Hazmat Accident Education
An Integrated Approach

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16. Abstract

The objective of this technology transfer project was to enhance the ability of emergency planners at the local and state level to prepare for hazardous-material related emergencies and their aftermath. Regulatory requirements dictate that planners prepare for emergencies that could be expected in these areas, but it is highly unusual to have transportation-related accidents detailed in most plans. It is rare to find plans that link the planning of traffic routing with the emergency response and the community repercussions. This project synthesized the information that is currently available on transportation-related hazardous materials accidents into an Internet site that is available for reference by professionals and others with Internet access. The web site URL is http://www.personal.psu.edu/faculty/s/e/sec16/. Class information for a graduate-level fate and effects class was assembled and can be found at http://unix.eng.ua.edu/~rpitt/Class/Classes.shtml. This material has been used in teaching graduate-level courses in hazardous materials fate and effects, in the springs of 2002, 2003, and 2005 at the University of Alabama. Modules from this project have also been incorporated into the following classes: Environmental Management (University of Alabama at Birmingham), Environmental Science (Penn State Harrisburg), and Occupational Safety and Environmental Health (Penn State Harrisburg).

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Executive Summary

This project builds upon the author's UTCA project 00214, "Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances." The integrated approach used in that study was novel because it linked the traditional accident concerns of material fate and transport with emerging issues such as planning for accidents in routing and the social/behavioral impacts in affected communities. This unified approach must be incorporated into the planning and response to these accidents. To do that successfully, professionals and those who are entering the profession must be trained to think in an integrated fashion. This project, through the use of classes and an Internet site, developed the material from the previous UTCA report and a related report (on using GIS to specify routing and minimize impacts) into modules for use in a classroom or workshop setting. The use of case studies was an integral part of the module development so that students could "see" how the decisions made during planning affect the results/effectiveness of the emergency response. Recent events have dramatically demonstrated the need to provide this integrated information to planners and responders so they can improve their plans and better inform the public.

This information will be important when planning for accidents involving transportation of hazardous materials. The possible social and environmental consequences of these accidents are often not given the attention that is deserved. Also, overlooked consequences need to be addressed when planning the transportation routes for hazardous materials in Alabama. The Baltimore train derailment and tunnel fire is one recent demonstration of the impacts that these types of accidents can have on a community.

Therefore, the objective of this technology transfer project was to enhance the ability of emergency planners, facility owners, transporters, and consulting engineers to adequately prepare for an emergency involving transportation of hazardous materials. Recent federal regulations require specific planning activities by facility owners and local and state agencies. This is an attempt to help them meet goals outlined in the regulations.

This project synthesized available information on hazardous materials accidents, particularly those involving the transportation infrastructure. This material is available for reference at the following website: http://www.personal.psu.edu/faculty/s/e/sec16/. Class information for a graduate-level fate and effects class can be found at http://unix.eng.ua.edu/~rpitt/Class/Classes.shtml. This material has been used in teaching graduate-level courses in hazardous materials fate and effects, in the springs of 2002, 2003, and 2005 at the University of Alabama. Modules from this project have also been incorporated into the following classes: Environmental Management (University of Alabama at Birmingham), Environmental Science (Penn State Harrisburg), and Occupational Safety and Environmental Health (Penn State Harrisburg).

Section 1.0
Introduction

The July 2001 train derailment and fire that occurred in Baltimore's Howard Street tunnel served as a powerful reminder of the continuing threat posed by hazardous-materials transportation accidents. The incident caused the closure of all major roads into Baltimore, necessitated the evacuation of the city's baseball stadium, forced many area residents to shelter in their homes, and resulted in substantial damage to roads and other infrastructure, including disruption of electronic communications along the entire U.S. East Coast. Personnel at the Alabama Department of Transportation (ALDOT) and the Alabama Department of Public Safety (DPS) have, in the past, expressed concerns about potential hazardous-materials accidents occurring in the Mobile tunnel, even with the restrictions on materials transport through the tunnel. The September 11, 2001 attacks and the threat of further attacks, when coupled with the Baltimore tunnel fire, have reminded people of the potential for significant short- and long-term effects of incidents in which hazardous materials are involved.

Since that time, two Birmingham Interstate highways have been affected by hazardous materials accidents – both of which shut down parts of the major urban freeway interchange and one of which resulted in a fatality. Both crashes caused damage through high-temperature fires (oil-based products burned), and both accidents required emergency replacement of major bridges in the state's busiest interchange. Impacts to the City of Birmingham and its residents included the loss of the tanker truck driver, potential release of hazardous smoke over nearby neighborhoods, and loss of the major north-south transportation route from central Alabama. The diversion of traffic onto city streets affected local residents and commuters. In addition, it caused major headaches establishing and explaining detour routes for people unfamiliar with the city. Large trucks were siphoned onto city streets that were not designed for the frequent heavy loads carried by tractor-trailer trucks. The impacts from these accidents were different from those seen in Baltimore, but were no less severe. In addition, had more people or different chemicals been involved, the results could have much more tragic on a human basis.

Major accidents involving hazardous materials are rare, but when they do occur, serious environmental health, safety and social problems have been documented. Indeed, depending on the nature and circumstances of an accident, some impacts can be both severe and long-lasting. Social and psychological impacts, for example, can extend well beyond the immediate emergency response phase of an accident. However, these potential longer-term problems are sometimes overlooked after the more dramatic acute problems are addressed.

This project, through the use of classes and an Internet site, presented the material from the previous UTCA project (UTCA report 00233, "Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances") to interested parties and incorporated an integrated approach to preparing for and evaluating accidents. As such, it would put Alabama at the forefront of efforts to tie together transportation safety, environmental health, and social policy concerns. Recent events have dramatically demonstrated the need to provide this integrated information to planners and responders in order for them to both improve their plans and to better inform the public.

The project used the knowledge and methodologies developed in the author's prior work to pursue two of UTCA's high priority topics: *technology transfer* and *human resources*, while also addressing UTCA's emphasis on *safety* issues. More specifically, a range of innovative educational tools were developed to provide professionals, students and interested members of the public with the latest information about short- and long-term environmental, safety and community impacts of these accidents. The project also fostered intercampus collaboration by incorporating a team of professionals from diverse backgrounds at the University of Alabama (UA) and the University of Alabama at Birmingham (UAB).

This information will be important when planning for accidents involving transportation of hazardous materials. The possible social and environmental consequences of these accidents are often not given the attention that is needed. Also, overlooked consequences need to be addressed when planning the transportation routes for hazardous materials in Alabama. The Baltimore train derailment and tunnel fire is one recent demonstration of the impacts that these types of accidents can have on a community.

The second part of this project involved using the material in classes and preparing the materials for inclusion in workshops. Several graduate-level Fate and Effects of Hazardous Materials classes focused specifically on this material as they were taught at the UA Department of Civil and Environmental Engineering. In addition, specific modules were developed for the project and incorporated in many other classes both in Alabama and outside of the state. While a faculty at UAB, Dr. Clark used the modules on fate prediction and psychosocial impacts in a School of Public Health course entitled Environmental Management. The students in this course were from a variety of graduate majors: medicine, public health, and engineering. In addition, modules on fate and the problems of transport (including case studies) were used at Penn State Harrisburg (PSH) in two undergraduate courses: Environmental Science, and Occupational Safety and Environmental Health. These courses required students to perform analyses on available data in terms of frequency of spills and materials most-frequently spilled. In addition, the courses required the students to prepare case studies on several accidents each. The guidance required that students research the accident from available information like accident reports and newspaper accounts (personal interviews were discouraged since the students were not skilled in interviews), and determine from the available information the amount of the material spilled and where it went. The students also had to prepare a section on impacts – both environmental and community.

Section 2.0
Organization and Conduct of the Project

This project builds upon the author's UTCA project 00233, "Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances." The integrated approach used in that study was novel because it linked the traditional accident concerns of material fate and transport with emerging issues such as planning for accidents in routing and the social and behavioral impacts in affected communities. This unified approach must be incorporated into the planning and response to these accidents. To do that successfully, professionals and those who are entering the profession must be trained to think in an integrated fashion. This project, through the use of classes and an Internet site, developed the material from the previous UTCA report and a related report (on using GIS to specify routing and minimize impacts) into modules for use in a classroom or workshop setting. The use of case studies was an integral part of the module development so that students could "see" how the decisions made during planning affect the results/effectiveness of the emergency response. Recent events have dramatically demonstrated the need to provide this integrated information to planners and responders so they can improve their plans and better inform the public.

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Preparation of the Manual and Internet Site

Drs. Becker, Pitt, and Clark reviewed federal requirements and guidelines for emergency planning and response, as well as existing literature databases on accident statistics, preparedness training, prediction of pollutant fate, and psychosocial impacts of these accidents. This material was synthesized into a class reference site that is currently housed at the University of Alabama (Dr. Pitt's website). In addition, supporting documentation and updated references can be found on Dr. Clark's website (http://www.personal.psu.edu/faculty/s/e/sec16/). The Internet site has been organized into the following modules:

Module 0: Overview and Introduction
Module 1: Basic Concepts of Chemical Fate and Transport
Module 2: Surface Water Processes
Module 3: Subsurface Water Processes
Module 4: Atmospheric Processes

Module 5: Accidental Releases
Module 6: Basic Prediction Procedures
Module 7: Case Study for Hydrocarbon Spills
Module 8: Case Study for Ammonia Spills
Module 9: Case Studies of Long-term Community Impacts

The material was first taught as a class UA. The units on Accidental Releases and Community Impacts were incorporated into the Environmental Management course at UAB and into the Occupational Safety and Health course at PSH.

The class by itself raised the awareness among the students about the potential for substantial short- and long-term problems due to an accidental release of hazardous materials. The accidents in Birmingham, when combined with the train accident in Baltimore, highlight the problems when these accidents are transportation-related and occur in areas where the population density is either high and/or is near the transportation infrastructure in question. In addition, the authors hope that the classes and project material have raised the awareness of land-use and community emergency planners about growth issues in terms of transportation infrastructure, especially given that the lack of land-use planning led to many communities being situated near the infrastructure that is carrying these potentially-dangerous materials.

Section 3.0
The Internet-Based Manual

The reference sites contain materials that enable instruction of an integrated approach to preparing for hazardous materials accidents. The background information is readily available for the public at the Department of Homeland Security website under Emergencies and Disasters, at http://www.dhs.gov/dhspublic/display?theme=14. The website is organized in sections, depending on the reader's area of interest, as shown below:

- Emergencies & Disasters
- First Responders
- Planning & Prevention
- Hazard Mitigation
- Natural Resource Protection
- Marine Safety
- Response & Recovery
- Declared Disasters & Assistance

This Internet-based resource incorporates the planning and evaluation work done under the auspices of several past UTCA projects. The two primary projects of interest for developing these materials were UTCA project 00214, which focused on developing GIS methods for planning the transport of hazardous materials and UTCA project 02215 (this project) which focused on the impacts of transportation-related hazardous materials accidents.

Specific sections on the website include twenty years of accident data – available for statistical analysis on topics like which materials are most likely to be involved in a hazardous-materials accident – and workshop material supporting the use of GIS (and reviewing other planning tools and models) to predict the likelihood of a transportation-related hazmat accident for various routes of transport. In addition, the modules listed below are incorporated into a standalone course on Fate and Effects of Hazardous Materials.

Module 0: Overview and Introduction
Module 1: Basic Concepts of Chemical Fate and Transport
Module 2: Surface Water Processes
Module 3: Subsurface Water Processes
Module 4: Atmospheric Processes
Module 5: Accidental Releases
Module 6: Basic Prediction Procedures
Module 7: Case Study for Hydrocarbon Spills
Module 8: Case Study for Ammonia Spills
Module 9: Case Studies of Long-term Community Impacts

Rather than use a textbook that may quickly become outdated, the researchers put this material onto an Internet site. This will allow regular update to ensure the materials remain current. Also, this site will be accessible through a web search by professionals both in Alabama and out of state, who may not be aware of a published manual. The URLs for the reference material are shown below:

http://www.personal.psu.edu/faculty/s/e/sec16/
http://unix.eng.ua.edu/~rpitt/Class/Classes.shtml.

Section 4.0
Course Delivery and Evaluation

Courses

This material has been vetted through incorporation, in part or whole, in several undergraduate and graduate campuses both in and outside of Alabama. In particular, several semesters of a graduate course entitled Fate and Effects of Hazardous Materials has been offered by Dr. Robert Pitt at the University of Alabama. His course focused on both the general topic of hazardous-materials accidents and on the development and evaluation of transportation-related case studies. Dr. Clark has incorporated individual units from the project materials into her past offerings – a graduate-level course in Environmental Management offered through the UAB School of Public Health, and two of her current undergraduate offerings at PSH – and Environmental Science course designed for non-engineering majors and an Occupational Safety and Environmental Health course designed for environmental engineering seniors.

Course enrollments for the full-semester offering at UA have been consistently been either or more 10 students. The School of Public Health class had 15 enrollees, while the Occupational Safety class had between five and 10 participants.

The full-semester course was taught by Dr. Pitt at the University of Alabama. During his last offering of the course, it was presented via interactive television to students at UAB. Drs. Clark and Becker have guest-lectured in Dr. Pitt's classes. Drs. Clark and Becker have both taught the Public Health Environmental Management class and Dr. Becker regularly offers a course in Environmental Disasters.

Instructors

Dr. Pitt is the Cudworth Professor of Urban Water Systems at the University of Alabama. He has over 20 years experience in the fate and transport of materials in the natural environment. During his 15 years in industry, Dr. Pitt participated on a variety of hazardous material management planning projects as the task leader for air and water quality modeling of hazardous conditions. These hazardous conditions included toxic and explosive concentrations of many materials in water and air. He has calculated the spread of material on/in water and the air quality effects of many accidental spills (including downwind photochemical oxidant and hydrocarbon increases in Southern California associated with major oil field accidents). He has also analyzed the probabilities for losses to occur and estimated how much of the material may be spilled. He has also analyzed the effects of these various materials in urban areas, especially if the material interacted with storm drainage.

Dr. Becker is Associate Professor of Environmental Health Sciences at the UAB School of Public Health. Becker, who is also a Scientist at the Center for Disaster Preparedness, is a leading authority on the social, psychosocial, public health, and public policy implications of hazardous material accidents. He has conducted on-site fieldwork at a range of chemical and radiological accident sites in North America, Europe and Asia. In 1997 he developed an Environmental Disasters course at UAB. Dr. Becker also serves as a member of a national panel on nuclear/radiological incidents, and he is a member of the International Working Group on the Psychosocial Aspects of Ecological Disasters.

Dr. Clark is an Assistant Professor of Environmental Engineering at PSH, and was formerly an Assistant Professor in the Department of Civil and Environmental Engineering at UAB. Prior to pursuing her Ph.D., Dr. Clark worked for several northeast U.S. consulting firms, focusing on remediation projects (primarily for asbestos). Her training was in the field of chemical engineering and her graduate work focused on the fate and transport of pollutants in the natural environment. She currently teaches classes in Environmental Engineering, including the aforementioned class on Occupational Safety and Environmental Health.

Class Sessions

The full course has traditionally been presented as an elective in the spring semester graduate program at the UA. The PSH Occupational Safety and Environmental Health class is also a spring offering. These classes usually are taught in the late afternoon or evening to allow part-time students to take the class.

Class Assignments

The mid-term assignment in the initial offering of the graduate class was to analyze data available on transportation-related hazardous materials spills in Alabama for a particular year. Students were required to cull from the National Response Center database the appropriate accidents, to separate accidents that occurred in Alabama, and to determine the materials spilled most frequently and in the greatest quantities. For a final project, the students were required to develop preliminary case studies for future revision. The development of the modules under this project scope provided the background material essential for current students to perform in-depth development of several transportation-related case studies. Each current student is assigned several accidents and is given directions that require answers for the following questions:

1. What happened?
2. How much material was spilled?
3. What are the environmental hazards of the material spilled?
4. Based on the modeling covered in class, where is the material expected to end up?
5. What are the consequences of the dispersion of this material into the environment?
6. What community impacts resulted from the accident?

7. What were the lessons learned from the accident (including those recorded by the accident inspectors and those developed by the student after compiling this information)?

Course Reviews

The conclusion of the PIs, based on course reviews, was that these classes and modules were very helpful to students' education. They provided an opportunity to see how many different areas/specialties should be brought to bear on issues such as planning for, preventing, and coping with the aftermath of transportation-related hazardous materials accidents. The students used knowledge of chemistry, pollutant dispersion, psychology and sociology to prepare their case studies. Students comments about the case students used terms like "eye-opening" to describe what they felt they learned in the class.

When these modules were incorporated into additional classes, students have found them to be interesting and applicable. Students commented about seeing trucks on the highway and wondering what they were carrying, and about living near chemical companies or railroads. They felt that when they graduate and pursue careers which utilize this material, they will be better educated to view the entire scope of the issue rather than the very narrow focus of either transportation-route planning or hazardous spills cleanup. This led the project PIs to conclude that their goals for the development of curricula material were met.

Section 5.0
UTCA Technology Transfer Policy Requirements

UTCA has an administrative policy with specific requirements for preparing and conducting technology transfer projects. This section of the report constitutes the required course-end report, and addresses the ten required topics in the following text:

1. *Course announcement/brochure* – The courses were sponsored by UA and UAB. The module material has also been used in courses at PSH. Announcements for the courses have been done in a manner typical all academic courses. PSH attempts to solicit non-degree seeking graduate students with specific academic interests through advertising of upcoming semester offerings in the local ASCE newsletter.

2. *Attendance list, with names, addresses and telephone numbers* – Student attendance was tracked in accordance with the policies of the respective universities.

3. *Date, time and location of the course offerings* – The courses were scheduled in the late afternoon or evening to accommodate the schedules of working engineers. Courses have been held in previous years during the spring semester, allowing graduate students time in the fall to take any requisite courses that could be helpful in preparing to take this course.

4. *Copy of the agenda/syllabus* – The syllabus is distributed to the students at the beginning of each term and is available on the course website.

5. *Copy of the course notes* – Course materials are located on the two websites referenced in this report – one at UA and one at PSH.

6. *Copy of visual aids* – PDF copies of the visual aids are available via the websites referenced above.

7. *Evaluation of the class* – The reviewers found the instructors to be very knowledgeable about the topic, but indicated that the some of the topics were not directly applicable to their current or future careers. However, those students who had been or were currently employed in industry found this class to be particularly relevant. Most students said that they had never thought about the community ramifications of a hazardous material accident, and if they had, they had focused on the fixed facility, not on the transportation route. For students in older areas of the country where industrial and residential facilities were intermingled, this was a particularly important lesson. They saw tractor trailers and rail cars carrying many different types of materials passing through city streets and often through neighborhoods. As they pondered employment in the local industries or with consulting firms who prepared emergency plans for industry, they felt that they had a

broader knowledge of emergency preparedness and of how to assist their employer in preparing a more useful emergency response plan.

8. *Other pertinent materials* – There were no other pertinent materials.

9. *A financial summary of all sources of income, amount of registration fee, total collected from participants, itemized costs, and balance of income less expenses* – Since the courses and modules were taught as part of the current academic load, there were no participant registration fees, and there is no separate financial report of instructional revenues and expenses for this project.

10. *A short written summary of successes and lessons learned* – The course was considered an "eye-opener" by many participants. They had not considered the issue of hazardous materials except in the industrial context where it is assumed the material was on-site. They had not considered how the material was transported to a facility – routing, types of transportation and storage – or what the ramifications were to the community if an accident were to happen. Most students also expressed that they did not realize how much hazardous material was transported in the United States in an average year. They also did not realize the number of accidents and the variety of materials spilled. Students thought the use of case studies allowed them to begin planning from start to finish of a potential accident. Occupational safety and health students said that this was an area that they had not considered and that was not addressed in any other class in their educational experience. They felt that this topic needed to be incorporated somewhere in the curriculum since someone owned the hazardous material at any given time. They also learned from the case studies that not all accidents were the transporter's fault although generally the transporter had to help pay cleanup costs. In general, they thought it was useful and interesting.

Section 6.0
References for Module Development

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Section 7.0
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Section 8.0
Appendix

The following attachments are included as part of this appendix:

A: Example handout page for the morning workshop ("Introduction to Highway Construction Erosion and RUSLE")

B: Example handout page for the afternoon workshop ("Site Hydrology's Impact on Erosion and Selection of Appropriate Controls")

A: Sample handout page from Module 4.

"Transport of Chemicals in the Atmosphere"

Module 4: The Atmosphere, Lecture 2

Chemical Fate and Transport in the Environment, 2nd edition. H.F. Hemond and E.J. Fechner-Levy. Academic Press. London. 2000.

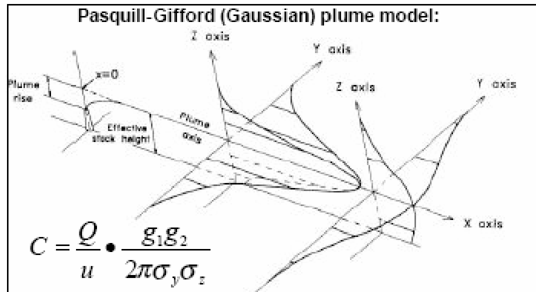
4.4 Transport of Chemicals in the Atmosphere

- Physical transport and chemical reaction rates are both needed to predict downwind concentrations of air pollutants.
- It is important to compare chemical reaction rates with advective velocities and mixing rates.
  - If chemical transformations are relatively slow compared to mixing rates, it may be appropriate to use simple box models in which air volumes are considered well mixed.
  - When chemicals are transported significant distances in the time it takes for the chemical reactions to reach equilibrium, then advection-dispersion-reaction equation solutions are most useful.

4.4.2 Local-Scale Outdoor Air Pollution

- The smallest spatial scale at which outdoor air pollution is of concern corresponds to the air volume affected by pollutant emissions from a single point source.
- Chemicals are carried downwind by advection, while turbulent (Fickian) transport cause the concentrations to become more diluted.
- Possible to predict the distance to and the concentration at which the plume from an elevated emission reaches the ground (classically considered the worst-case scenario).

Pasquill-Gifford (Gaussian) plume model:



$$C = \frac{Q}{u} \bullet \frac{g_1 g_2}{2\pi\sigma_y\sigma_z}$$

Hemond and Fechner-Levy 2000

$$g_1 = \exp\left(-0.5y^2/\sigma_y^2\right)$$

$$g_2 = \exp\left(-0.5 \bullet (z-H)^2/\sigma_z^2\right) + \exp\left(-0.5 \bullet (z+H)^2/\sigma_z^2\right)$$

B: Sample handout page from Module 6: Accidental Releases

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 and quantity released.
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 and quantity released.
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 and quantity released.
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,
- The release that results in the greatest distance to the endpoint for the regulated toxic or flammable

End of Handout