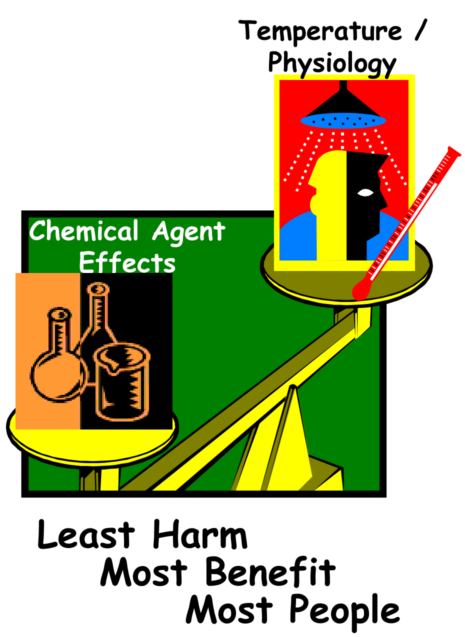
Regardless of the ambient temperature, people who have been exposed to a known life-threatening level of chemical contamination should disrobe, undergo decontamination with copious amounts of high-volume, low-pressure water or alternative decontamination method, and be sheltered as soon as possible.

Guidelines for Cold Weather Mass Decontamination During a Terrorist Chemical Agent Incident



Prepared by:
U.S. Army Soldier and Biological Chemical Command (SBCCOM)

January 2002

Disclaimer

EXECUTIVE SUMMARY

The fiscal year (FY) 1997 Defense Authorization Bill (P.L. 104-201, Sept 23, 1996), commonly called the Nunn-Lugar-Domenici legislation, funded the U.S. Domestic Preparedness initiative. Under this initiative, the Department of Defense (DoD) was charged with enhancing the capability of federal, state, and local emergency responders in incidents involving nuclear, biological, and chemical terrorism. The U.S. Army Soldier and Biological Chemical Command (SBCCOM), Aberdeen Proving Ground, Maryland, was assigned the mission of developing an Improved Response Program (IRP) to identify problems and develop solutions to the tasks associated with responding to such incidents. The Chemical Weapons (CW) IRP was established to deal specifically with terrorists' use of chemical weapons.

This report provides guidance on cold weather mass decontamination procedures for emergency responders. All methods discussed in this report are potential options under extreme circumstances. As the ambient air temperature decreases, some wet decontamination processes, while potentially life-saving, present risks that must be balanced against the hazards posed by the chemical agents. The guidelines presented in this document are intended to provide responders with mass decontamination options based on decreasing ambient air temperatures. These recommendations were developed with input from cold weather experts and rescue personnel. **Responders should use whatever resources are available in time of need and should select the fastest method available because decontamination is most effective when performed immediately. The key to successful decontamination is to use the fastest approach that will cause the least harm and do the most good for the majority of the people.**

Despite misconceptions among responders, the risk of hypothermia as a result of cold weather mass casualty decontamination is minimal. Less well recognized is the risk of cold shock, which can be minimized by following the recommended guidelines presented in the report (see 6.0, Conclusions and Recommendations: The Bottom Line). Special populations, such as the elderly and the very young, should be given priority for limited resources such as blankets and indoor shelter because of limited or impaired ability to maintain body temperature.

Regardless of the ambient temperature, people who have been exposed to a known, life-threatening level of chemical contamination should disrobe, undergo decontamination with copious amounts of high-volume, low-pressure water or alternative decontamination method, and be sheltered as soon as possible.

The key to successful decontamination is to use the fastest approach that will cause the least harm and do the most good for the majority of the people.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GUIDELINES FOR COLD WEATHER MASS DECONTAMINATION DURING A TERRORIST CHEMICAL AGENT INCIDENT

1.0 INTRODUCTION

In response to growing concerns about domestic terrorism, Congress enacted legislation that established the Domestic Preparedness Program, with the Department of Defense as the Executive Agent. The U.S. Army Soldier and Biological Chemical Command was designated the lead agent and established the Chemical Weapons Improved Response Program (CW-IRP) in partnership with other federal agencies. The CW-IRP Mass Casualty Decontamination Research Team identified the requirement for cold weather mass casualty decontamination guidelines. General principles for mass casualty decontamination from earlier CW-IRP reports are summarized in Table 1.

Table 1. Mass Casualty Decontamination General Principles

- Expect at least a 5:1 ratio of unaffected to affected casualties
- Decontaminate victims as soon as possible
- Disrobing (head to toe) is decontamination; more removal is better
- Water flushing generally is the best mass decontamination method
- After a known exposure to liquid chemical agent, emergency responders should be decontaminated as soon as possible

Background information on the CW-IRP and a more detailed discussion of mass casualty decontamination is presented in Appendix I. References reviewed for this report are included in Appendix II. Relevant reports are listed in Appendix III and can be accessed from SBCCOM's Homeland Defense Home Page on the Internet at http://www2.sbccom.army.mil/hld/. Appendix IV is a listing of acronyms used in this report.

The panel that prepared this report focused on the challenges of mass casualty decontamination in cold weather environments. Discussions about temperature refer to ambient air temperature unless otherwise stated. Information relevant to first responder decision-making for cold weather mass casualty decontamination is presented in sections 4.0 (Results) and 6.0 (Conclusions and Recommendations: The Bottom Line).

2.0 OBJECTIVE

The objective of this study was to establish physiologically sound and operationally practical mass casualty decontamination guidelines for first responders to use in cold environments and to present those guidelines in a user-friendly format.

3.0 TECHNICAL APPROACH

A panel of experts was assembled to review previous studies and address the issues associated with cold weather decontamination. The panel addressed the following topics with regard to cold weather mass casualty decontamination: Hypothermia and Cold Shock, Behavioral Effects, and Wind Chill. Summaries of these discussions are presented in Section 5, Cold Weather Considerations.

4.0 RESULTS

An initial first responder on-scene assessment will result in a presumptive finding that a chemical agent exposure (a) has occurred, or (b) is unlikely or undeterminable. This section discusses various phases of cold weather mass casualty decontamination subsequent to the initial on-scene assessment. These phases include (1) Collection and Assessment, (2) Decontamination, and (3) Post-decontamination.

4.1 Collection and Assessment – Agent Exposure Likely

The most important consideration during the collection and assessment phase of mass casualty decontamination operations is triage, which must consider the hazards imposed by the chemical agent and the inherent risks of the decontamination process. Based on an assessment of the situation, prospective casualties should be grouped into two categories:

- Symptomatic
- Asymptomatic

Individuals exhibiting symptoms[1] of chemical exposure should be treated immediately (if possible, without exposing responders to the agent), followed by prompt field decontamination. Asymptomatic individuals should be examined for physical signs[2] of chemical agent contamination and observed for onset of symptoms. Those with signs or symptoms of agent exposure should receive priority for decontamination; the remainder should be carefully observed and decontaminated as soon as possible.

If responders are able to determine the state of the agent (i.e., liquid or vapor), priority should be given to decontaminating victims exposed to liquid agent since their dose may increase from the remaining liquid agent.

4.2 Collection and Assessment – Agent Exposure Unknown or Unlikely

When responders are unable to determine if an actual chemical agent exposure has occurred, and in those situations where an actual exposure appears unlikely, decontamination may be deferred. In this situation, one would **NOT** expect to see individuals with signs or symptoms of chemical agent exposure. **If signs or symptoms develop, proceed as above in section 4.1.** In the absence of either symptoms or a clear

[1] See Appendix VI: Chemical Agent Medical Management Summary.
[2] Only the liquid form of a chemical agent is likely to be observable on exposed skin or clothing; no physical evidence of gas or vapor exposure would be observable.

indication of chemical exposure, decontamination should be delayed pending observation and/or on-scene investigation. There are some risks involved in the decontamination process; the risks are discussed in the subsequent sections of this report. The decision to decontaminate should be made after taking into consideration the probability of chemical exposure, the risks inherent in the decontamination process, the environmental conditions at the scene, and the health status of the individuals potentially exposed. If symptoms develop, individuals should be treated immediately if responders are appropriately protected from agent exposure, followed by prompt field decontamination by the most expeditious means available. **The procedures presented in section 4.3 are applicable once the decision to decontaminate has been made.** Figure 4-1 depicts mass casualty collection and assessment.

Figure 4-1. Collection and Assessment

When responders are unable to determine if an actual chemical agent exposure has occurred, and in those situations where an actual exposure appears unlikely, decontamination should be deferred PENDING OBSERVATION AND/OR SCENE INVESTIGATION. If symptoms develop, individuals should be treated immediately (if possible, without exposing responders to the chemical agent), followed by prompt field decontamination by the most expeditious means available.

4.3 Decontamination

There are three main purposes for decontamination (see Appendix I):

- Remove chemical agent from the victims
- Protect response and medical personnel
- Offer psychological comfort to victims

If victims are actually contaminated with a chemical agent, timely physical removal of the agent is of primary importance to accomplish lifesaving decontamination procedures.[3] Therefore, the key to successful decontamination is to use the fastest approach that will cause the least harm and do the most good for the majority of the people. In most situations, this will be a combination of disrobing and water flushing. Where feasible, if victims are obviously contaminated, self-decontamination by physical removal of the agent should be encouraged while responders are en-route to the scene.

The cold weather experts assembled recommended an ambient air temperature of 65°F as a "breakpoint" for outdoor decontamination. Comfort, rather than physiological limits, was identified as the overriding consideration for this recommendation. At ambient air temperatures below 65°F, individuals would be much less willing to participate in outdoor showering because of the significant perception of discomfort. As the ambient air temperature decreases, the risk of serious health complications from exposure to cold water increases for some people. Encouraging people to enter the shower stream gradually, and allowing the body to adjust to the cold water can minimize this risk. If small children must be decontaminated, they should remain with a parent or other responsible adult who should assist in the decontamination process. When the ambient air temperature approaches freezing, the risk of accidents from frozen shower water and equipment must be considered. Various decontamination alternatives are presented for consideration based on the ambient air temperature and availability of resources. These alternative methods are summarized graphically in Figure 4-2, Decontamination Methods, and in Figure 6-1, Method Selection for Cold Weather Decontamination.

> Time is critical to the decontamination process. Select the most expeditious method available based on temperature constraints and available resources.

[3] "The most important and most effective decontamination of any chemical exposure is that decontamination done within the first minute or two after exposure." Medical Management of Chemical Casualties Handbook, 3d Ed., August 1999, USA Medical Research Institute for Chemical Defense, Aberdeen Proving Ground, MD 21010.

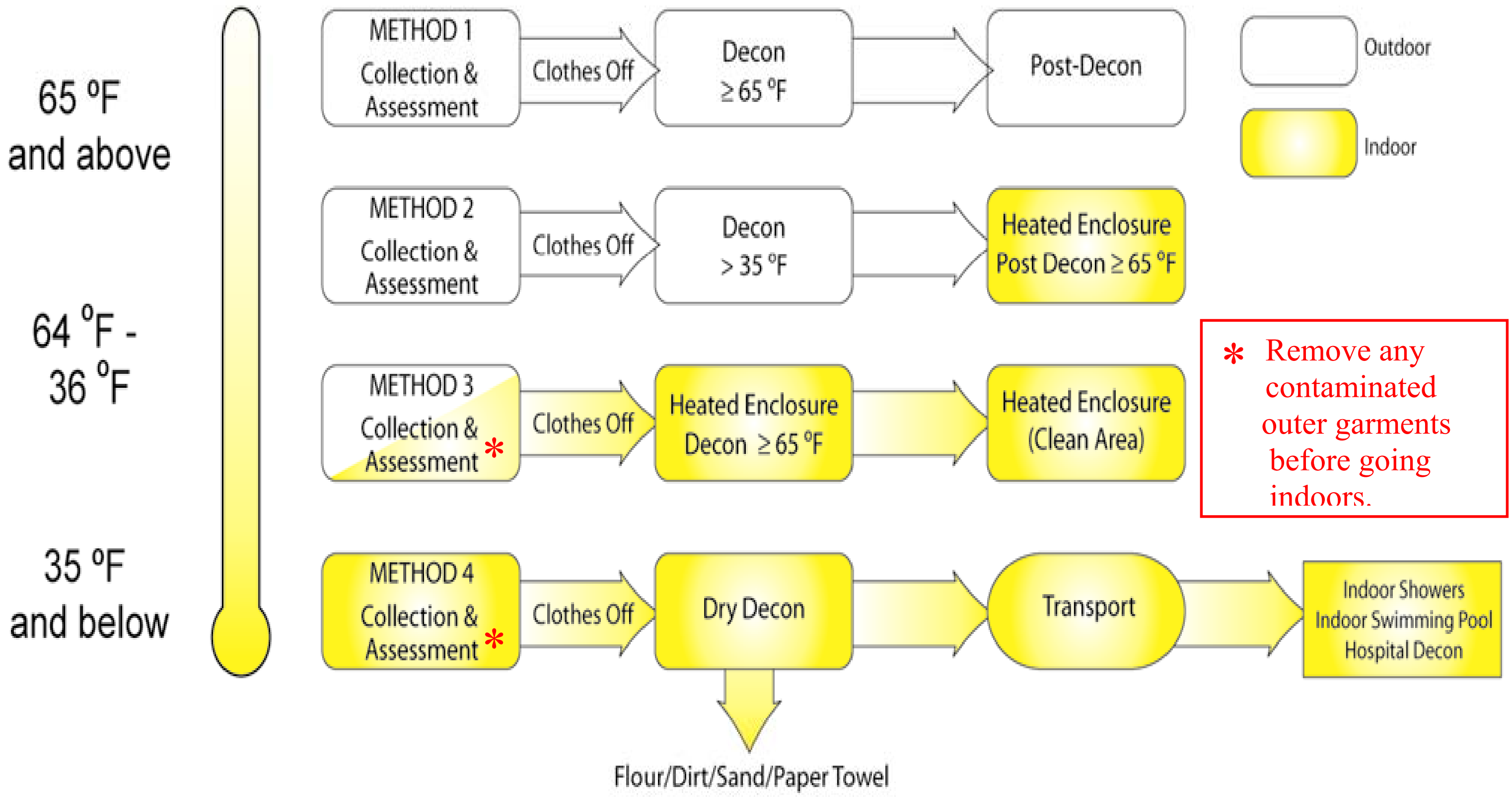


Figure 4-2. Decontamination Methods[4]

4.3.1 Method 1: Baseline Decontamination

Method 1 is the baseline decontamination method and is described as the outdoor collection and assessment of victims, outdoor decontamination, and outdoor post-decontamination shelter. In situations where the ambient temperature is 65°F or above, all methods are acceptable, but Method 1 is recommended. This method is quickest to execute and does not require as much planning as the other methods, which are offered as alternatives to the baseline. At ambient temperatures of 65°F and above, firefighters can decontaminate the general population using the baseline method with minimal risk of precipitating a serious cold-related injury.

[4] The term "decontamination" is represented as "decon" in the schematic diagrams for convenience.

Figures 4-3 and 4-4 show the Ladder Pipe Decontamination System (LDS), which is an example of a Method 1 shower source.

Figure 4-3. The Ladder Pipe Decontamination System (LDS)

The LDS provides a large capacity shower of high-volume, low-pressure water spray. Ladder pipes, deck guns, and fog nozzles are positioned strategically to create a mass decontamination corridor.

Figure 4-4. Outdoor Decontamination with LDS

Two engines can create a corridor with water spray from both sides using hose lines and deck guns while the ladder pipe provides the high-volume, low-pressure flow from above. Multiple LDSs use more than one ladder pipe in order to increase the decontamination corridor length to accommodate extremely large groups of victims. Multiple corridors can be established for ambulatory or non-ambulatory victims.

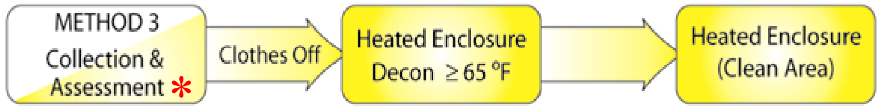
4.3.2 Method 2: Outdoor Decontamination into Heated Enclosure

In Method 2, the primary difference from the baseline method is the post-decontamination procedure. Method 2 requires that people be moved into a heated building following decontamination. Figure 4-5 shows the use of an enclosure for post-decontamination shelter.

Figure 4-5. Outdoor Decontamination with Enclosure

A decontamination corridor can be set up near the entranceway to a facility such as a hospital or a hotel. Victims should discard their outer layer of clothing before entering and showering. Hospitals and hotels have access to large quantities of robes and linens, eliminating the need for first responders to haul their own supply. Method 2 is recommended when the ambient temperature is above 35°F. If the ambient temperature drops to freezing (32°F), outdoor water decontamination may create serious safety hazards associated with ice formation and Methods 3 and 4 should be considered.

4.3.3 Method 3: Indoor Decontamination



* Remove any contaminated outer garments before going indoors

In Method 3, collection and assessment can be done outdoors or indoors, depending on the situation. The remainder of the decontamination process is accomplished indoors. Method 3 is recommended when the ambient temperature is below 35°F. Figure 4-6 shows firefighters giving instructions to victims prior to indoor decontamination.

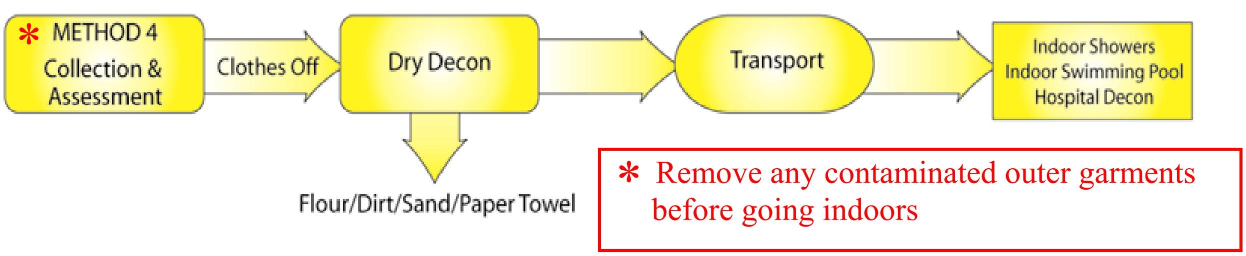
Figure 4-6. Outdoor Pre-Decontamination

Buildings that have indoor shower or pool facilities can serve as locations for mass decontamination, making cold weather a non-issue because the complete decontamination process will take place in a controlled environment. People should disrobe as they move into the building. Figure 4-7 shows people using indoor showers for decontamination.

Figure 4-7. Indoor Decontamination with Showers

Indoor automatic building sprinkler systems may provide an all-weather solution to decontamination. Sprinkler systems that are typically installed in buildings for occupant life safety could be used in an emergency mass decontamination scenario if a more suitable means of decontamination was not available. If possible, separate corridors or hallways should be used to segregate gender and age groups. Long-term impact on the building should be considered in making the decision to use building sprinkler systems for mass casualty decontamination.

4.3.4 Method 4: Dry Decontamination and Transport



In Method 4, alternative dry decontamination techniques, such as blotting the victim with paper towels, dirt, sand, flour, or oil absorbent, are used and then victims are transported to an indoor facility where wet decontamination can be performed. Whenever possible, outer garments should be removed at the earliest opportunity. Figure 4-8 shows a bus transporting victims to an indoor facility. It may be possible to use an indoor pool as a decontamination facility if the pool is relatively close to the incident site.[5] In this case, victims must disrobe prior to transport since the goal is to remove as much harmful substance from the victim as quickly as possible. Figure 4-9 shows a pool being used to decontaminate potentially exposed victims. Method 4 is recommended for extreme weather conditions or when the ambient temperature is below 35°F and when other methods of decontamination are not available.

Figure 4-8. Transport to Indoor Decontamination

Figure 4-9. Indoor Decontamination with Pool

[5] Details of pool capacity and chemical agent loading are presented in Appendix V.

4.4 Post-Decontamination

4.4.1 Observation of Victims. Care must be exercised after mass casualty decontamination to prevent unnecessary exposure of the victims to the environment during cold weather. Whenever possible, some form of shelter or dry clothing should be provided. In addition to minimizing physiological hazards from exposure, the shelter can afford an opportunity to provide gender segregation pending availability of clean clothing. Gender-segregated shelter may help minimize psychological stress from the decontamination experience. In cold weather situations where shelter or dry clothing cannot be provided, victims decontaminated with water should be observed for signs of shivering. Shivering generates body heat and is an indication of **normal bodily response** to the cold environment. Should shivering STOP in such situations, medical attention should be sought immediately since cold weather injury could be imminent.

4.4.2 Risk Communication. Additionally, the post-decontamination process should include feedback from the Incident Commander or medical advisor on the risks associated with the specific incident, what signs and symptoms the potentially exposed population should watch for, and follow-up care that may be needed. If not completed earlier, there should be a complete listing of all individuals decontaminated and/or deferred from decontamination for observation.

5.0 COLD WEATHER CONSIDERATIONS

5.1 Cold Shock and Hypothermia

This section contains information that may be useful in assessing the on-scene situation in a cold environment.

Cold shock refers to the sudden evocation of physiological responses such as an increase in blood pressure triggered by cold-water exposure. This **can result in sudden death** in susceptible individuals. Cold shock occurs almost immediately and must be anticipated by the responder community. The risk of serious health implications from cold shock is greater for those with pre-existing medical conditions, such as heart disease, and among the aged. There is tremendous variability in individual physiological responses at specific temperatures. Cold shock is more likely to cause serious medical problems than would hypothermia during mass decontamination operations. **Cold shock can be minimized by inquiring about pre-existing medical conditions before decontamination, if the on-scene situation permits, and by encouraging people to gradually get wet, rather than being instantaneously deluged in cold water.** The information on cold shock is presented to help responders make informed decisions at the scene based on the competing risks of chemical exposure verses the decontamination process.

Hypothermia, although a genuine threat to inadequately protected individuals in some outdoor exposure situations, **is not a significant risk for most people undergoing mass decontamination in cold weather**. Hypothermia is a condition of deep body cooling that usually takes longer to develop than one would normally encounter in a mass decontamination situation. Most individuals can tolerate 55°F water, and although they would shiver severely and experience great discomfort, they would not be in an immediate life-threatening situation due to hypothermia. For a wet individual in a cold environment, shivering is a sign that the body is trying to warm itself and is not in and of itself a sign for alarm. **If an individual is cold and wet and is NOT shivering, prompt medical attention should be sought since some people are not able to shiver and are at greater risk of developing hypothermia.** Firefighters can decontaminate the general population using the baseline method (Method 1), when the ambient temperature is at or above 65˚F, with minimal risk of precipitating a serious cold-related injury, provided the decontaminated victims are not required to stand outside unprotected from the environment for an extended length of time. This report provides alternative decontamination methods (Methods 2 through 4) so that unprotected outside exposure of victims can be minimized.

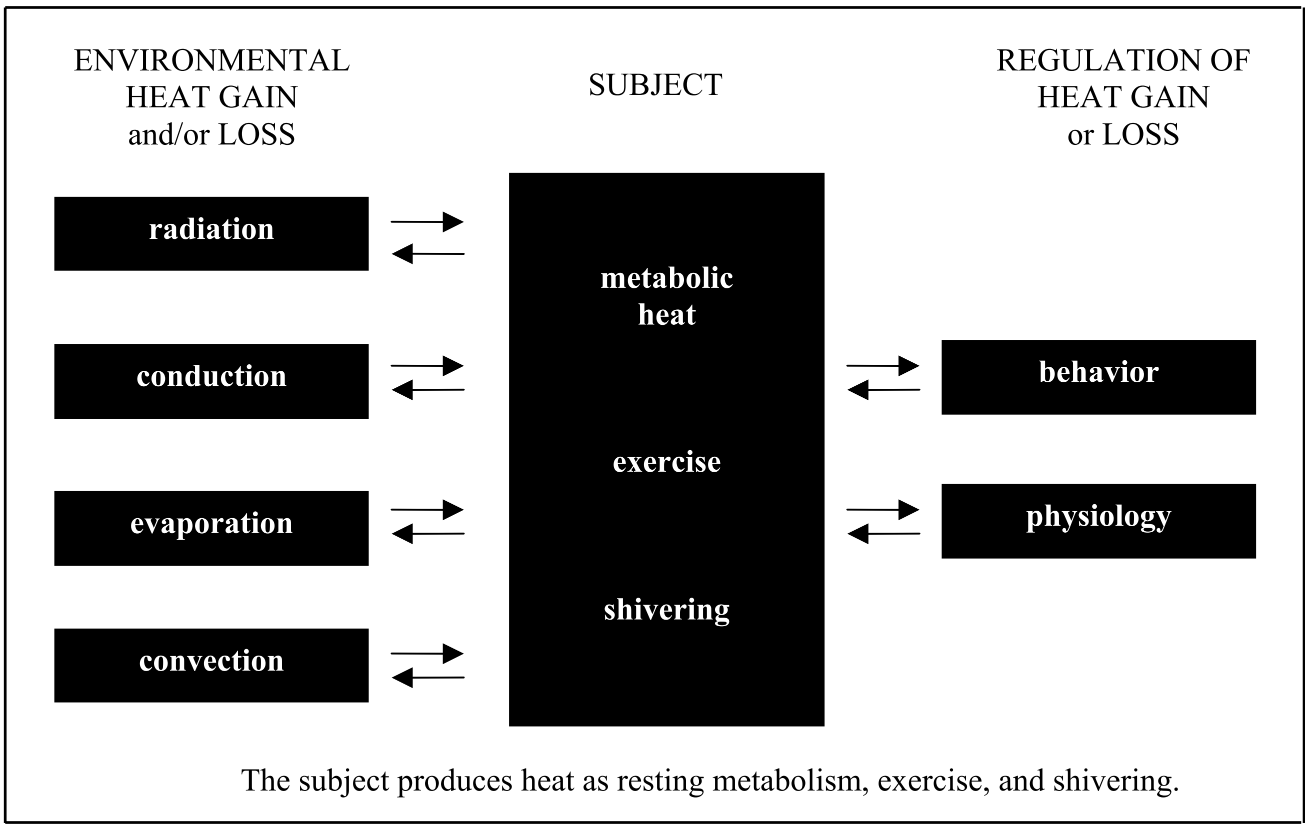
More information on Cold Weather Physiology is presented in the remainder of this section (refer to Appendix II, References, for more detailed information). Humans and other "warm-blooded" animals must keep a near constant body temperature regardless of environmental temperature. Humans can distinguish slight temperature differences of 0.5°F, are negatively impacted at a 2°F difference, and cannot function effectively at 7°F from their normal core temperature of 98.6°F (37°C). Because of this, humans must maintain their core temperatures within a narrow range. Yet, human bodies are constantly losing heat except in rare circumstances—e.g., sauna-like conditions with very high heat (≥ 99°F) and humidity (~ 100%). Since human bodies constantly produce heat, there are four highly developed mechanisms for releasing heat to the environment:

- Evaporation – transition of a liquid to vapor with resultant heat loss
- Conduction – heat exchange between two objects in direct contact
- Convection – heat gain or loss to air or water moving over the body surface
- Radiation – heat exchange between two objects not in direct contact

Most people are unaware of all four heat transfer mechanisms. Evaporation occurs during processes such as perspiration and respiration. The evaporation of water during respiration allows people to "see" their breath when the environment is cold. Conductive heat loss occurs, for example, when a warm hand is placed on a cold object, and eventually the hand becomes cold. Convective heat loss occurs when, for example, a breeze passes a warm face, replacing the layer of warm air next to the skin with cold air. Radiative heat loss occurs when the environment is colder than the uncovered surface of the body. In these transfer mechanisms, it is the difference in temperature between the body and the environment that results in heat gain or loss.

Conversely, the human body has three physiological ways of maintaining and producing heat: resting (quiescent body state) metabolism, exercise, and shivering (the involuntary contraction of muscles). Resting metabolism (conversion of food stores to energy) produces heat as a by-product during rest. Exercise is an obvious voluntary method of producing heat; to warm up, a person might do jumping jacks, run in place, or walk around for short periods of time. However, if individuals have no means of sustaining exercise, shivering becomes the main source of heat for people who are exposed to cold for long periods of time. Shivering can potentially generate five times the amount of heat normally produced by the resting metabolic rate.

Shivering, increased activity, and behavioral responses such as adding clothing are simple ways for an individual to maintain body temperature. More complex, physiological responses are vasoconstriction (decreased blood flow) and vasodilation (increased blood flow) when the body is cooled or warmed, respectively. Because the blood from a person's core is cooled as it flows through the periphery (hands, feet, arms, and legs), vasoconstriction minimizes this avenue of heat loss and helps the body to conserve heat in a cold environment. Figure 5-1 presents a graphic representation of the heat gain and loss process.



* This figure is used by permission by the author, Lorentz E. Wittmers Jr., M.D., Ph.D., University of Minnesota School of Medicine, Duluth Campus, 10 University Drive, Duluth, MN 55812.

Figure 5-1. Physical, Physiological, and Behavioral Factors Associated with Heat Loss and Gain

Mild hypothermia is characterized by normal shivering, and the person is likely to report the sensation of being cold. Goosebumps may appear on the surface of the skin, and some people may be unable to perform simple or complex tasks with their hands, such as fastening a button.

People suffering from **moderate** hypothermia may be ill-tempered and/or slow moving. They may stumble when on their feet, fumble with their hands, mumble, slur their speech, and shiver more intensely. Shivering stops at about 86°F (30°C) core temperature. A person with moderate hypothermia will have difficulty with higher cognitive functioning, may be more difficult to manage in a group setting, and may act inappropriately.

Severe hypothermia is characterized by a lack of shivering, unresponsiveness, pupil dilation, and cloudy consciousness. The person may be unable to walk or move his/her arms and legs and may curl up into a fetal position. If untreated, a healthy adult with severe hypothermia can progress to respiratory failure, cardiac arrest, and death.

The effects of alcohol, altitude sickness, diabetic seizure, overdose, and other conditions can mimic the signs and symptoms of hypothermia and may compound the medical problem. Therefore, the suspected hypothermic patient must be carefully assessed for coexisting injuries and illnesses. First responders should be aware of these physiological and mental symptoms when monitoring victims with suspected cold injury. Most of the guidelines offered in this report are based on core temperatures; however, it may not be practical to measure the core temperature of chemical victims. Rectal temperatures offer the most accurate readings, while oral and axillary (armpit) temperatures are poor indicators of core temperature. The simplest assessment a first responder might perform to determine a potential cold stress injury in a decontaminated individual is to place an ungloved hand on the skin of the patient's chest or back. If the skin feels warm, then hypothermia is unlikely. This method of assessment can be used in the absence of a low-reading rectal thermometer. Household thermometers are not effective because they usually only read to 94°F. A hypothermia assessment thermometer should read as low as 70°F in order to accurately measure low core temperatures. Table 2 lists stages and symptoms of hypothermia.

Table 2. Stages and Symptoms of Hypothermia

Stage	Core Temp		Status	Symptoms
	°C	°F		
Normal	35.0–37.0	95.0–98.6	control & responses fully active	cold sensation; shivering
Mild	32.0–35.0	89.6–95.0		physical (fine & gross motor) and mental (simple & complex) impairment
Moderate	28.0–32.0	82.4–89.6	responses attenuated/ extinguished	~30°C (86°F) shivering stops; loss of consciousness
Severe	< 28.0	< 82.4	responses absent	rigidity; vital signs reduced or absent; risk of ventricular fibrillation/cardiac arrest (especially with rough handling)
	< 25.0	< 77.0	spontaneous ventricular fibrillation; cardiac arrest	
Source: Giesbrecht 2001				

5.2 Behavioral Effects

Human behavior can be a factor in developing cold injuries. For example, a marked increase in the number of patients going to an emergency room for cold related injuries was reported during the weekend in comparison to the number of patients reported during the weekdays. In over 60% of emergency room cold weather injury cases reviewed, blood alcohol level (BAL) was over the legal limit (0.10% at the time of the study). Alcohol diminishes one's ability to perceive a cold threat and thus may impair thermoregulation and appropriate defensive action against cold injury. Alcohol leads to increased heat loss by causing peripheral vasodilation and may affect behavior by impairing judgment that could lead to inappropriate choices of clothing or risk taking.

Historical experience with Sarin attacks in Matsumoto and Tokyo serve as real-life models of the impact of human behavior on a situation. In these emergencies, the risk for psychological injury was greater than the health risk posed by exposure to the chemical—80% of the victims in those incidents were suffering from psychological trauma or were part of the worried well. Only 20% of the victims were chemically contaminated. A first responder may be unable to ascertain whether chemicals or stress or cold injury incapacitates a person.

5.3 Wind Chill

A wind chill estimate or temperature is an attempt to quantify the effect of moving a cold air stream over a warm body. In effect, this air movement displaces the warm air at the body surface (which has been heated by conduction) and replaces it with a layer of air at ambient temperature. The amount of heat loss is therefore a function of **both** air temperature and wind speed. If the body surface is wet, then heat loss is magnified by evaporation. The wind chill "threat" may be overstated by some cold weather information sources because the basis for wind chill factor calculations is subjective. Wind chill is a means of expressing how cold **exposed skin feels** to an individual. If the wind is below 4 mph, there is negligible wind chill effect; at higher wind speeds, the wind chill effect increases. For example, if the actual air temperature outside is 30°F, a wind speed of 10 mph will make the air feel like 21°F. At a wind speed of 30 mph, the air will feel like 15°F (see http://205.156.54/om/windchill/). However, even in cases of extremely cold weather, a person's body temperature cannot drop below the ambient air temperature, regardless of wind speed.[6] For people who already may be wet from decontamination, the conventional wind chill factor cannot be applied because it does not take into account the additional cooling of the skin due to water evaporation. Wetness will cause greater discomfort during cold exposure and will reduce the time it takes for a person to reach a colder temperature through the processes of evaporation and convection. Colder air temperatures are better tolerated than colder water temperatures because heat is lost 26 times faster when skin is exposed to water than when skin is exposed to the ambient air. For the purposes of cold weather mass decontamination, responders should be aware of an increased risk of cold shock and hypothermia when wind is present.

6.0 CONCLUSIONS AND RECOMMENDATIONS: THE BOTTOM LINE

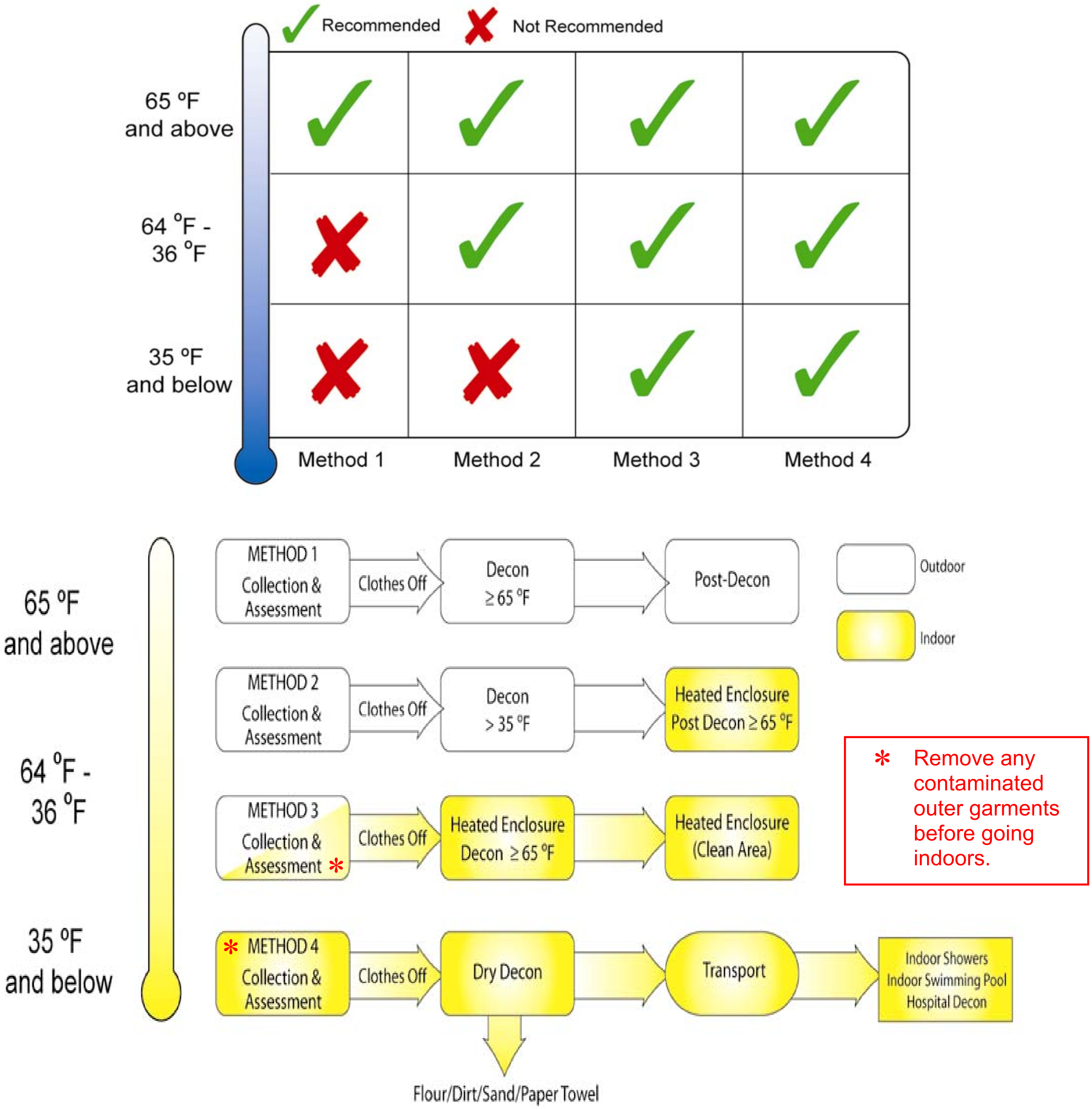
Successful decontamination methods must be executable with the resources available to the responders. The decontamination methods must save lives by effectively reducing the victim's chemical contamination level and minimizing exposure to medical treatment personnel. At the same time, the methods must not place the contaminated victim or responders at greater risk than that posed by the incident. Factors that will help the first responder determine which method of decontamination to use include the following:

- Available resources
- Number of potential victims
- Number of symptomatic victims
- Age of victims
- Outdoor ambient temperature

Figure 6-1 is a method selection table for cold weather decontamination based on ambient temperature. Figure 6-2 is a decision tree for determining decontamination procedures based on ambient temperature. Both figures present the same information in a slightly different format. The implementation time for each method should be a major factor when deciding which decontamination method to use. The breakpoints, or environmental limits, provide guidance on when a particular method is recommended for use—or more importantly—when a particular method is **not** recommended.

Regardless of the ambient temperature, people who have been exposed to a known life-threatening level of chemical contamination should disrobe, undergo decontamination with copious amounts of high-volume, low-pressure water or alternative decontamination method, and be sheltered as soon as possible.

[6] This assumes the individual is on land. If a person is submerged in water that is colder than air, the body will readily lose heat to the colder water.



Time is critical to the decontamination process. Select the most expeditious method available based on temperature constraints and available resources. Method 1 is the simplest and Method 4 is the most complex.

Figure 6-1. Method Selection for Cold Weather Decontamination

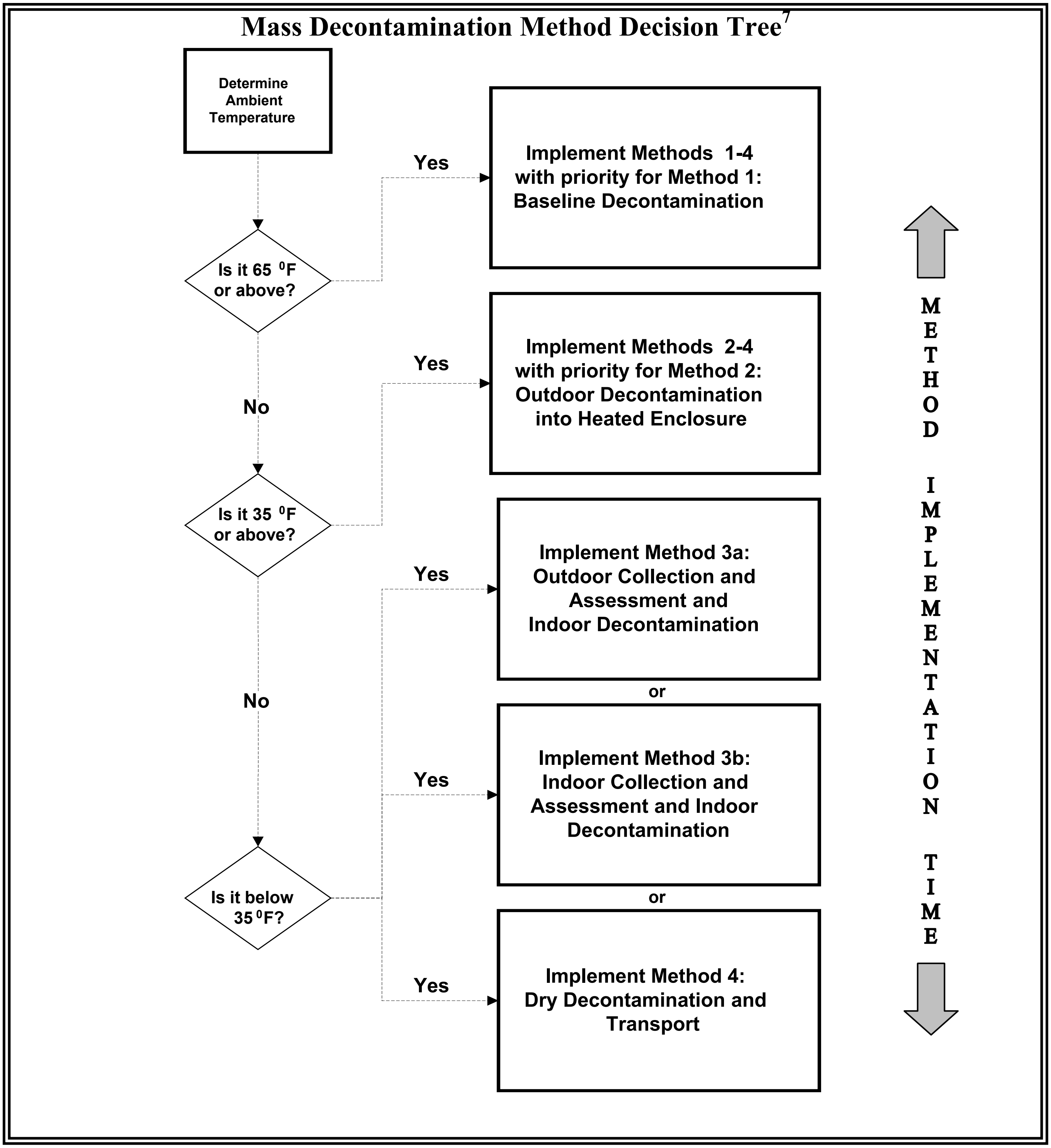


Figure 6-2. Mass Decontamination Method Decision Tree

[7] **Because time is critical to the decontamination process, select the most expeditious method available based on the temperature constraints and available resources.**

APPENDIX I
CW-IRP AND MASS CASUALTY DECONTAMINATION BACKGROUND INFORMATION

A. CW-IRP History and Products

In response to growing concerns about domestic terrorism, Congress enacted legislation in Public Law 104-201, the National Defense Authorization Act for Fiscal Year 1997, to help prepare the United States for a potential terrorist incident. The legislation contained two principal provisions. First, it allocated funding to train first responders to respond to incidents involving weapons of mass destruction (WMD). Additionally, the legislation required that the Secretary of Defense develop and execute a program for testing and improving federal, state, and local agency responses to incidents involving biological, chemical, and radiological weapons. As a result, the U.S. Army Soldier and Biological Chemical Command (SBCCOM) was designated the lead agent for Department of Defense and was charged with establishing and implementing these programs. In response to the latter element of the legislation, SBCCOM established the Chemical Weapons (CW) Improved Response Program (IRP) in partnership with other federal agencies.

The CW-IRP was a multi-year program designed to identify, evaluate, and demonstrate the best practical approaches to improving CW domestic preparedness. A multi-agency team consisting of experienced emergency responders, emergency managers, and technical experts representing federal, state, and local agencies from around the nation was assembled to execute the program. The products from the CW-IRP effort include nine tabletop exercises of varying sizes, threats, and complexity; two functional exercises to demonstrate concepts and procedures; and technical studies. The technical studies include reports on the assessment of firefighter personal protective equipment (PPE), positive pressure ventilation (PPV), techniques for mass casualty decontamination, assessment of law enforcement and emergency medical system (EMS) personal protective equipment, analyses of protective clothing for SWAT teams, studies on an alternate medical care facility for chemical casualties, chemical mass fatality management, and an emergency response video. Most of these reports are available to the public on the SBCCOM Web page (http://www2.sbccom.army.mil/hld/cwirp/).

B. Mass Casualty Decontamination

The CW-IRP provided guidelines on decontaminating large numbers of people involved in a chemical terrorism incident. That report, titled “Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident,” is dated January 2000. Work of the CW-IRP can be reviewed at http://www2.sbccom.army.mil/hld/cwirp/.

SBCCOM formed a Mass Casualty Decontamination Research Team (MCDRT) under the CW-IRP in February 1998 to address specific technical and operational issues associated with performing mass casualty decontamination after a terrorist incident involving chemical weapons of mass destruction. The MCDRT was assembled from emergency response and technical disciplines. The research team included a broad scientific and operational knowledge base of general experts and specialized staff, including physicians with knowledge of the physiological and toxicological effects of chemical agents, government emergency responders, and contract research subject matter experts.

Over several months, the MCDRT collectively addressed the issue of how to effectively decontaminate large numbers of people. Emphasis was placed on decontamination methods that could be performed with equipment and expertise readily available to most responder jurisdictions. Effective physical and medical approaches were identified through a review of over 200 research papers, books, articles, manuals, and Internet sites. From this review, decontamination principles and procedures were developed to effectively decontaminate large numbers of people. The general principles identified to guide emergency responder policies, procedures, and actions after a chemical agent incident include the following[8]:

- Expect at least a 5:1 ratio of unaffected to affected casualties
- Decontaminate victims as soon as possible
- Disrobing (head to toe) is decontamination; more removal is better
- Water flushing generally is the best mass decontamination method
- After a known exposure to liquid chemical agent, emergency responders should be decontaminated as soon as possible to avoid serious effects

There are three main purposes for decontamination:

- Remove chemical agent from the victims
- Protect response and medical personnel
- Offer psychological comfort to victims

Chemical Agent Removal: The primary purpose of decontamination is to remove agent from the victim's clothing and skin to immediately reduce the chemical hazard. The simple act of removing the victim's contaminated clothing can reduce the potential for fatal injuries. Physical means, such as flushing the victim with large amounts of clean water or blotting obvious contamination can be used effectively to remove chemicals. Agent removal diminishes further injury from vapor hazards to the victim and those nearby.

Protect Others: Decontamination also protects responders and subsequent medical personnel, facilities, and equipment from inadvertent contact with the agent. Members of the medical community have stated that in order to protect their personnel, hospitals and clinics will "close their doors" to contaminated victims, regardless of the situation. Treatment likely will be conducted in hospital parking lots—triage style. Decontamination of victims prior to treatment is essential because it minimizes further victim exposure to the agent and ensures that medical personnel and facilities do not become contaminated.

Provide Comfort: Decontamination provides potentially exposed individuals with psychological assurance. People who believe they have been exposed to an agent may develop psychologically-based symptoms (i.e., shortness of breath) even if they have not actually been contaminated.

The first responder may not be able to ascertain whether the victim's distress is chemical exposure or psychological, so decontamination may be indicated. It is generally acknowledged

[8] The ensuing bullets were extracted verbatim from the SBCCOM report "Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident - January 2000," page 2.

that the best approach for mass casualty decontamination is plain water of high volume and low pressure. The pressure should be around 60 to 90 pounds per square inch (similar to a household shower). Decontamination with high-pressure water is not recommended since it may force the agent through clothing, increasing the hazard for victims. When available, such as at hospitals, hotels, and other fixed facilities, tempered water and soap should be used for mass decontamination. For on-scene emergency response decontamination operations, untempered water directly from the water main can be used if the risk/benefit evaluation discussed in Sections 4 and 5 of this report has resulted in a decision to decontaminate.

The operational and environmental constraints encountered in a real situation may require a different approach from the recommendations in this report, so the first responder should consider each factor that will influence the safety and success of the decontamination process. Factors to consider in choosing a decontamination method include the following:

- Type of resources available
- Number of conventionally injured victims
- Number of potentially contaminated victims
- Wind speed and direction
- Ambient temperature
- Immediate threats to responder personnel
- Water temperature of available water supply
- Volume of available water supply

APPENDIX II
REFERENCES

1. *2000 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 171–179.
2. Army Medical Surveillance Activity. "Cold weather injuries in active duty soldiers, 1997–2000." *MSMR* 3 (1): 2–7 (2000).
3. Army Medical Surveillance Activity. "Cold weather injuries in active duty soldiers, 1995–1996." *MSMR* 3 (1): 2–7 (1997).
4. Carroll, Warren. "Efficacy of Showering for Chemical Agent Removal." PowerPoint presentation during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January 2001.
5. Curtis, R. "Outdoor Action Guide to Hypothermia and Cold Weather Injuries." Princeton University, 1995.
6. *Draft Final Report for the Workshop on Cold Weather Mass Decontamination*. March 2001.
7. Giesbrecht, GG. "Pre-hospital treatment of hypothermia." 2001.
8. Hamlet, Murray. Personal communication during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January–1 February 2001.
9. Lake, William. PowerPoint presentation during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January 2001.
10. O'Connor, Laurel. "Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident: Principles of Decontamination." PowerPoint presentation during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January 2001.
11. O'Connor, Laurel. "Mass Casualty Decontamination Follow-On." PowerPoint presentation during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January 2001.
12. Rintamaki, H. "Predisposing factors and prevention of frostbite." *Int J Circumpolar Health* 59 (2): 114–121 (2000).
13. Schimelpfenig, T. and Lindsey, L. "Cold Injuries." Chapter 9 in *NOLS Wilderness First Aid*. Lander, WY: National Outdoor Leadership School, 2001.
14. *State of Alaska Cold Injuries and Cold Water Near Drowning Guidelines*. 1–7, 35. Alaska Community Health and Emergency Medical Services Section, January 1996.
15. Taylor M.S., Kulungowski, M.A., and Hamelink, J.K. "Frostbite injuries during winter maneuvers: a long-term disability." *Mil Med* 154 (8): 411–412 (1989).
16. Taylor, M.S. "Cold weather injuries during peacetime military training." *Mil Med* 157 (11): 602–604 (1992).
17. Tikuisis, Peter. "Cold Weather Decon Tutorial." Defence and Civil Institute of Environmental Medicine, Canada, 29 January 2001.
18. Tikuisis, Peter. Personal communication during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January–1 February 2001.

19. U.S. Army Soldier and Biological Chemical Command. “Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident, public release version.” SBCCOM, January 2000.
20. Wittmers, Lorentz. “Hypothermia Presentation.” Presented during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January 2001.
21. Wittmers, Lorentz. “Temperature Regulation and Hypothermia.” University of Minnesota, Hypothermia Laboratory, Duluth, MN, 31 January 2001.
22. Wittmers, Lorentz. Personal communication during the Chemical Weapons Improved Response Program, Cold Weather Mass Decontamination Working Group Panel Meeting, 31 January–1 February 2001.
23. Wittmers, Lorentz. “Pathophysiology of Cold Exposure.” *Minnesota Medicine* 84 (1): 30-36 (2001). Accessible online at: http://www.mmaonline.net/publications/MnMed2001/November/Whittmers.html

APPENDIX III
IMPROVED RESPONSE PROGRAM DOCUMENTS

CW-IRP Reports
http://www2.sbccom.army.mil/hld/

- An Alternative Health Care Facility: Concept of Operations for the Off-Site Triage, Treatment, and Transportation Center (OST^3C) Mass Casualty Care Strategy for a Chemical Terrorism Incident (March 2001)
- Chemical Weapons Improved Response Program (CW-IRP) 2000 Summary Report
- CW-IRP Playbook: Guidelines for Responding to and Managing a Chemical Weapons of Mass Destruction Terrorist Event (November 2000)
- Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident (January 2000)
- Guidelines for Mass Fatality Management During Terrorist Incidents Involving Chemical Agents (November 2001)
- Guidelines for Use of Personal Protective Equipment by Law Enforcement Personnel During A Terrorist Chemical Agent Incident (June 2001)
- Chemical Protective Clothing for Law Enforcement Patrol Officers and Emergency Medical Services when Responding to Terrorism with Chemical Weapons (November 1999)
- Use of Positive Pressure Ventilation (PPV) Fans To Reduce the Hazards of Entering Chemically Contaminated Buildings Summary Report (October 1999)
- Two Test Methods for Personal Protective Clothing Systems in Chemical Environments (October 1999)
- Guidelines for Incident Commander's Use of Firefighter Protective Ensemble (FFPE) with Self-Contained Breathing Apparatus (SCBA) for Rescue Operations During a Terrorist Chemical Agent Incident (August 1999)

APPENDIX IV
ACRONYMS

BAL	Blood Alcohol Limit
DoD	Department of Defense
EDCS	Emergency Decontamination Corridor System
HAZMAT	Hazardous Materials
IRP	Improved Response Program
LDS	Ladder Pipe Decontamination System
MCDRT	Mass Casualty Decontamination Research Team
OSHA	Occupational Safety & Health Administration
PPE	Personal Protective Equipment
PPV	Positive Pressure Ventilation
SBCCOM	U.S. Army Soldier and Biological Chemical Command
WMD	Weapons of Mass Destruction

APPENDIX V
SWIMMING POOL AGENT DECONTAMINATION DATA

Assumptions

- Olympic sized pool – 3,000,000 L
- Severe effects cutaneous dose for 154 lb person
    - GB –1000 mg
    - VX –1 mg
- Dose brought into pool by each person—assumed to be a no-effects dose
    - GB –100 mg
    - VX – 0.1 mg
- Personnel with doses greater than the no-effects dose have already been taken to treatment centers for medical care
- Agent is completely removed from personnel in the pool
- Agent molecules can move through dissociation approximately 0.1 cm
- Complete and uniform mixing of the agent in the pool water and uniform distribution of the agent throughout the pool
- Each individual is contaminated with agent at the no-effect level
- Theoretically-based calculations assume that the chlorine or other disinfectant in the pool does not react with the agent to reduce the available agent

Average body surface area – men	1.94 m^2	Assume population average at 1.8 m^2
Average body surface area – women	1.69 m^2	

Calculations

$1.8\ m^2 \times 0.1\ cm \times 10{,}000\ cm^2/m^2 = 1.8 \times 10^3 cm^3$ – water in contact with the body
$1.8 \times 10^3 cm^3 \div 1000\ cm^3/L = 1.8\ L$ – water in contact with the body

GB 100 mg/1.8 L = 55.6 mg/L – No effects concentration
VX 0.1 mg/1.8 L = 0.0556 mg/L – No effects concentration

To determine the number of people you can put in the pool without exceeding the no-effects level:

$$\text{GB} \quad 55.6\ mg/L \times \frac{3{,}000{,}000\ L}{100\ mg/person} = 1{,}668{,}000 \text{ people}$$

$$\text{VX} \quad 0.0556\ mg/L \times \frac{3{,}000{,}000\ L}{0.1\ mg/person} = 1{,}668{,}000 \text{ people}$$

Comments:

From the calculations above, the resultant number of people that can be put in a pool without exceeding the no-effects level has been reduced by 50% to add an additional margin of safety. In summary, for the agents above (GB and VX), approximately 800,000 people could be processed through an Olympic-sized swimming pool; therefore, using community swimming pools for mass casualty decontamination is a reasonable option.

APPENDIX VI[9]
CHEMICAL AGENT MEDICAL MANAGEMENT SUMMARY
Medical Management of Chemical Casualties Handbook
USAMRICD
Third Edition, August 1999

Nerve Agents

GA GB GD GF VX

Summary

Signs and Symptoms:
Vapor: *Small exposure*–Mitosis, rhinorrhea, mild difficulty breathing. *Large exposure*–Sudden loss of consciousness, convulsions, apnea, flaccid paralysis, copious secretions, miosis.
Liquid on skin: *Small to moderate exposure*–Localized sweating, nausea, vomiting, feeling of weakness. *Large exposure*–Sudden loss of consciousness, convulsions, apnea, flaccid paralysis, copious secretions.

Detection: M256A1; CAM; M8 paper; M9 paper; M8A1 and M8 alarm systems.

Decontamination: M291; M258A1; hypochlorite; large amounts of water.

Immediate management: Administration of **MARK I's** (atropine and pralidoxime chloride); diazepam in addition if casualty is severe; ventilation and suction of airways for respiratory distress.

Mustard

HD H

Summary

Signs and Symptoms: Asymptomatic latent period (hours). Erythema and blisters on the **skin**; irritation, conjunctivitis and corneal opacity and damage in the **eyes**; mild upper **respiratory** signs to marked **airway** damage; also gastrointestinal effects and bone marrow stem cell suppression.

Detection: M256A1, CAM, M8 paper, M9 paper, M8 alarm (NOT the M8A1 alarm).

[9] This summary is from the *Medical Management of Chemical Casualties Handbook*, Third Edition, August 1999, prepared by the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD), Chemical Casualty Care Division, MCMR-UV-ZM, 3100 Ricketts Point Road, Aberdeen Proving Ground, Maryland 21010-5400. The reader is referred to USAMRICD for updates at the USAMRICD Web Site: http://ccc.apgea.army.mil/reference_materials/reference.asp

Decontamination: Hypochlorite; M258A1 kit; M291 kit; water in large amounts.

Management: Decontamination immediately after exposure is the only way to prevent damage. Symptomatic management of lesions.

Lewisite

L

Summary

Signs and Symptoms: Lewisite causes immediate pain or irritation of skin and mucous membranes. Erythema and blisters on the skin and eye and airway damage similar to those seen after mustard exposure develop later.

Detection: M256A1 only. (NOT M8 or M8A1 systems, CAM, or M8 and M9 papers).

Decontamination: M258A1; hypochlorite; water in large amounts.

Management: Immediate decontamination; symptomatic management of lesions the same as for mustard lesions; a specific antidote (BAL) will decrease systemic effects.

Phosgene Oxime

CX

Summary

Signs and Symptoms: Immediate burning and irritation flowed by wheal-like skin lesions and eye and airway damage.

Detection: M256A1; M8 alarm (NOT the M8A1 alarm and CAM).

Decontamination: Water in large amounts.

Management: Immediate decontamination; symptomatic management of lesions.

Cyanide

AC CK

Summary

Signs and symptoms: Few. After exposure to high Ct: seizures, respiratory and cardiac arrest.

Detection: M256A1 Ticket. **NOT** the M8A1 alarm and CAM.

Decontamination: Skin decontamination is usually not necessary because the agents are highly volatile. Wet, contaminated clothing should be removed and the underlying skin decontaminated with water or other standard decontaminates.

Management: **Antidote**: Intravenous sodium nitrite and sodium thiosulfate. **Supportive**: Oxygen; correct acidosis.

Pulmonary Agents

CG

Summary

Signs and Symptoms: Eye and airway irritation, dyspnea, chest tightness, and **delayed** pulmonary edema.

Detection: **Odor** or newly mown hay or freshly cut grass or corn. There is no military detector for phosgene.

Decontamination: Vapor: fresh air. Liquid: Copious water irrigation.

Management: Termination of exposure, ABCs of resuscitation, enforced rest and observation, oxygen with or without positive airway pressure for signs of respiratory distress, other supportive therapy as needed.

Riot Control Agents

CS CN

Summary

Signs and Symptoms: Burning and pain on exposed mucous membranes and skin, eye pain and tearing, burning in the nostrils, respiratory discomfort, and tingling of the exposed skin.

Detection: No detector.

Decontamination: Eyes: Thoroughly flush with water, saline, or similar substance. Skin: Flush with copious amounts of water, alkaline soap and water, or a mildly alkaline solution (sodium bicarbonate or sodium carbonate). Generally, decontamination is not needed if the wind is brisk. Hypochlorite exacerbates the skin lesion and should not be used.

Immediate management: Usually none is necessary; effects are self-limiting.