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Assessing homeland chemical hazards outside the military gates: industrial hazard threat assessments for department of defense installations

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Abstract

As part of comprehensive joint medical surveillance measures outlined by the Department of Defense, the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) is beginning to assess environmental health threats to continental US military installations. A common theme in comprehensive joint medical surveillance, in support of Force Health Protection, is the identification and assessment of potential environmental health hazards, and the evaluation and documentation of actual exposures in both a continental US and outside a continental US setting. For the continental US assessments, the USACHPPM has utilized the US Environmental Protection Agency (EPA) database for risk management plans in accordance with Public Law 106-40, and the toxic release inventory database, in a state-of the art geographic information systems based program, termed the Consequence Assessment and Management Tool Set, or CATS, for assessing homeland industrial chemical hazards outside the military gates. As an example, the US EPA toxic release inventory and risk management plans databases are queried to determine the types and locations of industries surrounding a continental US military installation. Contaminants of concern are then ranked with respect to known toxicological and physical hazards, where they are then subject to applicable downwind hazard simulations using applicable meteorological and climatological data sets. The composite downwind hazard areas are mapped in relation to emergency response planning guidelines (ERPG), which were developed by the American Industrial Hygiene Association to assist emergency response personnel planning for catastrophic chemical releases. In addition, other geographic referenced data such as transportation routes, satellite imagery and population data are included in the operational, equipment, and morale risk assessment and management process. These techniques have been developed to assist military medical planners and operations personnel in determining the industrial hazards, vulnerability assessments and health risk assessments to continental United States military installations. These techniques and procedures support the Department of Defense Force Protection measures, which provides awareness of a terrorism threat, appropriate measures to prevent terrorist attacks and mitigate terrorism's effects in the event that preventive measures are ineffective. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Historically, toxic industrial materials were considered insignificant during military contingency operations, where the traditional nuclear, biological and chemical (NBC) weapons were the focused items. Since the 1980s, there have been several instances (e.g. Bhopal, India, methylisocyanate leakage; Chernobyl, USSR, radiological accident; and the Tokyo, Japan, subway Sarin release) where the associated proliferation of NBC weapons and toxic industrial materials have caused significant health consequences. Overall, a majority of these incidents affecting outside continental United States (OCONUS) government facilities have increased force protection/national security concerns with respect to the protection of fixed facilities.

To date, the US Department of Defense (DOD) has implemented various policies and guidance to enhance force protection measures for OCONUS DOD installations. Part of these policies/guidance integrate force health protection measures. Pertinent industrial facilities/toxic industrial materials are identified and assessed with respect to acute/catastrophic health consequences, resulting from potential exposures to industrial chemicals (Armed Forces Medical Intelligence Center, 1998). These OCONUS force health protection assessments for nearby industrial facilities support DOD directives/instructions on Joint Medical Surveillance for military deployments (Department of Defense, 1997).

In order to complete the pre-deployment environmental health surveillance assessments as outlined in by the Department of Defense (1997), analogous environmental health threat assessments for continental United States (CONUS) military installations are beginning to be conducted by DOD Agencies (e.g. US Army Center for Health Promotion and Preventive Medicine (USACHPPM); US Air Force Institute for Environment, Safety, and Occupational Health Risk Analysis (AFIERA). The CHPPM and AFIERA have collaborated to produce technical guidance for conducting vulnerability assessments for CONUS and OCONUS military installations (Air Force Institute for Environment, Safety, and Occupational Health Risk Analysis, 2000). Part of this collaborative technical guidance uses US Environmental Protection Agency data sets, to include toxic release inventories and risk management plans, to assist in the identification of industrial facilities near fixed location CONUS military installations. This paper outlines the assessment techniques for CONUS military installations/facilities in support of homeland defense and pre-deployment force health protection measures for toxic industrial materials.

2. Materials and methods

There are three main components of an industrial hazards assessment and they include: (1) identification of industrial facility and hazards; (2) a vulnerability analysis; and (3) an operational risk management analysis. The following describe each of the three components in relation to acute/catastrophic consequences.

2.1. Industrial facility/hazards identification

This primary component involves obtaining and documenting pertinent information to include: the location of industrial facilities that use, store, produce, or process toxic industrial materials; types/quantities of chemicals associated with facility; types of chemical storage containers/vessels; surrounding transportation routes; and toxicological/physical hazards of identified chemicals. The two main database reference sources of these are the Emergency Planning and Community Right-To-Know Act (EPCRA) (Environmental Protection Agency, 1986) and the US Environmental Protection Agency Risk Management Plans (RMPs) (Environmental Protection Agency, 1996).

The EPCRA focuses on community emergency planning with respect to industrial facilities reporting the names and/or types of hazardous chemicals when specified thresholds are exceeded. The EPCRA Toxic Release Inventory (TRI) requires industrial facilities to report annual emissions of hazardous chemicals/substances into the environment. The TRI Explorer is available at the universal record locator http://www.epa.gov/

triexplorer/. In addition, the EPRCA has created State Emergency Response Commissions and Local Emergency Planning Committees, which are responsible for coordination of local emergency planning districts and developing/maintaining local emergency plans, respectively.

The risk management plan consists of a hazards assessment program, accidental release program, and emergency response program to prevent the accidental release of hazardous chemicals, building upon the safety work under EPCRA. Part of the hazard assessment program includes conducting an off-site consequence analysis (OCA), which is an analytical estimate of the potential consequence of hypothetical worst-case release on the public and environment around the identified facility.

2.2. Vulnerability analysis

The second component, a vulnerability analysis, builds on the primary data collection component to identify geographic areas on/off the installation that may be exposed; personnel potentially subject to several injury levels; and what associated facilities, property, and/or environment is susceptible to damage from a toxic industrial material release. For this second component, the Consequence Assessment Tools Set (CATS) (Defense Threat Reduction Agency, 2000), is the selected geographic information system (GIS) solution to support the vulnerability analysis. Developed under the guidance of the US Defense Threat Reduction Agency (DTRA) and the US Federal Emergency Management Agency (FEMA), CATS provides significant assistance in emergency managers' training, exercises, contingency planning, logistical planning and calculating requirements for humanitarian aid. The CATS predicts the damage and assesses the consequences associated with that damage as a result of a technological or natural hazard. The technological portion of CATS provides for the calculation of damage and consequence using real-time weather and a variety of sources, particularly those associated with weapons of mass destruction (WMD), as employed by military forces or terrorists. User-friendly graphical user interfaces (GUIs) and pre-defined event scenarios assist the CATS user in predicting credible hazards resulting from the dispersal of radiological, biological and chemical agents, regardless of the user's level of expertise and access to information (Science Applications International Corporation, 2001).

The major factor in this component is the appropriate concentration guideline (or level of concern) to compare/display predicted results from the CATS solution. The level of concern is used as the input concentration endpoint in CATS to determine the geographic extent of the predicted plume and the resulting size of the associated vulnerability zone. For this assessment, we selected the use of the Emergency Response Planning Guides (ERPGs) (American Industrial Hygiene Association, 2000). The ERPGs are a three-tiered standard with common 1-h contact duration, and are the most widely used and accepted community exposure limits for emergency responders.

2.3. Operational risk management analysis

The third component is an assessment of the likelihood (probability) of an accidental toxic industrial material release, the severity of the release, and any associated consequences that might occur. These are based on estimated vulnerable zones derived from CATS scenarios. These procedures are similar to those used by the DOD for operational risk management measures in military operations (Department of the Army, 1998; Army Center for Health Promotion and Preventive Medicine, 2001). The risk analysis provides an estimation of the following: (a) probability of an accidental release based on the history of current operational/maintenance conditions; (b) severity of consequences of human injury that may occur; (c) potential mission impacts; and (d) type of damage to property and the environment. All of the information/data collected, documented, and assessed in components 1 and 2 are used as the basis for determining a relative measure of probability and severity of a possible toxic industrial material release event. Fig. 1 displays the operational risk management matrix and hierarchy of occupational and environmental health hazards (i.e. paradigm) adopted for this assessment.

HAZARD SEVERITY	HAZARD PROBABILITY				
	Frequent (A)	Likely (B)	Occasional (C)	Seldom (D)	Unlikely (E)
Catastrophic (I)	Extremely High	Extremely High	High	High	Moderate
Critical (II)	Extremely High	High	High	Moderate	Low
Marginal (III)	High	Moderate	Moderate	Low	Low
Negligible (IV)	Moderate	Low	Low	Low	Low
	RISK ESTIMATE				

Fig. 1. Operational risk management matrix and hierarchy of occupational and environmental health hazards.

The estimation of the hazard probability identified in Fig. 1 involves three primary considerations to include: (a) comparability of the field unit's exposure profile to the standard exposure profile used in the derivation of the exposure guidelines; (b) proportion of the field unit that is likely to experience exposures relative to specific exposure guideline; and (c) confidence in the available data with respect to uncertainty and variability sources. The estimation of the hazard severity identified in Fig. 1 involves three primary judgments to include: (a) proportion of the field unit that is likely to exhibit effects relative to the specific exposure guidelines; (b) nature of the health effect(s) associated with exposures at or above the guideline level; and (c) confidence in the available data with respect to uncertainty and variability sources. All the hazard probability considerations and the hazard severity judgments support the operational risk management characterization levels (i.e. extreme, high, moderate, and low) and are consistent with current operational guidance and the preventive medicine approach to assessing health and medical threat risks (Army Center for Health Promotion and Preventive Medicine, 2001).

3. Results

In order to demonstrate the materials and methods highlighted in this assessment, a hypothetical release scenario was developed. In this scenario, it was assumed that a brigade of military personnel would be assembling for an 8-h period at 'Fort X' to depart for an overseas deployment. The following describes the steps to determine the relative measure of probability and severity of a toxic industrial material release on the Fort X airfield and the associated consequence management measures.

3.1. Industrial facility/hazards identification

Since this assessment is applicable for a hypothetical release scenario, the geographic locations, facility types, and chemicals (with associated toxicological and physical hazards) at industrial facilities surrounding Fort X were fabricated. The fabricated industrial facilities and associated hazardous material operations were representative for the following types of industries: chemical plants; refineries; petroleum and natural gas tank farms; railroad yards; waste disposal and treatment facilities; and major transportation corridors and transfer points.

For this assessment, representative chemical-specific quantities, storage containers, toxicological and physical hazards were estimated from representative values found in the US EPA Toxic Release Inventories and Risk Management Plans. The (fabricated) industrial facilities surrounding Fort X were rank-ordered with respect to expected chemicals and associated toxicological and physical values. The Harnack Phosgene Plant, located in Simcity (approx. 5 km southeast of Scully Airfield), displayed the greatest health/medical threat from an accidental or intentional release of phosgene. A total of 3000 kg of phosgene was

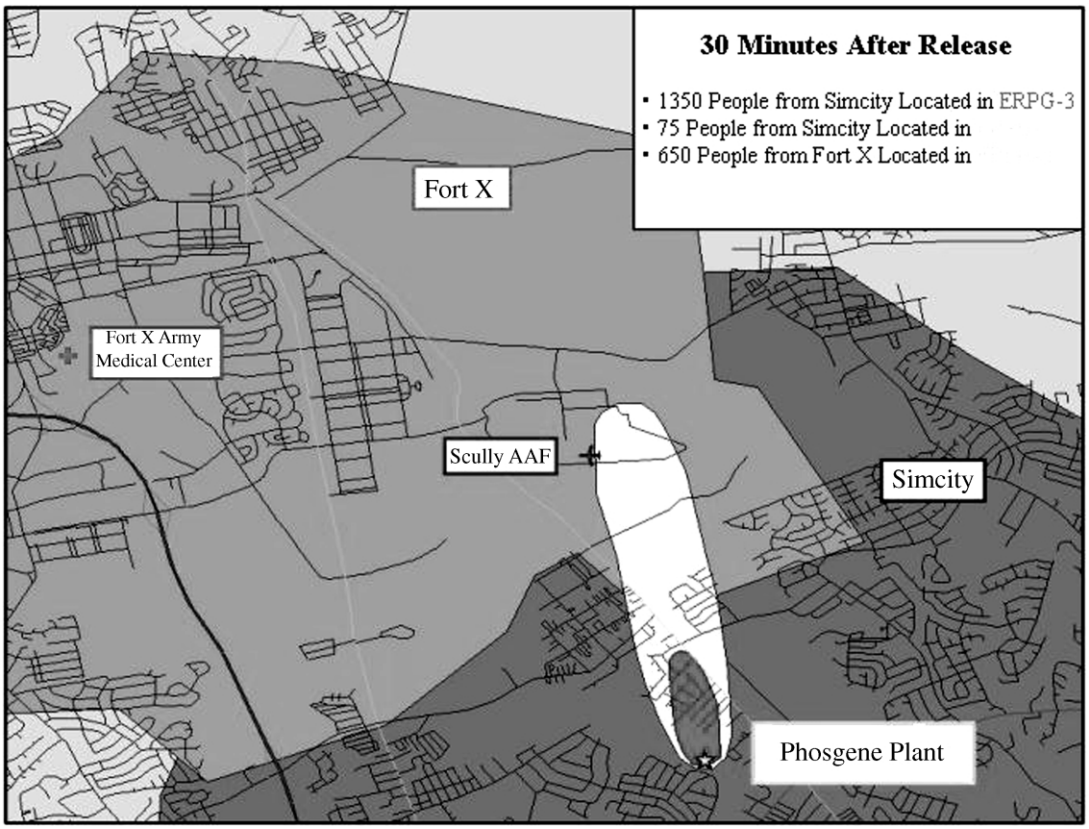

Fig. 2. Simulated downwind hazard areas for hypothetical release of phosgene gas.

assumed to be stored at the Harnack Phosgene Plant.

3.2. Vulnerability analysis

In order to simulate the downwind occupational and environmental health hazards to Scully Airfield from a phosgene release at the Harnack Phosgene Plant, the following assumptions were made. The meteorological data were set as a fixed wind direction and speed in order to simulate the downwind plume (i.e. vulnerable zone) impacting the Scully Airfield. A volumetric source simulating the phosgene gas storage containers was used. With the source terms, the resulting downwind hazard areas, predicted by the CATS software, were output to 15-min time-steps in order to animate the downwind hazard regions through time. All of the downwind hazard regions were mapped to respective ERPG levels for phosgene, which are 0.2 parts per million (ppm) and 1.0 ppm for ERPG-2 and ERPG-3 thresholds, respectively. The resulting downwind hazard area impacts both the Harnack Phosgene Plant surroundings and the Fort X installation. The mapped ERPG-2 and ERPG-3 thresholds for phosgene were maintained for 75 min after the phosgene gas release. In summary, the ERPG-3 hazard region remains in and around the Harnack Phosgene plant and these levels are not predicted to occur on the Fort X installation. The ERPG-2 hazard region impacts the Fort X installation for an approximate 1-h duration. The Scully Airfield is impacted at ERPG-2 levels for approximately a 30-min duration. Fig. 2 graphically depicts the composite phosgene gas downwind hazards areas for the Harnack Phosgene

Plant, Simcity, and Fort X/Scully Airfield. In addition, the CATS software hypothetically calculated 1350 personnel exposed to ERPG-3 phosgene levels (Simcity); 75 personnel exposed to ERPG-2 levels (Simcity); and 650 personnel exposed to ERPG-2 phosgene levels at Fort X. In addition, the personnel preparing for deployment at the Fort X Scully Airfield are exposed to ERPG-2 phosgene levels.

3.3. Operational risk management analysis

Based on the above methods and procedures and estimated outcomes, an overall *Moderate* operational risk category is selected for the Scully Airfield exposure scenario. This operational health risk category is derived from both a 'critical' hazard severity ranking (defined as mild illness or temporary irritation symptoms observed during the mission) and a seldom hazard probability (defined as 20–50% of the unit being exposed). With the *Moderate* operational risk category, the expected consequences are a degraded mission capability in terms of the required mission standard and the unit reporting at a 70–84% strength range (Army Center for Health Promotion and Preventive Medicine, 2001). In addition, the surrounding environment exposed to the listed ERPG-2 and ERPG-3 levels would be contaminated and require appropriate hazardous material site investigation and re-entry/re-use measures.

4. Discussion

Overall, these techniques have been developed to assist military medical planners and operations personnel in determining the industrial hazards, vulnerability assessments, and health risk assessments to continental United States military installations. These techniques have also supported several non-military industrial hazard assessments including: the January 2000 State of the Union Message (Washington, DC); the May 2000 Top Officials Exercise (Portsmouth, NH); and the August 2000 Republican National Convention (Philadelphia, PA). In all, those identified industrial facilities, which exhibited the greatest health/medical threat from an accidental or intentional release of a toxic industrial chemical, posed operational risk management levels, which could affect the installation and/or target population. One significant finding of this study was the availability of commercial off-the-shelf consequence assessment and management software technology, which greatly enhanced the industrial hazards/vulnerability assessment procedures. These techniques and procedures support the Department of Defense Force Protection measures, which provides awareness of a terrorism threat, appropriate measures to prevent terrorist attacks and mitigate terrorism's effects in the event that preventive measures are ineffective.

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