OAK RIDGE
NATIONAL LABORATORY

MANAGED BY UT-BATTELLE
FOR THE DEPARTMENT OF ENERGY

ORNL/TM-2000/342

Interim Report on Lessons Learned from Decontamination Experiences

Prepared for Fall Thrust Meeting, November 16, 2000

John H. Sorensen
Barbara Muller Vogt

UT-BATTELLE

ORNL-27 (4-00)

ORNL/TM-2000/342

INTERIM REPORT ON
LESSONS LEARNED FROM DECONTAMINATION EXPERIENCES

PREPARED FOR
FALL THRUST MEETING, NOVEMBER 16, 2000

John H. Sorensen
Barbara Muller Vogt
Oak Ridge National Laboratory

Date published—November 2000

Prepared for the

U.S. Department of Energy
Chemical and Biological National Security Program

Prepared by

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
Managed by
UT-BATTELLE, LLC
For the
U.S. DEPARTMENT OF ENERGY
under contract No. DE-AC05-00OR22725

CONTENTS

ABSTRACT v

LIST OF ACRONYMS AND ABBREVIATIONS vii

1. INTRODUCTION 1
   - 1.1 OBJECTIVES 1
   - 1.2 ORGANIZATION OF THE REPORT 1
   - 1.3 BACKGROUND 2

2. METHODS 5
   - 2.1 DATABASE DEVELOPMENT 5
   - 2.2 BIBLIOGRAPHIC RESOURCES 5
   - 2.3 INFORMATION COLLECTION PROTOCOL 6
   - 2.4 INITIATION OF INVESTIGATIONS 6

3. LITERATURE REVIEW 7
   - 3.1 BIOLOGICAL 7
     - 3.1.1 Building Decontamination 7
     - 3.1.2 People Decontamination 8
   - 3.2 CHEMICAL 9
     - 3.2.1 Building Decontamination 9
     - 3.2.2 People Decontamination 12
   - 3.3 CROSS CUTTING ISSUES 13
     - 3.3.1 Types of Decontamination 14
     - 3.3.2 Model Procedures 14
     - 3.3.3 Children 15
     - 3.3.4 Policy Issues 15
     - 3.3.5 Wastewater 15
     - 3.3.6 Personal Protective Equipment 16
     - 3.3.7 Decontamination Solution 16
     - 3.3.8 Secondary Contamination 16
     - 3.3.9 Decontamination Effectiveness 16
     - 3.3.10 Epidemic Hysteria 17
   - 3.4 GENERAL FINDINGS FROM THE LITERATURE REVIEW 17

4. CASE STUDY SUMMARIES 19
   - 4.1 CASE STUDY 1. SPILL AT AIRBORNE EXPRESS DISTRIBUTION FACILITY IN NEWTON, MA 19
     - 4.1.1 Background 19
     - 4.1.2 Incident Timeline, Response and Consequences 20
     - 4.1.3 Findings 20
   - 4.2 CASE STUDY 2. SPILL AT CHEMICAL PLANT IN TWIN CITY, GEORGIA 21

4.2.1 Background 21
4.2.2 Incident Timeline, Response, and Consequences 21
4.2.3 Findings 22
4.3 CASE STUDY 3. PCB RELEASE AT COMMERCE BUILDING, WASHINGTON, DC 23
4.3.1 Background 23
4.3.2 Incident Timeline, Response and Consequences 23
4.3.3 Findings 25
4.4 CASE STUDY 4. MERCURY RELEASED IN ELEMENTARY SCHOOL 26
4.4.1 Background 26
4.4.2 Incident Timeline, Response, and Consequences 26
4.4.3 Findings 27
4.5 CASE STUDY 5 WORKERS EXPOSED AT LAWN AND GARDEN TREATMENT PRODUCT COMPANY 27
4.5.1 Background 28
4.5.2 Incident Timeline, Response, and Consequences 28
4.5.3. Findings 29
4.6 CASE STUDY 6 MERCURY RELEASE AT INTERNATIONAL AIRPORT POSTAL HUB 29
4.6.1 Background 29
4.6.2 Incident Timeline, Response, and Consequences 30
4.6.3 Findings 31
4.7 CASE STUDY 7. INADVERTENT MIXING OF CHEMICAL INTO SULFURIC ACID CREATED TOXIC FUMES 31
4.7.1 Background 31
4.7.2 Incident Timeline, Response, and Consequences 31
4.7.3 Findings 32
4.8 GENERAL FINDINGS FROM CASE STUDIES 32

5. CONCLUSIONS 35
5.1 GENERAL FINDINGS 35
5.2 POLICY RECOMMENDATIONS 35
5.3 RESEARCH RECOMMENDATIONS 36

6. FUTURE OUTLOOK 37

7. REFERENCES 39

8. BIBLOGRAPHY 43

ABSTRACT

This interim report describes a DOE project currently underway to establish what is known about decontamination of buildings and people and the procedures and protocols used to determine when and how people or buildings are considered "clean" following decontamination. To fulfill this objective, the study systematically examined reported decontamination experiences to determine what procedures and protocols are currently employed for decontamination, the timeframe involved to initiate and complete the decontamination process, how the contaminants were identified, the problems encountered during the decontamination process, how response efforts of agencies were coordinated, and the perceived social psychological effects on people who were decontaminated or who participated in the decontamination process. Findings and recommendations from the study are intended to aid decision-making and to improve the basis for determining appropriate decontamination protocols for recovery planners and policy makers for responding to chemical and biological events.

LIST OF ACRONYMS AND ABBREVIATIONS

ARIP	Accidental Release Information Program
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIRC	Chemical Incident Reports Center
CSB	Chemical Safety Board
DHHS	Department of Health and Human Services
DOE	U.S. Department of Energy
EMA	Emergency Management Agency
EMS	Emergency Management System
EPA	U.S. Environmental Protection Agency
ERNS	Emergency Response Notification System
FBI	Federal Bureau of Investigations
FEMA	Federal Emergency Management Agency
ft^2	square feet
GAEMA	Georgia Environmental Protection Agency
GSA	General Services Administration
HVAC	heating, ventilating, and air conditioning
HAZMAT	hazardous materials
lb	pound(s)
m^3	cubic meters
mg	milligram
MSDSs	Material Safety Data Sheets
NCEH	National Center for Environmental Health
ng/m^2	nanogram per square meter
NIH	National Institutes of Health
NRC	National Response Center National Research Council
NTBS	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
PCDD	polychlorinated dibenzodioxins
PPE	personal protective equipment
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
TCDD	tetrachlorodibenzo-p-dioxin
USAMRID	U.S. Army Medical Research Institute of Infections Diseases

1. INTRODUCTION

Every year the United States experiences hundreds of chemical-related accidents that release toxic substances into the environment. Most events are handled as routine incidents involving the appropriate emergency agencies and hazardous materials response teams (HAZMAT). Many of the incidents expose people and facilities to hazardous chemicals and require extensive decontamination of people at the site of the incident or at a medical facility and temporary or permanent closure of structures until it is determined the building is safe to reoccupy. How reentry and decontamination decisions are made and what the consequences are for people and structures involved are the foci of this study.

1.1 OBJECTIVES

The main objective of this research is to examine historical and current incidents in which people or buildings were decontaminated in order to gain a better understanding of the interplay between scientific, social, and policy issues regarding decontamination. By examining protocols and criteria regarding reentry, the need to perform decontamination, and the standards set for reentry or public safety, we sought to identify critical issues/factors that require further research or policy formation. The question of "how clean is safe" is more than a technical or logistical issue, it has profound critical social and political dimensions that need to be considered in policy setting, emergency planning, and response procedures. We sought to identify how the current lack of scientifically validated standards affected decontamination decision making. We intend to use the findings from this research to better define the critical parameters that will facilitate an effective and timely response to a chemical or biological warfare agent event.

The study was designed to systematically examine reported decontamination experiences to determine

- what procedures and protocols are currently employed for decontamination,
- the timeframe involved to initiate and complete the decontamination process,
- how the contaminants were identified,
- the problems encountered during the decontamination process,
- how response efforts of agencies were coordinated, and
- the perceived social and psychological effects on people who were decontaminated.

Findings from the study are intended to aid decision-making and to improve the basis for determining appropriate decontamination protocols for recovery planners. Further, the study should identify issues needed to be addressed by policy decision-makers in areas involving response and recovery to chemical and biological events.

1.2 ORGANIZATION OF THE REPORT

The report is organized as follows. After presenting a background for this study, the report discusses the methods used to conduct the research. This includes discussions of database development, collection of bibliographic information, development of a data collections protocol, and the approach to conducting the case studies. Section 3 presents a concise review of literature. We have distinguished between biological and chemical agents where appropriate and decontamination of people and buildings when possible. This is followed by reviewing findings on ten cross-cutting topics including types of decontamination model procedures, children, policy issues, wastewater, personal protective equipment, solutions, secondary contamination, effectiveness and epidemic hysteria. This section concludes with the identification of general findings. The bibliography is organized in a similar manner. The next section summarizes the seven case studies conducted to date (Table 1). For each we present a background, incident timeline, response and consequences. Findings specific to the study are also provided. The section concludes with a presentation of the general finding. The next section presents our conclusions including preliminary recommendation for policy and recommendations for research. The final section discusses the future direction of this research.

1.3 BACKGROUND

An initial review of reports involving decontamination of buildings and persons indicated decontamination experiences had never been documented in a systematic fashion or examined for the important lessons learned. Such documentation is essential to developing effective protocols and consistent and valid information to give to the public and emergency managers and agencies on the appropriate decontamination procedures and other protective measures.

This study did not examine transportation accidents, radiological accidents, or soil or other environmental media contamination. Transportation events were excluded because they rarely involve widespread contamination of people or buildings and the data provided on the numerous transportation accidents by the National Transportation Safety Board (NTSB) is extensive. Radiological events were not included because they are investigated using very different criteria for contamination than those for chemical and biological accidents. Environmental decontamination (soils, aquifers, etc.) was excluded because of the extensive literature and case studies on remediation activities performed under CERCLA or RCRA. Some of the biological agent exposure threats, all hoaxes, were reviewed to assess the lessons learned from emergency response actions for their similarity or dissimilarity to chemical decontamination procedures.

For the purposes of this document, decontamination is the process of neutralizing or removing chemical or biological agents from people, structures, articles and/or equipment, and the environment (NRC 1999). For decontamination to be effective, three elements must be in place: the contaminants involved are correctly identified, the procedures and equipment are available and are appropriately employed to remove or neutralize the contaminant, and the reduction of risk from the contaminant is defensible by scientific and regulatory standards. Most current decontamination systems are labor intensive, require excessive quantities of water, and are environmentally unsafe. The issue is further complicated by the use of ultra-conservative standards to determine when it is safe to reenter a structure or transport victims to a health care facility. As the American Medical Association has pointed out, most decontamination guidelines for treating people exposed to hazardous chemicals were created by the military and are inappropriate in a civilian health care setting where resources and personnel are not as readily prepared nor deployable (Macintyre et al. 2000).

Table 1. Factors Affecting Decontamination Procedures in Case Studies

Case Study/CIRC[a]	Date/Time	Facility/Address	Substance	Structure Deconed	Articles Deconed	Population Deconed	Consequences
Case Study 1. CIRC 1999-4362	Package spill 9/13/99 7:45 a.m.	Airborne Express Newton, MA	Styrene monomer 1-2 cups	Yes-private vendor	Yes-conveyor belt	Yes-22	95 evacuated from facility; 22 deconed and sent to local hospital
Case Study 2. CIRC 2000-4838	Chem spill 5/12/00	CheMaster Chemical Plant Twin City, GA	20 gal. Of hydrofluoric acid	Yes-private vendor	Yes	Yes	1 fatality; 3 employees & 9 responders treated for exposure
Case Study 3. CIRC 1999-4381	Elec. Fire in transformer 10/1/9 6:15 a.m.	Commerce Bldg. Washington, D.C.	Small amount of PCBs	Yes-private vendor	Yes	Yes-30 employ, 12 firefighters & EMTs	Building evacuated; reopen 3 days later; clean-up to PCBs in vault takes 3 months
Case Study 4. CIRC 1999-4440	Mercury at school 10/26/99	North Grove Elem. School Greenwood, IN	Mercury	Yes	Yes-desks	Yes-20 students & staff	School evac.
Case Study 5. CIRC 2000-4958	Heat released fumes	Lawn and Garden Treat. Product Co. New Your Mills, NY	Dimethoate fumes	Unknown	Unknown	Yes-11 workers 7 hospital staff	No decon at site; workers sent to hospital cause secondary exposure to 7 ER staff
Case Study 6. CIRC 2000-4956	Spill 9/15/00 10:30 a.m.	Indianapolis International Airport Indianapolis, IN	Mercury - "amt. In thermometer"	Yes-private vendor	Yes-conveyor belt	Yes-34 people	3 workers exposed sent to hospital, others deconed at site sent by airport shuttle bus
Case Study 7. CIRC 2000-4952	Spill 9/13/00 9:51 a.m.	S&R of Kentucky Bowling Green, KY	Sulfuric acid mixed with aminonic shield conditioner	Yes-private vendor	Unknown	Yes-40 workers	Workers deconed in parking lot; clothing replaced, taken to hospital, 138 evauated

[a]Chemical Incident Report Center (CIRC).

The growing number of serious chemical accidents has prompted the federal government and states to enact regulations for reporting such occurrences. For example, under the provisions of Section 303(g) of the Emergency Planning and Community Right to Know Act of 1986 (SARA Title III), federal law requires that all chemical and oil spills be reported to the National Response Center (NRC) located in the U.S. Environmental Protection Agency (EPA). In 1999 the NRC received reports of 30,175 incidents. The Occupational Safety and Health Administration (OSHA) steps in when an accident at a facility involves a fatality or results in three or more workers being hospitalized. In 1992, the federal government initiated the Chemical Safety and Hazards Investigations Board to report incidents involving chemical releases and to examine procedures to improve the safety of the chemical industry.

Recent criticism has been directed at the large number of people decontaminated on site or at medical facilities based solely of perceived exposure or self-reported exposure. However, studies of the decontamination process are spotty and not well documented in the open literature because the event often involves several agencies. Highly trained HAZMAT teams respond directly to the site and may decontaminate people as a precautionary measure. Victims are then sent or they self-evacuate to a health care facility not directly involved in the instigating incident. For example, a pesticide release in California several years ago reportedly resulted in over 4000 civilians reporting to hospitals after exposure to oleum (concentrated sulfuric acid) (Morris and Ginley 1993). Often the chemical release contaminates buildings and property requiring evacuation of occupants. Commercial decontamination services are then called in for cleanup and remediation. To further complicate the reporting situation, there are often overlapping responsibilities among agencies and jurisdictions on decisions to reoccupy a decontaminated area or to release property to owners. Although local first responders are first on the scene and perform the critical identification of the contaminants and conduct response actions, procedures require notification to appropriate state and federal agencies who may not respond for several hours or even days after the event. Final reports often take months to prepare and disseminate.

Thus this study addressed how and where the decontamination was conducted, what logistical problems were encountered, if members of the public cooperated, and if not what were the refusal rates. Also examined were the procedures to ascertain the safe levels of residual contamination. To determine the time sequence of various events, the study also examined when decontamination efforts were initiated and how many people were decontaminated over what time period. The study also sought to determine who made the decision to reenter the impacted area and the factors influencing that decision. Finally the study examined changes following an incident such as how state or local governments or agencies changed procedures on decontamination as a result of lessons learned from the event.

2. METHODS

2.1 DATABASE DEVELOPMENT

We obtained information on historical events through extensive literature and electronic database searches to develop a historical incident database. ORNL staff searched Science Citation Index, Current Contents, Medline, Toxnet, DOE databases, and commercial databases such as Northern Light. The bibliography currently contains 147 references describing research on decontamination, decontamination events, decontamination recommendations by experts.

Recent chemical and biological events were identified and characterized for possible selections as case studies for further examination. We examined all pertinent databases, including the three federal databases on chemical accidents: the Chemical Safety Hazard and Investigation Board's Chemical Incident Reports Center (CIRC), EPA's Accidental Release Information Program (ARIP), and the National Response Team's Emergency Response Notification System (ERNS). The latter two contained no fields recording contamination of people or buildings, so we relied on the CIRC data to identify current events for further investigation. Using key word searches, we found 26 between October 12, 1998 and October 30, 2000 chemical releases that resulted in decontamination. A matrix using data pertinent to each event was developed.

One problem with CIRC reports is the heavy reliance on media reports that makes systematic analysis difficult as to what occurred and problematical as to validity of input. However, by using key word searches, we identified a number of events that likely resulted in decontamination of a building or people. After the incident was identified, follow-up included gathering secondary data from reports on the event. Two examples of studies of historical decontamination incidents that were particularly relevant to this study are the extensive remediation of a government building in Binghamptom, New York, and the decontamination following the ebola outbreak among primates at a Reston, Virginia, laboratory.

2.2 BIBLIOGRAPHIC RESOURCES

Currently we are extracting the key findings from and annotating the references in the bibliography that describe research on decontamination and the expert's recommended decontamination practices. The references have been grouped into the following categories:

- biological decontamination for buildings,
- biological decontamination of people,
- chemical decontamination for buildings,
- chemical decontamination of people,
- reentry criteria and human toxicology,
- epidemic hysteria situations, and
- both chemical and biological decontamination.

The final report will contain an annotated reference list to document the findings.

2.3 INFORMATION COLLECTION PROTOCOL

We developed an information collection protocol tool that was reviewed and tested for efficacy and ease of data collection. A questionnaire was designed to systematically collect information on decontamination incidents through telephone interviews with responders and/or managers of the incident. The questionnaire was slightly altered to adapt to the issues related to health care facilities.

The questionnaire included separate modules to address three possible aspects of decontamination:

- buildings (e.g., surfaces, attached fixtures, air spaces),
- articles (e.g., fixtures or items that could be removed from a structure), and
- people.

After a few interviews had been completed, it was evident that questions on decontamination of articles was subsumed under buildings or people by respondents and was not eliciting information. The telephone interview method was selected as the most efficient method to collect information, especially given the DOE restrictions on travel that were imposed during the fiscal year the project was initiated that prevented site visits. In addition, we needed to interview a number of responders regarding an incident because of the overlap in responsibilities for decontamination procedures.

2.4 INITIATION OF INVESTIGATIONS

Seven case studies of recent building decontamination experiences were initiated. The investigations were conducted by research staff unfamiliar with the literature findings. We did this to insure that the information collected from respondents would not be directed toward findings from the literature review and thus bias the results. Informants were chosen for their specific involvement in the event. Although firefighters or other first responders were interviewed in every study, some studies included a dozen informants while others included only six. When informants offered the names of other respondents with specific knowledge of the incident, those persons were interviewed also. These "snowball" methods provided a comprehensive overview of each event from which findings were derived.

Priorities for selecting events to investigate included:

- Federal facilities as they are high risk for terrorist attacks,
- transportation facilities because of their strategic importance,
- educational facilities, particularly elementary schools as children are a vulnerable subgroup, and
- hospitals with the potential for secondary contamination.

3. LITERATURE REVIEW

This section describes selected findings from the review of the open literature. To aid the reader in distinguishing between the chemical and biological literature, the findings are categorized into three headings:

- biological,
- chemical, and
- both biological and chemical.

3.1 BIOLOGICAL

3.1.1 Building Decontamination

Case study: Reston Primate Facility

Jax and Jax (in DHHS 1995) and Peters and Olshaker (1997) discuss the decontamination procedures used at the Reston Primate facility where 450 monkeys were destroyed when an ebola virus was discovered. The monkeys were disposed of and supplies were incinerated, all particulate matter was scraped from surfaces, and then surfaces and drains were drenched with bleach. Thirty-nine electric fry pans were placed on timers and filled with paraformaldehyde mixed with water. Every seam in the building was tightly taped and the paraformaldehyde was cooked off with a target of 10,000 ppm. The building was put up for sale but eventually demolished when the asking price dropped below the value of the land (Alexander 1998).

Decontaminating the fecal matter of the monkeys remained a problem. The US Army Medical Research Institute of Infectious Diseases (USAMRID) wanted to soak material in Clorox and send it down the sewer. Virginia environmental officials objected to putting the disinfectant down the sewer. Permission was finally given to proceed with the disposal when the Army told the state they would leave it for the state to dispose of.

Case study: Hospital Autopsy Room

Coldiron and Janssen (1984) describe the decontamination of a hospital autopsy room and ventilation system using formaldehyde. This was done because the ventilation system of the autopsy section were being remodeled. Hospital officials were concerned about potential transmission of disease from infected tissues or pathogens to the workers. Following NIH procedures, rooms and ventilation systems were exposed to paraformaldehyde concentrations estimated to be between 18,600 to 14,000 ppm for 3–4 hours. Tests performed after the procedure indicated no spore development after a 48-hour incubation period indicating effective sterilization.

Key Research Findings

Very little research has been performed on biological decontamination of buildings. Pasanen et al. (1997) tested eight biocides to assess their effectiveness of surface decontamination. The solutions containing sodium hydrochloride and glycol containing detergents performed best. Both completely prevented microbial growth on a dusty sheet metal and significantly inhibited growth on wallpaper. Debus et al. (1998) describe a hydrogen peroxide gas plasma sterilization procedure to decontaminate Mars 96 small station landers.

Alexander (1998) reviews the issue of building decontamination for biological agents, relying primarily on second-hand information based on interviews with public officials. He concludes that there are no civilian standards to certify a building is clean and safe for reoccupation.

3.1.2 People Decontamination

Case Study: B'nai B'rith Headquarters

A package was mailed to the B'nai B'rith headquarters in Washington D.C. that contained a petri dish labeled as a biological weapon. The District of Columbia Fire/EMS Department responded and arrived on scene 1 hour and 20 min after the package was opened. After consulting with the Centers for Disease Control (CDC), it was decided to shelter people in the building and set up a decontamination line. A total of 30 people were decontaminated including civilians, police officers and fire personnel.

Decontamination was problematic because no enclosed spaces were available and the operation was performed in front of live media cameras. Two police officers refused to go through the decontamination line and struck a fireman in charge of the quarantined areas. About 4 hours into the event, a security guard developed chest pains. He was carried through the decontamination line in a chair and transported to a hospital. Nine hours after the package was opened, analyses showed no chemical or biological hazard and people in the building were released. None of the findings in the Fire Administration report directly concerned decontamination.

Key Research Findings

Need to decontaminate. A variety of experts have recently published on the need for decontamination for biological agents. Franz et al. (1998) note the decontamination following an aerosolized biological attack is less likely to be needed than for a chemical at release. In most cases of biological contamination, decontamination is not needed; the main exceptions are for toxins (English et al. 1999). Skin decontamination for biological aerosols would be of minimal or no benefit (Keim and Kaufmann 1999).

People with grossly visible evidence of direct skin contamination by an etiological agent should be decontaminated thoroughly (Keim and Kaufmann, 1999, English et al., 1999).

Garland et al. (2000) suggest that reaerosolization of biological agents may be a problem after the deposition of aerosolized agent. They note that decontamination may cause reaerosolization although it has not been quantified. This may lead to a need for multiple decontamination of exposed patients.

Most of these observations, however, are based on opinion and not empirical evidence and some conclude that the need for decontamination of individuals exposed to infectious agents has not been carefully evaluated (Balk et al. 2000).

Methods of decontamination. Patients with acute exposure to a biological aerosol should shower at home (Richards et al. 1999). The preferred method of decontamination for a biological aerosol is to have people go home, bag their clothes, and shower with soap and water (Keim and Kaufmann 1999).

Given a patient with visible skin contact with a biological agent, they should be washed with soap and water and then swabbed with a bacterial sporicidal solution such as 0.5% bleach (Richards et al. 1999).

Workers bitten or scratched by an animal in a primate facility must scrub with soap and bleach for 5 min and then for 10 min with Betadyne (Gerone 1996).

Infection control. Virus infections can be managed effectively using standard hospital practices for dealing with infecting diseases, including barrier nursing, contact precautions, and respiratory protection (CDC 1998). Keim and Kauffman (1999) note that every infectious biological agent has a non-warfare biological disease counterpart that hospitals are prepared to handle. Thus, standard hospital procedures should be adequate to handle any biological warfare agent induced disease. However, a massive exposure may overwhelm health care capacities (Osterholm 1999).

3.2 CHEMICAL

3.2.1 Building Decontamination

Case Study: Binghamton State Office Building

One of the most interesting cases at building decontamination involves the Binghamton State Office Building in New York. A transformer fire in the basement of this 18-story modern office building in February 1981 contaminated the building with PCBs, dioxins, and dibenzofurans. A 30-min fire generated dense smoke and because of the design of the HVAC system, contaminated all 18 floors. The cleanup efforts have been documented in several journal articles (see Schecter and Charles 1991 and Schecter 1986) and numerous state reports.

Twenty-four-hour cleanup activities began immediately by state workers, but were suspended in late February after TCDD was detected. The state spent the next 6 months developing a protocol to guide the decontamination process. Reentry criteria were established for renovation workers and for office workers for both surfaces and air (Kim 1983). The criteria were based on working in the building for 250 days per year for 30 years. The exposure values were calculated based on not exceeding a cancer risk of 1×10^{-2} (Kim & Hawley 1982).

It was estimated that it would take 6 years to clean the building to a level where re-use could occur. As of 1991, floors 2–18 were authorized for reentry (Schecter and Charles, 1991), but reentry did not occur because the first floor, basement, and sub-basement were still sealed off. As of 1991, the cost of cleanup was $40 million for a building that originally cost $17 million.

By 1994, state officials decided to initiate efforts to reopen the building, however, environmental sampling showed levels of PCDDs in recessed light fixtures that exceeded reentry criteria (NYDH 1999). After additional cleanup, tests were conducted in August and September showed residual contamination to be considerably lower than the reentry criteria. Building reoccupancy began in October and was complete in December 1994. Extensive information materials were provided to workers in the building.

Plans were established to perform addition cleanup efforts every 3 years and to conduct yearly sampling. A long-term sampling plan was established and was signed off by labor unions, the Governor's Office, the BSOB Committee on Safety and Health (independent experts), the State Office of General Services, and the State Office of Health. All tests conducted since reoccupancy showed levels of PCBs and PCDDs to be well below the reentry criteria.

Case Study: Canadian Laboratory

In 1984 a high voltage testing laboratory in Canada experienced a fire resulting in widespread PCB contamination. A cleanup and repair committee was established based on Hydro-Quebec's organization for managing the construction of nuclear generating stations. Partial reuse of the 0.5 million-m^3 space was achieved in 3 months and full reuse was achieved in 11 months (Train et al. 1987).

Case Study: San Francisco Office Building

In 1983 (May 15), a 28-story office building in San Francisco experienced a transformer fire that contaminated a portion of the building with PCBs and several harmful byproducts (Maslowski and Rose 1985). Among the lessons learned from this experience are

1. Immediately organize a restoration management team to organize the cleanup efforts.
2. Develop a sampling plan and procedure. In the course of this cleanup, 11,000 samples were taken.
3. Establish formal work procedures for decontamination activities.

In recovering from the fire, it took 5 days to restore power to the building. Floors 7–28 of the building, which operate on a different air system from the one affected by the fire, were declared free of contamination and were re-oceupied 10 days after the fire.

Background testing became a major issue associated with the cleanup. Since no background levels of contamination were known, it was assumed that the pre-accident level of contamination was zero.

The City Health Department established the final reentry criteria for the building along with assistance from the state. These were based on 8 hours per day, 250 days per year and 40 years of exposure. The criteria were the same as those established for the Binghamton State Office building.

The building was re-occupied in late March 1994, 9.5 months after the incident.

Case Study: Baltimore Loft Apartment Building

In December 1994 residents of a condominium, recently converted from industrial use, observed mercury pods forming. The residents hired consultants and physicians to do environmental testing and biological monitoring of mercury levels in two units. Two of the children tested showed elevated mercury levels. In December 1995, the New Jersey Department of Health and DHHS were asked to evaluate the health impacts from the contamination. When their testing confirmed that a mercury hazard was present, the ATSDR issued a Public Health Advisory and the local health board declared the building unfit for human habitation. Future human occupancy will depend on the feasibility of remediation (Orloff et al. 1997).

Case Study: West Helena Hospital

Shortly after 1:00 p.m. on Thursday, May 8, 1997, clouds of foul-smelling smoke began pouring from a herbicide and pesticide packaging plant in West Helena, Arkansas. An alert was sounded, employees evacuated, and the West Helena fire department was called. As the odorous smoky cloud drifted away from the plant, authorities ordered residents in a 2-mile area downwind of the plant to evacuate and those in the 2- to 3-mile zone to shelter in place. The incident began when smoke was emitted from a 1500-lb bulk container of azinphos-methyl, a commercial brand of parathion, a chemical with toxicity similar to the chemical nerve agent Sarin (Vogt and Sorensen 1999).

Included in the evacuated area was The Phillips County Regional Medical Center. Established in 1909, the Center moved to its present location across the highway from the fields surrounding the industrial park in 1979. It is a complete service hospital, providing care for residents in a 50-mile radius. The hospital currently employs 325-330 people and has 155 beds. Included in its services is obstetrical care; last year the center had 500 births. The not-for-profit, fully accredited facility is owned by the county but professionally managed by Quorum.

Although monitors indicated no contamination in the facility, the state health department required a thorough cleanup of the hospital before patients could be admitted. This meant that all hard surfaces had to be scrubbed and all soft materials (drapes, etc.) had to be removed. The health department also required that all filters in the building be replaced before the interior cleanup was started. Staff were unable to locate the filters because of the special design and the fact the company making them did not operate on weekends. Recognizing the urgency of having the regional hospital operational, pressure was exerted from state officials to convince the company to alter its policy. The company extended its hours and worked through the night, delivering the replacement filters to the hospital on Saturday. The hospital staff started cleaning on Sunday in shifts, starting with the rooms where filters were replaced. The emergency room was considered priority and cleaned first. On Tuesday (6 days after the initial evacuation) the hospital was reopened.

Key Research Findings

Reentry criteria. PCB incidents are discussed by Rappe et al. (1986) in San Francisco, Santa Fe, Finland and Sweden. Each incident used a different level of residual surface contamination as the reentry standard. For PCDDs, these ranged from 1 to 50 ng/m^2.

One problem encountered by officials is the lack of baseline data on chemical contamination in a building. This effects decontamination efforts as the conservative assumption that the baseline is zero contamination is usually adopted (Perdek et al. 1991). It also has been noted that it is extremely difficult to established meaningful reentry criteria and make accurate measurements to verify it as safe to re-occupy a building (Stephens 1986).

Cleanup cost effectiveness. Little research has been conducted on the cost and effectiveness of alternative cleanup techniques. In one of the few studies identified, EPA compared two technologies—one chemical and one physical to cleanup a PCB-contaminated building. The first process involved treatment with an alkali metal/polyethylene glycolate mixture and the second involved shot blasting to remove the contaminated concrete surface. The study concluded that both techniques were effective at removing PCBs but not sufficient to meet cleanup criteria. The reagent technique cost $0.85/ft^2 and the shot blasting cost $2.19/ft^2 (Barkley 1990).

As part of the World Trade Center cleanup, the Port Authority cleaned all exposed surfaces in the building. It took 900 workers per shift, 3 shifts a day, for 3 weeks to complete the cleaning (Kirshner and Bleach 1994), amounting to about 450,000 person-hours of labor.

3.2.2 People Decontamination

Case Study: Tokyo Subway

On the 20th of March 1995 there was a coordinated terrorist attack on three subway lines in Tokyo, Japan during morning rush hour (7–8 a.m.). The nerve agent Sarin was released as a liquid in five subway cars. Sixteen subway stations were affected as passengers rushed out of the trains. The first emergency call reached the police at 8:14 a.m. and between 8:30 and 9:00 a.m. over 11,000 emergency workers were dispatched. Most patients were treated at four large hospitals in the vicinity of the attack, although over 275 medical facilities were eventually involved. An estimated 5500 people were contaminated (NCEH 1995).

In the Tokyo subway incident, there was no decontamination conducted at the scene of the accident (Okumura et al. 1998a) In that incident, it took about 3 hours to determine GB was the chemical involved (Okumura et al 1998a). Decontamination began only after the nerve agent was identified as the cause. The decontamination procedure was to undress and shower. There are no estimates of the number of patients that were decontaminated. Mildly exposed victims were not decontaminated due to lack of changing and showering facilities (Okumura et al. 1998b).

Sidell (DHHS 1995) notes that decontamination in the Tokyo incident was not needed for most of the victims because most people were exposed to low level vapors.

One of the major difficulties in the Tokyo subway attack was undressing of victims and disposing of clothing due to the shear volume of exposure (Holloway et al. 1997). A major impact of lack of decontamination areas at the hospitals was secondary contamination of hospital staff. In one study, 23% of the staff indicated acute symptoms of nerve agent exposure (Okumura et al. 1998b). Lack of ventilation also contributed to secondary exposure (Okumura et al. 1998b).

The train cars and subway stations exposed to Sarin in the Tokyo incident were decontaminated with water and detergent combined with industrial-strength cleansers. It was quickly applied and then washed off immediately, whereas a 15- to 20-min application before rinsing would be recommended (DHHS 1995). The decontamination was performed by both military personnel and firefighters. It took about 3 hours and 20 min on two of the lines, and was completed 9.5 hours after the release occurred. On the third line it took about 15 hours and was completed 21 hours after the release (Watson 1998).

Key Research Findings

Chemical warfare agents. There is a fairly large body of knowledge about chemical agent decontamination, most of which has been generated by the military. Sidell and Franz (1997) observe in *Medical Aspects of Chemical and Biological Warfare,*

> The only decontamination that prevents or significantly reduces damage from a chemical agent is that done within the first several minutes: self-decontamination. The importance of rapid self-decontamination cannot be overemphasized and must be clearly understood by anyone who might be exposed to chemical agents. To successfully reduce damage to the casualty, decontamination must be performed within minutes of exposure.

Other experts agree—decontamination for chemical agents is most effective if done within 1 min of exposure (Brennan et al. 1999). This is a strong argument against the establishment of national response capabilities or even regional capabilities. By the time a national response team could respond to a no-warning chemical agent attack, the incident would be over (Tucker 2000). Response will essentially be a locally managed situation for hours into the event.

In contrast to aerosol or liquid exposure decontamination for chemical agent vapor exposure is not necessary (Sidell in DHHS 1995). Others are less definitive about this topic: decontamination may not be needed for persons exposed to chemical vapor only (Brennan et al. 1999). Hazardous contamination from a vapor release would likely be limited to materials, such as clothing, which are in contact or very close proximity to the human body and should be best dealt with during personal decontamination (Shumpert et al., 1996).

HAZMAT decontamination. The major arena in which civilian decontamination has been addressed is HAZMAT response planning, exercises, and response. Most HAZMAT decontamination is patterned after the traditional military decontamination line consisting of a hot zone, warm zone, and a cold zone. Several major criticisms of this model have been made. Moles (1999) notes that mobile decontamination units will be too slow in mobilizing and deploying. In a decontamination line, the removal of contaminated clothing is a dangerous, time consuming, and exhausting job (Bellanger et al. 1993). The HAZMAT model of response to some chemical or biological agents may not be appropriate because of the time and labor intensiveness of decontamination (Waeckerle 2000). The CSEPP program advocates the use of self and buddy decontamination because of this issue (Copenhaver 1992).

The slow deployment of decontamination units may also allow contaminated victims to escape treatment (Moles 1999). In addition, civilian medical response to a toxic release is essentially different than military response (Baker 1999). Military responses are well planned and anticipatory. Civilian response is situational and typically conducted without detection capabilities.

HAZMAT decontamination involves both field and hospital decontamination. Some have questioned the realities of decontamination process at hospital (Pons and Dart 1999). What exposures can be safely decontaminated in the emergency department. Burgess et al. (1997) conducted a survey of 95 emergency care facilities in the state of Washington. Of those, 39 (41%) had no designated decontamination facilities and 53 (66%) did not have the ability to receive contaminated patients. Macintyre (2000) describes a model decontamination plan and facility for a hospital.

One practice advocated by some HAZMAT guides is reverse isolation where contaminated casualties are placed in bags to prevent exposure to emergency technicians. Moles (1999) strongly urges the avoidance of reverse isolation techniques because it exacerbates exposure to the victim. Others have recommended this technique after being decontaminated with water (McMullen 1996)

3.3 CROSS CUTTING ISSUES

A number of issues surfaced that cut across chemical and biological agents. These are summarized in this section.

3.3.1 Types of Decontamination

Moles (1999) identifies two types of decontamination—immediate, which permits safe triage and ful, which permits safe evacuation.

The military identifies three basic methods of decontamination: physical removal, chemical deactivation, and biological deactivation of the agent. Biological deactivation has not been developed to the point of being practical (Medical Management of Chemical Agent Casualties, date).

Following the Tokyo subway incident the French government established a plan for responding to an urban toxic release (Laurent et al. 1999). When a release occurs, they establish a liquid hazard area, a vapor hazard area, and a security zone. In general, the plan calls for decontamination, and then medical care, and evacuation to a medical facility. However, the plan also calls for physicians in protective suits to perform medical treatment within the hazard area. Following a release, a contamination detection point is set up outside the hazard area. Casualties are routed to this point and sent to the decontamination line or an exit from the security zone. The French approach to decontamination differentiates between emergency decontamination and zone decontamination (Laurent et al. 1999). Emergency decontamination using both wet and dry methods is performed when there is a need for rapid and immediate removal of the toxic substance. The wet method utilizes special portable sprinklers and a decontamination solution. The dry method uses Fuller's earth or talc that is gently removed after application. The zone method takes at least 1 hour to set up after arrival on the accident scene. The decontamination line has four operations:

- undressing and sealing clothes and effects,
- washing with water and then a specific decontamination solution,
- a check for remaining contamination, and
- dressing.

The victims are then processed through a triage point where they are transported to a medical facility or sent to an evacuation holding area.

3.3.2 Model Procedures

Currently there are no practical models for healthcare response that requires decontamination of mass casualties (Macintyre 2000). The NCEH (1995) report from the

Medical Delegation to Japan suggests that international decontamination standards should be developed, including planning for large-scale patient decontamination. Macintyre (2000) recommends that decontamination be simplified by establishing a universal protocol for all incidents. Others disagree and argue that decontamination techniques are specific to certain classes of chemicals and biological threats.

SSI Services (1996) describes an analytical technique to estimate resources needed to perform decontamination for various chemical agent accident scenarios.

3.3.3 Children

Children are disproportionally impacted by a chem/bio release for several reasons:

- They have a higher respiratory rate than adults, thus will receive a higher dosage of vapors or aerosols.
- They have more permeable skin and a higher surface to body mass relationship; thus, they will receive a higher absorbed dosage.
- Their breathing zone is lower to the ground and more vulnerable to dense gases (Balk et al. 2000).

Skin decontamination is more problematic for children and infants who, because of their proportionally larger body surface area, lose heat rapidly when showered with water. Special provisions such as heat lamps or other warming apparatus may be needed (Balk et al. 2000).

The authors recommend decontamination by showering for children in known chemical or biological exposure. In a suspected chemical event involving nerve or corrosive agents, decontamination is recommended if symptoms are present. If no symptoms are present, observation for a 2- to 4-hour period is recommended. In a suspected infectious agent with no appearance of a hoax, it is recommended that decontamination be considered.

3.3.4 Policy Issues

Cole (2000) notes that the legal authority to respond to a bioterrorism incident is not clear, particularly regarding the legality of forcing people to undergo treatment. Several possible mechanism in the federal government can guide response to a chem/bio event (Alexander 1998). These include the Presidential Decision Directive 39, the FBI's C/B Incident Contingency Plan, FEMA's National Response Plan, and EPA's National Contingency Plan. In any mass decontamination situation, the provision of privacy and assurance of modesty may have to be sacrificed (Holloway et al. 1997).

3.3.5. Wastewater

Decontamination can produce considerable amounts of wastewater. Whether this is or should be a serious concern is not known. It has been observed that the risks associated with such wastewater are largely unknown (Macintyre 2000). Disposal of contaminated water was a major problem in the Binghamton state office building decontamination (Kim 1983). Using household bleach will help neutralize the contamination from chemical agents (Watson 1998).

Pons and Dart (1999) question the feasibility of controlling run-off fluids in a hospital environment. For example, is a separate drain and holding tank affordable to install and maintain? Can effluent go into the sewer system or storm drains? Is dilution an alternative to containment?

EPA (2000) discusses liability issues associated with mass decontamination wastewater runoff. They conclude that based on the "good Samaritan" provision in CERCLA (Section 107d), first responders should undertake any necessary emergency action to save lives and protect the public and themselves. Section 107d states that no person will be liable for costs or damages resulting from actions taken or not taken rendering care, assistance, or advice under the National Contingency Plan or at the direction of the on-scene coordinator. This does not preclude liability for damages resulting from negligence. EPA recommends that once imminent threats to human life are addressed, reasonable attempts should be made to contain wastewater and prevent environmental insult.

3.3.6 Personal Protective Equipment

Currently there is no standardization of PPE to be used by the medical community while performing decontamination or other medical tasks (Macintyre 2000). Pons and Dart (1999) also note that there is a lack of information on what PPE is needed to perform decontamination in a hospital.

Very little empirical data exist on the risk of decontamination to emergency personnel. Schultz et al. (1995) performed experimental tests to determine level of exposure to emergency workers from chemicals while decontaminating a mannequin contaminated with chemicals or particulates. The breathing level tests showed that exposure to the workers was significantly lower than control limits. They concluded that decontamination did not pose a respiratory threat to the workers given the chemicals used in the test.

3.3.7 Decontamination Solution

A major issue in both chemical and biological contamination is whether to use bleach or not to use bleach (Macintyre 2000). Most agree that bleach or a hypochlorite solution is needed for liquid chemical exposure. While the military uses a 0.5% solution of hypochlorite, most civilian emergency units use 1.0% to 2.0% concentrations (Brennan et al. 1999). The Chemical Stockpile Emergency Preparedness Program (CSEPP) recommends a full strength solution of household bleach (5%) (Copenhaver 1992). The most desirable decontamination for chemical warfare agents would use undiluted household blotting (not swabbing or wiping) with a cloth wetted in undiluted household bleach followed by washing with lukewarm soapy water and rinsing with clear lukewarm water (Shumpert et al., 1996).

3.3.8 Secondary Contamination

Burgess et al. (1999) studied ten hospital evacuations in Washington State hospitals due to hazardous materials incidents. Two of those events resulted from secondary contamination of emergency room personnel from treatment of patients with chemical exposures who were not decontaminated prior to arrival. Kim and Burr (2000) studied hospital responses to three hazardous material incidents in Utah and found secondary contamination to be a significant problem in two events. Secondary contamination was also a problem during the Tokyo subway attack in hospitals and for emergency workers (Watson 1998).

3.3.9 Decontamination Effectiveness

A major issue concerns determining when a person is "clean." Moles (1999) notes that full decontamination is not currently quantifiable because of the lack of standard protocols and because measurement techniques and instruments have not been developed and approved. Some experts estimated that 75-95% of contamination is removed when people disrobe (Macintyre et al., 2000; Cox, 1994). There has been little research to support this assumption made by many "experts."

Tèorngren et al. (1998) conducted experiments to determine the effectiveness of a decontamination station and self-decontamination. Subjects wearing PPE were contaminated with Mustard and Sarin simulants. After a two-stage decontamination process, the air concentration of simulant was reduced by a factor of 10,000. In the self-decontamination experiment there was still a significant air concentration of simulant after decontamination due to absorption by the subject's underwear.

3.3.10 Epidemic Hysteria

Cases of epidemic hysteria have been found to exacerbate emergency response situations. Young children are especially vulnerable (Baker 1992). Officials and emergency responders should be taught how to recognize the symptoms of epidemic hysteria and immediately intervene to control the outbreak (Baker 1992). Granot and Brender (1991) have developed a checklist titled the Emergency Behavior-Response Wheel to train emergency responders to cope with the 19 forms of behavior typically found at emergency sites. The authors then provide parallel coping behaviors for responders.

Burgess et al. (1999) note that health care systems are often overwhelmed after a chemical release. They examined one incident where 117 individuals were evaluated at 13 emergency departments for exposure to NO_x and 13 individuals admitted for observation. Eighteen of the 117 patients were transported to a major trauma center where 7 were admitted for observation and released the following day. Given the estimated low-level dose of NO_x exposure and the patient's persistent hyperventilation after the exposure ceased, the authors suggest the cause of distress was anxiety, not chemical exposure. Their study emphasizes the need to study the psychological effects, not just the physiologic effects of large-scale chemical incidents when planning treatment of victims.

Selden (1989) studied a case of an explosive epidemic hysteria that occurred when 15 adolescent female students from a junior high school appeared ill from exposure to sewer gas. Seven hundred students and staff were triaged by paramedics and the physician EMS director at the school. The absence of laboratory and physical findings confirmed there was no organic cause. Symptoms in patients abated within 1 hour as patients disbanded and all were released within 2 hours. One student self-admitted to the ED that evening but was found asymptomatic and discharged to her parents.

3.4 GENERAL FINDINGS FROM THE LITERATURE REVIEW

1. A military model for decontamination of people exposed to biological or chemical agents is not effective because equipment takes too long to deploy and set up in situations where immediate decontamination is necessary.

2. Separate decontamination procedures are needed for specific sub-groups of populations. For example, a heat source is needed for the decontamination of children and infants as their bodies lose heat rapidly when showered.
3. There is no consensus on the need to decontaminate people exposed to aerosolized biological agents.
4. There is no consensus on the need to decontaminate people exposed to chemical agent vapors.
5. Secondary contamination for exposed patients is a problem for emergency responders and hospital workers. This type of contamination most often occurs when victims are inadequately decontaminated before arriving at a hospital or self-evacuate to a medial facility after exposure.
6. It is difficult to control run-off fluids when decontaminating people. The copious amounts of water required to sufficiently decontaminate people by showering cannot be contained through normal methods.
7. In mass decontamination situations, disposal of clothes has been a major problem.
8. Lack of ability to identify chemicals delays initiation of decontamination efforts.
9. Many hospitals do not have capability to receive contaminated patients.
10. It is extremely important to organize a decontamination management team to develop a comprehensive plan to guide decontamination efforts.
11. The time and cost of decontamination of buildings is usually underestimated.
12. Establishment of reentry criteria is hampered by lack of information or data on background contamination prior to accident/event.
13. It is important develop rigorous procedures for sampling and tracking the results of sample analyses.
14. Biocides and hypochlorite solutions are effective at decontaminating surfaces exposed to viruses and bacteria.

4. CASE STUDY SUMMARIES

This section describes the events and the information obtained from informants interviewed about the incidents. The number of informants varied by study. For example, over a dozen interviews were conducted for the Commerce Building study but only four respondents were interviewed for the Airborne Express study. These differences in the number of respondents arose in part because some persons identified refused to provide information, felt they were not involved, or cited liability concerns. The reader is cautioned that descriptions of the event and the information are subject to the informant's perception and recollection of the event.

The report from which the incident was derived is first described and then the information collected from respondents is presented. Names and contacts are withheld from the reports to maintain privacy. Findings from the case are then presented.

4.1 CASE STUDY 1. SPILL AT AIRBORNE EXPRESS DISTRIBUTION FACILITY IN NEWTON, MA

Occurrence Date:	13 September 1999
Location:	Newton, MA
Source:	Leaking Container
Material:	Styrene monomer
Impacts:	Unknown
Quantity Discharged:	1-2 cups

4.1.1 Background

Styrene (monomer) is a commercially important chemical used in the production of polymers, copolymers, and reinforced plastics. Exposure mainly occurs in industrial facilities and operations using styrene, and industrial sources are the most likely cause of general population exposure. Other potential sources of general population exposure include motor vehicle exhaust, tobacco smoke, and other combustion/pyrolysis processes. Acute effects can occur at exposure levels of 420 mg/m^3 (100 ppm) and above and cause irritation of the mucous membranes of the eyes and the upper respiratory tract in humans (WHO Working Group 1983).

The study was instituted in response to the CIRC 1999-4362 report describing a chemical spill at an Airborne Express facility in Massachusetts that sent 22 to the hospital after being decontaminated on site. Shut-down of such a facility because of contamination of articles or a building could affect or cripple essential airline transport networks.

4.1.2 Incident Timeline, Response and Consequences

At approximately 7:45 a.m. on September 13, 1999, a worker at a distribution facility of Airborne Express removed a package from a conveyer belt and placed it on the floor. The worker noticed the package was leaking and called for a supervisor. Two supervisors approached, unwrapped the package, and discovered a broken container leaking a liquid. The supervisors rewrapped the container in the package and took it outside the building. 911 was called. Police responded as did the fire department and a representative from OSHA. At the time of the incident, there were 12 people who had been in the immediate vicinity of the container and 95 overall in the facility. Within 20 minutes after arrival, personnel from the fire department decided to decontaminate potentially exposed workers before sending them to the hospital. Potentially exposed workers were identified as those who were in the immediate vicinity of the spill. Others who thought they may have been exposed were also decontaminated. In all, firefighters decontaminated 22 people in about 1 hour. The decontamination process included disrobing and placing personal items in plastic bags, then showering in temporary decontamination units in the building's parking lot. Those decontaminated then donned disposable jumpsuits and were transported to one of three hospitals. Women complained of being viewed by male firefighters while showering and not having separate facilities.

A commercial contractor was called to cleanup the spill and check for contamination. The vendor wore appropriate PPE, including a respirator. Absorbent materials were used to pick up the liquid on the floor and the vendor took air samples. Cleanup took about 2 hours. At that time decontamination was considered effective after the vendor showed the negative air samples to the manager and no lingering odor was noticed in the facility. Samples were not sent to a laboratory for confirmation.

4.1.3 Findings

1. Privacy was an issue in the decontamination process as women did not find the makeshift facility appropriate for disrobing and showering.
2. Supervisors did not follow training procedures about handling leaking containers, possibly contributing to further contamination.
3. Decontamination was determined effective by relying on vendor's monitoring equipment and subjective sense of smell and not based on a laboratory's confirmation.
4. The call to 911 was transferred to police rather than an appropriate responding agency (firefighters and HAZMAT team).
5. The media inaccurately reported 300 evacuated when there were only 95 workers in the building at time of event, contributing to misinformation in the CIRC database.

4.2 CASE STUDY 2. SPILL AT CHEMICAL PLANT IN TWIN CITY, GEORGIA

Occurrence Date:	12 May 2000
Location:	Twin City, Georgia
Source:	Spill when clamps loosened during transfer of liquid
Material:	Hydroflouric acid
Impacts:	1 fatality, 7 decontaminated
Quantity Discharged:	10-20 gal.

4.2.1 Background

On contact hydrofluoric acid [aqueous hydrogen fluoride (HF)] is an extreme irritant to any part of the body. The danger of hydrofluoric acid solutions depends on their concentrations. Signs and symptoms are likely to be immediate if the concentration is greater than 20%. The main route of exposure to HF is inhalation, followed by dermal contact for acute exposure and ingestion for chronic exposure. On contact with water, the decomposition product is HF.

This case was investigated because the affected employee immediately showered to remove the contaminant, would not allow paramedics to treat citing his contamination, entered the ambulance by himself, and died in transport to the hospital. However, the hospital refused to accept the employee's body until it had been decontaminated by the HAZMAT team.

4.2.2 Incident Timeline, Response, and Consequences

On May 12, 2000, an employee who had worked at the chemical plant for several years was transferring hydrofluoric acid from one drum to another without wearing protective equipment. One of the hose clamps became detached causing between 10 to 20 gallons of hydrofluoric acid to spill onto the floor and splatter the employee. The employee immediately undressed and showered but the water reacted with the chemical to create a toxic vapor which the employee inhaled. The employee went to the office and told the staff to leave the building and call 911. When the ambulance arrived, the employee refused treatment because he was contaminated and entered the vehicle on his own. He died on the way to the hospital but the body was left in the ambulance for six hours until the commercial vendor completed their work at the site. Later the vendor decontaminated the employee's clothes so they could be returned to the family who had requested them.

A policeman, who was also a volunteer firefighter, immediately responded along with the County Fire Chief and the County Emergency Management Agency. The policeman came in contact with the fumes on entering the building. The policeman then drove himself to the hospital because he was not feeling well. Unable to get out of the car by himself, hospital staff started immediate treatment and the person was revived, leaving the hospital after another few days.

The responding firefighters, all volunteers with little to no training, obtained the name of the chemical spilled, called the company and talked to the company biochemist. The manufacturer of the chemical recommended that any exposed person go to the hospital immediately. The manufacturer also recommended obtaining 12–15 50-lb bags of lime for cleanup. The manufacturer then called the hospital and explained how to treat the exposed people once they arrived. No decontamination occurred on site. Persons exposed spent approximately 2 days in the hospital.

Recognizing that decontamination would be required from the description of the chemical provided by the manufacturer and from learning of the employee's death en route to the hospital, the firefighters called in a HAZMAT team from Augusta, approximately 65 miles away. While waiting, an employee tried flushing the chemical on the floor down a drain in the building with a high pressure hose but a filmy residue remained on the floor. When the HAZMAT team arrived outfitted in PPE, they spread the lime on the floors then used a mixture of lime and water to clean the drums and the employee's clothing. Also responding was the Georgia Environmental Protection Agency (GAEMA) who contracted a commercial vendor from Augusta, Georgia to decontaminate the building and the articles exposed. Also responding were personnel from the Georgia Department of Natural Resources and the Georgia Emergency Management Association.

There was conflicting information on whether evacuation of residents nearby was advised. After the incident the secretary walked across the street to the drugstore. Fears that she could have tracked contaminant to the store prompted the team to decontaminate the drug store's carpeted area. Eventually a one block area with a doctor's office, drug store, and health clinic was evacuated. Later that day when GAEMA sent in people in "space suits" with monitoring equipment, one respondent noted that the number of people complaining of breathing problems increased substantially. After the event the police car and the ambulance were also decontaminated.

The decision to reenter the building was initiated by the HAZMAT team following cleanup. After the HAZMAT team finished, they turned it over to the GAEMA who turned it over to the Georgia Department of Natural resources, who turned it over to the firefighters, who turned it over to the owner of the building.

4.2.3 Findings

1. Lack of resources at the local level prevented prompt decontamination from occurring at the scene and may have lead to secondary contamination (at the drugstore and hospital). The HAZMAT team from Augusta likely took between 1.5 and 2 hours to mobilize and travel to the scene.
2. Lack of training at the local level placed the first responder (a policeman) in danger after breathing in the toxic fumes.
3. The characteristics of chemicals stored in the plant were unknown to emergency responders.
4. The manufacturer provided essential information in a timely manner.
5. The issue of not accepting the employee's body into the hospital could have been avoided with written cooperative agreements.

4.3 CASE STUDY 3. PCB RELEASE AT COMMERCE BUILDING, WASHINGTON, DC

Occurrence Date:	1 October 1999
Location:	Washington, D.C.
Source:	Leak from electrical capacitor
Material:	PCB contaminated oil
Impacts:	Unknown
Quantity Discharged:	Unknown

4.3.1 Background

Despite a ban on the manufacturing of polychlorinated biphenyls (PCBs) since 1977, significant quantities remain in older equipment such as electrical transformers and capacitors. Exposure to PCBs and related compounds has been reported to be neurotoxic to both humans and animals during embryonic development (Tilson et al. 1998). Historical events involving PCB contamination suggest that decontamination is difficult and costly, especially when fires release toxic by-products into air vents and HVAC systems. The case was chosen for further investigation based on media reports including CIRC report 1999-4381 that a PCB release had occurred at the Commerce Building in Washington, DC. Since federal buildings are considered highly vulnerable structures as targets for terrorists suggested this event was an appropriate case study. Information was obtained from about a dozen informants, including the head of the emergency room at the hospital where victims were taken. The systematic telephone interviews with respondents involved directly in the response or management of the event suggest a very different scenario than reported by the media. How and where the media obtained their information remains unclear.

4.3.2 Incident Timeline, Response and Consequences

The scenario developed from interviews suggests an electrical power surge at 6:15 a.m. resulted in a fire in one of the cabinets containing capacitors that regulated the Simplex clock system for the entire building. The clock system integrates the technology that insures all clocks in the building report the exact same time. The capacitors leaked oil containing PCBs onto the floor, the cabinet, a toolbox and its contents, and other electrical equipment in the vicinity. The clock system was located in one of the six vaults in the buildings sub-basement.

The housekeeping staff in the area at the time initiated the discovery of the leak when they noticed smoke coming from one of the six vaults and alerted the building security. Security officers called 911 and at 6:30 a.m., the District of Columbia's (D.C.'s) fire department arrived at the scene. Noticing that only one door (the door to the vault with the capacitor fire) was not marked with a placard stating "No PCBs," fire department personnel decided it prudent to treat the oil as possibly contaminated with PCBs and to treat persons, including responders, who had been in contact with the oil or smoke as contaminated. The few occupants in the building were evacuated and employees arriving at work were told to go home as the building was expected to be closed for the week-end. Fourteenth Street between Pennsylvania Avenue and Constitution Avenue was shut down, disrupting early morning traffic and a number of converging spectators. One respondent reported that the confusion was especially problematic because the second floor of the building housed a child-care facility and no information about the status of the facility was forthcoming.

As the D.C. fire department lacked the appropriate equipment to detect PCBs, immediate calls were made to surrounding jurisdictions to obtain an air sampling monitor for PCBs and dioxins that might have been released in the fire and consequent soot. Such equipment did not arrive until 1.5 hours after the initial calls. On arrival, the monitor was found to be outdated but air samples were collected and sent to a commercial laboratory for analysis. After controlling the fire, initial cleanup of gross materials was completed by the Hazardous Materials team.

As required, the National Response Center was notified of a possible hazardous materials release at 8:27 by the D.C. Emergency Management Agency (EMA) (NRT 1999). Other responders included representatives from the GSA Safety and Health (the building is federal property), EPA, FEMA, the FBI, OSHA, the Secret Service, the Federal Protective Services, the district's administration as well as the district's EMA, PepCo (the power company servicing the city), and representatives from the Simplex Clock company (manufacturer of the clock system containing the faulty capacitor).

Besides the number of agency personnel arriving at the scene, both onlookers and media converged at the site. In addition, a number of the building employees attempting to view the scene had walked through the oil that had leaked onto the floor and tracked it to other parts of the corridor outside the vaults. Uncertainty of the consequence of this behavior led the D.C. HAZMAT team to set up a portable unit in the building's courtyard parking lot for decontaminating persons. The decontamination process had individuals disrobe, separate their clothes and personal items into separate bags, shower, scrub with a bleach solution, and then shower again. Victims were given a clean disposable jumpsuit to wear before being transported to the hospital. In all 22 people were processed before going the hospital. Two workers in the basement were sent to the hospital with no decontamination. The entire decontamination of the 22 people took approximately 1 hour and occurred approximately 4 hours after the event had started. Before being admitted to the hospital, victims were again decontaminated in the facility's two decontamination corridors which supply a continuous stream of warm water and are separated for males and females. The 45 victims were diagnosed as non-symptomatic, observed, presented with a sheet of paper describing possible psychological effects from such incidents, and released.

When the hazardous material team left, the GSA and building's management decided to call in a commercial vendor to decontaminate the building. Sampling continued with surface wipes and air samples sent to a commercial laboratory for analysis. The GSA's decision to reopen the building to workers the following Monday was based on several factors. Although the entire building's heating, ventilating, and air conditioning (HVAC) system had been shut down as a precaution at the time of the event, the HVAC system that supplied the vaults where the capacitors were located was entirely separate from that supplying the rest of the building where employees were located. The vault HVAC system also vented directly to the outside. Responders reported that no soot or other fire debris was found outside the vault or in any of the ventilation systems, only sooty glove prints from responders hands and oil residue from foot prints were found on the outside corridor. However, as a precaution, the main building's

HVAC system was sampled and found without contamination. After the section of the basement with the contaminated vault was closed to employees, the decision was made to reopen the main building offices to employees on Monday while cleanup continued in the vault itself. Shortly after cleanup resumed in the vault area, it was found necessary to post a guard in the area to restrict employees from using the area as a shortened route between areas of the building.

Decontamination of the vaults in the second story basement would take another 3 months to complete. Absorbent materials were used for gross contamination followed by the use of solvents (turpentine, PipeX and MetalX) on all metallic surfaces. Non-metal articles were discarded. The surface of the cement flooring was cleaned with a commercial product (Less Than Ten) and mechanical means. When wipe samples of the floor and air monitoring samples finally came back negative, the area was declared safe.

4.3.3 Findings

1. Inadequate detection/monitoring equipment at the local level delayed efforts to identify the contaminant. The lack of equipment is troublesome in that Washington, D.C., supposedly has one of the best trained emergency response force in the nation.
2. Inadequate control of convergers at the site of the release may have led to unnecessary decontamination of people and resulted in secondary contamination of building surfaces from foot traffic.
3. The extensive number of organizations and agencies involved promoted a chaotic environment not conducive to efficient control of the situation. In this urban area, it snarled traffic for hours and exacerbated an already tense situation.
4. Misinformation provided by the media led to misrepresentation about the event in national databases.
5. Separate decontamination facilities are needed for decontaminating men and women on site.
6. A response time of 4 hours to initiate decontamination is too slow for many chemical release scenarios.
7. There is no evidence of long-term post-reentry monitoring of vault floors even with evidence that PCBs migrate to surfaces.
8. The biggest bottleneck in the decontamination process was the time taken to disrobe and place items, especially checkbooks and paychecks, in the two plastic bags.
9. Forty-five strangers disrobed and went through the decontamination process at hospital without a problem.
10. The doctor in charge of the event credited the well-executed hospital response to a well-conceived and exercised plan that prepared the hospital for such an emergency.
11. Hospital emergency room staff found PPE required by OSHA to be cumbersome and restricting when treating.
12. Given the circumstances of the magnitude of the exposure to most persons, decontamination was likely unnecessary except for those responders in direct contact with soot or oil.
13. The number of people who thought themselves exposed was not based on objective criteria and likely was based on overreaction and unfamiliarity with the toxicity of PCBs in oil.
14. Perceptions of the toxicity of PCB was that it was a highly toxic chemical. Knowledge of how to decontaminate if a person is exposed to PCB and what signs and symptoms to look for could have avoided the overreaction.

4.4 CASE STUDY 4. MERCURY RELEASED IN ELEMENTARY SCHOOL

Occurrence Date:	26 October 1999
Location:	North Grove Elementary School, Indiana
Source:	Substance brought to school and dropped
Material:	Mercury
Impacts:	Children and staff decontaminated, no injuries
Quantity Discharged:	50 cc

4.4.1 Background

Mercury, a silver, odorless, liquid, sometimes called "quicksilver," was a common substance in many households. Thermometers, blood pressure gauges, and older gas meters all contained the substance. Mercury poisoning can damage the brain and kidneys and harm a developing fetus. Purdue University (2000) reports that acute exposure to elemental mercury produces symptoms of metallic taste, burning, irritation, salivation, vomiting, diarrhea, abdominal pain and hemorrhaging. High levels of exposure usually cause sudden fever, chills, malaise, nausea, coughing, shortness of breath, chest pain and tightness. Exposure to high levels of mercury can cause death. Lower-dose, chronic inorganic mercury poisoning can cause tremors, memory loss, insomnia, depression, irritability, excessive shyness, emotional instability, delirium, and acrodynia and may result in a neurologic syndrome known as "mad hatter syndrome" (Purdue University 2000).

Information from CSB Report 1999-4440 stated that an Indiana elementary school had been evacuated after a student brought liquid mercury to school and spilled it inside a building. The report stated that firefighters hosed off more than 20 students and staff members who feared they came in contact with the substance. Because of the issues regarding decontamination of children and the possible psychological reactions, this incident was chosen to be a case study.

4.4.2 Incident Timeline, Response, and Consequences

The respondents surveyed reported that on Oct. 26, 1999, at 2:00 p. m., a call to 911 alerted the White River Township Fire Department that a quantity of mercury had been released at the North Grove Elementary School located in Greenwood, Indiana. A student had brought approximately 50 cc of mercury from his home to school where he shared the substance with friends while in his homeroom, two classrooms, and in the school cafeteria. While playing with the substance in one of the classrooms, the mercury fell to the floor and splattered.

Aware of the potential hazards from exposure to elemental mercury, the HAZMAT team called in as back-up recommended decontaminating students and staff exposed to the substance. The recommendation was highly disputed as unnecessary by the school principal, but the team proceeded and set up a portable decontamination station in the outdoor parking lot adjacent to the building. Decontamination was initiated 20–30 minutes after the initial call. Approximately 50 people were decontaminated in the school parking lot over the storm drain The Indiana Department of Emergency Management was also notified and a commercial contractor called in to decontaminate the building. None of those exposed were sent to a medical facility nor monitored after being sent home. Instructions on what to look for (signs and symptoms) for mercury poisoning were given out and people told to go to the hospital immediately if any symptom occurred. Because of the perceived necessity to decontaminate students as soon as possible, no attempt was made to contain the water that flowed into the storm drain.

One issue brought up by one respondent was establishing a quarantine area to prevent cross contamination. The decontamination zone was quite a distance from the school building, which meant the firefighters were walking in areas they should not have been allowed to enter. Another issue involved the media's presence. The newspaper printed a front page photo the next day of children being decontaminated by firefighters.

Determining what to decontaminate and when to safely reenter building was left to the commercial vendor. Some books, clothes, and carpet were thrown away but desks were decontaminated. The vendor used a field screen with black light to identify where the mercury was located. Mercsorb, a substance that absorbs mercury, was used with a vacuum recovery system. Cleanup personnel used saranix suits, booties, double layer latex gloves and respirators for PPE. Because respondents noted that it was difficult to know where all students with the mercury had been located in the classrooms, the vendor used a "plume definition" approach.

To determine areas were safe to reenter, the vendor relied on a visual inspection using the field screen with black light and the special powder that turns blue when mercury is present and air monitoring. Total time to decontaminate the building, surfaces, and desks was 72 hours. One respondent noted that no state or government agency can call for a cleanup vendor unless they are willing to pay the bill. The owner of the business, vehicle, etc., involved in the incident must be located so that the owner is liable, not the state or agency.

4.4.3 Findings

1. A school official unfamiliar with mercury's potential health hazards posed a problem in decontaminating students for exposure to mercury.
2. Students and staff were decontaminated in a portable structure that allowed mercury to flow directly into the storm water drain.
3. Students and staff were decontaminated with water from fire hoses in October in Indiana. Hypothermia was not considered even though young school children were involved.
4. Cross contamination was a problem because no quarantine area was established.

4.5 CASE STUDY 5 WORKERS EXPOSED AT LAWN AND GARDEN TREATMENT PRODUCT COMPANY

Occurrence Date:	14 September 2000
Location:	Bonide Corporation, New York Mills, New York
Source:	Overheated substance
Material:	Dimethoate
Impacts:	11 workers sent to hospital, 7 hospital employees exposed to victims also treated for exposure
Quantity Discharged:	Unknown

4.5.1 Background

Dimethoate, a pesticide, is described as an organophosphate cholinesterase inhibitor. When inhaled, it may cause increased watery nasal discharge, a sensation of chest tightness, and prolonged wheezing. Absorption by the lungs may produce these and other symptoms of cholinesterase inhibition within a few minutes or up to 12 hours after exposure. It is recommended that emergency personnel wear gloves and avoid secondary contamination. The incidence of secondary contamination affecting hospital emergency room personnel reported in CIRC document 2000-4958 suggested this was an appropriate case study. Anecdotal reports from hospital staff have indicated that wearing PPE in the emergency room is difficult when treating patients and recommendations to do so are often disregarded. Secondly, without knowledge of the substances to which patients reporting to the emergency room have been exposed, it is uncommon for staff to routinely don PPE to treat patients.

4.5.2 Incident Timeline, Response, and Consequences

Workers at a lawn and garden treatment product company inadvertently overheated an organophosphate pesticide. Instead of heating the dimethoate to the prescribed 150°F, the material was overheated to 220°F and began emitting fumes. Inhalation of dimethoate fumes can quickly result in severe respiratory problems and other symptoms and the victim should immediately seek medical treatment. Eleven workers transported themselves to a nearby hospital in Utica, New York, and walked into the emergency room without being decontaminated. Several hospital employees treating the workers became ill themselves.

When the emergency room doctor saw his staff becoming ill, he immediately called the Assistant Fire Chief (and HAZMAT coordinator for Utica) at his home to ask why the staff was getting sick. The Chief told him to immediately remove the people from the emergency areas and to treat everyone who had been in contact with them as contaminated. Outside in the parking lot, the male plant workers were decontaminated in a unit set up by the HAZMAT team. The emergency room workers and the three female plant workers were decontaminated inside the hospital emergency room area where showers were present.

Some male workers refused at first to be decontaminated, feeling they worked with the chemicals every day but they finally agreed to undergo decontamination. Fire department personnel wore Level B PPE when decontaminating victims. Approximately 20 people altogether went through the decontamination process which took approximately 1 hour. The decontamination process is a four-step procedure using a corridor. To prevent the pesticide from entering the area drain, neoprene pads were placed over the drain. The wastewater was then pumped into 55-gal drums and given to the hospital for proper disposal.

Hospital housekeeping staff dressed in scrubs, gloves, hairnets and wearing air filters were responsible for cleaning the emergency rooms where the exposed had first been taken and for the articles in those rooms. All walls were washed as well. The entire emergency room was shut down during the 2 hours it took to decontaminate the area. It is unclear who made the decision to reopen the emergency room to patients.

4.5.3 Findings

1. Procedures for screening for contamination were not in place for unannounced incidents involving persons contaminated with a toxic chemical.
2. Hospital personnel had no training in identifying the symptoms of a hazardous chemical exposure.
3. Lack of communication between jurisdictions (New York Falls and Utica was a significant problem. Although people exposed came from New York Falls, the emergency room doctor had to call the Utica fire chief to help identify the problem of his staff getting ill from treating victims.
4. Hospitals that receive patients from many jurisdictions should have information on all chemicals that could result in potential toxic exposure to better treat patients.
5. The hospital did not have a separate containment area for potentially exposed patients.
6. There were no separate decontamination facilities for men and women. Having the female plant workers shower inside in separate facilities from the male plant workers showering outside the hospital avoided the privacy issue associated with a single facility.
7. Even though male workers did not feel it necessary to decontaminate, they did not refuse and decontaminated as recommended.
8. Using housekeeping staff wearing minimum protection allowed the area to be cleaned rapidly and the emergency room to be reopened within 2 hours of shut-down.

4.6 CASE STUDY 6 MERCURY RELEASE AT INTERNATIONAL AIRPORT POSTAL HUB

Occurrence Date:	15 September 2000
Location:	Indianapolis International Airport, Indianapolis, Indiana
Source:	Leaking package
Material:	Mercury spill

Impacts:	3 workers transported directly to hospital, 40 others taken to hospital by airport shuttle
Quantity Discharged:	Unknown

4.6.1 Background

This incident was investigated because airports have been identified as primary targets for terrorist chem/bio attacks. Employees at this postal hub at a large international airport routinely handle very large quantities of materials and how they react to a toxic substance in such an environment is largely unknown in the literature. The postal hub is operated by a private firm, not the U.S. Postal Service.

4.6.2 Incident Timeline, Response, and Consequences

On an early Friday morning, a small amount of mercury about the size "found in a thermometer" was discovered on a conveyer belt in a sorting area of a large international airport postal hub. A supervisor was informed that an employee had picked up and handled some mercury. The supervisor decided the incident should be treated as a hazardous materials situation and the company called the airport fire department who in turn called the Wayne Township fire department. About 10:30 the fire department arrived on scene. The one employee who had been in contact with the mercury and two others who complained of breathing problems were sent to the hospital by ambulance. The fire department then proceeded to decontaminate approximately 40 others including anyone in the vicinity of the sorting area around the conveyor belt. Persons placed their clothes in one bag and personal articles in another bag, both of which they were allowed to carry with them into the hospital. One respondent observed several employees take cell phones from the bagged articles and use the equipment while in the hospital.

The Wayne County Emergency Department has a decontamination truck that was used to decontaminate female employees inside the unit. Male employees were decontaminated by firefighters outside in the parking lot near the facility. Both men and women had warm water for showering. Once decontaminated, persons were reclothed in Tyvek jumpsuits and told to go to the waiting buses for transport to the hospital.

About 11:30 a.m., representatives arrived from the County Health Department. Health officials reported conflicting statements by company personnel about the incident. Seeing the airport shuttle buses waiting to take the people to the hospital, they requested permission to check people for mercury contamination using a Jerome meter. They also checked another 40–50 people in street clothes for possible contamination. No contamination was found on anyone, and the employees who had been decontaminated were taken to the hospital. At the hospital, people were interviewed, charted, and checked for vital signs.

Urine and blood samples were collected and analyzed checked for mercury. After each person was evaluated, the patients were sent to the hospital auditorium for debriefing and told what signs and symptoms to watch for. One respondent reported that several people not in the original group that had been decontaminated arrived the day after the incident to be evaluated for mercury exposure.

Once all the employees had been taken to the hospital, a reconnaissance team entered the building to check for contamination and a commercial cleanup team hired for cleanup started decontamination. At that time the county health department personnel went to the hospital to check the clothing for contamination. One pair of shoes worn by the employee who had handled the mercury was found contaminated and disposed of. The health department then went back to the airport to check for contamination in employee's cars. None was found. Informational factsheets on mercury were distributed to all employees.

Meanwhile a commercial company had been hired to provide air monitoring. Once everything checked out, the company requested the health department personnel to certify the building was safe to begin work in again. The health department went through with the Jerome monitor and okayed the building for re-entry.

4.6.3 Findings

1. There were no criteria to distinguish people who were contaminated from those who were not.
2. County health department equipment and personnel arrived an hour after the incident, well after decontamination efforts had started.
3. Bagged articles taken with employees to hospital were not checked for contamination before being brought into the hospital.

4.7 CASE STUDY 7. INADVERTENT MIXING OF CHEMICAL INTO SULFURIC ACID CREATED TOXIC FUMES

Occurrence Date:	13 October 2000
Location:	S & R of Kentucky, Bowling Green, Kentucky
Source:	Mixing of incompatible chemicals
Material:	Sulfuric acid mixed with aminonic shield conditioner
Impacts:	40 workers decontaminated and taken to hospital
Quantity Discharged:	Fumes from unknown quantity of mixture

4.7.1 Background

The spill at the chrome plating factory illustrates the problems emergency responders have in responding to events in which the chemical release is unknown and people are experiencing severe respiratory distress, such as would be evident in a nerve agent release. The incident emphasizes the need for companies to establish work rules and retrain employees when new products are being tested or produced.

4.7.2 Incident Timeline, Response, and Consequences

According to the CIRC report, the spill at the chrome plating plant occurred just before 11:00 a.m. However, the emergency service unit and the fire department received the 911 call at the same time (9:50 am) and immediately headed for the plant. The plant is located in an industrial park approximately 8 miles from the town. Upon arriving at the plant, the responders reported seeing numerous people lying on the ground. Employees were upset and tried to reach responders. Unsure as to the contaminant, the responders corded off the area, telling patients by hand signals and verbal commands to keep in that area.

A decontamination facility was set up and approximately 40 workers were hosed down. Clothing was replaced when necessary. Both men and women were concerned about the decontamination procedures but once the dangers with not being decontaminated were explained, all agreed to procedures.

One respondent reported that the media with their cameras were also a detriment at the hospital decontamination site and that the emergency vehicles were placed to obscure media views when possible. One media representative from Nashville questioned the fire chief as to whether decontamination was really necessary under the circumstances. This bothered the fire chief.

Employees were decontaminated in pools but one pool had a leak and another overflowed. The water ran down the hill to an area of pavement that had been trenched and covered with gravel. Later EPA checked and concluded that the gravel would help neutralize the acid if it was there. It took approximately 2 hours to decontaminate all employees exposed. One respondent noted that there was only one decontamination line and they should have used two lines to speed up the process.

After decontamination, employees were checked for vital signs. About seven people were sent to the hospital for further monitoring and chest x-rays. Later other employees not decontaminated reported to the emergency room. Knowing they had come from the plant, hospital staff ushered them out and decontaminated them before allowing them into the emergency room.

The owner of the plant was required to retrain all workers in the use of equipment and the characteristics of the chemicals found on site. He was also required to submit Material Safety Data sheets (MSDSs) on all chemicals at the facility. An outcome has been the dedication of a three-room mini-shower unit by the hospital EMS team to the local firefighters for use by their HAZMAT team for decontamination. Issues on decontamination of people before entering an ambulance or the emergency room have been reviewed and, when necessary, revised.

4.7.3 Findings

1. The company was lax on updating MSDSs, slowing the identification of the chemicals involved in the release.
2. Media presence was a problem that contributed to patients' unease about decontamination procedures.
3. Emergency responders lack of knowledge about characteristics of chemicals involved slowed initiation of decontamination procedures.

4.8 GENERAL FINDINGS FROM CASE STUDIES

The conclusions reached from the case studies in this report support many of the findings presented int he literature review.

1. Lack of resources at the local level delays identification of contaminant and decisions on appropriate response procedures. Delays are exacerbated by the time required to elicit outside assistance and information about the contaminant. This issue is a problem in large urban areas (such as Washington, D.C.) as well as smaller communities but is more problematic in smaller communities where first responders are frequently volunteers without extensive training for hazardous or unfamiliar substances. Lack of training on how to detect hazardous materials may exacerbate this problem.
2. The HAZMAT model to decontaminate people as a precautionary measure needs to be reassessed. Using self-reporting as a decision measure to be included in decontamination efforts appears to lead to unnecessary decontamination.
3. Criteria to assess the effectiveness of decontamination efforts in the field are lacking in health care facilities. As a result, unnecessary repetitive decontamination often occurs at the health care facility. The unfamiliarity with decontamination procedures leads to confusion on who will be decontaminated and the reasons for the process. The conservative approach to decontaminate anyone who thought themselves at risk has led to unnecessary decontamination and waste of resources.
4. Unless warned, health care staff have difficulty recognizing patients that have been contaminated and are unprepared to effectively treat them. In one study this led to secondary contamination of medical staff and facilities and temporary closure of the facility. This situation can become a complex problem when contaminated people self-evacuate to a medical facility and provide the staff with no information about the potential hazard.
5. Lack of detection equipment or knowledge of potential contamination at the incident site places emergency responders at risk and delays the implementation of decontamination procedures. This is a problem when immediate action is needed to alleviate the effects of the contaminant.
6. Routing of emergency calls to 911 does not necessarily evoke a HAZMAT response and places police officers who respond at risk. Most police officers are trained to handle crises and are not trained to deal with hazardous materials incidents, especially unfamiliar substances.
7. There is no systematic method to determine when it is safe to reoccupy a structure. The decision to reoccupy buildings after decontamination is made on a case-by-case basis, and that decision is often left to the decision of the vendor who performed the cleanup which is not verified by responsible public officials.
8. In every case studied, the media reports were significantly different from information collected from respondents regarding the number of people affected. Information from the media is being used in at least one national database without concurrence of agencies or individuals involved in the actual event, such as firefighters, state or local emergency management agencies, or owners of buildings or companies.
9. No evidence was found from case studies to suggest that people refuse to reoccupy a building that has been decontaminated. No one refused to reoccupy the Commerce Building during the 3 months when the vault was being decontaminated. A guard had to

be stationed to keep people away from the area being decontaminated when security roping failed to deter people from moving through the area.

10. First responders have difficulty identifying hazardous chemicals because companies are lax in reporting inventories of toxic chemicals to local emergency response agencies.
11. There were no systematic methods to control wastewater disposal.
12. There were no alternative methods (instead of water and soap) used for decontaminating people. HAZMAT and medical teams rely instead on copious amounts of water for decontamination. Use of water will exacerbate the situation if a substance reactive to water is the contaminant.
13. Medical staff find it difficult to wear the required cumbersome PPE to treat contaminated patients.
14. Information (either verbal or written) about the potential reactions of people being decontaminated helps people understand the possible psychological reactions they might have experienced and alleviates their distress. One hospital studied has a preprinted information sheet written by a staff psychiatrist to routinely give to patients that have undergone decontamination.

5. CONCLUSIONS

5.1 GENERAL FINDINGS

The following are general findings based on a synthesis of the findings from both the case studies and literature review.

1. There is no national database maintained by either government, commercial, or private sources that adequately captures information on efforts to decontaminate and the results of those decontamination efforts. Thus, regulators are unable to identify the issues and address the deficiencies in decontamination procedures.
2. Current methods of mass decontamination take too much time to be effective fort substances requiring immediate actions. Alternatives to the military model of decontamination need to be established.
3. Reentry decisions are particularly difficult when residual contamination following decontamination efforts cannot be adequately supported with scientific certainty that no risk is involved in reuse or reentry. The reliance on ultra-conservative standards is not a desirable solution to the problem.
4. Multiple perspectives on roles and responsibilities complicate decision-making and prevent the immediate initiation of decontamination efforts.
5. Long-term or follow-up monitoring of decontaminated buildings and/or people doesn't occur in most instances. The Tokyo subway incident and the Binghamton State office building are exceptions.
6. Local emergency response organizations do not have the detection or sensor technology to identify chemical or biological contamination.
7. There is a reliance on private companies to perform building decontamination and to determine when it is safe for reentry. Since there are few standards for reentry, there is no guarantee that the structures have been appropriately decontaminated and are safe for reoccupation.

5.2 POLICY RECOMMENDATIONS

Based on the preliminary research findings from both the literature review and the case studies, we off the following recommendations

1. Improve and standardize protocols for decontaminating people in chemical and biological agent incidents
2. Develop a standard approach for setting reentry criteria for buildings exposed to chemical or biological agents and validate that approach through an independent scientific peer review process.
3. Develop building surface and air reentry criteria for specific warfare agents.

4. Develop information protocols for communicating with the public about critical decontamination topics. These topics include: the need to be decontaminated, the importance of timely decontamination, the risk of reoccupying decontaminated structures, and other public concerns.
5. Develop decontamination technical information resources for various chemical "hotlines" such as poison control centers, chemtrec, CDC's medical hotlines, and other sources of emergency assistance.

5.3 RESEARCH RECOMMENDATIONS

Based on the work to date we have started to formulate several recommendations for research. These will be refined and expanded in the final report.

1. There is a need to quantify the risk of decontamination activities to emergency workers. This should be done for different classes of materials including chem/bio agents and in both field and hospital settings.

2. Currently the need for PPE and the level of PPE while performing decontamination activities are not well defined. OSHA regulations address this issue but a scientific basis has not been established.

3. To date, the feasibility of mass decontamination has not been established, Research is needed to establish the basis and resource requirements for decontaminating various population sizes.

4. No empirical research has been conducted on the social and psychological effects of experiencing decontamination. Research should be conducted on several types of events including mixed male and female events and multiple decontamination events.

5. Little follow up work has been conducted post decontamination. A program is needed to monitor or conduct surveillance of post decontamination residual contamination or health effects.

6. Periodic post audits of decontamination events should be done to further our understanding of problems and issues and to monitor improvements in practices.

7. There is an underlying assumption that removal of clothes removes much of the contamination people are exposed to. Research is needed to verify this assumption.

6. FUTURE OUTLOOK

In fiscal year 2001 we will update the databases, develop a selective annotated bibliography, conduct additional research on historical incidents, and conduct additional case studies to fill gaps in the current knowledge. We will also develop recommendations to improve decontamination procedures and protocols, develop recommendations for research to provide a stronger technical basis for decontamination planning, and prepare a final project report. Further research may include developing a working group to determine how to implement the recommendations suggested by the findings from the case studies and literature review.

7. REFERENCES

Alexander, L. 1998. *Decontaminating Civilian Facilities: Biological Agents and Toxins*, Institute for Defense Analyses, Alexandria, Va.

Baker, P. 1992. "Malathion-Induced Epidemic Hysteria in an Elementary School," *Veterinary and Human Toxicology*, **34**(2), 156–60.

Baker, D.J. 1999. "The Pre-hospital Management of Injury Following Mass Toxic Release: a Comparison of Military and Civil Approaches," *Resuscitation*, **42**(2), 155–9.

Balk, S. J., Gitterman, B. A., Miller, M. D., Shannon, M. W., Shea, K. M., and W. B. Weil. 2000. "Chemical-Biological Terrorism and Its Impact on Children," *Pediatrics*, **105**(3), 662–70.

Barkley, N. P. 1990. "Update of Building and Structure Decontamination ," *Journal of the Air & Waste Management Association*, **40**(8), 1174–8.

Bellanger, C., Lison, D., and J. Willems 1993. "Decontamination of Chemical Casualties," *Journal of European Radiology*, **6**, 84–90.

Brennan, R. J., Waeckerle, J. F., Sharp, T. W., and S. Lillibridge 1999. "Chemical Warfare Agents: Emergency Medical and Emergency Public Health Issues," *Annals of Emergency Medicine*, **34**(2), 191–204.

Burgess, J. L., Blackmon, G. M., Brodkin, C. A., and W. O. Robertson 1997. "Hospital Preparedness for Hazardous Materials Incidents and Treatment of Contaminated Patients," *Western Journal of Medicine*, **167**(6), 387–91.

Coldiron, V. R. and H. E. Janssen 1984. "Safe Decontamination of Hospital Rooms and Ventilation System by Formaldehyde Generation," *American Industrial Hygiene Association Journal*, **45**(2), 136–7.

Cole, T. B. 2000. "When a Bioweapon Strikes, Who Will Be in Charge?" *Journal of the American Medical Association*, **23**(8), 944.

Copenhaver, E. D. 1992. *Response Phase Decontamination for CSEPP Training Guide*, ORNL/M-3081, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Cox, R. D. 1994. "Decontamination and Management of Hazardous Materials Exposure Victims in the Emergency Department," *Annals of Emergency Medicine*, **23**(4), 761–70.

Debus, A., Runavot, J., Rogovski, G., Bogomolov, V., Khamidullina, N., Darbord, J. C., Plombin, B. J., Trofimov, V. and M. Ivanov 1998. "Mars 96 Small Station Biological Decontamination," *Life Sciences: Exobiology*, **22**(3), 401–9.

DHHS (U.S. Department of Health and Human Services) 1995. *Proceedings of the Seminar on Responding to the Consequences of Chemical and Biological Terrorism*, sponsored by the Public Health Service, Office of Emergency Preparedness, and conducted at the Uniformed Services University of Health Sciences, Bethesda, Md., July 11–14, 1995.

English, J. F., Cundiff, M. Y., Malone, J. D., and J. A Pfeiffer 1999. *Bioterrorism Readiness Plan: A Template for Healthcare Facilities,* prepared for the Association for Professionals in Infection Control and Epidemiology (APIC) Bioterrorism Taskforce and the Centers for Disease Control (CDC) Hospital Infections Program Bioterrorism Working Group.

EPA (Environmental Protection Agency) 2000. *First Responder's Environmental Liability due to Mass Decontamination Runoff,* Office of Solid Waste and Emergency Response, Chemical Emergency Preparedness and Prevention Office, July.

Franz, D. R. 1998. "International Biological Warfare Threat in CONUS," Joint Hearing Before the Senate Judiciary Subcommittee on Technology, Terrorism, and Government and the Senate Select Committee on Intelligence, Mar. 4, 1998.

Garland, J. A., Watterson, J., Jayasekera, P. N., and D. W. Jones 2000. *Hazard from Reaerosolized Biological Warfare Agents*, Defence Evaluation and Research Agency, Port Down, England.

Gerone, P. 1996. "Research with Non-human Primates" in *Proceedings of the 4th National Symposium on Biosafety. January 27-31, 1996,* Westin Peachtree Plaza, Atlanta, Ga.

Granot, H. I. and Brender, M. 1991. "A Behavior-Response Wheel for Training and Field Use by Civil Defense Officers at Emergency Sites," *Journal of Traumatic Stress*, **4**, 223–31.

Holloway, H. C., Norwood, A. E., Fullerton, C. S., Engel, C. C., and R. J. Ursano 1997. "The Threat of Biological Weapons. Prophylaxis and Mitigation of Psychological and Social Consequences," *Journal of the American Medical Association*, **278**(5), 425–7.

Keim, M. and A. F. Kaufmann 1999. "Principles for Emergency Response to Bioterrorism," *Annals of Emergency Medicine*, 34(2), 177–182.

Kim, N. 1983. "Building Reclamation after Dioxin Contamination by PCB Fires," pp. 185–6 in *Accidental Exposure to Dioxins, Human Health Aspects*, F. Coulston and F. Pocchiari, eds.

Kim, D.H and R. E Burr 2000. "Chemical Spills: The Hospital Perspective," presented at the 219th National Meeting of the American Chemical Society, San Francisco, Mar. 26–30, 2000.

Kim, N. K. and J. Hawley 1982. *Risk Assessment: Binghamton State Office Building*, Bureau of Toxic Substance Assessment, Div. of Health Risk Control, New York Dept. of Health, Albany, N.Y.

Kirshner, M. and K. Bleach 1994. "Environmental and Occupational Remediation Subsequent to the World Trade Center Bombing," *Environmental International*, **20**(2), 253–61.

Laurent, J. F., Richter, F., and A. Michel 1999. "Management of Victims of Urban Chemical Attack: the French Approach," *Resuscitation*, **42**(2), 141–9, Oct.

Macintyre, A. G., Christopher, G. W., Eitzen, E., Gum, R., Weir, S. DeAtley, C. Tonat, K., and J. A. Barbera 2000. "Weapons of Mass Destruction Events with Contaminated Casualties: Effective Planning for Health Care Facilities," *Journal of the American Medical Association*, **283**(2), pp. 242–9.

Maslowki, R. and V. Rose 1985. "High-Rise Building Contamination After a Furan Incident," *IEEE Transactions on Power Delivery*, **PWRD-1**(1), 239–44.

McMullen, M. J. 1996. "Chemical Decontamination," letter to the editor and response to Schultz and Cisek, *Annals of Emergency Medicine*, **27**(2), 270–1.

Moles, T. M. 1999. "Emergency Medical Services Systems and HAZMAT Major Incidents," *Resuscitation*, **42**(2), 103–16.

Morris, W. and J. Ginley 1993. "Fumes send Thousands to Hospital, Jams Traffic," *Contua Costa Times,* July 28, p. 1A.

NCEH (National Center for Environmental Health) 1995. *Trip Report of the United States Medical Delegation to Japan*, Centers for Disease Control, Atlanta, Ga.

NRC (National Research Council) 1999. *Strategies to Protect the Health of Deployed U.S. Forces*, National Academy Press, Washington, D.C.

NRT (National Response Team) 1999. "Transformer Fire, Sitrep One, 1 October 1999," National Response Team of the National Oil and Hazardous Substances Pollution Contingency Plan," http://www.nrc.uscg.mil/transformer.htm, accessed July 6, 2000.

NYDH (New York State Dept. of Health) 1999. *Hazardous Substances Emergency Events Surveillance, Cumulative Report 1993-1997,* New York State Health Department, Albany.

Okumura, T., Suzuki. K., Fukuda, A., Takasu. N., Ishimatsu, S., and S. Hinohara 1998a. "The Tokyo Subway Sarin Attack: Disaster Management, Part 1—Community Emergency Response," *Academic Emergency Medicine*, **5**(6), 613–7.

Okumura, T., Suzuki. K., Fukuda, A., Takasu. N., Ishimatsu, S., and S. Hinohara 1998b. "The Tokyo Subway Sarin Attack: Disaster Management, Part 2—Hospital Response," *Academic Emergency Medicine*, vol. **5**(6), 618–24.

Orloff, K. G., Ulirsch, G., Wilder, L., Block, A., Fagliano, J., and J. Pasqualo 1997. "Human Exposure to Elemental Mercury in a Contaminated Residential Building," *Archives of Environmental Health*, **52**(3), 169–72.

Osterholm, M. T. 1999. "The Medical Impact of Bioterrorist Attack. Is it All Media Hype or Clearly a Potential Nightmare?" *Postgraduate Medicine*, **106**(2), 121–7.

Pasanen, P., Kalliokoski, P., and A-P. Pasanen 1997. "The Effectiveness of Some Disinfectants and Detergents Against Microbial Activity," *Building and Environment*, **32**(3), 281–7.

Perdek, J. M., Freestone, F. J., Sandifer, D. and A. Sherman 1991. "Closure of a Dioxin Facility," *Chemosphere*, **23**(8-10), 1295–1305.

Peters, C. J., and M. Olshaker 1997. *Virus Hunters,* Anchor Books (Doubleday), New York.

Pons, P. and R. C. Dart 1999. "Chemical Incidents in the Emergency Department: If and When," *Annals of Emergency Medicine*, **34**(2), 223–5.

Purdue University 2000. "Purdue and EPA Help Hospitals Keep Mercury out of the Environment," http://www.agcom.purdue.edu/AgCom/news/GPRA00/00harmony/environmercury.html, accessed Sept. 18, 2000.

Rappe, C., Kjeller, L. O., Marklund, S., and M. Nygren. 1986 "Electrical PCB Accidents: An Update," *Chemosphere*, **15**(9-12), 1291–5.

Richards, C. F., Burstein, J. L., Waeckerie, J. F., and H. R. Hutson 1999. "Emergency Physicians and Biological Terrorism?" *Annals of Emergency Medicine*, **34**(2), 183–90.

Schecter, A. 1986. "The Binghamton State Office Building Pcb, Dioxin, and Dibenzofuran Electrical Transformer Incident—1981–1986," *Chemosphere*, **15**(9-12), 1273–80.

Schecter, A. and K. Charles 1991. "The Binghamton State Office Building Transformer Incident after One Decade," *Chemosphere*, **23**(8-10) 1307–21.

Schultz, M., Cisek, J., and R.Wabeke 1995. "Simulated Exposure of Hospital Emergency Personnel to Solvent Vapors and Respirable Dust During Decontamination of Chemically Exposed Patients," *Annals of Emergency Medicine*, **26**(3), 324–9.

Selden, B. 1989. "Adolescent Epidemic Hysteria Presenting a Mass Casualty, Toxic Exposure Incident," *Annals of Emergency Medicine*, **18**(8), 892–5.

Shumpert, B., Watson, A., Rogers, G., Sorensen, J., Long, J., and R. Brooks 1996. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program,* ORNL-6764, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Sidell, F. R. and D. R. Franz. 1997. "Overview: Defense Against the Effects of Chemical and Biological Warfare Agents," F. R. Sidell, E. T. Takafuji, and D. R. Franz, eds., *Medical Aspects of Chemical and Biological Warfare*, Office of the Surgeon General, Walter Reed Army Medical Center, Washington, D.C.

SSI Services, Inc., 1996. *Assessment of Response Phase Decontamination and Personal Protective Equipment Needs for the Commonwealth of Kentucky, Chemical Stockpile Emergency Preparedness Program*, prepared for Project Manager, CSEPP, Aberdeen Proving Ground, Md. SSI Services, Inc. Harrisburg, Penn., Dec.

Stephens, R. D. 1986. "Transformer Fire, Spear Street Tower, One Market Plaza, San Francisco, California," *Chemosphere*, **15**(9-12), 1281–9.

Teorngren, S., Persson, S. A., Ljungquist, A., Berglund, T., Nordstrand, M., Heagglund, L., Rittfeldt, L., Sandgren, K. and E. Seoderman 1998. "Personal Decontamination after Exposure to Stimulated Liquid Phase Contaminants: Functional Assessment of a New Unit," *Journal of Toxicology - Clinical Toxicology*, **36**(6), 567–73.

Tilson, H.A., Kodavanti, P. R., Mundy, W.R., and P. J. Bushnell 1998. "Neurotoxicty of Environmental Chemicals and Their Mechanism of Action," *Toxicology Letters*, **102**, 631–5.

Train, D., Chamerland, A., Dupont, D., and J. Castonguay 1987. "Decontamination of IREQ's High voltage Laboratory Following a PCB Fire," *IEEE Transactions on Power Delivery*, **PWRD-2**(1), 77–86.

Vogt, B. M. and J. H. Sorensen 1999. *Description of Survey Data Regarding the Chemical Repackaging Plant Accident West Helena, Arkansas,* ORNL/TM-13722, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Waeckerle, J. F. 2000. "Domestic Preparedness for Events Involving Weapons of Mass Destruction" *Journal of the American Medical Association*, **283**(2), 252.

WHO Working Group 1983. *Styrene, TA: Environmental Health Criteria*, **1**(26), 1-123.

8. BIBLIOGRAPHY

Biological

Building Decontamination

Alexander, L. 1998. *Decontaminating Civilian Facilities: Biological Agents and Toxins*, Institute for Defense Analyses, Alexandria, Va.

Coldiron, V. R. and H. E. Janssen 1984. "Safe Decontamination of Hospital Rooms and Ventilation System by Formaldehyde Generation," *American Industrial Hygiene Association Journal*, **45**(2), 136–7.

Debus, A., Runavot, J., Rogovski, G., Bogomolov, V., Khamidullina, N., Darbord, J. C., Plombin, B. J., Trofimov, V. and M. Ivanov 1998. "Mars 96 Small Station Biological Decontamination," *Life Sciences: Exobiology*, **22**(3), 401–9.

Pasanen, P., Kalliokoski, P., and A-P. Pasanen 1997. "The Effectiveness of Some Disinfectants and Detergents Against Microbial Activity," *Building and Environment*, **32**(3), 281–7.

Rutalia, W. A. and D. J. Weber 1997. "Uses of Inorganic Hypochlorite (Bleach) in Health-care Facilities," *Clinical Microbiology Reviews*, **10**(4), 597–610.

People Decontamination

Carus, W. S. 1999. *Bioterrorism and Biocrimes—The Illicit Use of Biological Agents in the 20th Century (1999 Revision)*, Center for Nonproliferation Research, National Defense University, Washington D.C.

Centers for Disease Control and Prevention no date. *Filovirus in Non-human Primates: Overview of the Investigations in Texas*, Atlanta, Ga.

"Centers for Disease Control and Prevention: Bioterrorism Alleging Use of Anthrax and Interim Guidelines for Management," commentary by G. J. Moran, *Annals of Emergency Medicine*, **34**(2), 229–32.

Cole, T. B. 2000. "When a Bioweapon Strikes, Who Will Be in Charge?" *Journal of the American Medical Association*, **23**(8), 944.

Eitzen, E. M., Pavlin, J., Cieslak, T., Christopher, G., Culpepper, R. (eds.) 1998. *Medical Management of Biological Casualties Handbook*, 3rd. ed., U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Md.

Eitzen, E. M. 1999. "Education Is the Key to Defense Against Bioterrorism," *Annals of Emergency Medicine*, **34**(2), 221–3.

English, J. F., Cundiff, M. Y., Malone, J. D., and J. A Pfeiffer 1999. *Bioterrorism Readiness Plan: A Template for Healthcare Facilities,* prepared for the Association for Professionals in Infection Control and Epidemiology (APIC) Bioterrorism Taskforce and the Centers for Disease Control (CDC) Hospital Infections Program Bioterrorism Working Group.

Franz, D. R. 1998. "International Biological Warfare Threat in CONUS," Joint Hearing Before the Senate Judiciary Subcommittee on Technology, Terrorism, and Government and the Senate Select Committee on Intelligence, Mar. 4, 1998.

Franz, D. R., Jahrling, P. B., Friedlander, A. M. et al. 1997, "Clinical Recognition and Management of Patients Exposed to Biological Warfare Agents," *Journal of the American Medical Association*, **278** 399–411.

Garland, J. A., Watterson, J., Jayasekera, P. N., and D. W. Jones 2000. *Hazard from Reaerosolized Biological Warfare Agents*, Defence Evaluation and Research Agency, Port Down, England.

Gerone, P. 1996. "Research with Non-human Primates" in *Proceedings of the 4th National Symposium on Biosafety. January 27-31, 1996,* Westin Peachtree Plaza, Atlanta, Ga.

Keim, M. and A. F. Kaufmann 1999. "Principles for Emergency Response to Bioterrorism," *Annals of Emergency Medicine*, **34**(2), 177–82.

Holloway, H. C., Norwood, A. E., Fullerton, C. S., Engel, C. C., and R. J. Ursano 1997. "The Threat of Biological Weapons. Prophylaxis and Mitigation of Psychological and Social Consequences," *Journal of the American Medical Association*, **278**(5), 425–7.

Inglesby, T. V., O'Toole, T., Henerson, D.A. 2000. "Preventing the Use of Bioliogcal Weapons: Improving Response Should Prevention Fail," *Clinical Infection Diseases*, **30**(6), 926–9.

Inglesby, T. V., Henderson, D. A., Bartlett, J. G., Ascher, M. S., Eitzen, E., Friedlander, A. M., Hauer, J., McDade, J. Osterholm, M. T., O'Toole, T. Parker, G., Perl, T. M., Russell, P.K., and K. Tonat 1999. "Anthrax as a Biological Weapon—Medical and Public Health Management," *Journal of the American Medical Association*, **281**(18), 1735–45.

Khan, A.S., Morse, S., and S. Lillibridge. 2000. "Public-health preparedness for biological terrorism in the USA," *Lancet*, **356**(9236), pp. 1179–82.

Leggiadro, R. J. 2000. "The Threat of Biological Terrorism: a Public Health and Infection Control Reality," *Infection Control and Hospital Epidemiology*, **21**(1), pp. 53–6.

Macintyre, A. G., Christopher, G. W., Eitzen, E., Gum, R., Weir, S. DeAtley, C. Tonat, K., and J. A. Barbera 2000. "Weapons of Mass Destruction Events with Contaminated Casualties: Effective Planning for Health Care Facilities," *Journal of the American Medical Association*, **283**(2), pp. 242–9.

Peters, C. 1996. "Biosafety and Emerging Infections: Key Issues in the Prevention and Control of Viral Hemorrhagic Fevers" in *Proceedings of the 4th National Symposium on Biosafety January 27–31, 1996*, Westin Peachtree Plaza, Atlanta, Ga.

Peters, C. J., and M. Olshaker 1997. *Virus Hunters,* Anchor Books (Doubleday), New York.

Pesik, N., Keim, M., and T. R. Sampson 1999. "Do Emergency Medicine Residency Programs Provide Adequate Training for Bioterrism?"*Annals of Emergency Medicine*, **34**(2), 173–82.

Preston, R. 1994. *The Hot Zone*, Anchor Books (Doubleday), New York.

Osterholm, M. T. 1999. "The Medical Impact of Bioterrorist Attack. Is it All Media Hype or Clearly a Potential Nightmare?" *Postgraduate Medicine*, **106**(2), 121–7.

Richards, C. F., Burstein, J. L., Waeckerie, J. F., and H. R. Hutson 1999. "Emergency Physicians and Biological Terrorism?" *Annals of Emergency Medicine*, **34**(2), 183–90.

Richmond, J. Y., ed. 1996. "Working Safely with Research Animals," in *Proceedings of the 4th National Symposium on Biosafety January 27–31, 1996*, Westin Peachtree Plaza, Atlanta, Ga.

Rutalia, W. A., and D. J. Weber 1997. "Uses of Inorganic Hypochlorite (Bleach) in Health-care Facilities," *Clinical Microbiology Reviews*, **10**(4), 597–610.

Siegrist, D. W. 1999. "The Threat of Biological Attack: Why Concern Now?" *Emerging Infectious Diseases*, **5**(4), 505–8.

Swanson, E. R., and D. E. Fosnocht 2000. "Anthrax Threats: A Report of Two Incidents from Salt Lake City," *Journal of Emergency Medicine*, **12**(2), 229–32.

U.S. Department of Defense 1998. *911-Bio Consequence Management Advanced Concept Technology Demonstration (ACTD), Final Report*, Defense Threat Reduction Agency Counterproliferation, U.S. Department of Defense, Dulles, Va.

U.S. Fire Administration 1997. *Fire Department Response to Biological Threat to B'nai B'rith Headquarters, Washington, D.C. April 1997*, technical report 114, Federal Emergency Management Agency, Washington, D.C.

Chemical

Building Decontamination

Barkley, N. P. 1990. "Update of Building and Structure Decontamination ," *Journal of the Air & Waste Management Association*, **40**(8), 1174–8.

Burns, R. 1982. "Four Alarm Fire at Chemical Plant Causes Decontamination Problems," *Fire Engineering*, **135**(2), 22–4.

Defelip, E., Didomenico, A., Turrio, L., Volpi, F., andF. Merli 1990. "Analytical Approaches and Criteria to Define Environmental Contamination from an Accidental Polychlorobiphenyl (PCB) Spillage," *Toxicological and Environmental Chemistry*, **29**(1), 37–46.

desRoziers, P.E. and A. Lee 1986. "PCB Fires: Correlation of Chlorobenzene Isomer and PCB Homolog Contents of PCB fluids with PCDD and PCDF Contents of Soot," *Chemosphere*, **15**(9-12), 1313–23.

Deutsch, D. G. and T. D. Goldfarb 1988. "PCDD/PCDF Contamination Following a Plastics Fire in a University Lecture Hall Building," *Chemosphere*, **17**(12), 2423–31.

Donovan, K. and G. Jensen 1998. "Development of Decision Framework for Dispositioning Buildings with Potential Chemical Contamination," in *Proceedings of the 1998 Annual Meeting and Exposition of the Air & Waste Management Association*, San Diego, Ca., June 14–18, 1998.

Fischer, A. B., Bigalke, B., Herr, C., and T. Eikmann 1999. "Pest Control in Public Institutions," *Toxicology Letters*, **107**(1-3), 75–80.

Hoddinott, K. B. and A. P. Lee 2000. "The Use of Environmental Risk Assessment Methodologies for an Indoor Air Quality Investigation," *Chemosphere*, **41**(1-2), 77–84.

Horn, E. G., Aldous, K.M., Eadon, G. A., Dietz, R. N., and L. J. Honan 1991. "Binghamton State Office Building: Decontamination of the Basement Mechanical Room," *1991 Electric Power Research Institute (EPRI) Meeting*, Oct. 8–11, 1991, Baltimore, Md.

Hryhorczuk, D. O., Orris, P., Kominsky, J. R., Melius, J., Burton, W., and D. L. Hinkamp 1986. "PCB, PCDF, and PCDD Exposure Following a Transformer Fire: Chicago," *Chemosphere*, **15**(9-12), 1297–1303.

Kim, N. 1983. "Building Reclamation after Dioxin Contamination by PCB Fires," pp. 185–6 in *Accidental Exposure to Dioxins, Human Health Aspects*, F. Coulston and F. Pocchiari, eds.

Kim, N. K. and J. Hawley 1982. *Risk Assessment: Binghamton State Office Building*, Bureau of Toxic Substance Assessment, Div. of Health Risk Control, New York Dept. of Health, Albany, N.Y.

Kirshner, M. and K. Bleach 1994. "Environmental and Occupational Remediation Subsequent to the World Trade Center Bombing," *Environmental International*, **20**(2), 253–61.

Lagoy, P. K., Bohrer, R. L., and F. H. Halvorsen 1992. "The Development of Cleanup Criteria for an Acutely Toxic Pesticide at a Contaminated Industrial Facility," *American Industrial Hygiene Association Journal*, **53**(5), 298–302.

Lange, J. H., Kaiser, G., and K. W. Thomulka 1994. "Environmental Site Assessments and Audits—Building Inspection Requirements," *Environmental Management*, **18**(1), 151–60.

Maslowki, R. and V. Rose 1985. "High-Rise Building Contamination After a Furan Incident," *IEEE Transactions on Power Delivery*, **PWRD-1**(1), 239–44.

Michand, J.M., Huntley, S. L., Sherer, R. A., Gray, M. N., and D. J. Paustenbach 1994. "PCB and Dioxin Re-entry Criteria for Building Surfaces and Air," *Journal of Exposure Analysis and Environmental Epidemiology*, **4**(2), 197–227.

Milby, T. H., Miller, T. L., and T. L. Forrester 1985. "PCB-containing Transformer Fires: Decontamination Guidelines Based on Health Considerations," *Journal of Occupational Medicine*, **27**(5), 351–56.

National Institute for Occupational Safety and Health (NIOSH) 1986. *Polychlorinated Biphenyls (PCBs). Potential Health Hazards from Electrical Equipment Fires and Failures* Centers for Diseases Control, Atlanta, Ga.

National Research Council (NRC). 1988. *Acceptable Levels of Dioxin Contamination in an Office Building Following a Transformer Fire*, NRC, Community Life Sciences, Washington, D.C.

O,Keefe, P. W., Silkworth, J. B, Gierthy, J. F., Smith, R. M., DeCarprio, A. P., Turner, J.N., Eadon, G., Hilker, D. R., Aldous, K. M., Kaminski, L.S. et al. 1985. "Chemical and Biological Investigations of a Transformer Accident at Binghamton, NY," *Environmental Health Perspectives*, **60**, 201–9.

Orloff, K. G., Ulirsch, G., Wilder, L., Block, A., Fagliano, J., and J. Pasqualo 1997. "Human Exposure to Elemental Mercury in a Contaminated Residential Building," *Archives of Environmental Health*, **52**(3), 169–72.

Perdek, J. M., Freestone, F. J., Sandifer, D. and A. Sherman 1991. "Closure of a Dioxin Facility," *Chemosphere*, **23**(8-10), 1295–1305.

Rappe, C., Kjeller, L. O., Marklund, S., and M. Nygren. 1986 "Electrical PCB Accidents: An Update," *Chemosphere*, **15**(9-12), 1291–5.

Schecter, A. 1986. "The Binghamton State Office Building Pcb, Dioxin, and Dibenzofuran Electrical Transformer Incident—1981-1986," *Chemosphere*, **15**(9-12), 1273–80.

Schecter, A. and K. Charles 1991. "The Binghamton State Office Building Transformer Incident after One Decade," *Chemosphere*, **23**(8-10) 1307–21.

Seiler, F. A., Davis, H. T. Kominsky, J. R., Ronan, R. J., and C. D. Kowka 1987. "Use of Risk Assessment Methods in the Certification of Decontaminated Buildings," *Risk Analysis*, **7**(4), 487–95.

Stephens, R. D. 1986. "Transformer Fire, Spear Street Tower, One Market Plaza, San Francisco, California," *Chemosphere*, **15**(9-12), 1281–9.

Tharr, D. 1991. "Indoor Environmental Quality in a School Building: Identification of a Problem and Mitigation," *Applied Occupational and Environmental Hygiene*, **6**(10), 836–8.

Train, D., Chamerland, A., Dupont, D., and J. Castonguay 1987. "Decontamination of IREQ's High voltage Laboratory Following a PCB Fire," *IEEE Transactions on Power Delivery*, **PWRD-2**(1), 77–86.

Vogt, B. M. and J. H. Sorensen 1999. *Description of Survey Data Regarding the Chemical Repackaging Plant Accident West Helena, Arkansas,* ORNL/TM-13722, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Von der Trenck, K. T., and P. Fuhrmann 1991. "Environmental Cleanup Objectives Standard Procedure (ECOSP)," *Chemosphere*, **23**(8-10), 1322–35.

Wade, R. L., and J. P. Woodyard 1986. "Sampling and Decontamination Methods for Buildings Contaminated with Polychlorinated Dibenzodioxins," pp. 367–75 in *Solving Hazardous Waste Problems: Learning from Dioxins*, J. H. Exner, ed., ACS Symposium Series, no. 338, 1987.

People Decontamination

Bellanger, C., Lison, D., and J. Willems 1993. "Decontamination of Chemical Casualties," *Journal of European Radiology*, **6**, 84–90.

Brennan, R. J., Waeckerle, J. F., Sharp, T. W., and S. Lillibridge 1999. "Chemical Warfare Agents: Emergency Medical and Emergency Public Health Issues," *Annals of Emergency Medicine*, **34**(2), 191–204.

Burgess, J. L. 1999. "Hospital Evacuation Due to Hazardous Materials Incidents," *American Journal of Emergency Medicine*, **17**(1), 50-2.

Burgess, J. L., Kirk, M., Borron, S. W., and J. Cisek 1999. "Emergency Department Hazardous Materials Protocol for Contaminated Patients," *Annals of Emergency Medicine*, **34**(2), 205–12.

Burgess, J. L., Blackmon, G. M., Brodkin, C. A., and W. O. Robertson 1997. "Hospital Preparedness for Hazardous Materials Incidents and Treatment of Contaminated Patients," *Western Journal of Medicine*, **167**(6), 387–91.

Cone, D. C. and S. J. Davidson 1997. "Hazardous Materials Preparedness in the Emergency Department," *Prehospital Emergency Care*, **1**(2), 85–90.

Copenhaver, E. D. 1994. *Response Phase Decontamination for CSEPP Training Guide,* ORNL/M-3081, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Cox, R. D. 1994. "Decontamination and Management of Hazardous Materials Exposure Victims in the Emergency Department," *Annals of Emergency Medicine*, **23**(4), 761–70.

DeRoos, R. L. 1989. "Emergency Room Guidelines. Providing Services to Victims of Toxic Spills," *Journal of Environmental Health*, **52**(1), 331–33.

Foust, C. 1997. *Compilation of Existing Chemical Agent Guidelines,* ORNL/TM-13649, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Friel, F. G. 1993. "Memo to the National Response Center, Selection of Response Actions, Spring Valley, Washington, D.C." U.S. Army Chemical and Biological Defense Agency, Aberdeen, Md.

Grant, P. M., Haas, J. S., Whipple, R. E., and B. D. Andersen 1997. "A Possible Chemical Explanation for the Events Associated with the Death of Gloria Ramirez at Riverside General Hospital," *Forensic Science International*, **87**(3), 219–37.

Hau, M. L. 1995. "Emergency Care in Acute Chemical Exposure," *American Association of Occupational Health Nurses Journal*, **43**(5), 276–84.

Khan, F. I., and S. A. Abbasi. 2000. "Cushioning the Impact of Toxic Release from Runaway Industrial Accidents with Greenbelts," *Journal of Loss Prevention in the Process Industries*, **13**(2), 109–24.

Kim, D.H and R. E Burr 2000. "Chemical Spills: The Hospital Perspective," presented at the 219th National Meeting of the American Chemical Society, San Francisco, Mar. 26–30, 2000.

Laurent, J. F., Richter, F., and A. Michel 1999. "Management of Victims of Urban Chemical Attack: the French Approach," *Resuscitation*, **42**(2), 141–9, Oct.

Lavoie, F. W., Coomes, T., Cisek, J. E., and L. Fulkerson 1992. "Emergency Department External Decontamination for Hazardous Chemical Exposure," *Veterinary and Human Toxicology*, **34**(1), 61–4.

Levitin, H. W. and H. J. Siegelson. 1996. "Hazardous Materials. Disaster Medical Planning and Response," *Emergency Medical Clinics of North America*, **14**(2), 327–48.

McMullen, M. J. 1996. "Chemical Decontamination," letter to the editor and response to Schultz and Cisek, *Annals of Emergency Medicine*, **27**(2), 270–1.

Moles, T. M. 1999. "Emergency Medical Services Systems and HAZMAT Major Incidents," *Resuscitation*, **42**(2), 103–16.

Nagy, D. R. 2000. "Formaldehyde Solution Spill in a Clinical Patient Setting," presented at the 219th National Meeting of the American Chemical Society, March 26–30, 2000, San Francisco, Ca.

National Center for Environmental Health (NCEH) 1995. *Trip Report of the United States Medical Delegation to Japan*, Centers for Disease Control, Atlanta, Ga.

National Institute for Occupational Safety and Health (NIOSH) 1995. *Report to Congress on Workers' Home Contamination Study Conducted Under the Workers' Family Protection Act,* 29 U.S.C 671A (available at http:// www.cdc.gov/niosh/contamin.html).

New York State Dept. of Health (NYDH) 1999. *Hazardous Substances Emergency Events Surveillance, Cumulative Report 1993-1997,* New York State Health Department, Albany.

Okumura, T., Suzuki. K., Fukuda, A., Takasu. N., Ishimatsu, S., and S. Hinohara 1998. "The Tokyo Subway Sarin Attack: Disaster Management, Part 1—Community Emergency Response," *Academic Emergency Medicine*, **5**(6), 613–7.

Okumura, T., Suzuki. K., Fukuda, A., Takasu. N., Ishimatsu, S., and S. Hinohara 1998. "The Tokyo Subway Sarin Attack: Disaster Management, Part 2—Hospital Response," *Academic Emergency Medicine*, vol. **5**(6), 618–24.

Pons, P. and R. C. Dart 1999. "Chemical Incidents in the Emergency Department: If and When," *Annals of Emergency Medicine*, **34**(2), 223–5.

Schultz, M., Cisek, J., and R.Wabeke 1995. "Simulated Exposure of Hospital Emergency Personnel to Solvent Vapors and Respirable Dust During Decontamination of Chemically Exposed Patients," *Annals of Emergency Medicine*, **26**(3), 324–9.

Shumpert, B., Watson, A., Rogers, G., Sorensen, J., Long, J., and R. Brooks 1996. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program,* ORNL-6764, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Siren, K. 1993. "The Protection Ability of the Building Shell Against Sudden Outdoor Air Contamination," *Building and Environment*, **28**(3), 255–69.

SSI Services 1996. *Assessment of Response Phase Decontamination and Personal Protective Equipment Needs for the Commonwealth of Kentucky, Chemical Stockpile Emergency Preparedness Program*, prepared for the Project Manager, CSEPP, Aberdeen, Md.

Teorngren, S., Persson, S. A., Ljungquist, A., Berglund, T., Nordstrand, M., Heagglund, L., Rittfeldt, L., Sandgren, K. and E. Seoderman 1998. "Personal Decontamination after Exposure to Stimulated Liquid Phase Contaminants: Functional Assessment of a New Unit," *Journal of Toxicology - Clinical Toxicology*, **36**(6), 567–73.

Tokle, G. (ed.) 1993. *Hazardous Materials Response Handbook*, National Fire Protection Association, Quincy, Mass.

U.S. Army Medical Research Institute of Chemical Defense 1999. *Medical Management of Chemical Casualties Handbook*, 3rd ed., Chemical Casualty Care Office, Aberdeen Proving Ground, Md., Aug.

Vahdat, N., and R. Delaney 1989. "Decontamination of Protective Clothing," *American Industrial Hygiene Association Journal*, **50**(3), 152–6.

Vogt, B. 1999. *RE-ACTFAST Facilitator Guide*, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Vogt, B. M. and J. H. Sorensen 1994. *CSEPP Risk Communication and the Chemical Stockpile Emergency Planning Program,* ORNL-6824, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Weber, L., Zesch, A., and K. Rozman 1992. "Decontamination of Human Skin exposed to 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD) in Vitro," *Archives of Environmental Health*, **47**(4), 302–08.

Walmsley, B. 1987. "Decontamination: Dry Showers," *Fire Command*, **54**(10), 42-44.

Reentry Criteria and Human Toxicology

Amos, D. and B. Leake 1994. "Clean-up of Chemical Warfare Agents on Soils Using Simple Washing or Chemical Treatment Processes," *Journal of Hazardous Materials*, **39**, 107–17.

Committee on Toxicology (COT) 1997. *Review of Acute Human-Toxicity Estimates for Selected Chemical-Warfare Agents*, Subcommittee on Toxicity Values for Selected Nerve and Vesicant Agents, Committee on Toxicology, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council, National Academy Press, Washington, D.C.

Munro. N. B., Watson, A. P., Ambrose, K. R., and G. D. Griffin 1990. "Treating Exposure to Chemical Warfare Agents: Implications for Health Care Providers and Community Emergency Planning," *Environmental Health Perspectives*, **89**(11), 205–15.

Munro, N. B., Talmage, S. S., Griffin, G. D., Waters, L. C., Watson, A. P., King, J. K., and V. Hauschild 1999. "The Sources, Fate, and Toxicity of Chemical Warfare Agent Degradation Products," *Environmental Health Perspectives*, **107**(12), 933–74.

Opresko, D. M., Young, R.,A., Faust, R. A., Talmage, S. S., Watson, A. P., Ross, R. H., Davidson, K. A., and J. King (1998). "Chemical Warfare Agents; Estimating Oral Reference Doses," *Reviews of Environmental Contamination and Toxicology*, **156**, 1–183.

Reutter, S. A. and J. V. Wade 1994. *Review of Existing Toxicity Data and Human Estimates for Selected Chemical Agents and Recommended Human Toxicity Estimates Appropriate for Defending the Soldier*, ERDEC-SP-018, Edgewood Research, Development and Engineering Center, Aberdeen Proving Ground, Md., Classified.

Thacker, S.B., Assistant Surgeon General, Acting Director, National Center for Environmental Health, Centers for Disease Control and Protection, U.S. Department of Health and Human Services, letter establishing "Recommended Acute Threshold Effects Levels for Determining Emergency Evacuation Distances in the CSEPP Program," to COL J.M. Coverstone, Deputy for Chemical Demilitarization, Office of the Assistant Secretary (I, L & E), Washington, D.C., June 24, 1994.

U.S. Army Soldier & Biological Chemical Command (SBCCOM) 1999. *Colorado CSEPP Recovery Conference*, March, 25, 1999, Pueblo, Co.

U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) 1999. *Short-Term Chemical Exposure Guidelines for Deployed Military Personnel*, U.S. Army, Aberdeen, Md.

U.S. Department of Health and Human Services (DHHS) 1988. "Final Recommendations for Protecting the Health and Safety Against Potential Adverse Effects of Long-term Exposure to Low Doses of Agents: GA, GB, VX, Mustard Agent (H, HD, HT), and Lewisite (L)." *Federal Register* 53 (50): 8504-8507 (Mar. 15, 1988).

Watson, A. P. and N. B. Munro 1990. *Reentry Planning: The Technical Basis for Offsite Recovery Following Warfare Agent Contamination,* ORNL-6628, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Epidemic Hysteria

Alexander, R. W. and M. J. Fedoruk 1986. "Epidemic Psychogenic Illness in a Telephone Operators' Building," *Journal of Occupational Medicine*, **28**(1), 42–45.

Baker, P. 1992. "Malathion-Induced Epidemic Hysteria in an Elementary School," *Veterinary and Human Toxicology*, **34**(2), 156–60.

Burgess, J.L., Kovalchick, D. F., Keyes, K. B., Thompson, J. N., and S. Barnhart 1999. "Hyperventilation Following a Large-scale Hazardous Materials Incident," *International Journal of Occupational and Environmental Health*, **5**(3), 194–97.

Granot, H. I. and Brender, M. 1991. "A Behavior-Response Wheel for Training and Field Use by Civil Defense Officers at Emergency Sites," *Journal of Traumatic Stress*, **4**, 223–31.

Helbing, D., Farkas, I., and T. Vicsek. 2000. "Simulating Dynamical Features of Escape Panic," *Nature*, **407**(6803), 487–90.

Micale, M. S. 1995. *Approaching Hysteria: Disease and Its Interpretations,* Princeton University Press, Princeton, N.J..

Selden, B. 1989. "Adolescent Epidemic Hysteria Presenting a Mass Casualty, Toxic Exposure Incident," *Annals of Emergency Medicine*, **18**(8), 892–5.

Van Loock, F., Gallay, A., Demarest, S., Van Der Heyden, J., and H. Van Oyen 1999. "Outbreak of Coca-Cola-Related Illness in Belgium: A True Association," correspondence to *The Lancet*, **354** (Aug.)

Both biological and chemical

Ali, J., Rodrigues, L., and M. Moodie 1997. *Jane's U.S. Chemical-Biological Defense Guidebook*, Jane's Information Group, Alexandria, Va.

Balk, S. J., Gitterman, B. A., Miller, M. D., Shannon, M. W., Shea, K. M., and W. B. Weil. 2000. "Chemical-Biological Terrorism and Its Impact on Children," *Pediatrics*, **105**(3), 662–70.

Brasser, P. and A. Hin 1998. *Workshop on The Need for Decontamination (PML 1998-C45)*, TNO Prins Mauritis Laboratory, Riijswijk, The Netherlands

Baker, D.J. 1999. "The Pre-hospital Management of Injury Following Mass Toxic Release: a Comparison of Military and Civil Approaches," *Resuscitation*, **42**(2), 155–9.

Committee on R&D Needs for Improving Civilian Medical Response to Chemical and Biological Terrorism Incidents, Institute of Medicine 1999. *Chemical and Biological Terrorism. Research and Development to Improve Civilian Medical Response,* National Academy Press, Washington, D.C.

DiGiovanni, C. 1999. "Domestic Terrorism with Chemical or Biological Agents: Psychiatric Aspects," *American Journal of Psychiatry*, 156(10), 1500–05.

DeLorenzo, R. A., and R. S. Porter 1999. *Tactical Emergency Care. Military and Operational Out-of-Hospital Medicine,* Brady, Prentice Hall, Upper Saddle River, N.J.

Edwards, R., DiBerardinis, L., Galanek, M., Fink, R., VanSchalkwyk, W., and K. Samulson 1999. "Procedures for Decontamination and Decommissioning of Laboratory Buildings," *Chemical Health and Safety*, Sept./Oct., pp. 4–11.

Eckstein, M. 1999. "The Medical Response to Modern Terrorism: Why the 'Rules of Engagement' Have Changed, *Annals of Emergency Medicine*, **34**(2), 219–21.

Environmental Protection Agency (EPA) 2000. *First Responder's Environmental Liability due to Mass Decontamination Runoff,* Office of Solid Waste and Emergency Response, Chemical Emergency Preparedness and Prevention Office, July.

Hurst, C. G. 1997. "Decontamination," in *Medical Aspects of Chemical and Biological Warfare*, F. R. Sidell, E. T. Takafuji, and D. R. Franz, eds., Office of the Surgeon General, Walter Reed Army Medical Center, Washington, D.C.

Kadivar, H. and S. C. Adams 1991. "Treatment of Chemical and Biological Warfare Injuries—Insights Derived Form the 1984 Iraqi Attack on Majnoon Island," *Military Medicine*, **156**(4), 171–7.

National Research Council (NRC) 1999. *Strategies to Protect the Health of Deployed U.S. Forces*, National Academy Press, Washington, D.C.

Raber, E., Jin, A., Noonan, K., McGuire, R., and R. Kirvel 1999. *Decontamination Issues for Chemical and Biological Warfare Agents: How Clean is Clean Enough?* UCRL-JC-134030–Preprint, Lawrence Livermore National Laboratory, Livermore, Ca.

Sharp, T. W., Brennan, R. J., Keim, M., Willimas, R. J., Eitzen, E., and S. Lillibridge 1998. "Medical Preparedness for a Terrorist Incident Involving Chemcial or Biological Agents During the 1996 Atlanta Olympic Games," *Annals of Emergency Medicine*, 32(2), 214–23.

Sidell, F. R., Patrick, W. C., and T. R. Dashiell 1999. *Jane's Chem-Bio Handbook,* Jane's Information Group, Alexandria, Va.

Sidell, F. R., Takafuji, E. T., and D. R. Franz (eds.) 1997. *Medical Aspects of Chemical and Biological Warfare,* Office of the Surgeon General, Walter Reed Army Medical Center, Washington, D.C.

Sidell, F. R. and D. R. Franz. 1997. "Overview: Defense Against the Effects of Chemical and Biological Warfare Agents," F. R. Sidell, E. T. Takafuji, and D. R. Franz, eds., *Medical Aspects of Chemical and Biological Warfare*, Office of the Surgeon General, Walter Reed Army Medical Center, Washington, D.C.

Tucker, J. B. 1997. "National Health and Medical Services Response to Incidents of Chemical and Biological Terrorism," *Journal of the American Medical Association*, **278**(5), 362–7.

Tucker, P. No Date. *Report on the Expert Panel Workshop on the Psychological Responses to Hazardous Substances,* Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Dept. of Health and Human Services, Atlanta, Ga.

U.S. Department of Health and Human Services (DHHS) 1995. *Proceedings of the Seminar on Responding to the Consequences of Chemical and Biological Terrorism*, sponsored by the Public Health Service, Office of Emergency Preparedness, and conducted at the Uniformed Services University of Health Sciences, Bethesda, Md., July 11–14, 1995.

Waeckerle, J. F. 2000. "Domestic Preparedness for Events Involving Weapons of Mass Destruction" *Journal of the American Medical Association*, **283**(2), 252.

DISTRIBUTION

Internal

1.	G.E. Courville	6.	R. B. Shelton
2.	T.R. Curlee	7–11.	J.H. Sorensen
3.	S.G. Hildebrand	12-16.	B.M. Vogt
4.	C. I. Moser	17.	Central Research Library
5.	P.C. Ho	18.	RC

External

19. Dr. Lilia A. Abron, President, PEER Consultants, P.C., 1460 Gulf Blvd., 11th Floor, Clearwater, FL 34630
20. Dr. Susan L. Cutter, Professor and Chair, Department of Geography, Director, Hazards Research Lab, University of South Carolina, Columbia, SC 29208

21–22. OSTI

23. Mr. P. Richard Rittelmann, FAIA, Executive Vice President, Burt Hill Kosar Rittelmann Assoc., 400 Morgan Center, Butler, PA 16001-5977
24. Dr. Susan F. Tierney, The Economic Resource Group, Inc., One Mifflin Place, Cambridge, MA 02138
25. Dr. C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, Chairman, Department of Civil Engineering, University of Texas at Austin, Austin, TX 78712-1076