unknown)	Gasoline: automotive (unleaded) (120 gal)	Oil: diesel (6 gal)
23	Blakeley Island (Atlantic Marine), Mobile, Mobile	Other oil (CFO) (125 gal)	Oil, unknown (unknown)	Waste oil (75 gal)	Oil: hydraulic oil (mixed with water) (3 gal)	Oil, fuel: no. 2-D (0.25 gal)
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile	Oil, unknown (unknown)	Oil: crude (0.5 gal)	Waste oil (2 gal)	Oil, fuel: no. 6 (2 gal)	Oil, fuel: no. 6 (1 gal)
20	MP 363.4A (Railyard), Decatur, Morgan	Sodium hydroxide (10 gal)	Octyl mercaptas (1.5 gal)	Ethylene glycol (unknown)	Sewage (unknown)	Oil, fuel: no. 2-D (20 gal)
17	MP 149 MB (Mobile railyard), Mobile, Mobile	Sulfate turpentine, crude (1 gal)	Chlorine (unknown)	Methyl acetoacetate (unknown)	Oil: diesel (1500 gal)	Sulfuric acid (0.5 gal)
16	Mobile (unknown location), Mobile	Oil, unknown (unknown)	Oil: diesel (40 gal)	Unknown oil (drilling mud) (100 gal)	Gasoline: automotive (unleaded) (0.06 gal)	Oil, fuel: no. 2-D (10 gal)
15	Blakeley Island (Midstream Fuel), Mobile, Mobile	Oil, fuel: no. 6 (0.99 lbs)	Oil, fuel: no. 6 (0.8 gal)	Oil, fuel: no. 6 (5 gal)	Oil, fuel: no. 6 (5 gal)	Oil, unknown (unknown)
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson	Oil: hydraulic oil (0.25 gal)	Asbestos (unknown)	Oil: misc: lubricating (0.99 gal)	Oil: diesel (unknown)	Oil: misc: lubricating (unknown)
12	ATC USCG Aviation Training Center, Mobile, Mobile	Jet fuel: JP-4 (25 gal)	Jet fuel: JP-4 (5 gal)	Jet fuel: JP-4 (10 gal)	Jet fuel: JP-4 (5 gal)	Oil, misc: motor (0.03 gal)
11	Mobile Bay (unknown location), Mobile	Other oil (0.99 gal)	Oil: diesel (10 gal)	Oil, fuel: no. 2 (unknown)	Oil: hydraulic oil (0.2 gal)	Oil: hydraulic oil (5 gal)
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa	Asphalt (1 gal)	Gasoline: automotive (unleaded) (1000 gal)	Oil: crude (1 gal)	Sludge (100 gal)	Asphalt (5 gal)
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin	Oil: diesel (0.99 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil: unknown (unknown)
10	Pinto Island, Mobile, Mobile	Waste oil (2 gal)	Oil, fuel: no. 2 (10 gal)	Oil: diesel (unknown)	Oil, fuel: no. 6 (unknown)	Oil: hydraulic oil (20 gal)
10	Viaduct Rd (No. 50), Chickasaw, Mobile	Waste oil (50 gal)	Oil: misc: lubricating (1 gal)	Waste oil (unknown)	Oil, unknown (unknown)	Waste oil/lubricants (5 gal)
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile	Oil: diesel (10 gal)	Oil, fuel: no. 2-D (unknown)	Oil, fuel: no. 2-D (1 gal)	Oil: diesel (5 gal)	Oil, misc: motor (1 gal)
8	Blakeley Island (unknown location), Mobile, Mobile	Jet fuel (40 gal)	Gasoline: automotive (4.23 g Pb/gal) (10 gal)	Jet fuel: JP-4 (0.5 gal)	Jet fuel: JP-9 (40 gal)	Jet fuel (0.13 gal)
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile	Oil: diesel (70 gal)	Oil, fuel: no. 2-D (2 gal)	Oil: diesel (0.03 gal)	Oil, fuel: no. 2-D (10 gal)	Oil, fuel: no. 2 (0.99 gal)
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile	Waste oil/lubricants (15 gal)	Oil, misc: lubricating (25 gal)	Oil, fuel: no. 6 (20 gal)	Oil: crude (27 gal)	Oil: diesel (unknown)
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan	p-Xylene (1000 gal)	o-Xylene (360 gal)	Sulfur dioxide (unknown)	Oil: diesel (unknown)	Oil: diesel (25 gal)
7	OCSG 5753 Platform A, Mobile	Oil, unknown (unknown)	Oil: unknown (unknown)	Oil, misc: motor (0.5 gal)	Oil, fuel: no. 2-D (0.59 gal)	Waste oil (0.1 gal)
7	Viaduct Rd (No. 200), Chickasaw, Mobile	Asphalt (23000 gal)	Oil: misc: lubricating (2 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil: diesel (10 gal)
6	Erie St (No. 1327), Birmingham, Jefferson	Coal tar pitch (8000 gal)	Benzo(a)pyrene (330 lbs)	Creosote (1000 lbs)	Oil, misc: coal tar and water (200 gal)	Creosote (500 gal)

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 6 Chemicals	Incident 7 Chemicals	Incident 8 Chemicals	Incident 9 Chemicals	Incident 10 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel: no. 5 (0.5 gal)	Oil: diesel (0.06 gal)	Oil, fuel: no. 5 (0.06 gal)	Oil, fuel: no. 5 (0.13 gal)	Oil, fuel: no. 5 (unknown)
64	Hwy 17 at MM 163, Emelle, Sumter	Hazardous waste (400 gal)	Lead battery liquid (10 gal)	Wastewater treatment sludge (20 gal)	Hazardous waste, D008 (0.5 gal)	Bag house dust, D006,D008 (1 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Oil: diesel (10 gal)	Oil: hydraulic oil (unknown)	Pulping liquids (1 gal)	Hydrochloric acid (0.99 gal)	Styrene (1 gal)
50	Tenn-Tom Waterway MM 215 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, unknown (unknown)	Oil: diesel (1 gal)	Oil, unknown (unknown)	Oil: diesel (unknown)	Oil, unknown (unknown)
44	Alabama State Dock, Mobile, Mobile	Oil: diesel (3 gal)	Oil, unknown (unknown)	Gasoline: automotive (4.23 g Pb/gal) (40 gal)	Oil: hydraulic oil (0.5 gal)	Bilge material (5 gal)
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert	Oil, misc: lubricating (0.25 gal)	Oil: hydraulic oil (10 gal)	Alcohol, flammable (0.13 gal)	Oil, fuel: no. 2-D (2 gal)	Oil, edible: soya bean (3 gal)
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile	Oil: diesel (3 gal)	Waste oil/lubricants (15 gal)	Oil, fuel: no. 6 (80 gal)	Kerosene (unknown)	Oil: hydraulic oil (0.13 gal)
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile	Oil: diesel (5 gal)	Naphtha: solvent (25 gal)	Jet fuel (15 gal)	Gasoline: automotive (unleaded) (40 gal)	Oil: diesel (5 gal)
23	Blakeley Island (Atlantic Marine), Mobile, Mobile	Oil, unknown (5 gal)	Oil, unknown (20 gal)	Oil, unknown (2 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile	Oil, fuel: no. 6 (8 gal)	Oil, fuel: no. 6 (5 gal)	Oil, misc: lubricating (3 gal)	Oil, fuel: no. 6 (0.01 gal)	Oil, unknown (unknown)
20	MP 363.4A (Railyard), Decatur, Morgan	Oil: hydraulic oil (30 gal)	Sodium hydroxide solution (10 gal)	Terephthalic acid (5 gal)	Oil, unknown (100 gal)	Oil: diesel (unknown)
17	MP 149 MB (Mobile railyard), Mobile, Mobile	Sulfuric acid (1 gal)	Sodium hydroxide (0.5 gal)	Sulfuric acid (unknown)	Sulfur dioxide (1 lbs)	Acrylonitrile propionitric Rmenral (6 gal)
16	Mobile (unknown location), Mobile	Oil: diesel (0.1 gal)	Oil, unknown (unknown)	Gasoline (unknown)	Oil: diesel (50 gal)	Unknown Material (unknown)
15	Blakeley Island (Midstream Fuel), Mobile, Mobile	Oil: diesel (20 gal)	Oil, misc: lubricating (10 gal)	Oil, misc: lubricating (1.5 gal)	Oil, fuel: no. 6 (30 gal)	Oil, misc: motor (1 gal)
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson	Oil, unknown (unknown)	Oil: diesel (2500 gal)	Waste oil (2 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)
12	ATC USCG Aviation Training Center, Mobile, Mobile	Jet fuel: JP-4 (15 gal)	Jet fuel: JP-4 (3 gal)	Jet fuel: JP-5 (kerosene, heavy) (10 gal)	Jet fuel: JP-4 (20 gal)	Oil, misc: lubricating (5 gal)
11	Mobile Bay (unknown location), Mobile	Gasoline: automotive (unleaded) (unknown)	Oil, misc: motor (0.99 gal)	Oil: diesel (1 gal)	Other oil (15 gal)	Oil: diesel (unknown)
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa	Oil: diesel (8 gal)	Other oil (fuel oil no. 5) (5 gal)	Asphalt (6 gal)	Oil: crude (2 gal)	Other oil (fuel oil no. 5) (1 gal)
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin	Oil: diesel (unknown)	Oil, unknown (unknown)	Oil: diesel (unknown)	Oil, unknown (unknown)	Oil, unknown (unknown)
10	Pinto Island, Mobile, Mobile	Oil: diesel (15 gal)	Oil: hydraulic oil (6 gal)	Drilling fluid (20 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)
10	Viaduct Rd (No. 53), Chickasaw, Mobile	Oil, unknown (unknown)	Waste oil (1 gal)	Oil, misc: lubricating (0.13 gal)	Oil, unknown (unknown)	Oil, misc: lubricating (1 gal)
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile	Oil, fuel: no. 2-D (400 gal)	Oil: diesel (20 gal)	Oil, fuel: no. 2-D (3 gal)	Oil: diesel (30 gal)	Oil, fuel: no. 2-D (5 gal)
8	Blakeley Island (unknown location), Mobile, Mobile	Paint, petroleum based (0.04 gal)	Oil, unknown (unknown)	Oil: hydraulic oil (4.5 gal)		
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile	Oil: diesel (unknown)	Sodium hypochlorite (15% or less) (3500 gal)	Oil, fuel: no. 2-D (1 gal)		
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile	Epoxy cure (42 gal)	Oil, unknown (25 gal)	Other oil (2 gal)		
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan	Oil, unknown (unknown)	m-Xylene (1 gal)			
7	OCSG 5753 Platform A, Mobile	Oil, unknown (unknown)	Jet fuel (30 gal)			
7	Viaduct Rd (No. 200), Chickasaw, Mobile	Unknown oil (possibly bilge slops) (unknown)	Oil, fuel: no. 6 (unknown)			
6	Erie St (No. 1327), Birmingham, Jefferson	Creosote (100 gal)				

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 11 Chemicals	Incident 12 Chemicals	Incident 13 Chemicals	Incident 14 Chemicals	Incident 15 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel: no. 5 (1 gal)	Oil, fuel: no. 5 (unknown)	Oil, fuel: no. 5 (0.13 gal)	Oil, fuel: no. 6 (0.06 gal)	Oil: diesel, bunker C (0.13 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	D006, D007, D009, D018 (5 gal)	Waste Fuel, D008 (1 gal)	Hazardous waste, D001, F003, F005, U056 (1 gal); Hazardous waste, U120, U156, U188 (1 gal)	Benzene (3 gal)	Lead, liquid (2 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Oil: diesel (5 gal)	Oil, misc: lubricating (100 gal)	Oil, misc: lubricating (50 gal)	Liquefied petroleum gas (unknown)	Turpentine (2 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, unknown (unknown)	Oil, fuel: no. 2-D (0.13 gal)	Oil: diesel (unknown)	Oil, fuel: no. 2-D (10 gal)	Oil, fuel: no. 2-D (1 gal)
44	Alabama State Dock, Mobile, Mobile	Oil, fuel: no. 6 (unknown)	Oil, fuel: no. 2-D (100 gal)	Oil, misc: motor (5 gal)	Oil: diesel (10 gal)	Oil, fuel: no. 2-D (10 gal)
32	MP 401 A (Sheffield Railyard), Sheffield, Colbert	Phosphoric acid (0.25 gal)	Hominy feed (200 lbs)	Gasoline: automotive (unleaded) (0.06 gal)	Gasoline: automotive (unleaded) (1 gal)	Ammonia, anhydrous (unknown)
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile	Oil: diesel (unknown)	Oil: hydraulic oil (15 gal)	Oil: hydraulic oil (0.25 gal)	Oily waste (20 gal)	Oil: diesel (unknown)
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile	Jet fuel: JP-1 (1 gal)	Oil: diesel (unknown)	Heavy olefin seed (35 gal)	Gasoline: automotive (4.23 g Pb/gal) (800 gal)	Oil, unknown (unknown)
23	Blakeley Island (Atlantic Marine), Mobile, Mobile	Other oil (5 gal)	Oil: hydraulic oil (15 gal)	Oil: hydraulic oil (unknown)	Bilge slops (300 gal)	Oil, misc: transmission (1.1 gal); Ethylene glycol (2.3 gal); Oil, misc: lubricating (2.7 gal); Oil: diesel (6 gal)
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile	Oil, fuel: no. 6 (5 gal)	Oil, fuel: no. 6 (unknown)	Vacuum gas oil (2 gal)	Oil: diesel (1 gal)	Oil, fuel: no. 6 (0.99 gal)
20	MP 363.4A (Railyard), Decatur, Morgan	Oil, misc: lubricating (50 gal)	Chlorine (unknown)	Terephthalic acid (2 lbs)	Sodium hydroxide (2 gal)	Other oil (condensate) (0.25 gal)
17	MP 149 MB (Mobile railyard), Mobile, Mobile	Hydrochloric acid (2 gal)	Propionitrile (0.99 lbs)	Carbon dioxide (unknown)	Vitropylamine (3 gal)	Sulfuric acid (1 gal)
16	Mobile (unknown location), Mobile	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil: diesel (0.1 gal)	Waste oil/lubricants (unknown)
15	Blakeley Island (Midstream Fuel), Mobile, Mobile	Oil, fuel: no. 2 (0.5 gal)	Oil, fuel: no. 2-D (10 gal)	Oil, unknown (unknown)	Oil, fuel: no. 2-D (5 gal)	Ammonia, anhydrous (unknown)
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson	Oil, misc: lubricating (5 gal)	Unknown Material (unknown)	Oil, unknown (unknown)		
12	ATC USCG Aviation Training Center, Mobile, Mobile	Oil: hydraulic oil (0.1 gal)	Oil, unknown (unknown)			
11	Mobile Bay (unknown location), Mobile	Oil, unknown (unknown)				
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5754 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 16 Chemicals	Incident 17 Chemicals	Incident 18 Chemicals	Incident 19 Chemicals	Incident 20 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel no. 5 (0.06 gal)	Oil, fuel no. 5 (1 gal)	Oil, fuel no. 5 (0.13 gal)	Oil, fuel no. 5 (0.03 gal)	Oil, fuel, no. 5 (0.06 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Leachate, F039 (5 gal)	Chemical waste products (2 gal)	Hexachlorobutadiene (0.5 gal)	Flammable waste liquids (NOS) (30 gal)	Dichloromethane (25 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Sulfuric acid (20 gal)	Oil, fuel no. 2-D (1 gal)	Oil, fuel no. 2-D (50 gal)	Carbon dioxide (refrigerant) (unknown)	Oil, misc: lubricating (50 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, fuel no. 2-D (3 gal)	Finish (170 gal)	Oil, fuel no. 2-D (10 gal)	Unknown Material (unknown)	Oil, diesel mixed with water (2.5 gal)
44	Alabama State Dock, Mobile, Mobile	Oil, diesel (3 gal)	Oil, misc: lubricating (0.25 gal)	Oil, diesel (10 gal)	Oil, misc: lubricating (150 gal)	Waste oil (500 gal)
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert	Oil, diesel (150 gal)	Hydrochloric acid (unknown)	Oil, diesel (unknown)	Oil, hydraulic oil (25 gal)	Sulfur dioxide (unknown)
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile	Waste oil and water mixture (500 gal)	Gasoline: automotive (4.23 g Pb/gal) (unknown)	ODS and OSX mixture (1 gal)	Oil, diesel (10 gal)	Oil, fuel no. 6 (unknown)
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile	Oil, unknown (unknown)	Oil, unknown (unknown)	Jet fuel: JP-8 (5 gal)	Jet fuel: JP-10 (unknown)	Oil, crude (unknown)
23	Blakeley Island (Atlantic Marine), Mobile, Mobile	Oil, no. 6 oil mixed with diesel (0.25 gal)	Oil, unknown (unknown)	Oil, diesel (5 gal)	Oil, hydraulic oil (2.6 gal)	Oil, hydraulic oil (30 gal)
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile	Oil, fuel no. 6 (unknown)	Oil, Marine diesel (unknown)	Waste oil/lubricants (20 gal)	Oil, diesel (unknown)	Oil, fuel no. 6 (12000 gal)
20	MP 363 4A (Railyard), Decatur, Morgan	Acetic acid (1 gal)	Nitrogen fertilizer solution (1 gal)	Sodium hydroxide solution (0.13 gal)	Nitrogen fertilizer solution (0.25 gal)	Sodium hydroxide (1 gal)
17	MP 149 MB (Mobile railyard), Mobile, Mobile	Iso-butyraldehyde (0.1 gal)	p-Xylene (5 gal)			
16	Mobile (unknown location), Mobile	Oil, unknown (unknown)				
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widows Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate 8 Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 21 Chemicals	Incident 22 Chemicals	Incident 23 Chemicals	Incident 24 Chemicals	Incident 25 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel no. 5 (unknown)	Oil, fuel no. 5 (unknown)	Oil, fuel no. 6 (unknown)	Oil, fuel no. 5 (unknown)	Oil, fuel: no. 6 (0.03 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Hazardous liquid waste, F034 (10 lbs)	Soil, creosote contaminated and debris (10 gal)	Fuel waste (5 gal)	RCRA incinerator ash (5 gal)	Incinerator ash (3 lbs)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Carbon dioxide (refrigerant) (0.13 gal)	Oil, misc: lubricating (0.5 gal)	Oil: hydraulic oil (50 gal)	Sodium chlorate (0.25 gal)	Ammonia, anhydrous (unknown)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, unknown (unknown)	Oil, fuel no. 2-D (0.5 gal)	Oil, unknown (unknown)	Gasoline: automotive (unleaded) (0.5 gal)	Oil, unknown (unknown)
44	Alabama State Dock, Mobile, Mobile	Oil: fuel oil (26 gal)	Oil: fuel oil (26 gal)	Oil, misc: motor (1.5 gal)	Oil, fuel no. 2-D (40 gal)	Oil: diesel (unknown)
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert	Oil: hydraulic oil (30 gal)	Fluorosulfonic acid (unknown)	Hydrochloric acid (0.06 gal)	Oil: hydraulic oil (8 gal)	Carbutadienes, inhibited (unknown)
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile	Benzyl chloride (15 gal)	Oil: hydraulic oil (15 gal)	Oil, fuel: no. 2-D (1 gal)	Oil: engine oil (unknown)	Oil, fuel: no. 2-D (200 gal)
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile	Jet fuel (1 gal)	Oil, fuel no. 2-D (120 gal)	Gasoline: automotive (4.23 g Pb/gal) (2000 gal)	Oil, fuel no. 2 (0.25 gal)	
23	Blakeley Island (Atlantic Marine), Mobile, Mobile	Other oil (10 gal)	Oil, unknown (unknown)	Other oil (gas oil) (unknown)		
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile	Oil, 90% fuel no. 6, 10% diesel fuel (unknown)				
20	MP 363.4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widows Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 26 Chemicals	Incident 27 Chemicals	Incident 28 Chemicals	Incident 29 Chemicals	Incident 30 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel: no. 5 (0.03 gal)	Oil, fuel: no. 5 (0.03 gal)	Oil, fuel: no. 5 (unknown)	Oil: diesel (0.03 gal)	Oil, fuel: no. 5 (0.03 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Mixed waste solvents, possibly contaminated (20 gal)	D008 (0.5 gal)	Waste material D001, D004, F001, F004 (10 gal)	Fuel waste (15 gal)	Incinerator debris (0.5 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Oil: diesel (50 gal)	Asphalt (unknown)	Potassium hydroxide (2 gal)	Oil, misc: lubricating (1 gal)	Sodium chlorite (0.13 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil: diesel (unknown)	Oil, fuel: no. 2-D (unknown)	Oil, fuel: no. 2-D (5 gal)	Bilge slops (2 gal)	Oil, fuel: no. 2-D (1 gal)
44	Alabama State Dock, Mobile, Mobile	Oil, misc: lubricating (40 gal)	Oil: hydraulic oil (4 gal)	Oil, fuel: no. 6 (2.99 gal)	Oil, misc: lubricating (unknown)	Oil, unknown (unknown)
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert	Oil, misc: lubricating (5 gal)	Oil, fuel: no. 2-D (400 gal)	Butyl acetate (2 gal)	Potassium hydroxide (1 gal)	Hydrochloric acid (0.04 gal)
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363.4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 437 S (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 31 Chemicals	Incident 32 Chemicals	Incident 33 Chemicals	Incident 34 Chemicals	Incident 35 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil: diesel (unknown)	Oil, fuel no. 5 (0.03 gal)	Oil:Diesel (bunker C #5) (0.13 gal)	Oil, fuel no. 5 (unknown)	Oil, fuel no. 6 (0.06 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	RCRA waste runoff, D008 (lead) (1 gal)	D008 (3 gal)	Sweeper trash, D007 (10 gal)	Waste oil sludge (1 gal)	Blast furnace slag (2 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Oil, fuel: no. 2-D (1000 gal)	Flammable liquid, waste (0.5 gal)	Oil: diesel (25 gal)	Potassium hydroxide (1 gal)	Oil. diesel (5 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, fuel, no. 2-D (2 gal)	Bilge slops (30 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil: diesel (1 gal)
44	Alabama State Dock, Mobile, Mobile	Oil: diesel (5 gal)	Oil: hydraulic oil (unknown)	Oil: diesel (unknown)	Oil: hydraulic oil (0.13 gal)	Oil, emulsified (15 gal)
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert	Phosphoric acid (0.1 gal)	Oil, fuel: no. 2-D (500 gal)			
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363 4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407 S (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 36 Chemicals	Incident 37 Chemicals	Incident 38 Chemicals	Incident 39 Chemicals	Incident 40 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel no. 5 (unknown)	Oil: diesel (bunker C) (0.03 gal)	Other oil (bunker C) (unknown)	Other oil (bunker C) (unknown)	Other oil (bunker C, fuel oil no. 5) (0.03 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Lead, unknown type (2 gal)	D008, F006 (3 gal)	Hazardous waste (15 gal)	Hazardous Waste, D008 (3 gal)	Alkaline corrosive material (25 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Cyclohexanone (unknown)	Oil, misc: lubricating (0.25 gal)	Phosphoric acid (2 gal)	Oil, misc: lubricating (1 gal)	Petroleum naphtha (0.5 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, misc: motor (5 gal)	AFFF Foam (180 gal)	Oil: diesel (5 gal)	Oil, unknown (unknown)	Oil: diesel (0.5 gal)
44	Alabama State Dock, Mobile, Mobile	Oil: hydraulic oil (50 gal)	Bilge oil (20 gal)	Oil: hydraulic oil (unknown)	Oil, fuel: no. 2-D (25 gal)	Oil, unknown (unknown)
32	MP 461-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No. 765) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363.4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1527), Birmingham, Jefferson					

Incidents Sorted by Location

No of Incidents	Incident Location	Incident 41 Chemicals	Incident 42 Chemicals	Incident 43 Chemicals	Incident 44 Chemicals	Incident 45 Chemicals
75	Battleship Pkwy (No 2703), Mobile, Mobile	Oil, fuel: no 6 (unknown)	Other oil (no. 5) (1.5 gal)	Oil, fuel no 5 (unknown)	Other oil (bunker C) (1 gal)	Oil, fuel: no 5 (0.06 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	NOS 9 MA3077 (2 gal)	Leachate, F040 (3 gal)	Arsenic (RQ OF 1 lb) (1 lbs)	Polychlorinated biphenyls (contaminated soil) (500 lbs)	Incinerator debris (5 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Ferric sulfate (1 gal)	Styrene (30 gal)	Oil crude (0 13 gal)	Oil diesel (30 gal)	Sulfuric acid (2 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil, fuel: no 2-D (10 gal)	Oil: diesel (0.02 gal)	Oil: diesel (0.25 gal)	Oil, fuel: no. 2-D (0.5 gal)	Oil, fuel: no 2 D (0.02 gal)
44	Alabama State Dock, Mobile, Mobile	Oil, unknown (unknown)	Oil: diesel (unknown)	Oil: diesel (80 gal)	Gasoline: automotive (unleaded) (unknown)	
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363 4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No 50), Chickasaw, Mobile					
10	Water St S (No 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 46 Chemicals	Incident 47 Chemicals	Incident 48 Chemicals	Incident 49 Chemicals	Incident 50 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel no. 5 (unknown)	Oil, fuel no. 6 (0.5 gal)	Oil Diesel (bunker C #5) (unknown)	Oil: diesel (0.06 gal)	Oil: diesel (unknown)
64	Hwy 17 at MM 163, Emelle, Sumter	Waste solid NOS 9 and NA3077 (10 gal)	Battery plant trash (40 lbs)	Leachate, F039 (15 gal)	Pipeline debris and equipment parts, K0088 (20 gal)	Waste lead, D008 (3 gal)
58	MP 793 (Norris Yard), Birmingham, Jefferson	Polychlorinate (5 gal)	p-Xylene (unknown)	Carbon dioxide (5 gal)	Oil: diesel (25 gal)	Liquefied petroleum gas (5 gal)
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo	Oil: diesel (0.25 gal)	Oil: diesel (0.05 gal)	Oil, fuel no. 2-D (0.25 gal)	Oil, unknown (unknown)	Oil: diesel (5 gal)
44	Alabama State Dock, Mobile, Mobile					
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363.4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No of Incidents	Incident Location	Incident 51 Chemicals	Incident 52 Chemicals	Incident 53 Chemicals	Incident 54 Chemicals	Incident 55 Chemicals
75	Battleship Pkwy (No 2703), Mobile, Mobile	Oil, fuel: no. 6 (unknown)	Oil, fuel: no. 5 (2 gal)	Oil, fuel: no. 5 (0.25 gal)	Oil, fuel: no. 5 (0.25 gal)	Oil, fuel: no. 6 (0.03 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Hazardous waste solid, D006 (500 lbs)	Waste liquid (2 gal)	Leachate, F039 (5 gal)	Waste derived fuels (3 gal)	Incinerator ash (2000 lbs)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Ammonia, anhydrous (unknown)	Tallow (unknown)	Isopropylamine (1 gal)	Oil, unknown (20 gal)	Oil: crude (1 gal)
50	Tenn Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo					
44	Alabama State Dock, Mobile, Mobile					
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363.4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No 50), Chickasaw, Mobile					
10	Water St S (No 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No 200), Chickasaw, Mobile					
6	Erie St (No 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 56 Chemicals	Incident 57 Chemicals	Incident 58 Chemicals	Incident 59 Chemicals	Incident 60 Chemicals
75	Battleship Pkwy (No 2703), Mobile, Mobile	Other oil (unknown)	Oil, fuel no. 5 (unknown)	Oil, diesel, no 5 bunker C (20 gal)	Oil, fuel no 2 (3 gal)	Oil, fuel no 5 (1 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Incinerator ash (4 gal)	Hazardous waste solid NOS, F006 (100 lbs)	Leachate, F039, F001, F004, F005, U051, U076, U159 (5 gal)	Hazardous waste solid NOS (contains lead oxide) Class IX (200 lbs)	Fuel waste (25 gal)
58	MP 791 (Norris Yard), Birmingham, Jefferson	Spent pot liquor from aluminum reduction (100 lbs)	Methylene dipheny diisocyanate (1 gal)	Oil, fuel no 2-D (100 gal)		
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo					
44	Alabama State Dock, Mobile, Mobile					
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (I.L&F Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363 4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407 5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No 50), Chickasaw, Mobile					
10	Water St S (No 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No 200), Chickasaw, Mobile					
6	Erie St (No 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 61 Chemicals	Incident 62 Chemicals	Incident 63 Chemicals	Incident 64 Chemicals	Incident 65 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel: no. 5 (5 gal)	Oil, fuel: no. 5 (2 gal)	Oil: diesel (1 gal)	Oil, fuel: no. 5 (unknown)	Other oil (2 gal)
64	Hwy 17 at MM 163, Emelle, Sumter	Polychlorinated biphenyls (1 lbs)	Polychlorinated biphenyls (1300 ppm) (49180 lbs)	Polychlorinated biphenyls (unknown)	Fly ash with water (10 lbs)	
58	MP 791 (Norris Yard), Birmingham, Jefferson					
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo					
44	Alabama State Dock, Mobile, Mobile					
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
23	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363.4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No of Incidents	Incident Location	Incident 66 Chemicals	Incident 67 Chemicals	Incident 68 Chemicals	Incident 69 Chemicals	Incident 70 Chemicals
75	Battleship Pkwy (No 2703), Mobile, Mobile	Oil diesel, bunker C (0.5 gal)	Oil diesel (unknown)	Oil diesel (unknown)	Oil, fuel no 5 (50 gal)	Oil diesel (unknown)
64	Hwy 17 at MM 163, Emelle, Sumter					
58	MP 791 (Norris Yard), Birmingham, Jefferson					
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N. Demopolis, Marengo					
44	Alabama State Dock, Mobile, Mobile					
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&F Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363 4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 417 5 (Widows Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No 200), Chickasaw, Mobile					
6	Erie St (No 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 71 Chemicals	Incident 72 Chemicals	Incident 73 Chemicals	Incident 74 Chemicals	Incident 75 Chemicals
75	Battleship Pkwy (No. 2703), Mobile, Mobile	Oil, fuel: no. 5 (unknown)	Oil: diesel, bunker C (3 gal)	Oil, fuel: no. 5 (unknown)	Other oil (unknown)	Oil, diesel (bunker C & #5 fuel oil) (50 gal)
64	Hwy 17 at MM 163, Emelle, Sumter					
58	MP 791 (Norris Yard), Birmingham, Jefferson					
50	Tenn-Tom Waterway MM 216 (Demopolis Yacht Basin), Hwy 43 N, Demopolis, Marengo					
44	Alabama State Dock, Mobile, Mobile					
32	MP 401-A (Sheffield Railyard), Sheffield, Colbert					
25	Water St S (No. 265) (Bender Shipyard), Mobile, Mobile					
24	Industrial Pkwy (LL&E Dock), Saraland, Mobile					
23	Blakeley Island (Atlantic Marine), Mobile, Mobile					
21	Blakeley Island (Coastal Fuel Docks), Mobile, Mobile					
20	MP 363 4A (Railyard), Decatur, Morgan					
17	MP 149 MB (Mobile railyard), Mobile, Mobile					
16	Mobile (unknown location), Mobile					
15	Blakeley Island (Midstream Fuel), Mobile, Mobile					
13	Tennessee River MM 407.5 (Widow's Creek Fossil Plant), Bridgeport, Jackson					
12	ATC USCG Aviation Training Center, Mobile, Mobile					
11	Mobile Bay (unknown location), Mobile					
10	Fairlawn Rd (No. 1855) Barge Dock, Tuscaloosa, Tuscaloosa					
10	Perdido Beach Blvd (No. 26619), Orange Beach, Baldwin					
10	Pinto Island, Mobile, Mobile					
10	Viaduct Rd (No. 50), Chickasaw, Mobile					
10	Water St S (No. 5) (Radcliff Economy Marine), Mobile, Mobile					
8	Blakeley Island (unknown location), Mobile, Mobile					
8	Dauphin Island Pkwy (No. 7778), Theodore, Mobile					
8	Dunlap Dr Gate B Pinto Island, Mobile, Mobile					
7	Finley Island Rd (BP Amoco Chemical Company), Decatur, Morgan					
7	OCSG 5753 Platform A, Mobile					
7	Viaduct Rd (No. 200), Chickasaw, Mobile					
6	Erie St (No. 1327), Birmingham, Jefferson					

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 1 Chemicals	Incident 2 Chemicals	Incident 3 Chemicals	Incident 4 Chemicals	Incident 5 Chemicals
5	5th St (No. 1650), Decatur, Morgan	Octyl mercaptan (1 gal)	Sulfuric acid (0.13 gal)	Nitrogen fertilizer solution (2 gal)	Hexamethylenediamine (0.5 gal)	Trimethyl hexamethylene diamine (25 gal)
5	Blakeley Island (Amoco Dock), Mobile, Mobile	Hydro treated gas oil (5 gal)	Oil, fuel no. 2-D (500 gal)	Asphalt/diesel fuel mixture (6 gal)	Other oil (thermal oil) (40 gal)	Oil: hydraulic oil (20 gal)
5	Chickasaw Bogue (I.L&E), Mobile, Mobile	Virgin gas oil (2 gal)	Asphalt (10 gal)	Gasoline: automotive (4.23 g Pb/gal) (40 gal)	Jet fuel: JP 4 (10 gal)	Gasoline: automotive (4.23 g Pb/gal) (5 gal)
5	Chickasaw Bogue (unknown location), Mobile, Mobile	Jet fuel (5 gal)	Oil, unknown (unknown)	Jet fuel (5 gal)	Oil: diesel (unknown)	Oil: diesel (80 gal)
5	County Rd 25 (Lacouche Industries), Cherokee, Colbert	Ammonia fertilizer solution (unknown)	Ammonia, anhydrous (1500 lbs)	Nitric acid (1150 lbs)	Nitric acid (3000 lbs)	Nitric acid (200 lbs)
5	Dauphin Island (unknown location), Mobile	Oil, misc. lubricating (5 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil, fuel: no. 2 (5 gal)	Drilling mud: Mineral-based (80 gal)
5	EOTT Energy Barge Dock, Mobile, Mobile	Oil: crude (80 gal)	Oil, fuel: no. 2-D (25 gal)	Oil: unknown (unknown)	Oil: crude (160 gal), Asphalt, water-based (200 gal)	Oil: crude (80 gal)
5	Hoke Av (No. 1002), Dolomite, Jefferson	Mineral spirits (5 gal)	Petroleum naphtha (1 gal)	Mineral spirits (5 gal)	Naphtha: solvent (50 gal)	Oil, unknown (unknown)
5	Hwy 43 & 158 (I.L&E Terminal), Mobile, Mobile	Unspecified jet fuel (5 gal)	Oil, fuel: no. 2 (0.25 gal)	Unspecified jet fuel (15 gal)	Gasoline: automotive (unleaded) (0.06 gal)	Gasoline: automotive (unleaded) (900 gal)
5	Louisville St (No. 1415), Montgomery, Montgomery	Creosote (9 lbs)	Hazardous waste, F032 (2 gal)	Creosote (4 gal)	Creosote, coal tar (2 gal)	Pentachlorophenol (0 gal); Creosote (combination of both materials) (30 gal)
5	Mobil Oil Co, Mobile	Oil, misc. lubricating (0.99 gal)	Oil: hydraulic oil (0.99 gal)	Oil: diesel (1 gal)	Oil: hydraulic oil (0.2 gal)	Oil: diesel (0.99 gal)
5	Mobile River MM 3 (Kimberly Clark Fleet Office), Mobile, Mobile	Oil: diesel (5 gal)	Oil: diesel (10 gal)	Oil: crude (3 gal)	Oil: diesel (unknown)	Oil, fuel: no. 2-D (50 gal)
5	Old Rock Rd (No. 5201), Coden, Mobile	Corrosion inhibitor oil (40 gal)	Triethylene glycol (35 gal)	Lean amine (CAS 105599) (45 gal)	Oil, diesel (42 gal)	Oil: diesel (150 gal)
5	Paper Mill Rd, Chickasaw Bogue, Mobile, Mobile	Oil, misc: motor (250 gal)	Oil: crude (0.1 gal); Mercaptan (120 lbs); Dimethyl sulfide (130 lbs)	Methyl mercaptan (370 lbs)	Oil: hydraulic oil (1 gal)	Other oil (0.99 gal)
5	Redstone Arsenal, Redstone Arsenal, Madison	Unknown Caustic Material (unknown)	Polyoxypropylenediamine (4.5 gal)	Oil, unknown (unknown)	Unknown Fuel Oil (1000 gal)	Oil, misc: motor (unknown)
5	South Blvd W (No. 980), Montgomery, Montgomery	Oil, fuel: no. 2-D (40 gal)	Oil: diesel (75 gal)	Oil: diesel (30 gal)	Oil: diesel (75 gal)	Oil, fuel: no. 2-D (15 gal)
5	Tennessee River MM 245 (Colbert Steam Plant), Cherokee, Colbert	Oil, unknown (unknown)	Oil: diesel (0.5 gal)	Oil, unknown (unknown)	Oil, unknown (unknown)	Oil, unknown (unknown)
4	Billy Goat Hole Public Ramp, Dauphin Island, Mobile	Oil: diesel (unknown)	Oil: diesel (2 gal)	Oil, unknown (unknown)	Oil: diesel and bilge slops (unknown)	
4	Birmingham International Airport, Birmingham, Jefferson	Oil: Jet A Jet fuel (70 gal)	Oil: Jet A Jet fuel (400 gal)	Jet fuel: JP-5 (kerosene, heavy) (75 gal)	Oil: Jet A Jet fuel (100 gal)	
4	Chickasaw Bogue MM 2.6 (Coastal Refinery), Chickasaw, Mobile	Oil, unknown (0.25 gal)	Oil: diesel (4.9 gal)	Unknown oil (vacuum gas oil) (unknown)	Oil, diesel (0.01 gal)	
4	DeSoto Dr (No. 1119) (Crew Boat Services), Dauphin Island, Mobile	Oil, fuel: no. 2-D (15 gal)	Oil: diesel (10 gal)	Oil, fuel: no. 2-D (0.01 gal)	Oil, fuel: no. 2-D (20 gal)	
4	Hwy 20 (unknown location), Decatur, Morgan	Oil, unknown (unknown)	Oil, unknown (unknown)	Sulfuric acid (150 lbs)	Unknown Material (unknown)	
4	Hwy 20 W (Monsanto Chemical Co.), Decatur, Morgan	Ethylene glycol (2 lbs)	Ethylene glycol (unknown)	Styrene (10 gal)	Propionitrile (100 lbs)	
4	Industrial Rd (Olin Chemical), McIntosh, Washington	Sulfuric acid (1000 lbs)	Sulfuric acid (unknown)	Sulfuric acid (unknown)	Sulfuric acid (71%) (1500 lbs)	
4	Magazine Point (Amarada Hess Corp), Mobile, Mobile	Oil: diesel (2 gal)	Oil: crude (5 gal)	Oil: crude (0.4 gal)	Oil: crude (5 gal)	
4	Mobile River (McDuffie Coal Terminal), Mobile, Mobile	Other oil (light fuel oil) (10 gal)	Oil, fuel: no. 2 (unknown)	Other oil (bunker fuel) (15 gal)	Oil, fuel: no. 6 (unknown)	
4	Mobile River MM 0.2 (Amoco Dock), Mobile, Mobile	Gasoline (40 gal)	Oil, unknown (unknown)	Oil, fuel: no. 2-D (unknown)	Oil: diesel (unknown)	
4	MP 193N (Selma Railyard), Selma, Dallas	Caustic soda solution (0.13 gal)	Potassium hydroxide (0.06 gal)	Caustic soda solution (0.25 gal)	Sulfuric acid (0.25 gal)	
4	MP 862 (County Rd 63 S (No. 3114)), Berry, Fayette	Coal (unknown)	Coal (furnace coal) (14000 lbs)	Coal (10000 lbs)	Waste oil (unknown)	
4	Shell Belt Rd (No. 310), Bayou La Batre, Mobile	Oil: diesel (unknown)	Oil, fuel: no. 2-D (100 gal)	Oil: diesel (1800 gal)	Waste oil (unknown)	
4	State Docks Rd, Decatur, Morgan	Methyl Alcohol (unknown), Acetone (unknown)	Chloroform (1250 lbs)	Ethylene glycol (3 lbs)	Glycol ether (300 gal)	

Incidents Sorted by Location

No of Incidents	Incident Location	Incident 1 Chemicals	Incident 2 Chemicals	Incident 3 Chemicals	Incident 4 Chemicals	Incident 5 Chemicals
4	Tombigbee River MM 216, Demopolis, Marengo	Waste oil/lubricants (2 gal)	Oil, misc lubricating (0.06 gal)	Waste oil (0.25 gal)	Oil, fuel: no 1-D (0.5 gal)	
4	Virginia St (McDuffie Coal Terminal), Mobile, Mobile	Oil: crude (10 gal)	IFO380 (blend of diesel and no 6 oil) (200 gal), Oil, fuel no 6 (unknown); Oil: diesel (unknown)	Oil: diesel (20 gal)	Oil, fuel: no 2-D (unknown)	
3	Alabama Ship Yard, Inc , Mobile, Mobile	Oil: diesel (10 gal)	Oil: diesel (3 gal)	Oil, misc. lubricating (28 gal)		
3	Bayou La Batre (Deep Sea Marine Products), Mobile	Oil diesel (unknown)	Oil, fuel no 2-D (10 gal)	Oil, unknown (unknown)		
3	Bayou La Batre (unknown location), Mobile	Oil diesel (1 gal)	Oil. unknown (unknown)	Oil, unknown (unknown)		
3	Birmingham Hwy, Anniston, Calhoun	Biphenyl (100 lbs)	Benzene (300 lbs)	Diphenyl oxide (10 gal)		
3	Bon Secour Bay (unknown location), Fairhope, Baldwin	Oil, unknown (unknown)	Oil: diesel (unknown)	Oil, unknown (unknown)		
3	County Rd 85 (No 1613), Stevenson, Jackson	Oil hydraulic oil (1 gal)	Oil, misc. lubricating (0.13 gal)	Oil hydraulic oil (0.01 gal)		
3	Dauphin Island (unknown location), Mobile	Oil diesel (300 gal)	Oil, unknown (unknown)	Oil, misc lubricating (0.5 gal)		
3	DeSoto Dr (No 1112) (McHugh Oil Field Svcs), Dauphin Island, Mobile	Oil hydraulic oil (2 gal)	Lube grease (unknown)	Oil, unknown (unknown)		
3	Exxon Platform, Mobile	Oil hydraulic oil (1 gal)	Oil hydraulic oil (0.9 gal)	Oil, misc: lubricating (0.1 gal)		
3	Ft Rucker Alabama Army Air Field, Fort Rucker, Coffee	Jet fuel: JP 5 (kerosene, heavy) (450 gal)	Jet fuel (7000 gal)	Jet fuel JP-4 (1000 gal)		
3	Ft Rucker, Fort Rucker, Dale	Jet fuel (25 gal)	Jet fuel (13 gal)	Oil, fuel, no. 2 D (70 gal)		
3	Hwy 158 E (LL&E Mobile Refinery) Saraland, Mobile	Crude oil and diesel mixture (160 gal)	Washwater with a trace oil (1000 gal)	Oil, misc lubricating (200 gal)		
3	Hwy 158 E (Midstream Towing Co.), Saraland, Mobile	Oil, unknown (1 gal)	Oil diesel (1 gal)	Oil diesel (100 gal)		
3	Hwy 163 (Dauphin Island Marina), Dauphin Island, Mobile	Oil, diesel (unknown)	Oil diesel (unknown)	Oil, diesel (unknown)		
3	Hwy 188 Coden Bridge, Bayou La Batre, Mobile	Oil: diesel (unknown)	Oil diesel (30 gal)	Oil, unknown (unknown)		
3	Hwy 31 S (unknown location), Brewton, Escambia	Waste paint (unknown)	Chlorine (unknown)	Oil, fuel no 2-D (150 gal)		
3	Hwy 43 (No 10565), Creola, Mobile	Groundwater, contaminated (20 gal)	Groundwater, contaminated (10 gal)	Chlorine (unknown)		
3	Hwy 43 N (ELF Atochem), Axis, Mobile	Butadiene (20 lbs)	Monochloroacetic acid (11000 lbs)	Oil, fuel no 2-D (15 gal)		
3	Hwy 43, Bucks, Mobile	Acetonitrile (130 lbs)	Thiophenol residue (100 gal)	Tenneco T500-100 (1500 lbs)		
3	Market St (No. 500), Decatur, Morgan	Oil: hydraulic oil (5 gal)	Asphalt (400 gal)	Refined chemical oil (5 gal)		
3	Market St NE (No 1400), Decatur, Morgan	Soybean oil, degummed (75 gal)	Oil, edible soya bean (3 gal)	Oil, edible soya bean (5 gal)		
3	Mobile Bay mouth, Mobile, Mobile	Oil diesel (0.1 gal)	Oil, fuel no 2 (5 gal)	Oil, unknown (unknown)		
3	Mobile Bay near N Sand Island, Mobile, Mobile	Oil, fuel no. 2 (unknown)	Oil, fuel no 2 (2 gal)	Gear oil (0.25 gal)		
3	Mobile Bay Woodchip dock, Theodore, Mobile	Oil, fuel no. 6 (160 gal)	Oil, fuel no 6 (IFO-180) (80 gal)	Oil, fuel: no. 6 (160 gal)		
3	Mobile Harbor (unknown location), Mobile, Mobile	Oil crude (5 gal)		Oil, fuel: no. 6 (1 gal)		
3	Mobile River MM 4 (National Marine Fleet), Mobile, Mobile	Oil hydraulic oil (0.02 gal)	Oil diesel (10 gal)	Oil, misc: lubricating (20 gal)		
3	MP 106MB, McIntosh, Washington	Oil diesel (20 gal)	Turpentine (0.06 gal)	Sodium hydroxide (2 gal)		
3	MP 139.4N (Railyard), Wilton, Shelby	Other oil (1 gal)	Oil diesel (30 gal)	Oil: diesel (2500 gal)		
3	MP 339 8 Huntsville, Madison	Oil hydraulic oil (50 gal)	Blaze master powder (10 lbs)	Unknown Material (unknown)		
3	MP 409.9/12 Hwy 25, Vincent Shelby	Jet fuel JP-4 (20 gal)	Oil crude (0.12 gal)	Oil, fuel: no. 2 D (160 gal)		
3	OCSG 5749, Mobile	Oil, unknown (unknown)	Oil diesel (unknown)	Oil, unknown (unknown)		
3	Olin Rd, McIntosh, Washington	Sodium hydroxide (5000 lbs)	Sodium hydroxide (unknown)	Chlorine (8.1 lbs)		
3	River Rd (No 10730), Selma, Dallas	Chlorine (unknown)	Chlorine (33 lbs)	Sulfuric acid (18000 gal)		
3	Rte 8, Jasper, Walker	Oil, misc motor (unknown)	Oil: diesel (unknown)	Unknown (unknown)		
3	Seacliff Dr (No 848), Fairhope, Baldwin	Oil diesel (unknown)	Oil diesel (20 gal)	Foam sheeting (plastic) (unknown)		
3	Shell Oil Co, Mobile	Oil, misc motor (0.99 gal)	Shell sol 71 oil (400 gal)	Oil diesel (unknown)		
3	State Lease 350, Coden, Mobile	Oil hydraulic oil (1 gal)	Oil, fuel: no 2-D (3 gal)	Oil diesel (20 gal)		

Incidents Sorted by Location

No. of Incidents	Incident Location	Incident 1 Chemicals	Incident 2 Chemicals	Incident 3 Chemicals	Incident 4 Chemicals	Incident 5 Chemicals
3	Steam Plant Rd (No 900) (Colbert Fossil Plant), Tuscumbia, Colbert	Oil, unknown (unknown)	Oil diesel (1 gal)	Other oil (unknown)		
3	Tennessee River MM 259 4, Hwy 133 (TVA power service shops) Wilson Dam Hwy	Oil misc motor (1 gal)	Ethylene glycol (1 lbs)	Waste oil (5 gal)		
3	Tennessee River MM 299 5 Finley Island Rd, Decatur, Morgan	Xylene (o-, m-, p-, & mixtures) (1 gal)	Hydrocarbon mixture (1 gal)	Heavy aromatic hydrocarbons (3 gal)		
3	Torch, Inc , Mobile	Oil hydraulic oil (20 gal)	Oil hydraulic oil (0 13 gal)	Oil hydraulic oil (1.3 gal)		
3	Warrior River Mulberry Fork MM 416, River Rd, Cordova, Walker	Asphalt (200 gal)	Asphalt (80 gal)	Oil, unknown (unknown)		
3	Wilson Dam Rd N (No. 1000), Muscle Shoals, Colbert	Oil diesel (15 gal)	Potassium hydroxide (unknown)	Potassium hydroxide (1000 gal)		
2	14th St N (No 14), Birmingham, Jefferson	Chloroform (17 lbs)	Chloroform (68 lbs)			
2	AKZO Blvd (No 7526), Scottsboro, Jackson	Latex (unknown)	Styrene/butadiene latex (200 gal)			
2	Anniston Army Depot Building 512, Anniston, Calhoun	NTX (75% methylene chloride, formic acid) (200 gal)	Waste oil (unknown)			
2	Barry Steam Plant, Mobile, Mobile	Oil, fuel: no 2-D (0.06 gal)	Oil, unknown (unknown)			
2	Bates Field, Mobile, Mobile	Jet fuel JP-4 (100 gal)	Jet fuel JP-4 (100 gal)			
2	Bay Bridge Road (No. 100), Mobile, Mobile	Caustic soda solution (unknown)	Oil: diesel (0.06 gal)			
2	Bayou La Batre (Gulf City Marina), Mobile	Oil, fuel: no. 2-D (200 gal)	Oil, unknown (unknown)			
2	Bayou La Batre (Star Seafood), Mobile, Mobile	Oil, unknown (unknown)	Oil, unknown (unknown)			
2	Bill Vance Rd, Vance, Houston	Oil, misc motor (unknown), Oil diesel (unknown)	Oil, misc motor (3 25 gal)			
2	Black Warrior River MM 332, Tuscaloosa, Tuscaloosa	Natural gas (unknown)	Natural gas (unknown)			
2	Black Warrior River MM 337, Tuscaloosa, Tuscaloosa	Oil crude (1 gal)	Oil hydraulic oil (30 gal)			
2	Black Warrior River MM 338, Tuscaloosa, Tuscaloosa	Oil diesel (30 gal)	Oil, fuel no. 2-D (5 gal)			
2	Black Warrior River MM 339, Tuscaloosa, Tuscaloosa	Oil, diesel (unknown)	Waste oil/lubricants (1 gal)			
2	Blakeley Island (Cochran Bridge), Mobile, Mobile	Oil, unknown (unknown)	Oil, diesel (50 gal)			
2	Blakeley Island (Gulf Coast Asphalt Co), Mobile, Mobile	Asphalt blending stocks roofers (unknown)	Asphalt blending stocks roofers (unknown)			
2	Block 76 Mobile Bay, Dauphin Island, Mobile	Waste oil/lubricants (unknown)	Oil, fuel no 2-D (unknown)			
2	Bucks (unknown location), Mobile	Oil, crude (200 gal)	Oil crude (400 gal)			
2	Calaway Bridge, Gulf Shores, Baldwin	Oil, unknown (unknown)	Oil, unknown (unknown)			
2	Canal Rd (No 27844) (Sportsman Marina), Orange Beach, Baldwin	Gasoline automotive (unleaded) (5 gal)	Oil: diesel (20 gal)			
2	Chickasaw Port, Chickasaw, Mobile	Oil, unknown (unknown)	Waste oil/lubricants (unknown)			
2	Conception Rd (Gulf Lumber Co), Mobile, Mobile	Gasoline automotive (4 23 g Pb/gal) (100 gal)	Gasoline automotive (4.23 g Pb/gal) (100 gal)			
2	County Rd 46 (Andalusia Municipal Airport), Andalusia, Covington	Jet fuel, JP-13 (75 gal)	Malathion (30 gal)			
2	County Rd 49S (No 17449), Bon Secour, Baldwin	Oil diesel (5 gal)	Oil, fuel: no. 2-D (unknown)			
2	Craig Air Force Base, Selma, Dallas	Unknown Material (unknown), Ethylene glycol (unknown)	Jet fuel: JP-4 (40 gal)			
2	Cyanamid Rd, Mobile, Mobile	Other oil, paraffin solvent (300 gal)	Sulfuric acid (93%) (800 gal)			
2	Dauphin Island Pkwy (No 7800), Theodore, Mobile	Oil diesel (2 gal)	Oil, misc motor (3 gal)			
2	Dauphin Island Pkwy (unknown location), Mobile, Mobile	Oil diesel (unknown)	Ammonia, anhydrous (125 lbs)			
2	Decatur Riverwalk Marina, Decatur, Morgan	Gasoline automotive (4 23 g Pb/gal) (50 gal)	Unknown Blue Material (unknown)			

Incidents Sorted by Location

Appendix C. Data for Toxic Substances

The following tables provide the data needed to carry out the calculations for toxic substances using the methods presented in the previous sections. Table C-1 presents data for toxic gases, Table C-2 presents data for toxic liquids, and Table C-3 presents data for several toxic substances commonly found in water solutions and for oleum. The data used to develop the factors in tables C-1 and C-2 are primarily from Design Institute for Physical Property Data (DIPPR), American Institute of Chemical Engineers, *Physical and Thermodynamic Properties of Pure Chemicals, Data Compilation.* Other sources, including the National Library of Medicine's Hazardous Substances Databank (HSDB) and the *Kirk-Othmer Encyclopedia of Chemical Technology,* were used for Tables C-1 and C-2 if data were not available from the DIPPR compilation. The factors in Table C-3 were developed using data primarily from *Perry's Chemical Engineers' Handbook* and the *Kirk-Othmer Encyclopedia of Chemical Technology*.

Table C-1: Data for Toxic Gases (EPA 1999)

CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Toxic End point[a]			Liquid Factor Boiling (LFB)	Density Factor (DF) (Boiling)	Gas Factor (GF)[k]	Vapor Pressure @25 ℃ (psia)	Worst-Case Condition[b]
				mg/L	ppm	Basis					
7664-41-7	Ammonia (anhydrous)[c]	17.03	1.31	0.14	200	ERPG-2	0.073	0.71	14	145	Buoyant[d]
7784-42-1	Arsine	77.95	1.28	0.0019	0.6	EHS-LOC (IDLH)	0.23	0.30	30	239	Dense
10294-34-5	Boron trichloride	117.17	1.15	0.010	2	EHS-LOC (Tox[e])	0.22	0.36	36	22.7	Dense
7637-07-2	Boron trifluoride	67.81	1.20	0.028	10	EHS-LOC (IDLH)	0.25	0.31	28	f	Dense
7782-50-5	Chlorine	70.91	1.32	0.0087	3	ERPG-2	0.19	0.31	29	113	Dense
10049-04-4	Chlorine dioxide	67.45	1.25	0.0028	1	EHS-LOC equivalent (IDLH)I	0.15	0.30	28	24.3	Dense
506-77-4	Cyanogen chloride	61.47	1.22	0.030	12	EHS-LOC equivalent (Tox)[h]	0.14	0.41	26	23.7	Dense
19287-45-7	Diborane	27.67	1.17	0.0011	1	ERPG-2	0.13	1.13	17	f	Buoyant[d]
75-21-8	Ethylene oxide	44.05	1.21	0.090	50	ERPG-2	0.12	0.55	22	25.4	Dense
7782-41-4	Fluorine	38.00	1.36	0.0039	2.5	EHS-LOC (IDLH)	0.35	0.32	22	f	Dense
50-00-0	Formaldehyde (anhydrous)[c]	30.03	1.31	0.012	10	ERPG-2	0.10	0.59	19	75.2	Dense
74-90-8	Hydrocyanic acid	27.03	1.30	0.011	10	ERPG-2	0.079	0.72	18	14.8	Buoyant[d]
7647-01-0	Hydrogen chloride (anhydrous)[c]	36.46	1.40	0.030	20	ERPG-2	0.15	0.41	21	684	Dense
7664-39-3	Hydrogen fluoride (anhydrous)[c]	20.01	1.40	0.016	20	ERPG-2	0.066	0.51	16	17.7	Buoyant[i]
7783-07-5	Hydrogen selenide	80.98	1.32	0.00066	0.2	EHS-LOC (IDLH)	0.21	0.25	31	151	Dense
7783-06-4	Hydrogen sulfide	34.08	1.32	0.042	30	ERPG-2	0.13	0.51	20	302	Dense
74-87-3	Methyl chloride	50.49	1.26	0.82	400	ERPG-2	0.14	0.48	24	83.2	Dense
74-93-1	Methyl mercy tan	48.11	1.20	0.049	25	ERPG-2	0.12	0.55	23	29.2	Dense
10102-43-9	Nitric oxide	30.01	1.38	0.031	25	EHS-LOC (TLV[j])	0.21	0.38	19	f	Dense
7-44-5	Phosgene	98.92	1.17	0.00081	0.2	ERPG-2	0.20	0.35	33	27.4	Dense
7803-51-2	Phosphine	34.00	1.29	0.0035	2.5	ERPG-2	0.15	0.66	20	567	Dense
7446-09-5	Sulfur dioxide (anhydrous)	64.07	1.26	0.0078	3	ERPG-2	0.16	0.33	27	58.0	Dense
7783-60-0	Sulfur tetrafluoride	108.06	1.30	0.0092	2	EHS-LOC (Tox[e])	0.25	0.25 (at -73℃)	36	293	Dense

Notes:

[a] Toxic endpoints are specified in Appendix A to 40 CFR part 68 in units of mg/L. To convert from units of mg/L to mg/m^3, multiply by 1,000.
[b] "Buoyant" refers to the figures for neutrally buoyant gases and vapors; "Dense" refers to the figures for dense gases and vapors.
[c] See Table C-3 of this appendix for data on water solutions.
[d] Gases that are lighter than air may behave as dense gases upon release if liquefied under pressure or cold; consider the conditions of release when choosing the appropriate figure.
[e] LOC is based on the IDLH-equivalent level estimated from toxicity data.
[f] Cannot be liquefied at 25 ℃.
[g] Not an EHS; LOC-equivalent value was estimated from one-tenth of the IDLH.
[h] Not an EHS; LOC-equivalent value was estimated from one-tenth of the IDLH-equivalent level estimated from toxicity data.
[i] Hydrogen fluoride is lighter than air, but may behave as a dense gas upon release under some circumstances (e.g., release under pressure, high concentration in the released cloud) because of hydrogen bonding; consider the conditions of release when choosing the appropriate figure.
[j] LOC based on Threshold Limit Value (TLV) - Time-weighted average (TWA) developed by the American Conference of Governmental Industrial Hygienists (ACGIH).
[k] Use GF for gas leaks under choked (maximum) flow conditions.

Table C-2: Data for Toxic Liquids (EPA 1999)

CAS Number	Chemical Name	Molecular Weight	Vapor Pressure at 25 °C (mm Hg)	Toxic Endpoint[a]			Liquid Factors		Density Factor (DF)	Liquid Leak Factor (LLF)[i]	Worst Case Condition[b]
				mg/L	ppm	Basis	Ambient (LFA)	Boiling (LFB)			
107-02-8	Acrolein	56.06	274	0.0011	0.5	ERPG-2	0.047	0.12	0.58	40	Dense
107-13-1	Acrylonitrile	53.06	108	0.076	35	ERPG-2	0.018	0.11	0.61	39	Dense
814-68-6	Acrylyl chloride	90.51	110	0.00090	0.2	EHS-LOC (Tox[c])	0.026	0.15	0.44	54	Dense
107-18-6	Allyl alcohol	58.08	26.1	0.036	15	EHS-LOC (IDLH)	0.0046	0.11	0.58	41	Dense
107-11-9	Allyamine	57.10	242	0.0032	1	EHS-LOC (Tox[c])	0.042	0.12	0.64	36	Dense
7784-34-1	Arsenous trichloride	181.28	10	0.01	1	EHS-LOC (Tox[c])	0.0037	0.21	0.23	100	Dense
353-42-4	Boron trifluoride compound with methyl ether 1:1	113.89	11	0.023	5	EHS-LOC (Tox[c])	0.0030	0.16	0.49	48	Dense
7726-95-6	Bromine	159.81	212	0.0065	1	ERPG-2	0.073	0.23	0.16	150	Dense
75-15-0	Carbon disulfide	76.14	359	0.16	50	ERPG-2	0.075	0.15	0.39	60	Dense
67-66-3	Chloroform	119.38	196	0.49	100	EHS-LOC (IDLH)	0.055	0.19	0.33	71	Dense
542-88-1	Chloromethyl ether	114.96	29.4	0.00025	0.05	EHS-LOC (Tox[c])	0.0080	0.17	0.37	63	Dense
107-30-2	Chloromethyl methyl ether	80.51	199	0.0018	0.6	EHS-LOC (Tox[c])	0.043	0.15	0.46	51	Dense
4170-30-3	Crotonaldehyde	70.09	33.1	0.029	10	ERPG-2	0.0066	0.12	0.58	41	Dense
123-73-9	Crotonaldehyde, (E)-	70.09	33.1	0.029	10	ERPG-2	0.0066	0.12	0.58	41	Dense
108-91-8	Cyclohexylamine	99.18	10.1	0.16	39	EHS-LOC (Tox[c])	0.0025	0.14	0.56	41	Dense
75-78-5	Dimethyldichlorosilane	129.06	141	0.026	5	ERPG-2	0.042	0.20	0.46	51	Dense
57-14-7	1,1-Dimethylhydrazine	60.10	157	0.012	5	EHS-LOC (IDLH)	0.028	0.12	0.62	38	Dense
106-89-8	Epichlorohydrin	92.53	17.0	0.076	20	ERPG-2	0.0040	0.14	0.42	57	Dense
107-15-3	Ethylenediamine	60.10	12.2	0.49	200	EHS-LOC (IDLH)	0.0022	0.13	0.54	43	Dense
151-56-4	Ethyleneimine	43.07	211	0.018	10	EHS-LOC (IDLH)	0.030	0.10	0.58	40	Dense
110-00-9	Furan	68.08	600	0.0012	0.4	EHS-LOC (Tox[c])	0.12	0.14	0.52	45	Dense
302-01-2	Hydrazine	32.05	14.4	0.011	8	EHS-LOC (IDLH)	0.0017	0.069	0.48	48	Buoyant[d]
13463-40-6	Iron, pentacarbonyl-	195.90	40	0.00044	0.05	EHS-LOC (Tox[c])	0.016	0.24	0.33	70	Dense
78-82-0	Isobutyronitrile	69.11	32.7	0.14	50	ERPG-2	0.0064	0.12	0.63	37	Dense
108-23-6	Isopropyl chloroformate	122.55	28	0.10	20	EHS-LOC (Tox[c])	0.0080	0.17	0.45	52	Dense
126-98-7	Methacrylonitrile	67.09	71.2	0.0027	1	EHS-LOC (TLV[c])	0.014	0.12	0.61	38	Dense
79-22-1	Methyl chloroformate	94.50	108	0.0019	0.5	EHS-LOC (Tox[c])	0.026	0.16	0.40	58	Dense
60-34-4	Methyl hydrazine	46.07	49.6	0.0094	5	EHS-LOC (IDLH)	0.0074	0.094	0.56	42	Dense
624-83-9	Methyl isocyanate	57.05	457	0.0012	0.5	E1tPG-2	0.079	0.13	0.52	45	Dense
556-64-9	Methyl thiocyanate	73.12	10	0.085	29	EHS-LOC (Tox[c])	0.0020	0.11	0.45	51	Dense
75-79-6	Methyltrichlorosilane	149.48	173	0.018	3	ERPG-2	0.057	0.22	0.38	61	Dense
13463-39-3	Nickel carbonyl	170.73	400	0.00067	0.1	EHS-LOC (Tox[c])	0.14	0.26	0.37	63	Dense
7697-37-2	Nitric acid (100%)[f]	63.01	63.0	0.026	10	EHS-LOC (Tox[c])	0.012	0.12	0.32	73	Dense
79-21-0	Peracetic acid	76.05	13.9	0.0045	1.5	EHS-LOC (Tox[c])	0.0029	0.12	0.40	58	Dense
594-42-3	Perchloromethylmercaptan	185.87	6	0.0076	1	EHS-LOC (IDLH)	0.0023	0.20	0.29	81	Dense
10025-87-3	Phosphorus oxychloride	153.33	35.8	0.0030	0.5	EHS-LOC (Tox[c])	0.012	0.20	0.29	80	Dense
7719-12-2	Phosphorus trichloride	137.33	120	0.028	5	EHS-LOC (IDLH)	0.037	0.20	0.31	75	Dense

Table C-2 : Data for Toxic Liquids (EPA 1999) (continued)

CAS Number	Chemical Name	Molecular Weight	Vapor Pressure at 25 °C (mm Hg)	Toxic Endpoint[a]			Liquid Factors		Density Factor (DF)	Liquid Leak Factor (LLF)[i]	Worst Case Condition[b]
				mg/L	ppm	Basis	Ambient (LFA)	Boiling (LFB)			
110-89-4	Pipridine	85.15	32.1	0.022	6	EHS-LOC (Tox[c])	0.0072	0.13	0.57	41	Dense
107-12-0	Propionitrile	55.08	47.3	0.0037	1.6	EHS-LOC (Tox[c])	0.0080	0.10	0.63	37	Dense
109-61-5	Propyl chloroformate	122.56	20.0	0.010	2	EHS-LOC (Tox[c])	0.0058	0.17	0.45	52	Dense
75-55-8	Propyleneimine	57.10	187	0.12	50	EHS-LOC (IDLH)	0.032	0.12	0.61	39	Dense
75-56-9	Propylene oxide	58.08	533	0.59	250	ERPG-2	0.093	0.13	0.59	40	Dense
7446-11-9	Sulfur trioxide	80.06	263	0.010	3	ERPG-2	0.057	0.15	0.26	91	Dense
75-74-1	Tetramethyllead	267.33	22.5	0.0040	0.4	EHS-LOC (IDLH)	0.011	0.29	0.24	96	Dense
509-14-R	Tetranitromethane	196.04	11.4	0.0040	0.5	EHS-LOC (IDLH)	0.0045	0.22	0.30	78	Dense
7550-45-0	Titanium tetrachloride	189.69	12.4	0.020	2.6	ERPG-2	0.0048	0.21	0.28	82	Dense
584-84-9	Toluene 2 4-diisocyanate	174.16	0.017	0.0070	1	EHS-LOC (IDLH)	0.000006	0.16	0.40	59	Buoyant[d]
91-08-7	Toluene 2 6-diisocyanate	174.16	0.05	0.0070	1	EHS-LOC (IDLH[g])	0.000018	0.16	0.40	59	Buoyant[d]
26471-62-5	Toluene diisocyanate (unspecified isomer)	174.16	0.017	0.0070	1	EHS-LOC equivalent (IDLH[h])	0.000006	0.16	0.40	59	Buoyant[d]
75-77-4	Trimethylchlorosilane	108.64	231	0.050	11	EHS-LOC (Tox[c])	0.061	0.18	0.57	41	Dense
108-05-4	Vinyl acetate monomer	86.09	113	0.26	75	ERPG-2	0.026	0.15	0.53	45	Dense

Notes:
[a] Toxic endpoints are specified in the Appendix A to 40 CFR part 68 in units of mg/L. To convert from units of mg/L to mg/m^3, multiply by 1,000.
[b] "Buoyant" in the column refers to the figures for neutrally buoyant gases and vapors; "Dense" refers to the figures for dense gases and vapors.
[c] LOC is based on IDLH-equivalent level estimated from toxicity data.
[d] Use dense gas figure if substance is at an elevated temperature.
[e] LOC based on Threshold Limit Value (TLV) - Time-weighted average (TWA) developed by the American Conference of Governmental Industrial Hygienists (ACGIH).
[f] See Table C-3 of this appendix for data on water solutions.
[g] LOC for this isomer is based on IDLH for toluene 2,4-diisocyanate.
[h] Not an EHS; LOC-equivalent value is based on IDLH for toluene 2,4-diisocyanate.
[i] Use the LLF only for leaks from tanks at atmospheric pressure.

Table C-3: Data for Water Solutions of Toxic Substances and for Oleum For Wind Speeds of 1.5 and 3.0 Meters per Second (m/s) (EPA 1999)

CAS Number	Regulated Substance in Solution	Molecular Weight	Toxic Endpoint[a]			Initial Concentration (Wt %)	10-min. Average Vapor Pressure (mm H)		Liquid Factor at 25°C (LFA)		Density Factor (DF)	Liquid Leak Factor (LLF)	Worst-Case Condition[b]
			mg/L	ppm	Basis		1.5 m/s	3.0 m/s	1.5 m/s	3.0 m/s			
7664-41-7	Ammonia	17.03	0.14	200	ERPG-2	30	332	248	0.026	0.019	0.55	43	Buoyant
						24	241	184	0.019	0.014	0.54	44	Buoyant
						20	190	148	0.015	0.011	0.53	44	Buoyant
50-00-0	Formaldehyde	30.027	0.012	10	ERPG-2	37	1.5	1.4	0.0002	0.0002	0.44	53	Buoyant
7647-01-0	Hydrochloric acid	36.46	0.030	20	ERPG-2	38	78	55	0.010	0.0070	0.41	57	Dense
						37	67	48	0.0085	0.0062	0.42	57	Dense
						36`	56	42	0.0072	0.0053	0.42	57	Dense
						34`	38	29	0.0048	0.0037	0.42	56	Dense
						30`	13	12	0.0016	0.0015	0.42	55	Buoyant[d]
7664-39-3	Hydrofluoric acid	20.01	0.016	20	ERPG-2	70	124	107	0.011	0.010	0.39	61	Buoyant
						50	16	15	0.0014	0.0013	0.41	58	Buoyant
7697-37-2	Nitric acid	63.01	0.026	10	EHS-LOC (IDLH)	90	25	22	0.0046	0.0040	0.33	71	Dense
						85	17	16	0.0032	0.0029	0.33	70	Dense
						80	10.2	10	0.0019	0.0018	0.33	70	Dense
8014-95-7	Oleum - based on SO_3	80.06 (SO_3)	0.010	3	ERPG-2	30 (SO_3)	3.5 (SO_3)	3.4 (SO_3)	0.0008	0.0007	0.25	93	Buoyant[d]

Notes:
[a] Toxic endpoints are specified in the Appendix A to 40 CFR part 68 in units of mg/L.
[b] "Buoyant" refers to the figures for neutrally buoyant gases and vapors; "Dense" refers to the figures for dense gases and vapors.
[c] Hydrochloric acid in concentrations below 37 percent is not regulated.
[d] Use dense gas figure if substance is at an elevated temperature.

Appendix D. Data for Flammable Substances

These tables provide the data needed to carry out the calculations for flammable substances using the methods presented in this section. Table D-1 presents heat of combustion data for all regulated flammable substances, Table D-2 presents additional data for flammable gases, and Table D-3 presents additional data for flammable liquids. The heats of combustion in Table D-1 and the data used to develop the factors in Tables D-2 and D-3 are primarily from Design Institute for Physical Property Data, American Institute of Chemical Engineers, *Physical and Thermodynamic Properties of Pure Chemicals, Data Compilation.*

Table D-1: Heats of Combustion for Flammable Substances (EPA 1999)

CAS No.	*Chemical Name*	Physical State at 25°C	Heat of Combustion (kjoule/k)
75-07-0	Acetaldehyde	Gas	25,072
74-86-2	Acetylene [Ethyne]	Gas	48,222
598-73-2	Bromotrifluoroethylene [Ethene, bromotrifluoro-]	Gas	1,967
106-99-0	1,3-Butadiene	Gas	44,548
106-97-8	Butane	Gas	45,719
25167-67-3	Butene	Gas	45,200*
590-18-1	2-Butene-cis	Gas	45,171
624-64-6	2-Butene-trans [2-Butene, (E)]	Gas	45,069
106-98-9	1-Butene	Gas	45,292
107-01-7	2-Butene	Gas	45,100*
463-58-1	Carbon oxysulfide [Carbon oxide sulfide (COS)]	Gas	9,126
7791-21-1	Chlorine monoxide [Chlorine oxide]	Gas	1,011*
590-21-6	1-Chloropropylene [1-Propene, 1-chloro-]	Liquid	23,000*
557-98-2	2-Chloropropylene [1-Propene, 2-chloro-]	Gas	22,999
460-19-5	Cyanogen [Ethanedinitrile]	Gas	21,064
75-19-4	Cyclopropane	Gas	46,560
4109-96-0	Dichlorosilane [Silane, dichloro-]	Gas	8,225
75-37-6	Difluoroethane [Ethane, 1,1-difluoro-]	Gas	11,484
124-40-3	Dimethylamine [Methanamine, N-methy1-]	Gas	35,813
463-82-1	2,2-Dimethy1propane [Propane, 2,2-dimethyl-]	Gas	45,051
74-84-0	Ethane	Gas	47,509
107-00-6	Ethyl acetylene [1-Butyne]	Gas	45,565
75-04-7	Ethylamine [Ethanamine]	Gas	35,210
75-00-3	Ethyl chloride [Ethane, chloro-]	Gas	19,917
74-85-1	Ethylene [Ethene]	Gas	47,145
60-29-7	Ethyl ether [Ethane, 1,1'-oxybis-]	Liquid	33,775
75-08-1	Ethyl mercaptan [Ethanethiol]	Liquid	27,948
109-95-5	Ethyl nitrite [Nitrous acid, ethyl ester]	Gas	18,000
1333-74-0	Hydrogen	Gas	119,950
75-28-5	Isobutane [Propane, 2-methyl]	Gas	45,576
78-78-4	Isopentane [Butane, 2-methyl-]	Liquid	44,911
78-79-5	Isoprene [1,3-Butadiene, 2-methyl-]	Liquid	43,809
75-31-0	Isopropylamine [2-Propanamine]	Liquid	36,484
75-29-6	Isopropyl chloride [Propane, 2-chloro-]	Liquid	23,720
74-82-8	Methane	Gas	50,029
74-89-5	Methylamine [Methanamine]	Gas	31,396
563-45-1	3-Methyl-1-butene	Gas	44,559
563-46-2	2-Methyl-1-butene	Liquid	44,414
115-10-6	Methyl ether [Methane, oxybis-]	Gas	28,835
107-31-3	Methyl formate [Formic acid, methyl ester]	Liquid	15,335
115-11-7	2-Methylpropene 1-Propene, 2-meth 1-]	Gas	44,985
504-60-9	1,3-Pentadiene	Liquid	43,834
109-66-0	Pentane	Liquid	44,697
109-67-1	1-Pentene	Liquid	44,625
646-04-8	2-Pentene, (E) -	Liquid	44,458
627-20-3	2-Pentene, (Z) -	Liquid	44,520
463-49-0	Propadiene [1,2-Propadiene]	Gas	46,332
74-98-6	Propane	Gas	46,333
115-07-1	Propylene [1-Propene]	Gas	45,762
74-99-7	Propyne [1-Propyne]	Gas	46,165

Table D-1: Heats of Combustion for Flammable Substances (EPA 1999) (continued)

CAS No.	*Chemical Name*	Physical State at 25°C	Heat of Combustion (kjoule/k)
7803-62-5	Silane	Gas	44,307
116-14-3	Tetrafluoroethylene [Ethene, tetrafluoro-]	Gas	1,284
75-76-3	Tetramethylsilane [Silane, tetramethyl-]	Liquid	41,712
10025-78-2	Trichlorosilane [Silane, trichloro-]	Liquid	3,754
79-38-9	Trifluorochloroethylene [Ethene, chlorotrifluoro-]	Gas	1,837
75-50-3	Trimethylamine [Methanamine, N,N-dimethyl-]	Gas	37,978
689-97-4	Vinyl acetylene [1-Buten-3- yne]	Gas	45,357
75-01-4	Vinyl chloride [Ethene, chloro-]	Gas	18,848
109-92-2	Vinyl ethyl ether [Ethene, ethoxy-]	Liquid	32,909
75-02-5	Vinyl fluoride [Ethene, fluoro-]	Gas	2,195
75-35-4	Vinylidene chloride [Ethene, 1,1-dichloro-]	Liquid	10,354
75-38-7	Vinylidene fluoride [Ethene, 1,1-difluoro-]	Gas	10,807
107-25-5	Vinyl methyl ether [Ethene, methoxy-]	Gas	30,549

* Estimated heat of combustion

Table D-2: Data for Flammable Gases (EPA 1999)

CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Flammability Limits (Vol%)		LFL (mg/L)	Gas Factor (GF)[g]	Liquid Factor Boiling (LFB)	Density Factor (Boiling) (DF)	Worst-Case Conditions[a]	Pool Fire Factor (PFF)	Flash Fraction Factor (FFF)[f]
				Lower (LFL)	Upper (UFL)							
75-07-0	Acetaldehyde	44.05	1.18	4.0	60.0	72	22	0.11	0.62	Dense	2.7	0.018
74-86-2	Acetylene	26.04	1.23	2.5	80.0	27	17	0.12	0.78	Buoyant[b]	4.8	0.23[f]
598-73-2	Bromotrifluoroethylene	160.92	1.11	c	37.0	c	41[c]	0.25[c]	0.29[c]	Dense	0.42[c]	0.15[c]
106-99-0	13-Butadiene	54.09	1.12	2.0	11.5	44	24	0.14	0.75	Dense	5.5	0.15
106-97-8	Butane	58.12	1.09	1.5	9.0	36	25	0.14	0.81	Dense	5.9	0.15
25167-67-3	Butene	56.11	1.10	1.7	9.5	39	24	0.14	0.77	Dense	5.6	0.14
590-18-1	2-Butene-cis	56.11	1.12	1.6	9.7	37	24	0.14	0.76	Dense	5.6	0.11
624-64-6	2-Butene-trans	56.11	1.11	1.8	9.7	41	24	0.14	0.77	Dense	5.6	0.12
106-98-9	1-Butene	56.11	1.11	1.6	9.3	37	24	0.14	0.78	Dense	5.7	0.17
107-01-7	2-Butene	56.11	1.10	1.7	9.7	39	24	0.14	0.77	Dense	5.6	0.12
463-58-1	Carbon oxysulfide	60.08	1.25	12.0	29.0	290	26	0.18	0.41	Dense	1.3	0.29
7791-21-1	Chlorine monoxide	86.91	1.21	23.5	NA	830	31	0.19	NA	Dense	0.15	NA
557-98-2	2-Chloropropylene	76.53	1.12	4.5	16.0	140	29	0.16	0.54	Dense	3.3	0.011
460-19-5	Cyanogen	52.04	1.17	6.0	32.0	130	24	0.15	0.51	Dense	2.5	0.40
75-19-4	Cyclopropane	42.08	1.18	2.4	10.4	41	22	0.13	0.72	Dense	5.4	0.23
4109-96-0	Dichlorosilane	101.01	1.16	4.0	96.0	160	33	0.20	0.40	Dense	1.3	0.084
75-37-6	Difluoroethane	66.05	1.14	3.7	18.0	100	27	0.17	0.48	Dense	1.6	0.23
124-40-3	Dimethylamine	45.08	1.14	2.8	14.4	52	22	0.12	0.73	Dense	3.7	0.090
463-82-1	2,2-Dimethylpropane	72.15	1.07	1.4	7.5	41	27	0.16	0.80	Dense	6.4	0.11
74-84-0	Ethane	30.07	1.19	2.9	13.0	36	18	0.14	0.89	Dense	5.4	0.75
107-00-6	Ethyl acetylene	54.09	1.11	2.0	32.9	44	24	0.13	0.73	Dense	5.4	0.091
75-04-7	Ethylamine	45.08	1.13	3.5	14.0	64	22	0.12	0.71	Dense	3.6	0.040
75-00-3	Ethyl chloride	64.51	1.15	3.8	15.4	100	27	0.15	0.53	Dense	2.6	0.053
74-85-1	Ethylene	28.05	1.24	2.7	36.0	31	18	0.14	0.85	Buoyant[b]	5.4	0.63[f]
109-95-5	Ethyl nitrite	75.07	1.30	4.0	50.0	120	30	0.16	0.54	Dense	2.0	NA
1333-74-0	Hydrogen	2.02	1.41	4.0	75.0	3.3	5.0	e	e	d	e	NA
75-28-5	Isobutane	58.12	1.09	1.8	8.4	43	25	0.15	0.82	Dense	6.0	0.23
74-82-8	Methane	16.04	1.30	5.0	15.0	33	14	0.15	1.1	Buoyant	5.6	0.87[f]
74-89-5	Methylamine	31.06	1.19	4.9	20.7	62	19	0.10	0.70	Dense	2.7	0.12
563-45-1	3-Methyl-1-butene	70.13	1.08	1.5	9.1	43	26	0.15	0.77	Dense	6.0	0.030
115-10-6	Methyl ether	46.07	1.15	3.3	27.3	64	22	0.14	0.66	Dense	3.4	0.22
115-11-7	2-Methylpropne	56.11	1.10	1.8	8.8	41	24	0.14	0.77	Dense	5.7	0.18
463-49-0	Propadiene	40.07	1.16	2.1	2.1	34	21	0.13	0.73	Dense	5.2	0.20
74-98-6	Propane	44.10	1.13	2.0	9.5	36	22	0.14	0.83	Dense	5.7	0.38
115-07-1	Propylene	42.08	1.15	2.0	11.0	34	21	0.14	0.79	Dense	5.5	0.35
74-99-7	Propyne	40.07	1.16	1.7	39.9	28	21	0.12	0.72	Dense	4.9	0.18

Table D-2: Data for Flammable Gases (EPA 1999) (continued)

CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Flammability Limits (Vol%)		LFL (mg/L)	Gas Factor (GF)[g]	Liquid Factor Boiling (LFB)	Density Factor (Boiling) (DF)	Worst-Case Conditions[a]	Pool Fire Factor (PFF)	Flash Fraction Factor (FFF)[f]
				Lower (LFL)	Upper (UFL)							
7803-62-5	Silane	32.12	1.24	c	c	c	19[c]	e	e	Dense	e	0.41[f]
116-14-3	Tetrafluoroethylene	100.02	1.12	11.0	60.0	450	33	0.29	0.32	Dense	0.25	0.69
79-38-9	Trifluorochloroethylene	116.47	1.11	8.4	38.7	400	35	0.26	0.33	Dense	0.34	0.27
75-50-3	Trimethylamine	59.11	1.10	2.0	11.6	48	25	0.14	0.74	Dense	4.8	0.12
689-97 1	Vinyl acetylene	52.08	1.13	2.2	31.7	47	24	0.13	0.69	Dense	5.4	0.086
75-01-4	Vinyl chloride	62.50	1.18	3.6	33.0	92	26	0.16	0.50	Dense	2.4	0.14
75-02-5	Vinyl fluoride	46.04	1.20	2.6	21.7	49	23	0.17	0.57	Dense	0.28	0.37
75-38-7	Vinylidene fluoride	64.04	1.16	5.5	21.3	140	27	0.22	0.42	Dense	1.8	0.50
107-25-5	Vinyl methy1 ether	58.08	1.12	2.6	39.0	62	25	0.17	0.57	Dense	3.7	0.093

Notes:

NA: Data not available
[a] "Buoyant" refers to neutrally buoyant gases and vapors; "Dense" refers to dense gases and vapors.
[b] Gases that are lighter than air may behave as dense gases upon release if liquefied under pressure or cold; consider the conditions of release when choosing the appropriate table.
[c] Reported to be spontaneously combustible.
[d] Much lighter than air; table of distances for neutrally buoyant gases not appropriate.
[e] Pool formation unlikely.
[f] Calculated at 298 K (25 ℃) with the following ex ceptions:

Acetylene factor at 250 K as reported in TNO, *Methods for the Calculation of the Physical Effects of the Escape of Dangerous Material* (1980).
Ethylene factor calculated at critical temperature, 282 K.
Methane factor calculated at critical temperature, 191 K.
Silane factor calculated at critical temperature, 270 K.

[g] Use GF for gas leaks under choked (maximum) flow conditions.

Table D-3: Data for Flammable Liquids (EPA 1999)

CAS Number	Chemical Name	Molecular Weight	Flammability Limit (Vol%)		LFL (mg/L)	Liquid Factors		Density Factor	Liquid Leak Factor (LLF)[a]	*Worst-Case Condition*[b]	Pool Fire Factor (PFF)
			Lower (LFL)	Upper (UFL)		Ambient (LFA)	Boiling (LFB)				
590-21-6	1-Chloropropylene	76.53	4.5	16.0	140	0.11	0.15	0.52	45	Dense	3.2
60-29-7	Ethyl ether	74.12	1.9	48.0	57	0.11	0.15	0.69	34	Dense	4.3
75-08-1	Ethyl mercaptan	62.14	2.8	18.0	71	0.10	0.13	0.58	40	Dense	3.3
78-78-1	Isopentane	72.15	1.4	7.6	41	0.14	0.15	0.79	30	Dense	6.1
78-79-5	Isoprene	68.12	2.0	9.0	56	0.11	0.14	0.72	32	Dense	5.5
75-31-0	Isopropylamine	59.11	2.0	10.4	48	0.10	0.13	0.71	33	Dense	4.1
75-29-6	Isopropyl chloride	78.54	2.8	10.7	90	0.11	0.16	0.57	41	Dense	3.1
563-46-2	2-Methyl-1-butene	70.13	1.4	9.6	40	0.12	0.15	0.75	31	Dense	5.8
107-31-3	Methyl formate	60.05	5.9	20.0	140	0.10	0.13	0.50	46	Dense	1.8
504-60-9	1,3-Pentadiene	68.12	1.6	13.1	44	0.077	0.14	0.72	33	Dense	5.3
109-66-0	Pentane	72.15	1.3	8.0	38	0.10	0.15	0.78	30	Dense	5.8
109-67-1	1-Pentene	70.13	1.5	8.7	43	0.13	0.15	0.77	31	Dense	5.8
646-04-8	2-Pentene, (E)-	70.13	1.4	10.6	40	0.10	0.15	0.76	31	Dense	5.6
627-20-3	2-Pentene, (Z) -	70.13	1.4	10.6	40	0.10	0.15	0.75	31	Dense	5.6
75-76-3	Tetramethylsilane	88.23	1.5	NA	54	0.17	0.17	0.59	40	Dense	6.3
10025-78-2	Trichlorosilane	135.45	1.2	90.5	66	0.18	0.23	0.37	64	Dense	0.68
109-92-2	Vinyl ethyl ether	72.11	1.7	28.0	50	0.10	0.15	0.65	36	Dense	4.2
75-35-4	Vinylidene chloride	96.94	7.3	NA	290	0.15	0.18	0.44	54	Dense	1.6

Notes:
NA: Data not available.
[a] Use the LLF only for leaks from tanks at atmospheric pressure.
[b] “Dense” refers to the tables for dense gases and vapors.

Appendix E. Acknowledgements

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