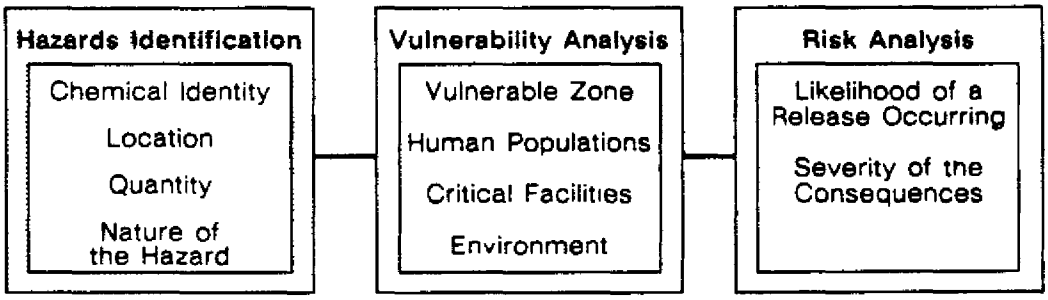
2. Hazards Analysis: An Overview

This chapter provides an overview of hazards analysis as it relates to emergency planning for extremely hazardous substances (EHSs) under Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). The approach to hazards analysis presented here is not mandatory but it will assist localities in meeting the planning requirements of SARA Title III. As in Chapter 1 this chapter follows the same general format and supports the principles presented in NRT-1. It represents a relatively simple yet effective means of evaluating potential hazards resulting from the accidental release of an EHS. The three basic components in the hazards analysis discussed here are (1) hazards identification, (2) vulnerability analysis, and (3) risk analysis.

The step-by-step process planners should follow in conducting a hazards analysis is outlined in Exhibit 2-11 (pp. 2-26 and 2-27) and described in detail in Chapter 3. The overview in this chapter should be carefully read and understood before attempting an actual hazards analysis as outlined in Chapter 3. The information in Appendices I and J should also be reviewed.

2.1 Hazards Identification



Hazards identification, the first step in hazards analysis, is the process of collecting information on:

- The types and quantities of hazardous materials in a community;
- The location of facilities that use, produce, process, or store hazardous materials;
- Conditions of manufacture, storage, processing, and use,
- Transportation routes used for transporting hazardous materials; and
- Potential hazards associated with spills or releases.

This information can be used by emergency planners, as well as by fire/rescue services, police departments, and environmental protection departments as they prepare for, respond to, and recover from emergencies involving hazardous materials. Section 2.1.1 discusses the types of hazards that chemicals may pose to the community. Section 2.1.2 discusses sources of data for hazards identification and procedures that planners may use in gathering data. Information derived from hazards identification will subsequently be used in vulnerability analysis (described in Section 2.2) and risk analysis (described in Section 2.3).

2.1.1 Identification of Hazardous Chemicals

Hazards are situations that have the potential for causing injury to life and/or damage to property and the environment. Chemicals may be potentially hazardous because of their toxicity or physical/chemical properties such as flammability and reactivity. Comprehensive planning for hazardous materials emergencies should encompass all hazards capable of causing loss of life, injury or damage to health, or damage to property or the environment. The guidance in this document focuses on the single hazard of acute toxicity, specifically acute lethality to individuals as a result of airborne releases of EHSs.

Extremely Hazardous Substances

Chemicals with high acute lethality have the potential for causing death in unprotected populations after relatively short exposure periods at low doses. On the basis of toxicity criteria (discussed in Appendix B), EPA identified a list of chemicals with high acute toxicity (listed in Appendix C) from the more than 60,000 chemicals in commerce. This is the list of EHSs required by Title III of SARA. Because airborne releases of acutely lethal substances, while infrequent, can be catastrophic, Title III requires consideration of these EHSs in emergency plans.

Although all of the listed substances are extremely toxic, the hazards presented by a spill will also vary depending on the physical and chemical properties of the substance spilled and the conditions under which the substance is handled (e.g., elevated temperatures and pressures). Some substances are highly volatile and thus likely to become airborne, while others are non-powdered solids that are unlikely to become airborne. The potential to become airborne was considered in the determination of the threshold planning quantity (TPQ) for EHSs.

A summary of publicly available information on the listed substances is presented in the EPA Chemical Profiles issued in December 1985 as part of the Chemical Emergency Preparedness Program (CEPP) Interim Guidance. The profile for each chemical includes synonyms as well as information on recommended exposure limits, physical/chemical characteristics, fire and explosion hazards and fire fighting procedures, reactivity, health hazards, use, and precautions. Profiles for each EHS are available. The profiles are currently being updated and supplemented with additional information, including emergency medical treatment guidance and information about personal protective equipment which should be used by emergency response teams. The revised profiles should be available by spring 1988. See Appendix E for a revised sample chemical profile.

Other Hazards

In addition to acute lethality, substances may cause other types of toxic effects in people exposed to them (e.g., long-term or short-term illness, damage to skin or eyes). Criteria for the identification of chemicals (other than those that are acutely lethal) that cause serious health effects from short-term exposures are being developed on a priority basis. When such criteria are established, they will be used in expanding the list of EHSs. At that time, guidance will be provided to address planning for chemicals that cause these other toxic effects. It should be noted that even substances that are relatively less toxic may pose a hazard if they become airborne in large quantities.

Hazards other than toxicity (e.g., fire, explosion, and reactivity) that may be associated with both EHSs and other substances should be considered in emergency preparedness and response planning and are discussed briefly in Appendix F. In many cases, emergency response agencies such as fire departments may have already addressed these types of hazards. Hazards other than toxicity will be considered in future revisions to the list of EHSs.

2.1.2 Procedures for Hazards Identification

Hazards identification begins with the identification of the facilities that have EHSs in the community. Mandatory reporting by facilities, under Title III, will now identify those facilities that possess one or more of the EHSs in excess of its TPQ. In addition, because considerable information on the properties, amounts, and conditions of use of EHSs is needed to prepare reliable emergency plans, Title III specifically states: "the owner or operator of the facility shall promptly provide information to such committees necessary for developing and implementing the emergency plan" (Section 303(d)(3)). Supplemental information on the quantity and location of hazardous chemicals will

become available in March of 1988, fulfilling requirements under Sections 311 and 312, Title III of SARA. Facility inspections will remain important information-gathering activities for local planners, as well as for safety and emergency response personnel who must establish accident prevention programs and pre-emergency plans. Other information available from the site may include facility hazard assessments, facility safety audits, spill prevention and control countermeasures (SPCC), and probability-based risk assessments (PRAs). Although hazards identification should also include identification of transportation routes through the community for EHSs, this information will not be reported under Title III of SARA.

This section will discuss how to obtain information on EHSs and the types of facilities that are engaged in manufacturing, processing, storing, handling, selling, and transporting EHSs. This section also briefly discusses sources of information on other hazardous substances.

Extremely Hazardous Substances

EHSs present in quantities above their TPQ will be identified for the Local Emergency Planning Committee (LEPC) by the reporting facilities. However, EHSs in quantities below the TPQ could also present a hazard to the community under certain circumstances and the LEPCs may wish to include them in their hazards analysis. As noted in Section 1.5.3, Title III of SARA includes the following provisions concerning EHSs:

- If a facility has one or more chemicals from the current list of EHSs in quantities exceeding its TPQ, it must report this fact to the State emergency response commission (SERC).
- The committee can obtain from the facility information on what chemicals are present and in what amounts. The facility emergency coordinator will be the primary source of information. The specific chemical identity of an EHS may sometimes be withheld as a trade secret. Even when the chemical identity is held confidential, however, certain information on the specific chemical is important for subsequent steps in hazards analysis and will be provided by the facility.

The following points should be discussed with facility representatives to obtain information for hazards identification:

- Chemical identity, including chemical name and Chemical Abstract Service (CAS) number for substances not claimed as trade secret;
- Quantities of EHSs normally present, including:
  (1) Total quantity of each EHS at the facility. The quantity of chemical can vary from day to day depending on operations. Planners should determine the amount that is typically on hand on any given day. This information is necessary to assess the potential impact should an accident involving this quantity occur.
  (2) Maximum quantity that could be present in each storage or processing location. Facilities may use the same chemical in many different locations and have the capacity to store more than what is typically on hand. Planners need to determine the maximum quantity, even though the facility may rarely have this much on-site. Hazards associated with the maximum quantity may be much different than the hazards associated with the typical quantity. These differences need to be addressed by planners.
  (3) Configuration of storage, including the maximum potential quantity in a single storage or processing vessel. Some facilities handle quantities of chemicals in isolated storage vessels while others may have two or more interconnected vessels to allow greater flexibility in the use of storage capacity. It is possible that an accident involving one vessel will involve the inventory in another if they are interconnected. The maximum potential quantity in a single vessel or group of interconnected vessels must be known to estimate the impact of an accidental release (see "vulnerability analysis" in Section 2.2).

- If the chemical identity is held confidential, information about certain properties of the substance will be provided by the facility to allow a hazards analysis to proceed, including:
  (1) Physical state. At ambient conditions (room temperature and atmospheric pressure) is the chemical a gas, liquid, or solid? If solid, is it powdered (with less than 100 micron particle size), in solution, or molten?
  (2) Approximate vapor pressure (in millimeters of mercury or atmospheres), if the substance is a liquid or is a solid handled in molten form. For the liquid, the vapor pressure at handling temperature should be obtained, while the vapor pressure at the melting point should be obtained for the molten solid.
  (3) Approximate level of concern (LOC) (the concentration of EHS in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time). The approximate concentration in air that equals the LOC in grams per cubic meter is needed in the vulnerable zone analysis (see Appendices C and D).

  The approximate values provided should be sufficiently close so as not to significantly alter the size of the estimated zones (see Section 2.2).
- Conditions under which the chemicals are processed, handled, or stored, including:
  (1) Temperature. Facilities may keep certain substances at temperatures other than ambient depending on their use.
  (2) Pressure. Some substances must be stored under pressure (e.g., liquefied gases)
  (3) Other unique features of the handling systems employed to manufacture, process, store, use or otherwise handle the substance at the facility. This information is useful for the risk analysis portion of the hazards analysis. See Appendix J for more information. Note that some of this information might be held as trade secret by the facility. Planners should work closely with facility representatives to obtain information necessary for emergency plan development.

Exhibit 2-1 presents several chemicals from the list of EHSs and some types of facilities other than chemical plants where these chemicals might be present in quantities exceeding the TPQ. Some of the EHSs in the exhibit might be found in other types of facilities in smaller quantities (e.g., chemicals in laboratories).

Hazardous materials, including EHSs, are also transported through, by, or over communities by highway vehicles, rail cars, watercraft, and aircraft virtually 24 hours a day. Shipments may range from less than a pound to thousands of pounds of material. Because transporters are not required to report under SARA Sections 302 and 303, identification of routes through a community over which EHSs are transported will be more difficult than the identification of fixed facilities. Nevertheless, transportation routes and transported chemicals should be identified if possible.

The experience gained through Department of Transportation (DOT) pilot planning projects demonstrates that identification of transportation hazards for emergency planning can be done by gathering information directly at the community level (see Hazardous Materials Transportation: A Synthesis of Lessons Learned from the DOT Demonstration Project). Useful information may be collected with assistance from representatives of trucking, rail, air freight, and shipping industries. Facility representatives may be able to provide data on the shipping and transfer of EHSs, although this approach will identify only those transported materials destined for local facilities. The following points could be discussed with facility representatives:

- Frequency of shipments (daily, weekly, irregular schedule);
- Form of shipment (tank truck, tank car, drums, boxes, carboys in trucks or vans, pipelines, barges);

Exhibit 2-1

Types of Facilities where Certain Extremely Hazardous Substances Might be Found in Quantities Greater than their TPQs

Type of Facility	Extremely Hazardous Substance (TPQs in parentheses)				
	Ammonia (100 lbs)	Chlorine (100 lbs)	Sulfuric Acid (500 lbs)	Phosgene (10 lbs)	Aldicarb* (100 lbs/ 10,000 lbs)
Blueprinting Facilities	X		X		
Bulk Storage Facilities	X		X		
Farms	X				X
Frozen Food Processing Facilities	X				
Pesticide Distributors					X
Processing Plants/ Formulators	X	X	X	X	
Plumbing, Heating, and Air Conditioning Companies	X				
Pulp and Paper Plants		X	X		
Retail Stores	X				
Swimming Pools		X			
Warehouses	X		X		X
Water Treatment Facilities		X	X		

**TPQ for Aldicarb is 100 pounds for fine powders or solutions 10,000 pounds otherwise*

- Quantity of shipments (tons; gallons; number of drums, tanks, vats or carboys); and
- Transportation routes through the community (highways, railroads, pipelines).

The Hazardous Materials Transportation Act (HMTA) establishes DOT as the responsible agency for guidance on routing controls. Proposed changes in routes should be made in accordance with the Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials, DOT FHWA 1980.

Other Hazardous Materials

Planners can apply the toxicity criteria used by EPA for the list of EHSs (see Appendix B) to determine whether other chemicals at facilities in the area qualify as EHSs even though they are not listed as such under the Federal regulations. Planners may also want to obtain information on transportation of other hazardous materials, as described above for EHSs. The discussion points listed in the previous section on EHSs could also be raised with facility representatives and transportation industry representatives with reference to other hazardous substances.

Hazardous materials can be found throughout most communities in several types of sites and facilities. Besides obvious sites and facilities (e.g., flammable liquid storage tanks, gasoline stations, chemical supply companies), hazardous materials are likely to be found at other places, see Exhibit 2-1 (e.g., dry cleaners, auto body shops, hospitals, and construction sites).

Information on hazards other than toxicity associated with the chemicals on the list of EHSs may be obtained from the EPA Chemical Profiles. Flammability and reactivity data on many other chemicals are available in the Fire Protection Guide on Hazardous Materials developed by the National Fire Protection Association (NFPA). The Hazardous Materials Table (49 CFR 172), developed by DOT, classifies hazardous materials in transportation by the type of hazards they present. (See also the DOT Hazardous Materials Table in the Proposed Rule of November 6, 1987, Federal Register, Vol. 52, No. 215, pp. 42787-42931.) Planners might want to use those chemicals listed by the NFPA with the highest flammability and reactivity ratings, and those listed by DOT in certain hazard classes, as a starting point for identification of these types of hazards in the community. The United Nations publication, Recommendations on the Transport of Dangerous Goods, is also a useful source of information. Another source of information on many chemicals is the Coast Guard's Chemical Hazards Response Information System (CHRIS) hazardous chemical data base.

2.1.3 Summary of Useful Information Resulting from Hazards Identification

At the conclusion of the hazards identification step of hazards analysis, planners should have the following information:

- A list of EHSs present at facilities in the district in quantities exceeding the TPQ; the properties of these EHSs; and where, in what quantity, and under what conditions they are used, produced, processed, or stored. Mixtures of chemicals will be reported if the portion of EHS in the mixture is equal to or greater than one percent and more than the TPQ.
- Information on chemicals claimed as trade secret, including physical state, approximate vapor pressure of liquids and molten solids, and approximate LOC as defined in this guidance.
- Routes used for transportation of EHSs through the planning district.

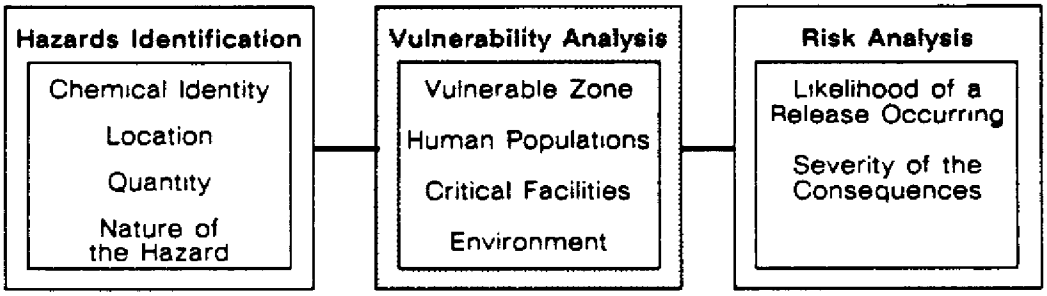
In addition, although it is not presently required to meet the statutory requirements for emergency plan development under Title III of SARA, planners may obtain the following information during hazards identification if necessary for developing and implementing an emergency plan:

- A list of EHSs present in quantities less than the TPQ and where, in what quantity, and under what conditions they are used, produced, processed, or stored.
- Hazards besides airborne toxicity posed by the EHSs in the community.
- Chemicals other than those listed that meet the acute lethality criteria.

- A list of other hazardous chemicals and where, in what quantity, and under what conditions they are used, produced, processed, or stored; and the type of hazard they pose
- Routes used for transportation of other hazardous materials through the community.

Exhibit 2-2 summarizes the types and sources of information obtained during hazards identification.

2.2 Vulnerability Analysis for Airborne Hazardous Substances



Vulnerability analysis is the second part of the three-part hazards analysis. This section outlines a process that can be used in performing a vulnerability analysis for facilities that have chemicals on the Section 302 list of extremely hazardous substances (EHSs) and transportation routes used for transporting these substances to and from the fixed facilities or through the communities. (The facilities and transportation routes should be identified as described in Section 2.1).

The vulnerability analysis will provide information that will be helpful in fulfilling planning requirements under Title III of SARA. This information includes:

- An estimation of the vulnerable zone for each EHS reported and the conditions and assumptions that were used to estimate each vulnerable zone;
- The population, in terms of numbers and types (e.g., neighborhood residents; high density transient populations such as workers and spectators in auditoriums or stadiums; sensitive populations in hospitals, schools, nursing homes, and day care centers) that could be expected to be within the vulnerable zones; and
- Essential service facilities such as hospitals, police and fire stations, emergency response centers, and communication facilities.

Although this guide is primarily concerned with the impact of EHSs on the surrounding human population, planners may also choose to consider as part of their vulnerability analysis the private and public property (e.g., homes, schools, hospitals, businesses, offices) that may be affected, including essential support systems (e.g., water, food, power, medical), as well as sensitive environments (e.g., drinking water supplies, food crops, or animal habitats). Consideration of property and sensitive environments may be particularly important for chemical releases that pose hazards other than those associated with acute toxicity. Planners can refer to community emergency services (e.g., fire departments, police departments, hospitals) for assistance in obtaining information about the population and essential services within the vulnerable zone.

2.2.1 General Description of Estimation of Vulnerable Zones

For purposes of this guidance, a vulnerable zone is an estimated geographical area that may be subject to concentrations of an airborne EHS at

Exhibit 2-2

INFORMATION FROM HAZARDS IDENTIFICATION

Essential Information	Source of Information
• Facilities in community with EHSs in quantities exceeding the TPQ	Facilities must report to SERC information will be made available to LEPC's
• Identity of EHSs in community	Facility emergency coordinator
• Quantity of EHSs present	Facility emergency coordinator
• Transportation routes for EHSs	Facility emergency coordinator, representative of transportation industries
Other Useful Information	
• Identity and location of other acutely toxic chemicals	Information to be provided now under Section 303 (d)(3) and in the future under Sections 311, 312, and 313 of SARA; facility emergency coordinators
• Information on hazards other than toxicity of EHSs	EPA Chemical Profiles; facility emergency coordinators
• Information on other hazardous substances, including:	Information to be provided now under Section 303 (d)(3) and in the future under Sections 311, 312, and 313 of SARA; community sources
○ Identity ○ Location ○ Quantity ○ Hazards	
○ Transportation routes	Representatives of transportation industries and facilities receiving shipments of chemicals

levels that could cause irreversible acute health effects or death to human populations within the area following an accidental release. Vulnerable zones are based on estimates of the quantity of an EHS released to air, the rate of release to air, airborne dispersion, and the airborne concentration that could cause irreversible health effects or death. Release and dispersion methodologies are not precise and provide only estimates of the actual distances and areas that may be affected by an accidental release. Many methods are available to evaluate both releases and airborne dispersion. They vary in their assumptions and therefore the results obtained may differ. The dispersion models selected for this guidance are described in Appendix G.

At the time of an accidental release, with the wind generally moving in one direction, the area affected by a release is the area downwind only. Because the wind direction at the time of an actual accidental release cannot be predicted, planners must consider all possible wind directions and subsequent plume paths. (A plume is the cloud formation of airborne chemical that results from a release (Exhibit 2-3).) Consequently, the estimated vulnerable zones are circles with the potential release site located at the center (Exhibit 2-4). Because it is not possible to predict the exact location of a transportation accident, the estimated vulnerable zone for potential releases associated with transportation of an EHS is a "moving circle" or corridor (Exhibit 2-5).

The size of an estimated vulnerable zone depends upon the distance the airborne chemical travels before it disperses and is diluted in the air to a concentration below a "level of concern" (see subsection D below) for acute health effects or death. This distance depends on several variable factors.

2.2.2 Variables in Estimating Size of Vulnerable Zones

Many of the variables are very complex and it is beyond the scope of this document to discuss them all in detail. In addition many do not have a significant impact on the size of estimated vulnerable zones given the imprecise nature of these assumptions. The major factors affecting the size of a vulnerable zone for emergency planning are described below.

A. Quantity and Rate of Release to Air

Not all of a released chemical will necessarily become airborne. The quantity that actually becomes airborne and the rate at which it becomes airborne depend upon:

- Total quantity released or spilled;
- Physical state (solid, liquid, gas); and
- Conditions (e.g., temperature, pressure) under which the chemical is stored or handled.

Gases typically become airborne more readily than liquids. Liquids or molten solids generally become airborne by evaporation. The rate at which they become airborne (rate of volatilization) depends on their vapor pressure, molecular weight, handling temperature, the surface area of the spill (pool size), and the wind speed at the time of the spill. A spilled liquid with a higher vapor pressure will become airborne (through evaporation) more rapidly than a spilled liquid with a low vapor pressure at the same temperature. Also, a liquid will evaporate faster if the surface area or pool size of the spill is increased, if the liquid has a higher than ambient temperature, and if it is exposed to greater wind speeds. Molten solids will volatilize much faster than those in solid state. Solids as powders are likely to become airborne only if propelled into the air by force (e.g., by an explosion or the loss of air filtration in a pneumatic conveying system). Solids that are not powdered are less likely to become airborne.

The size of an estimated vulnerable zone is proportional to the quantity and rate of release. Smaller release volumes based on similar assumptions will yield lower release rates which will reduce the size of the estimated vulnerable zone.

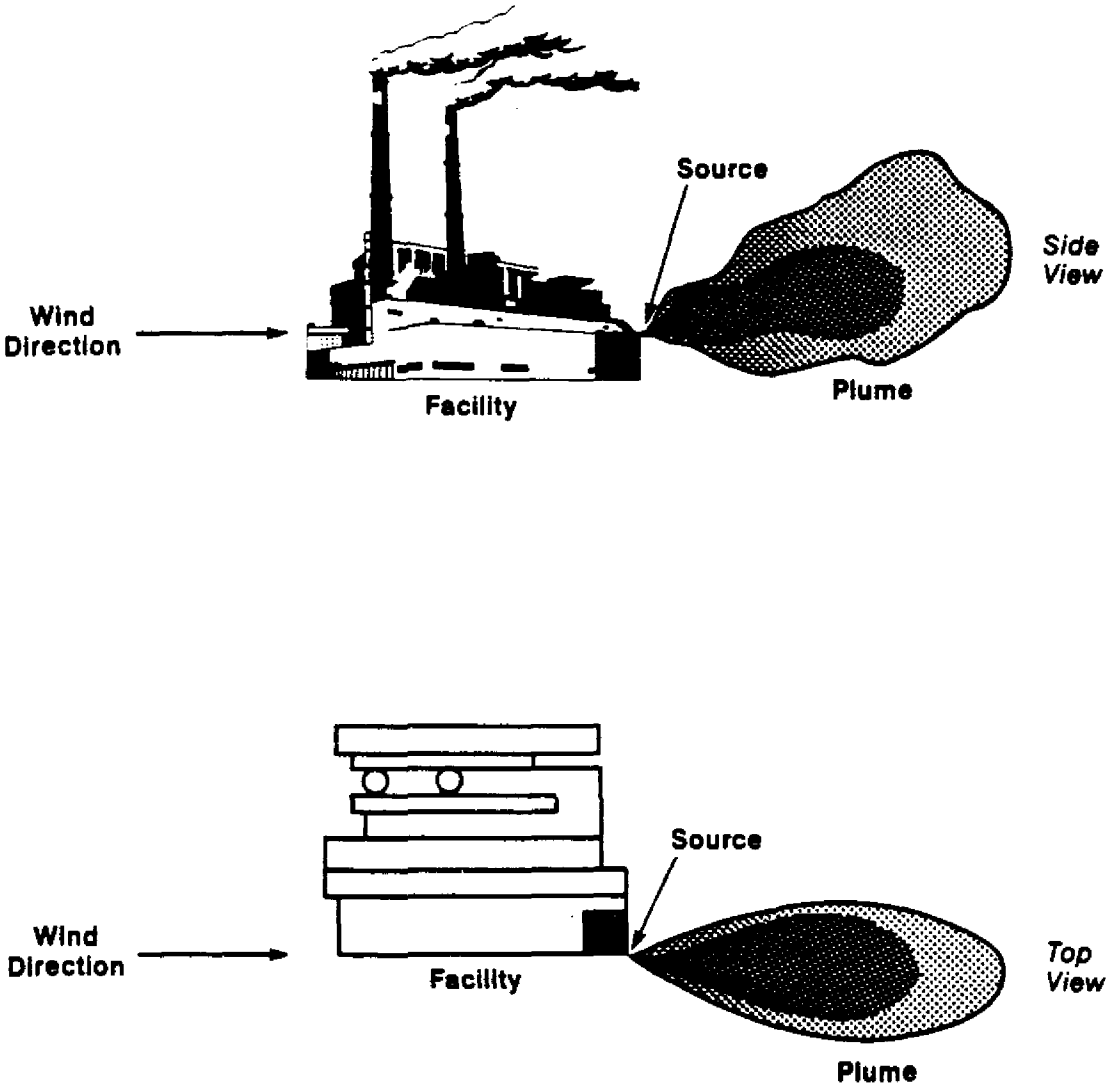
The application of these variables in the vulnerable zone estimate will be discussed later in this chapter and also in Chapter 3. For more information on the calculations and derivations related to these variables, see Appendix G.

B. Meteorological Conditions

Among the many meteorological factors, wind speed and atmospheric stability have the greatest effect on the size of estimated vulnerable zones. Increased wind speed and the

Exhibit 2-3

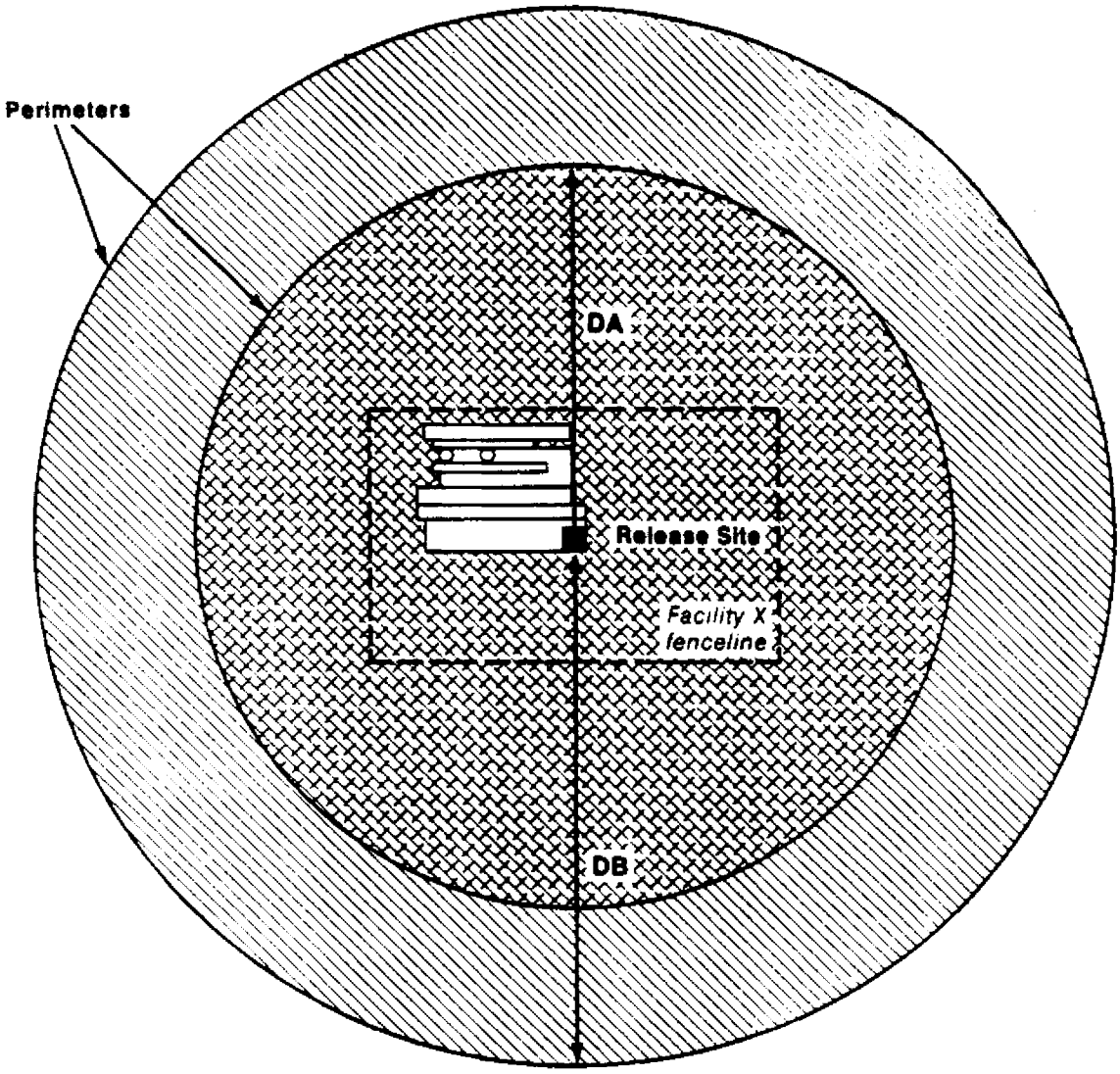
The Movement Downwind of a Plume of an Airborne Extremely Hazardous Substance Following an Accidental Release.



Note: Plume moves in the same direction as wind and tends to become longer and less concentrated as it moves downwind. This is due to the dispersion of the extremely hazardous substance in air.

Exhibit 2-4

Vulnerable Zones for Community Planning Resulting from Airborne Releases of Chemicals A and B



Estimated vulnerable zone for Chemical A

Estimated vulnerable zone for Chemical B

DA - Distance from release site to the point at which the airborne chemical concentration equals the level of concern for Chemical A

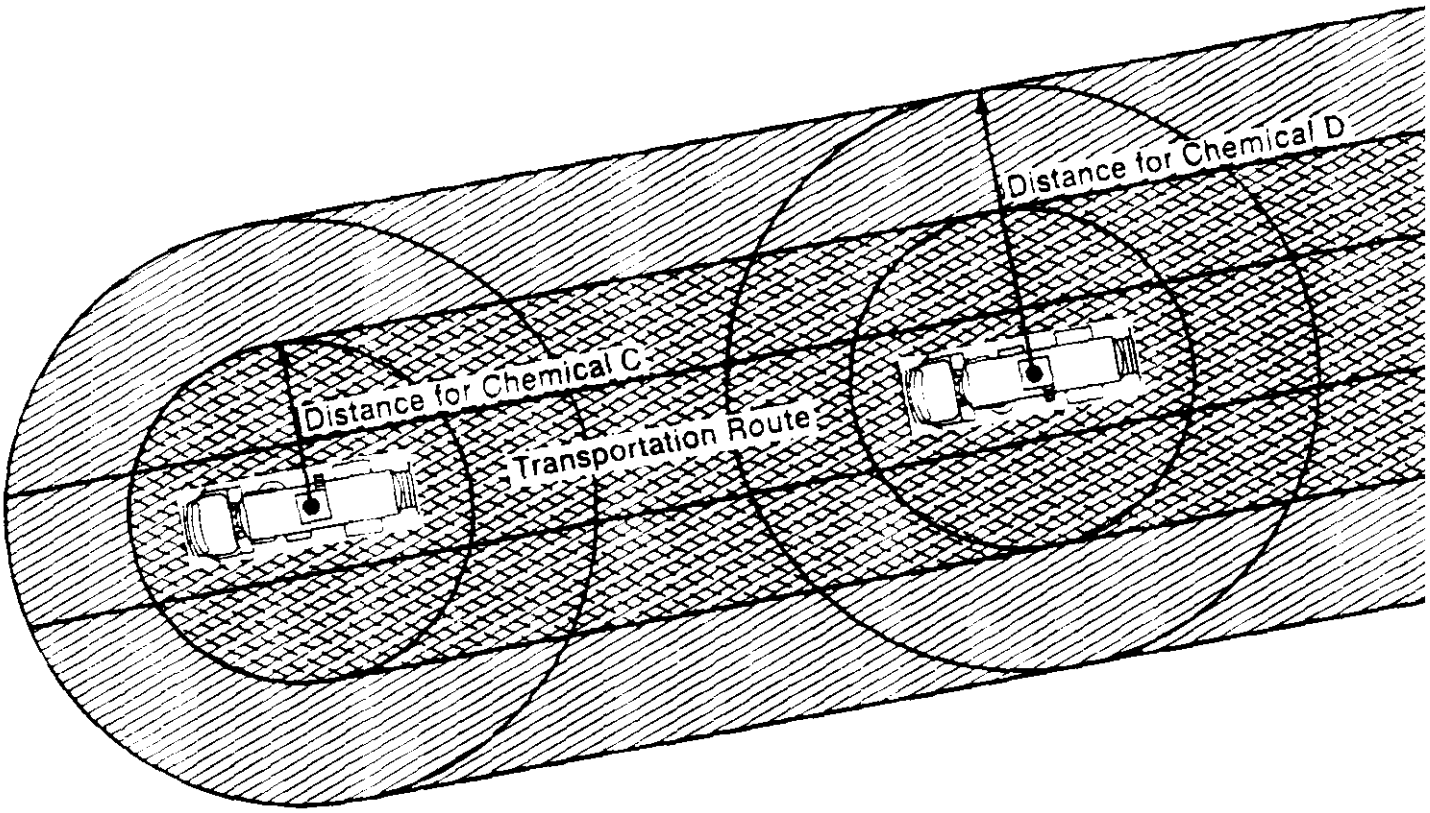
DB - Distance from release site to the point at which the airborne chemical concentration equals the level of concern for Chemical B

Note: Differences in the estimated vulnerable zones of Chemical A and Chemical B under identical meteorological conditions may be due to amount released, rate of release to air (volatilization rate), level of concern, or any combination of these variables.

For purposes of planning the vulnerable zone is expressed as a circle since the wind direction at the time of an actual release is not known. Under conditions of an accidental release, the area enveloped by a plume will represent only a portion of the circle.

Exhibit 2-5

Vulnerable Zones along a Transportation Route When Airborne Releases of Chemicals C and D Occur



Estimated vulnerable zone for Chemical C

Estimated vulnerable zone for Chemical D

Note: Transportation route would also be considered part of the estimated vulnerable zone.

accompanying decreased atmospheric stability will result in greater airborne dispersion (and dilution) of a chemical, and a resultant decrease in the size of the estimated vulnerable zone. Additional information on these meteorological variables is presented in Appendix G.

C. Surrounding Topography

The topography of the area surrounding a potential release site will affect the size of the estimated vulnerable zones.

The principal topographical factors are natural obstructions such as hills and mountains, and man-made structures such as high-rise buildings. Natural formations and surface conditions are always site-specific and therefore beyond the scope of this guidance. If significant natural barriers exist within estimated vulnerable zones, appropriate technical support should be solicited from local, State, or EPA Regional meteorologists or experts in the private sector including the facility. On the other hand, general methodologies do exist for describing the dispersion of chemical substances in urban areas containing high buildings and in flat, rural areas. The methodology for estimating vulnerable zones in urban and rural areas is discussed later in this chapter and is presented in Chapter 3.

D. Levels of Concern

A level of concern (LOC), for purposes of this document, is defined as the concentration of an EHS in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time.

There is at present no precise measure of an LOC for the chemicals listed as EHSs. Various organizations over the past several years have been developing acute exposure guidelines for a limited number of hazardous chemicals; the methodology, however, is still under development. The preliminary guidelines and the progress to date are described in detail in Appendix D. Until more precise measures are developed, surrogate or estimated measures of the LOC have been identified for the listed EHSs. Local officials may choose values for the LOC different from those estimated in this guidance, depending upon their requirements, the specific characteristics of the planning district or site, and the level of protection deemed appropriate. Extreme caution and prudence should be exercised when choosing an LOC.

For the purposes of this guidance, an LOC has been estimated by using one-tenth of the "Immediately Dangerous to Life and Health" (IDLH) level published by the National Institute for Occupational Safety and Health (NIOSH) or one-tenth of an approximation of the IDLH from animal toxicity data. Other exposure guidelines that may be used to estimate LOC include the "Threshold Limit Value" (TLV) published by the American Conference of Governmental Industrial Hygienists (ACGIH), guidelines developed by the National Research Council (NRC) of the National Academy of Sciences (NAS), and Emergency Response Planning Guidelines (ERPGs) under development by a consortium of chemical companies. These values are discussed and listed in Appendix D. The use of LOC in the vulnerable zone estimate is discussed later in this chapter and in Chapter 3.

2.2.3 The Relationship of Estimated Vulnerable Zones to Actual Releases

The estimated vulnerable zones are shown as circles with different radii in Exhibits 2-6 and 2-7 to illustrate how changing conditions or assumptions can influence the vulnerable zone estimate. At the time of an accidental release, only some portion of the estimated vulnerable zone will actually be involved. The specific area covered by the plume will be determined principally by wind direction and the degree of dispersion of the plume. The area through which the plume moves is generally referred to as a plume "footprint." Exhibit 2-8 shows the plume footprint for the release of a sample chemical substance. Note that the actual concentration of the airborne chemical tends to decrease as it moves further downwind from the release site because of continual mixing and dilution (dispersion) of the chemical with air. Note also that the plume movement is affected by the speed of the wind.

Although a footprint represents the area enveloped by a plume, it is not possible to predict with any high degree of accuracy the wind direction and wind speed. Therefore the direction and shape which the plume may take at the time of an accidental release is not known in advance.

Exhibit 2-6

The Effect of Different Assumptions on the Calculation of the Radius of Estimated Vulnerable Zones

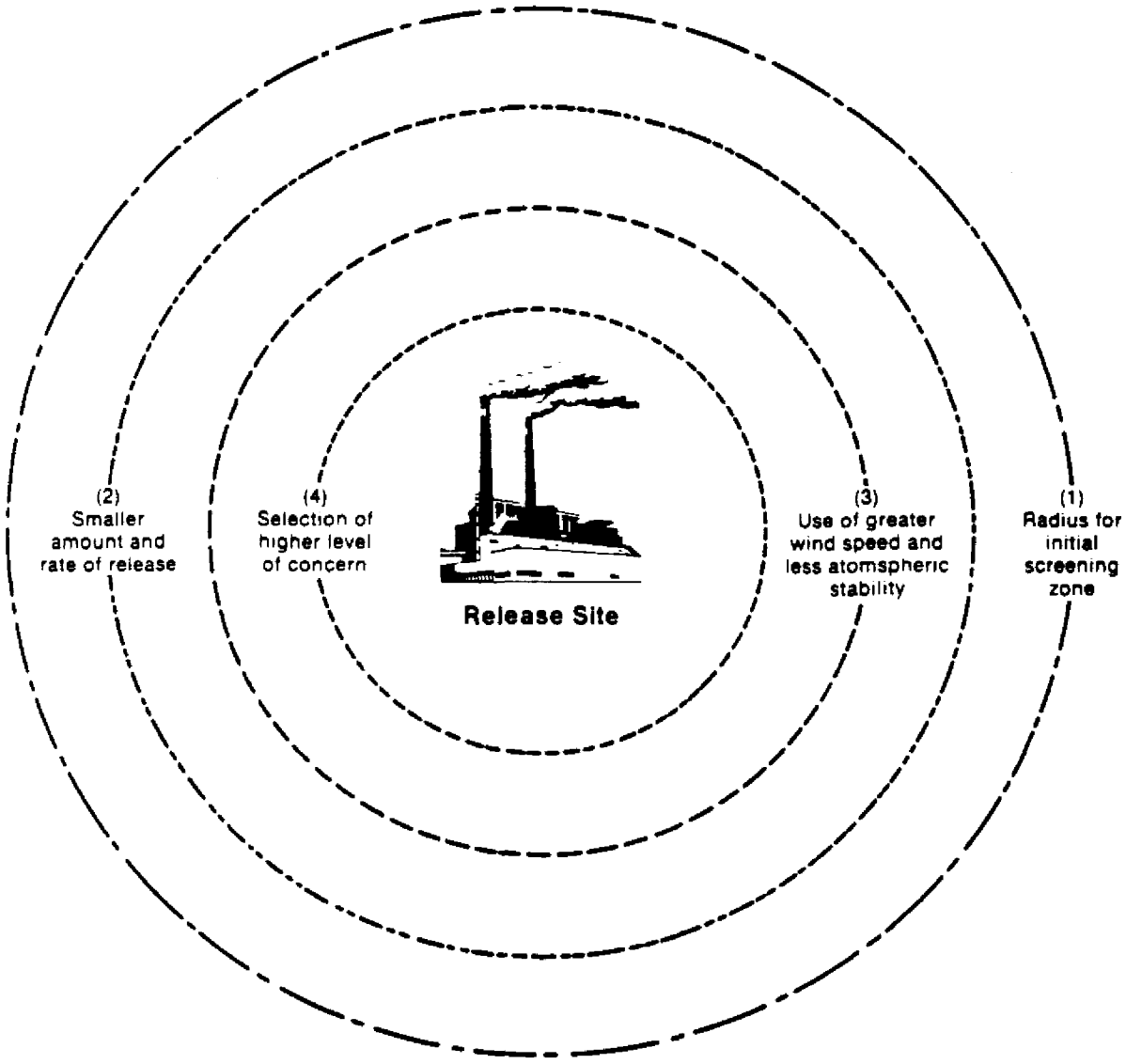


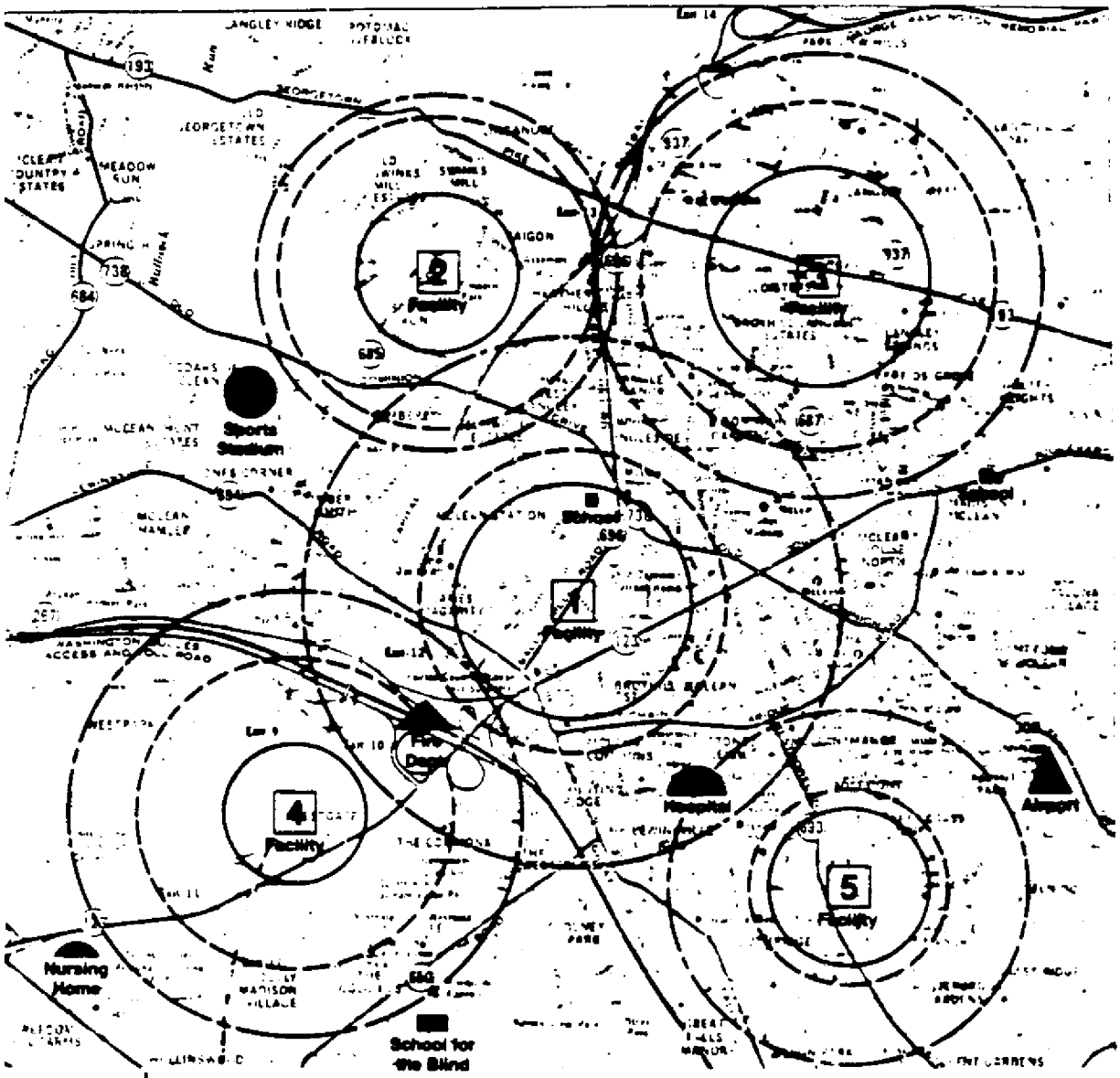
Diagram not drawn to scale.

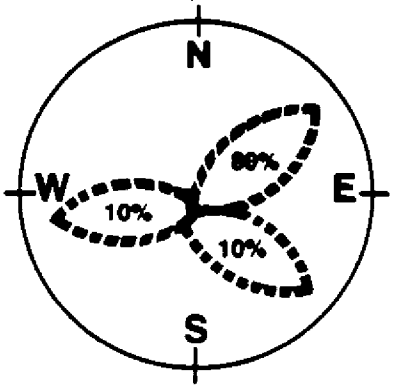
The effect of altering major assumptions on the downwind distance (radius) of the estimated vulnerable zone. Calculations made using (1) credible worst case assumptions for initial screening zone (2) reevaluation and adjustment of quantity released and/or rate of release of chemical (3) reevaluation and adjustment of wind speed (increase) and air stability (decrease) (4) selection of a higher level of concern. Note that adjustment of two or more variables can have an additive effect on reducing the size of the estimated vulnerable zone.

Note also that the relative sizes of the altered zones are not to scale (e.g., choosing a higher value for the level of concern does not always result in a smaller zone than the use of greater wind speed and less atmospheric stability.

Exhibit 2–7

Vulnerable Zones for Five Facilities in a Hypothetical Community





Wind rosette indicates % of time wind typically blows in that direction

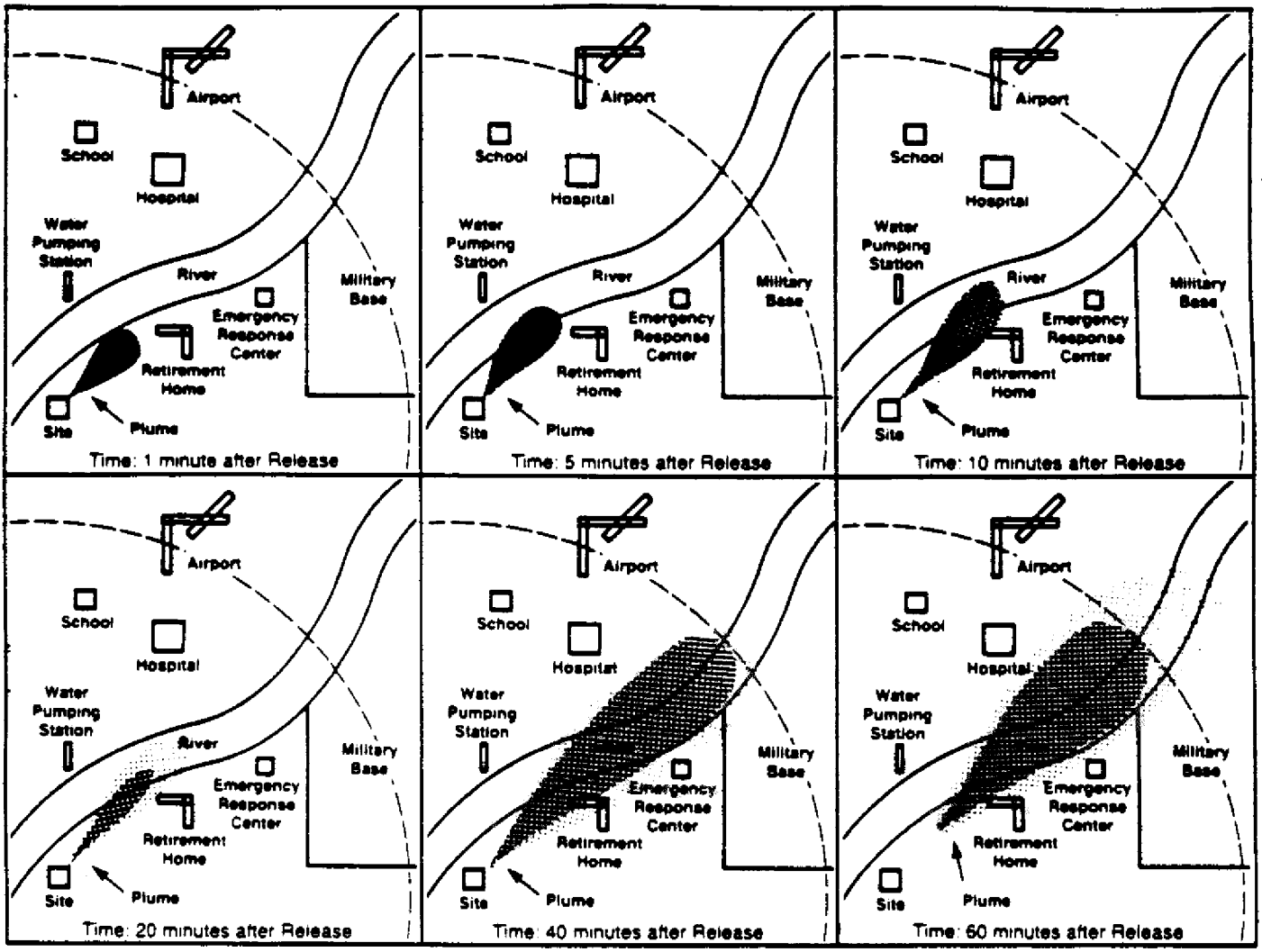
—— Estimated initial screening zones based on credible worst case assumptions

—— Changes in assumptions for meteorological conditions more characteristic of a specific community

—— Changes in other initial screening assumptions (variables) based on reevaluation of assumptions and conditions

Exhibit 2–8

Plume Development and Movement during a Hypothetical Accidental Release



perimeter of the estimated zone beyond which the airborne concentration of the chemical is below the level of concern

Note: As the plume dissipates, the gas becomes less concentrated. The shading of the plume indicates its concentration: the darker the plume, the more concentrated the gas is. This plume represents a neutrally buoyant gas with constant wind speed and direction. Release duration is 45 minutes.

Note also, that although the plume moves beyond the perimeter of the estimated vulnerable zone, the concentration of the chemical in the air is below the level of concern at that distance and beyond.