LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-701202

Mass Casualty Chemical Incident Operational Framework, Assessment and Best Practices

R. Greenwalt, W. Hibbard

August 24, 2016

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LLNL-TR-691105

Lawrence Livermore
National Laboratory

Mass Casualty Chemical Incident Operational Framework, Assessment and Best Practices

How to Assess a Community's Response Risk along with Recommendations and Best Practices

Prepared for Department of Homeland Security Office of Health Affairs by Lawrence Livermore National Laboratory

Authors: R. Greenwalt, W. Hibbard

S Program/Global Security
Lawrence Livermore National Laboratory,
P.O. Box 808, Livermore, CA 94551-0808

August 9, 2016

Disclaimer

Lawrence Livermore National Laboratory is operated by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy, National Nuclear Security Administration under Contract DE-AC52-07NA27344.

Table *of* Contents

Introduction

Emergency response agencies in most US communities are organized, sized, and equipped to manage those emergencies normally expected. Hospitals in particular do not typically have significant excess capacity to handle massive numbers of casualties, as hospital space is an expensive luxury if not needed. Unfortunately this means that in the event of a mass casualty chemical incident the emergency response system will be overwhelmed.

This document provides a self-assessment means for emergency managers to examine their response system and identify shortfalls. It also includes lessons from a detailed analysis of five communities: Baltimore, Boise, Houston, Nassau County, and New Orleans. These lessons provide a list of potential critical decisions to allow for pre-planning and a library of best practices that may be helpful in reducing casualties in the event of an incident.

The document is organized in three major sections and a series of appendices. The first section describes a way to consider the problem – it establishes the Response Risk Framework and describes developing test scenarios to use to examine the community response capability. The second section describes a way to examine the problem in detail – it explains an analysis process using those scenarios that can identify shortfalls in capability or capacity. The third section provides information that may possibly be directly applied in other communities – it summarizes observations, recommendations and best practices identified in the analysis of the five communities. The appendices are how-to documents going into more detail. Appendix A lists a set of useful references. Appendix B provides a method for developing test scenarios. Appendix C is an example applying the Response Risk framework and process to a generic community to develop test scenarios. Appendices D through H provide detailed instructions on the application of different analysis steps. Appendix I is a listing of typical critical shortfalls. Appendices J and K discuss identifying and preplanning critical decisions, as well as listing typical critical decisions for consideration for preplanning.

The body of the document is designed to support decision makers wishing to understand a method for assessing their community's ability to manage a mass casualty chemical incident and provide information on identifying potential shortfall areas. It also establishes some basic principles that may dramatically reduce casualties and lethality. The appendices provide more detailed information for emergency managing agencies and staff that wish to conduct a more in depth analysis of their community to assist developing community-specific solutions to reduce response shortfalls.

Throughout the document, key definitions are shown in yellow boxes.

Section One: Response Risk Assessment philosophy and process

Response Risk Assessment (RRA) is a process to examine the emergency response system in a community when faced with a mass casualty chemical incident. It assumes an incident has occurred and identifies those functions which will be overwhelmed producing additional risk to the population.

Response Risk: the risk of increased consequences due to the response system's inability or inadequate capacity to handle the incident.

There are only three critical functions in the emergency response system. They are: to recognize the problem, contain the effects, and mitigate the consequences. These tasks can be further described in relationship to the appropriate agency as incident recognition, facility actions, responder actions, and medical system actions. This breakdown forms an Operational Framework for emergency response with these four functions containing the subtasks listed in figure 1.

Detection
Identification
Information Flow
Situational Awareness
Decision-making
Warning
SIP/Evacuation
Decontamination
Immediate Medical
Rescue/Extraction
Triage
Transport
Emergency Room/Department
Medical Resources
Extended Care
Population Management

Figure 1, Emergency response subtasks

Response Risk Assessment challenges each agency and all of their subtasks with specific chemical release scenarios to identify shortfalls in capability or capacity. Different toxic chemicals produce different challenges to the emergency response system. No one chemical threat adequately identifies all problem areas. A thorough assessment requires examination of the effectiveness of each subtask against the toxic chemical that most challenges it.

Overview of the Response Risk Assessment Process

Response Risk Assessment addresses the three critical functions (recognize the problem, contain the effects, and mitigate the consequences) through an operational framework that assists in defining agency roles, critical decisions, and critical tasks. The operational framework along with the role definition is shown in figure 2.

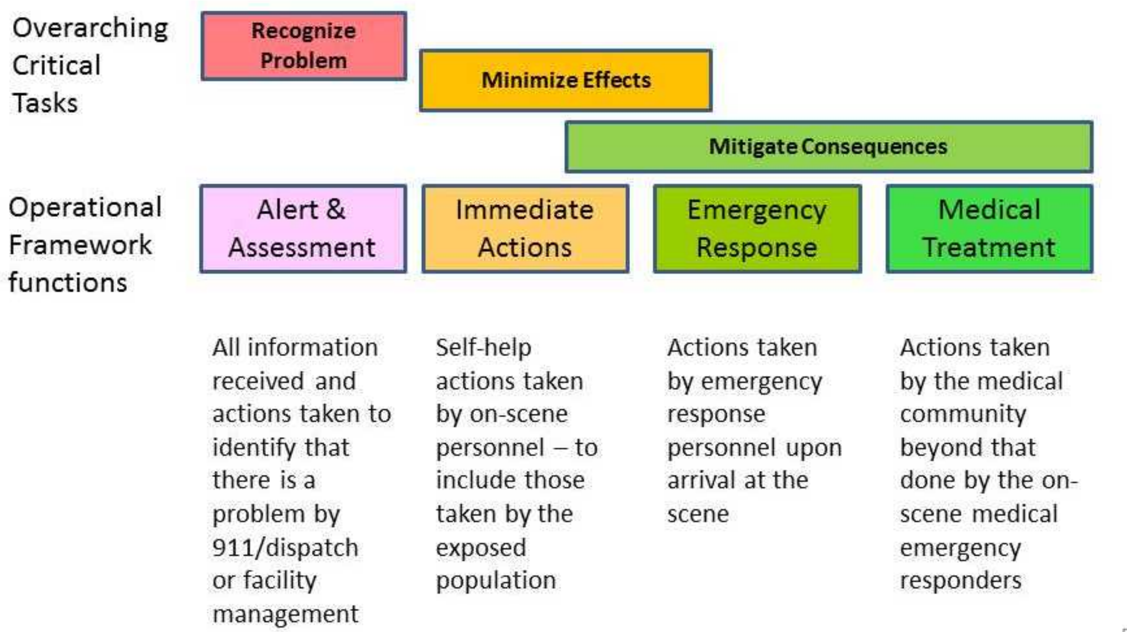

Figure 2, Operational Framework

The complete Operational Framework, which includes major actions within each area, is shown in figure 3.

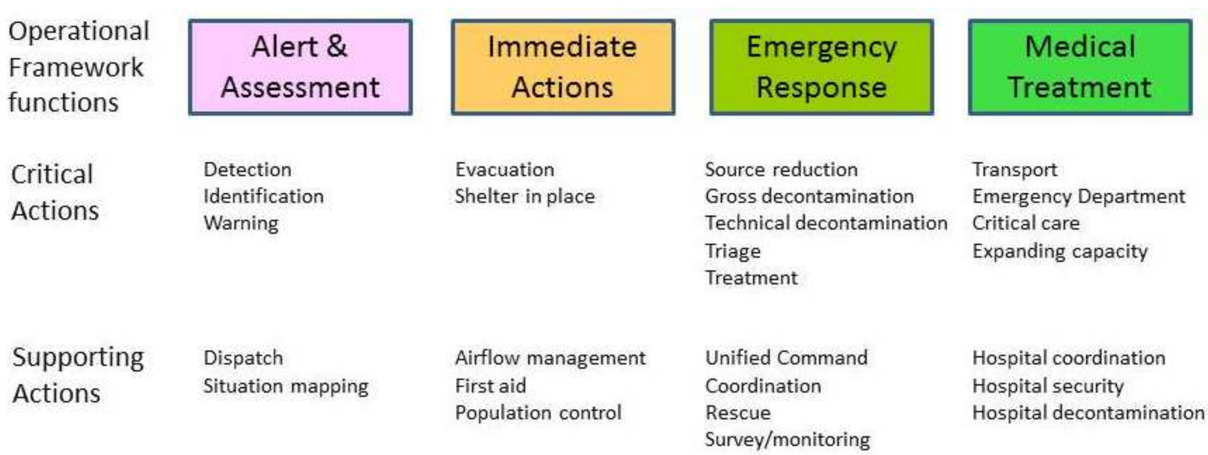

Figure 3, Expanded Operational Framework

The Response Risk Assessment process uses the Operational Framework as a model to examine the emergency response system in detail, from initiation of an incident through definitive medical care.

Process Description

The Response Risk Assessment process is most easily described using the flow diagram in Figure 4. Step one is a data gathering step focused on the unique factors of the community. It is broken into three sub categories identifying sources, possible agents, and possible community areas of concern ("targets"). Step two combines the data into a set of realistic scenarios. Step three examines the community's response system and compares against the scenarios to select those that will challenge critical parts of the system to allow analysis and gap identification. For this reason, the scenarios selected may not be those considered the most likely, but instead are those possible scenarios that pose the most difficulty. Step four compares current capabilities in these scenarios. A description of each step in the process follows the diagram.

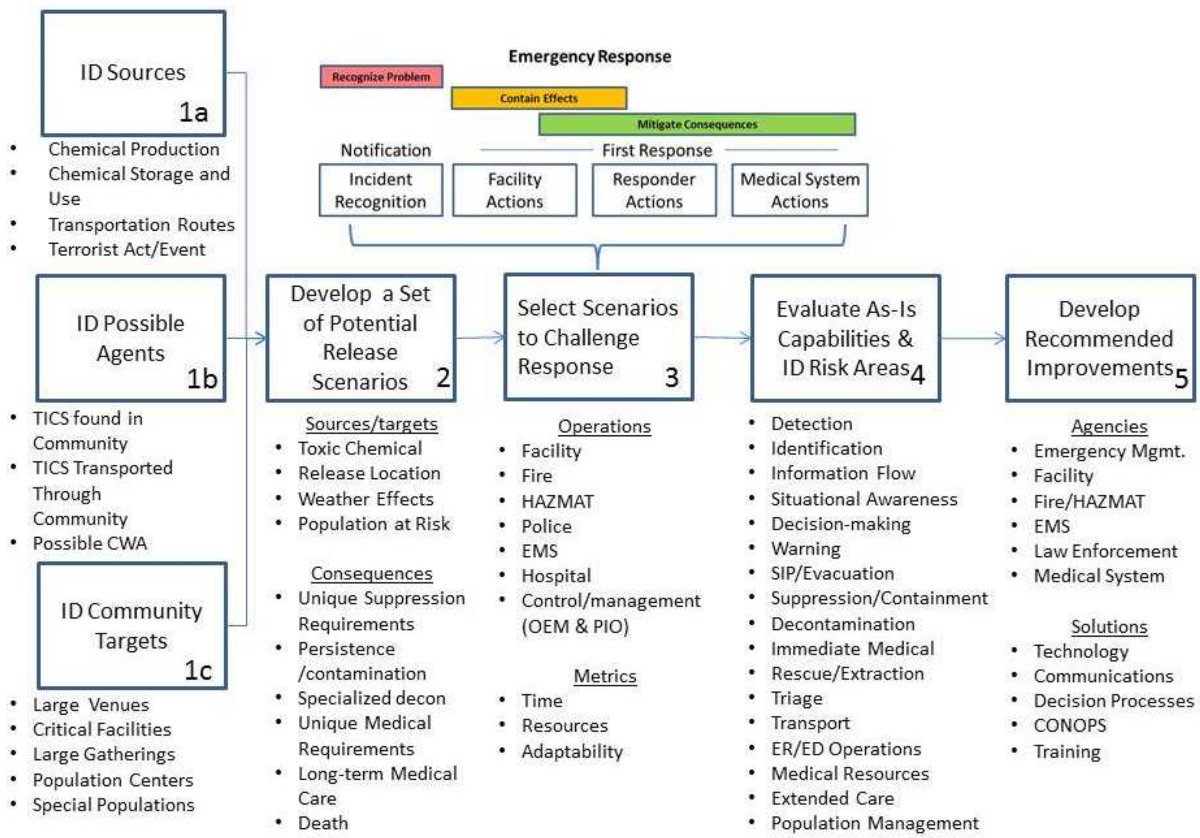

Figure 4, Response Risk Assessment Process

1a. ID Sources: This step requires an assessment of the community and those places where toxic chemicals are produced, stored or used, as well as those transportation routes (rail, highway, city street) where they might be carried on commercial vehicles.

1b. ID Possible Agents: This is an identification of the top toxic industrial chemicals used, stored, or transported through the community.

1c. ID Community Targets: This identifies those locations or venues/buildings where large gatherings may occur, large numbers live or work, or s that will contain large populations during events. Note: for purposes of this document, venue refers to a location containing a large population for a special event such as a concert or sporting event. A building refers to a structure housing a large population such as an office building.

2. Potential Scenarios: This is a creative step, where sources, targets, and potential consequences are combined into a set of plausible scenarios. Possible consequences depend on many factors, some of which are the weather conditions, possible population exposure, and the chemical's public exposure toxic levels. One of the most common public exposure guidelines are the Acute Exposure Guideline Levels (AEGLs). There are three levels of AEGLs, labeled 1, 2 and 3. Understanding the population exposed to the different levels is critical input to the analysis.

One of the most common public exposure measures that can be found for most toxic chemicals are the Acute Exposure Guideline Levels (AEGLs). There are three levels of AEGLs
AEGL-3: life threatening
AEGL-2: person could experience irreversible or other serious, long-lasting adverse effects
AEGL-1: person could experience notable discomfort, irritation, or asymptomatic nonsensory effects.

3. Scenario Selection: A limited number of plausible scenarios are chosen that will challenge the components of the response system. Generally, a matrix is used to ensure that the chosen scenarios adequately challenge all areas for analysis. It may be necessary to include a low probability scenario, such as a terrorist event, in order to consider all response aspects.

4. Identify as-is Capabilities and Risk Areas: This is the heart of the analysis process. Using the scenarios, the agency actions listed in figure 1 and management processes (i.e., information flow, situational awareness, and decision processes) are examined to identify gaps and shortfalls.

5. Finally, potential improvements are devised and tested in the analysis process to determine a set of recommendations. Many possible improvements can be selected from the critical decisions, recommendations, and best practices contained in this document derived from detailed assessment of the five cities in the Chemical Defense Demonstration Project.

Developing Scenario Test Cases

As step three in the process defines the threat against which the response will be measured, it requires additional discussion. Figure 5 illustrates an example of a pre-analysis assessment map of the fictitious city of Hybernia for the impact of the different scenarios on the response system. Each scenario is assessed against the critical actions from the Operational Framework.

The columns reflect the most serious response system actions. The rows list the selected scenarios and the toxic chemicals to be considered. An inference was then made to evaluate the comparative level of challenge a particular scenario/chemical would provide to the response system component. Low implies no significant challenge, medium is a major challenge, and high means a possible overwhelming challenge.

		Detection	Identification	Warning	Evacuation	SIP	Source Reduction	Gross Decon	Technical Decon	Treat	Triage	Transport	ER	Bed Space	Med Equip/meds
		Observe release	ID Chemical	Warn population	Execute & control	Execute	Suppress release	Initiation & Throughput	Resources & Throughput	EMS	Delayed Symptoms	Resources & Routes	Capacity and Throughput	Capacity	Resources
Downtown,	*Railcar*														
	Chlorine	Medium	Medium	High	Low	Medium	Medium	Low	NA	Medium	High	High	Medium	High	High
Port	*Storage Tank*														
	Cyclohexylamine	Low	Medium	High	Low	High	High	Medium	NA	Medium	High	Medium	High	Medium	High
Stadium	*Crop Duster*														
	Parathion	Low	High	Low	High	Low	NA	High	High	High	High	Medium	Medium	High	High

Figure 5, Scenario Challenge Map

The intent is to select a set of scenarios that produce at least medium challenges (and preferably high challenges) to all of the emergency response areas.

Mass casualty chemical incidents fall into four general categories (with some exceptions). The chemical agent either is predominately a respiratory threat, or a dermal threat (with associated contamination). The exposed population is either concentrated as in a stadium or arena, or is distributed like the population in an urban downtown or residential area. This forms a simple matrix that can be used to ensure that the selected scenarios address all significant possibilities. Figure 6 illustrates the matrix cross check on the example Hybernia scenarios.

	Concentrated Casualties	Dispersed Casualties

Primary Threat from Inhalation	• Storage tank
	  • Cyclohexylamine
	  • schools
		• Railcar
		  • Chlorine
		  • Downtown area
		• Storage tank
		  • Cyclohexylamine
		  • residential area

Primary Threat from Dermal Exposure	• NFL Stadium
	  • Parathion
		• NFL Stadium
		  • Parathion
		  • self evacuees

Figure 6, Chemical Incident Categories

Section Two: Analysis Processes

Analysis is conducted in order to determine how many casualties must be handled at each step in the emergency management process so that the points where the casualties overwhelm the system can be identified. This requires examination of the following areas, which will be discussed in turn.

1. How does the size of the exposed population grow with time
   - What is the airflow
   - Where is the population
2. What are the agency actions and interactions
   - What was the source of information – where did it go
   - What actions were done – by whom and where
   - What decisions were made – by whom and when
3. What was the decision process
   - Recognize need for decision
   - Obtain critical information
   - Select best option
4. What was the casualty flow
   - How did severity change with time
   - What were the numbers at each stage
   - Where were the chokepoints/gaps
   - How did timing affect numbers at chokepoints
5. What mitigation techniques or processes can be applied to reduce chokepoints/gaps

Exposure

Chemical release will begin at a point: a ruptured tank, pipeline, dispersing device, explosion, etc. As the agent expands away from the point it will form an expanding cloud affecting more and more people. Modeling this expansion and overlaying it on the distributed population will allow determining the increasing numbers of exposed people as time progresses.

Airflow predictions

External air movement is calculated using the Aloha and Marplot tools from the EPA along with the weather conditions at the time of the release (from historic data). ALOHA generates the plume model from weather and the chemical release conditions. MARPLOT provides a map of the area with census block population numbers. When the ALOHA plume map is overlaid, it will provide numbers exposed to AEGL1, AEGL2, and AEGL3 concentrations. It also provides plume arrival times at designated downwind points.

Internal airflow is somewhat more complicated and is dependent on air entry through doors, windows, and air intakes as well as the HVAC produced air movement within the facility. A simplifying assumption is provided in Appendix E.

Population distribution
MARPLOT provides an evenly distributed population in each census block. Additional population data comes from local information on the transient population – for example, the daytime population in a downtown area from commuters and shoppers. Law enforcement may have a good estimate of this. Finally, specific locations of high density population (schools, sporting venues, etc.) should be considered.

Studies have shown that the average outdoor population in urban areas during the daytime is approximately 10-15%. This makes a good assumption for determining outdoor exposure.

The population distribution within a venue from seating charts serves in place of census block numbers for an indoor release.

Timing of population exposure
The movement of the plume across a distributed population, and its arrival at various high density population locations is developed using ALOHA for an external threat. This is used to estimate the number of exposed individuals over a period of time. The chemical cloud movement across the patrons in response to air movement within in a venue or building allows estimating the number exposed individuals over a period of time for an internal release.

Agency actions and interactions

Task decomposition
Emergency response agency tasks are identified for each scenario and then decomposed into subordinate tasks in order to quantify agency workloads. Capacities and timings are also identified at this time – as an example, determining that city fire crews can establish four ladder-pipe decontamination lanes within 30 minutes, and each has a throughput of 72 exposed people per hour. Typical agency tasks are listed in Appendix F.

Multi-agency, cross-functional analysis
A cross-functional (sometimes known as a “swim-lane”) analysis is a suggested method to map agency tasks and decisions. This identifies dependencies where an agency decision depends on information from some other source and where a task cannot be accomplished until some other task is finished. Information flow between agencies and directives passed to operators are indicated to show relationships and allow timing determinations.

Decision process
Important decisions are identified during task decomposition and cross-functional analysis. These are important as they initiate the various response actions. Some decisions are identified as critical because of critical timing or serious consequences of choosing the wrong action.

Decision analysis

For each critical decision, the decision maker, alternatives (along with the benefits and consequences of making correct or incorrect decision), information sources, the trigger event, and the minimum actionable information necessary to select the correct decision should be identified as a preplanning step. A model that can be used for preplanning critical decisions is included in Appendix J.

Casualty Flow

A process diagram of the major tasks within the Operational Framework is developed to show the flow of casualties until final disposition. Figure 7 is a generic process diagram for an indoor release.

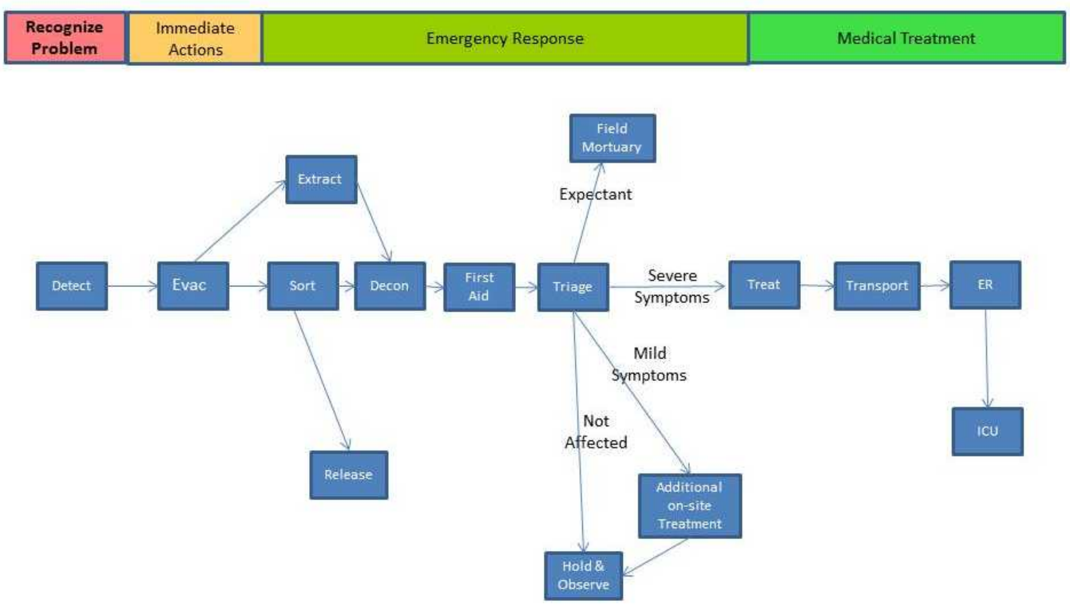

Figure 7, Emergency Response Process Model for Indoor Release

Timing analysis

As progress of exposure and chemical induced damage increases with time, the time to provide each level of protective or mitigating action will directly affect consequences to the community. In broad terms the critical times are:

- Time required to **protect population from additional exposur**e – this will establish the numbers exposed and initial doses received
- Time required to **decontaminate exposed victims** – to stop additional damage caused by residual agent on the person. Delay will cause increasing damage which can move a patient from a severe to a critical category, or cause death.
- Time to **provide stabilizing medical care** – this is temporary lifesaving care while the patient is awaiting transport. Delay will cause increasing damage or death.

- Time to provide **definitive medical care** – this is final care needed for long term recovery of the patient. Delay will cause increasing damage or death.

An estimate for time to accomplish various subordinate tasks is obtained both directly from responders during interviews and from process calculations. This is compared with the symptom progression at each task to calculate the numbers of casualties required to be handled at successive steps. Figure 8 adds example numbers of casualties to the generic process diagram, converting it into a casualty flow model.

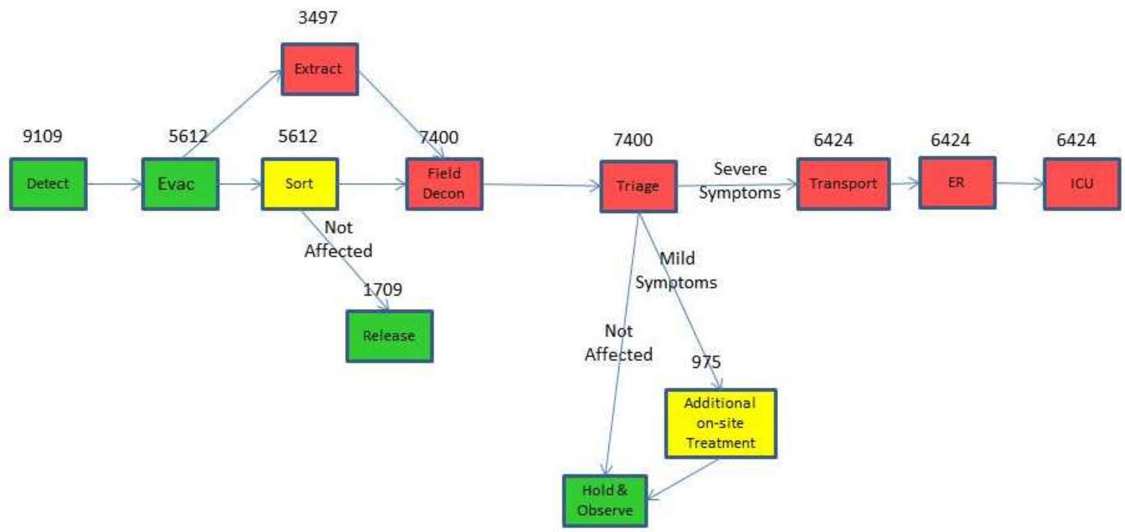

Figure 8, Casualty Flow Model

Gap analysis

Shortfalls in response capability were developed comparing the casualty flow to responder capacity at each step. This assessment was then displayed as a simple color code applied to the blocks, where green is acceptable capacity, yellow is a serious shortfall, and red is a critical gap. This is also illustrated as an example in figure 23.

The initial Response Risk Assessment identifies the risk areas (yellow and red) from the as-is state. In other words, with existing capabilities and capacities what/where are the expected chokepoints and shortfalls?.

Mitigation analysis

Gap analysis sets the stage for examining possible mitigation methods to reduce shortfalls in the various stages. The final analysis step is an iterative process, where various potential mitigation techniques are applied to the problem's risk areas. Many recommendations and Best Practices are discussed in Section Three.

Each stage in the process diagram provides the casualty input to the next. Delays in the early phases affect the number of casualties in subsequent phases. One possible mitigation methodology is to start at the last phase (Medical Treatment) and work backward, examining possible mitigation methods to adjust casualty numbers in previous phases/tasks. In other words, determine what would be the maximum number of casualties the ICU could handle after applying any possible mitigation methods – then examine in succession each preceding stage to see if possible reductions in casualties reaching the ICU could be achieved.

While focusing mitigation measures on early phases is extremely important to minimize casualty numbers in later phases, in a mass casualty incident all phases will be overstressed. Therefore capacity improvements should be considered for all.

Section Three: Observations, Critical Actions, and Recommendations

This section summarizes lessons learned from examining the results of analyzing nine scenarios with nine different chemical agents employed in five different cities in five separate workshops or TTX. It is split into a section of general observations, a set of overarching immediate actions, and a section identifying by phase and [action] agency the most critical actions with resulting recommendations and best practices.

Observations

Decisions, actions, and delays in acting within the initial 30 minutes will set the stage for all following actions. Any delay will result in increased casualty load on subsequent phases of the response.

Decision makers must make decisions with incomplete information. This requires understanding those few critical decisions with significant impact, the consequences of different courses of action, and the critical information necessary to making a correct decision.

Reducing the numbers exposed to a toxic chemical is perhaps the most important consideration in saving lives and preventing injury. This necessitates speed in executing shelter-in-place or evacuation – both in decision and in implementation

A second critical part of reducing exposure is suppressing toxic chemical movement into populated areas. This is done through fire department actions to suppress the release and knock down the agent in the air, as well as by venue operators shutting down internal airflow (HVAC systems).

The third critical part of reducing exposure applies to contamination on the individual. Removing the chemical agent before it can be absorbed through the skin will dramatically reduce injury. This is accomplished through clothing removal and hasty flushing with water (gross decontamination).

It must be recognized and understood that people are going to die! All actions must be predicated on the fact that the good of the many outweighs the good of the individual. (Triage and treatment)

No part of the medical response system will be adequate. There must be a plan to augment normal ambulance transportation assets. There must be a plan to rapidly expand hospital capacities.

It is far better to overwhelm the hospital facilities and staff than the on-scene EMS personnel.

Overarching Immediate Actions

Initial actions can dramatically reduce exposure and casualties if immediately implemented prior to first response arrival. The basic principles, similar to the fire principle of "stop, drop, and roll," are quite simple and should be immediately executed by everyone without external directions. These should be taught as a part of community safety programs.

- If there's an outside chemical cloud – go or stay inside (Get in)
- If there's an indoor chemical release – go outside (Get out)
- If contaminated with chemical – get it off (Get wet)

These actions can be expanded into the following rules of thumb (figure 9) to be directed by anyone in authority in the event of a toxic chemical release.

- When a toxic plume is observed or suspected outside, immediately shelter in place (enter nearest building and close doors and windows)
- When in an enclosed venue or building and a chemical release is suspected inside, immediately evacuate
- When in an enclosed venue or building, whether sheltering in place or evacuating, immediately stop the airflow (stop HVAC) – exception being an enclosed space dependent on HVAC for breathable air such as a subway tunnel
- If contamination on the skin is suspected, immediately disrobe as a first aid measure followed by a hasty flush with water after disrobing (gross decontamination)

Figure 9, Immediate Action Rules of Thumb

Identified Critical Actions

Critical actions are those actions discovered in the various scenarios studied in the five cities most important to reducing the number and severity of casualties. They serve as a guide for examining community agency capabilities and establishing necessary policies and procedures.

Alert and Assessment

Recognize release

Identify airborne hazard or possible toxic contaminant

Dispatch HAZMAT

Conduct initial information fusion between available sources to develop situational awareness

Notify nearest vulnerable populations/schools

Warn hospitals – possible mass chemical incident

Immediate Actions

If outside release:

Identify downwind hazard area (Emergency Response Guide (ERG))

Provide shelter in place warning

Venues or buildings contain their population within (shelter in place)

Venues or buildings stop air movement (HVAC, doors)

If inside release:

Evacuate venue/building

Stop air movement (HVAC)

Emergency Response

Suppress source

Establish Unified Command

Develop Hot and Warm zones

Conduct rescue/extraction

Direct disrobing

Conduct gross decontamination

Provide for eyewash

Deploy medical countermeasures (including chempacks)

Conduct technical decontamination

Conduct triage and continuous monitoring

Provide treatment

Conduct survey to determine expanding safe areas as plume moves on

Medical Treatment

Early State of Emergency declaration to allow adjusting standards of care

Regional hospital coordination

Rapid transport to medical treatment facilities

Decontamination at hospitals

Hospital capacity expansion

Receipt of additional medical equipment, supplies, and medications

Identified Critical Decisions

Critical decisions are those time-critical, difficult decisions that so significantly affect incident outcome that they should be thought through in advance. In the heat of the moment, decision makers will fall back on their previous experience comparing what they see with previous experiences. As massive chemical incidents are extremely rare, they generally will have nothing with which to compare. This requires examining those time-critical decisions in advance, as well as practicing them in exercises and TTX in order to train decision makers and give them the necessary background.

This section identifies typical critical decisions based on the type of chemical threat. Details for preplanning are contained in Appendix K.

Alert and Assessment

Recognize attack/release – 911/dispatch, venue/building staff

Immediate Actions

Provide warning and necessary actions – external release, indoor venue/building

Provide warning and necessary actions – internal release, indoor venue/building

Provide community Shelter in Place or Evacuation Warning

Emergency Response

Determine tactical and suppression approach

Determine PPE requirements for rescue

Strategy for provision of EMS care

Cause immediate disrobing

Execute immediate gross decontamination

If organophosphate is suspected, quickly mobilize atropine stocks

Medical Treatment

Mass casualty transportation augmentation

Recommendations

This section contains recommendations and Best Practices for reducing shortfalls identified through analysis, responder discussions, and workshops/TTXs for the five cities, nine scenarios, and nine toxic chemicals covered by the Chemical Defense Demonstration Project. Best practices are procedures observed in communities that may be applicable for other communities. Best practices are identified by a bold, underlined text. All other actions are recommendations.

Recommendations have been developed from all of the study scenarios. These have been converted into a general set that apply to any chemical incident. These recommendations are aligned with the response framework phases and responsible agencies. The recommendations, if appropriate, could be incorporated into plans, SOPs, and checklists.

Alert and Assessment

911/dispatch:

Establish a situational awareness system to display calls with summarized data to allow building a situational awareness picture.

911 operator checklists should:

- Include indicators that would imply a chemical release
- Automatically dispatch HAZMAT with suspected chemical release
- Alert EOC staff responsible for immediately issuing a warning

EOC (Emergency Operations Center):

Develop a plan to automatically alert large gathering areas such as conference center and sports venues when there is a potential toxic agent release in the vicinity. Include notifying facilities with sensitive populations that may be outside, such as schools.

If a chemical release alert comes from a knowledgeable source (chemical plant, railroad) the EOC/dispatch supervisor should automatically produce a shelter in place order prior to responders arriving on scene. The EOC should also develop an initial warning area from the Emergency Response Guide and prevailing weather conditions.

It is also important to consider continuity of operations planning (COOP) for the EOC in the event of a large chemical release. It is important for communities to look at the COOP concerns identified in their planning scenarios.

Railroad dispatch:

Establish a "hotline" to the 911/dispatch center to allow immediate alerting of the city when there is a rail accident

Immediate Actions

Involve the private sector in community emergency response exercises.

Emergency Operations provide situational awareness information to large private sector venues and organizations as early as possible.

Railroad dispatch:

Automatically dispatch the railroad HAZMAT and immediately notify the railroad's HAZMAT contractor if a train transporting toxic chemicals is involved in an accident.

Venue or building staff – internal release:

Persons exposed to a l potentially toxic liquid chemical should be separated from unexposed persons and moved out of the area of contamination. As contaminated personnel may be directed to disrobe, have separate pre-identified collection points for men and women. Contain those exposed until further actions directed by Incident Commander. Unexposed persons should be directed to leave the facility, but remain in outdoor collection areas until emergency response assessment.

Upon direction of Incident Commander, have messages and procedures to cause immediate patron disrobing. Messages should include direction to disrobe down to undergarments immediately upon reaching the collection areas. In order to facilitate compliance, there needs to be a strongly worded message to convince spectators of the impact from not disrobing. It also should include that spectators are allowed to hand carry personal critical items through decontamination.

Best Practice: Immediately evacuate persons in distress. If the numbers are increasing, staff sound fire alarm on exiting to initiate evacuation of entire venue/ building.

Best Practice: Instruct balcony and mezzanine evacuees to hold handrails on stairs. This will assist evacuation when people have vision difficulties.

Best Practice: The venue and building staff contains many medically trained personnel (approximately 50% of the venue staff EMT trained).

Upon any indication of an airborne contaminate, regardless of source, immediately turn off the venue's HVAC system.

Develop an assembly area plan that takes into consideration, venue evacuation needs, emergency responders' needs, and potential other sites at risk.

Develop messaging to convince patrons to remain on site after evacuation, and train staff to handle panic and excessive concern.

Venue or building staff -- external release:

Automatically close outer doors when an external chemical agent is suspected.

Shelter in place plan should include closing all doors and windows, immediately shutting down the venue's HVAC system, and closing interior doors to limit the spread of contamination inside. The SOP needs to address the need to close the doors quickly to limit risk to patrons inside even though this will cause greater risk to those who have not yet entered.

Develop messaging to convince patrons to remain inside, and train staff to handle panic and excessive concern.

Have an evacuation plan that can evacuate the venue/ building very quickly when outside concentrations drop to safe levels.

Emergency Response

Train responders and supervisors on quick decisions and actions upon arrival and in the first 10-20 minutes for a mass casualty chemical release.

Emergency Operations Center:

Coordinate existing plans for mass casualties and HAZMAT to ensure that a mass chemical incident is adequately covered.

Best Practice: Establish a "bridge call" process to immediately link Incident Command, technical experts, hospitals, and response assets in the event of a large chemical incident.

Initiate a bridge call immediately upon the incident commander recognizing a chemical incident, as hospitals need warning time to handle walk-ins.

Best Practice: Engage the regional Poison Center immediately (in the "bridge call" system if one is in place).

Initiate the process to mobilize the state's National Guard Civil Support Team, as it will take time to authorize, mobilize, and arrive on scene.

Best Practice: Initiate a process to develop and execute preformatted messages in a variety of languages covering the major languages in use in the city.

The SIP warning should be disseminated without delay using a variety of means- reverse 911 on landlines, text messages to cell phones in the area, PA broadcast, police car PA systems, etc. If a unique message is required, the message should be released initially without waiting for translation into multiple languages – these should follow as quickly as possible.

Implement a cellphone warning system as soon as possible to enable reaching people outside of buildings.

The SIP message should be preformatted to simply direct people to take shelter in the closest building. The initial message should be followed by more instructions on actions to take, including shutting off AC systems, closing all doors and windows to the outside, moving to a higher floor, flush eyes with water if burning, stay off of cellphones, report injuries to 911. Also, update SIP boundaries if needed. An additional message should instruct sheltering individuals to report locations and casualties to 911 using a short format with just that information. Communities may also want to monitor social media for messages of trapped individuals.

The regional medical management organization should have a plan to rapidly acquire respiratory distress equipment and medical supplies such as additional oxygen, oxygen manifolds, CPAP machines, ventilators, albuterol.

If a release of a nerve agent class (CWA or pesticide) of toxic chemical is suspected through symptoms or other means, immediately mobilize all community atropine stocks including chempacks and arrange for rapid movement to the site.

911/dispatch

In a chemical plume incident, develop a method to take quick calls from shelters and build a map displaying locations and numbers of casualties.

Chemical facility:

Best Practice: Chemical industries within the region develop an industry-wide consortium to provide mutual aid and coordination between facilities and their emergency teams. Also, agree to provide chemical incident response assets to any facility emergency.

Incident Command:

Verify a chemical release based on observations and reports – do not wait for chemical identification.

As soon as an expanding cloud is recognized, direct shelter in place based on the Emergency Response Guide, and later adjust based on Aloha or other plume models and additional information.

If there are indications of chemical contamination on people (a liquid or powder) immediately direct disrobing.

For contaminated people, have an established procedure for the employment of two-stage decontamination – initially a hasty washdown (gross decontamination) as quickly as possible, followed by a short Ladder Pipe Decontamination System (LDS) process (technical decontamination) to increase throughput (spectators should spend 30 seconds under the LDS sprays). Since speed of removal of the chemical is critical, an initial flushing followed by a short LDS, will significantly reduce casualties. We have labeled this ad-hoc flushing as gross decontamination. The standard LDS is referred to as technical decontamination. Based on recent studies, dramatically reducing the time in the LDS line not only speeds throughput, it also reduces adsorption of the chemical through the skin.

Disrobing: a self-help first aid measure to minimize residual agent on the individual and to allow decontamination

Gross decontamination: an ad hoc flushing with water to quickly remove as much agent as possible

Technical decontamination: decontamination using a formal process such as a ladder-pipe system to produce complete decontamination and allow medical care

Immediately establish Unified Command. A mass casualty chemical incident is by its nature multi-agency and the command structure needs to be in place quickly.

HAZMAT:

Best Practice: HAZMAT to begin donning level A equipment while in route to the incident to allow rapid entry into toxic chemical areas. This may require changes in communities' policies and procedures, however some communities are currently doing this.

Best Practice: A process to allow reduced PPE requirements for rescue operations so that firefighter teams in turnout with SCBA can conduct rescue missions to extract visually impaired and incapacitated.

Stock reasonably inexpensive, fast extraction equipment such as Sked stretchers to minimize rescuer exposure.

For a chemical plume, HAZMAT should develop a "skirmish line" procedure, where HAZMAT personnel in PPE move down streets perpendicular to the wind using handheld detectors to track the edge of the plume and allow quick access by EMS teams to casualties and shelters.

Fire Department:

Best Practice: the fire department immediately and automatically initiate suppression of the source of a chemical release.

The Battalion Chief should determine if water is an appropriate material for suppression prior to initiating water sprays. The chemical facility with a release or HAZMAT can assist with this determination. As an example, for oleum a downwind water mist may significantly knock down the chemical plume by dissolving the sulfuric acid in the air which will immediately rain out, however applying water to the oleum pool will significantly increase the toxic plume generation.

In the absence of chemical identification, begin with water suppression and stop if it makes the problem worse.

Fireboats from ship channel or river should be considered for suppression at waterside chemical facilities.

Develop a detailed personnel decontamination plan focused on mass casualties. In general, an elaborate decontamination system is appropriate for technical decontamination, but takes too long to set up and has too slow a throughput for initial gross decontamination. An initial flushing with water will remove the bulk of the agent, slowing absorption into the body until technical decontamination is available.

If contamination is expected, have people disrobe immediately after evacuation from the hot zone. As time is the most important characteristic of decontamination, plan for an initial flushing with water using hand-held water lines or ladder pipe flushing (gross decontamination). This can be followed by a formal decontamination line (technical decontamination) if necessary.

Develop plans for alternative mass decontamination processes, considering using the sprinklers on playing fields during warmer weather, building fire sprinklers, etc.

Plan for expedient eye flushing methods such as handing out water bottles for individuals to flush their own eyes as chemical contaminants will affect the eye.

Develop a detailed mass casualty non-ambulatory personnel decontamination plan. Clothing will have to be removed before decontamination.

Coordinate current plans that exist for mass casualties and HAZMAT to ensure that a mass chemical incident is adequately covered.

Emergency Medical Services:

Best Practice: Operate a centrally managed EMS system with experienced medical doctors in charge in order to control all EMS response elements and place medical doctors on scene in a major emergency.

Best Practice: Initiate a “HAZMED” team, which consists of EMS personnel trained and equipped to work in a contaminated environment.

For a chemical plume, EMS teams should be organized to follow the HAZMAT survey teams at a safe distance, and enter each shelter as it is reached.

Develop an SOP for EMS personnel entering a downtown shelter in a mass casualty situation which may contain large numbers of casualties and worried well. As casualties may be on multiple floors, EMS should be augmented with law enforcement to aid in building search and control.

EMS teams entering shelters will need oxygen and albuterol to treat respiratory distress and bronchospasm. As quantities carried by ambulances and EMS teams will be insufficient, teams should be trained to employ physical methods to assist breathing, such as sitting position, manual artificial respiration, methods to drain liquid from lungs, etc. As respiratory distress may occur at any time, it is necessary to organize EMS personnel or volunteers for continuous monitoring until transport.

For multiple dispersed shelters, ambulance teams directly attached to medical teams entering shelters to allow rapid transport. Otherwise the EMS team must remain longer to monitor the casualties, and casualties in other shelters will not receive possible life-saving care.

Additional medical supplies should be brought to shelters on ambulance returns from hospitals. A system to rapidly acquire and provide oxygen and albuterol should be developed.

Establish a process to provide incident-specific medical care information to EMT/Paramedic personnel sheltering within a venue or building.

Augment EMT/Paramedic personnel inside a venue or building by having members of the staff also EMT trained.

For contaminated casualties, triage should begin immediately after gross decontamination, as symptoms may begin to manifest prior to completion of technical decontamination.

Normal triage procedures are based on trauma injuries and do not fit well for chemical incidents. For chemical incidents triage procedures should be developed based on simple, observable chemical injury criteria such as not being able to see, displaying respiratory distress, showing shock or trauma, pupil dilation, or seizures. Triage for nerve class agents is based on determining the need for atropine injections. Pain management should wait on hospital care.

All triage plans for chemical victims should include provisions for continuous monitoring, as symptoms may present over time. For nerve agent class chemicals, monitoring to determine the need for additional atropine treatment will be required periodically until transport to hospitals

Plans for nerve agent treatment must include methods to track how many atropine and 2-pam injections individual casualties have received.

In addition to the combined atropine injectors, EMS personnel must have the ability to inject straight atropine, as a patient should only receive 3 combined doses due to the 2-Pam content.

For any mass chemical incident, plans should include large numbers of medical personnel being mobilized and brought to the site to monitor and handle patients.

After marshalling all available ambulances, augment transportation with buses. Ambulances should be used for patients in respiratory distress, as they are equipped with life support systems. Buses should be used to transport severe casualties that have not yet gone into respiratory distress. Buses should be staffed with EMTs and limited oxygen capability in order to monitor and stabilize those going into respiratory distress during transport.

Best Practice: plan to use buses at the scene to provide a heated or cooled shelter for casualties awaiting transport.

Transportation capacity will exceed nearby hospital receiving capacity. The normal procedure is to meter patients to nearest hospitals and transport overflow to hospitals further and further out. Delaying transport to match hospital capability will overwhelm EMS personnel on-site, while increasing the transportation distance will require many more transport assets and more delay in treatment/injury progression.

Medical Treatment

Hospitals:

Develop a community plan to handle hospital overflow which balances hospital capabilities with EMS on site treatment. Hospitals should have internal plans to significantly increase their ability to take casualties in a mass casualty incident, which include where the patients will be taken and what medical assets will be provided at those locations.

Best Practice: Employ a central hospital and medical coordination organization to manage hospital loading and bed space across the region.

A regional medical management organization should coordinate clearing hospital space by moving current less-critical patients by private ambulance services to out-of-area hospitals.

In a mass casualty incident, those casualties suffering from respiratory distress do not require the full ICU capability but need close supervision and ventilator. Hospitals should have a plan to turn ward space into ad hoc ICU space with additional staff overseen by ICU staff. Moderate respiratory casualties need monitoring and oxygen. The plan should include both increasing the number of patients that can occupy individual ward rooms and converting additional space to wards by making oxygen available.

Best Practice: Hospitals have preplanned off-site spaces that can be converted to augment hospital capacity.

Plan for and train health facilities such as urgent care facilities, private clinics, etc. to be part of a large scale response. Include private health facilities in notification and exercises.

For nerve agent casualties, hospital plans should include acquisition of significant atropine stocks.

State Governor's Office:

If necessary under state law, declare a disaster in order to allow reduced medical standards of care.

State Bureau of Homeland Security:

Develop requirements and a process to request early activation of the National Disaster Medical System for medical teams and USAF medical evacuation aircraft. This needs to go from the state to the regional federal coordinator.

State Emergency Medical Services:

Develop detailed medical equipment and supply augmentation plan, with sources and mutual aid agreements to transfer material quickly to an incident to establish augmented treatment facilities.

Appendix A, References

Books

Zajtchuk, R., Ed. (1997), Medical Aspects of Chemical and Biological Warfare, Textbook of Military Medicine, Part I: Warfare, Weaponry, and the Casualty (Office of the Surgeon General, Washington, District of Columbia).

Articles

Kirk, M., Deaton, M., (2007) "Bringing Order Out of Chaos: Effective Strategies for Medical Response to Mass Chemical Exposure" Emergency Medicine Clinics , Volume 25 , Issue 2 , 527 – 548

Mitchell, J.T., Edmonds, A.S., Cutter, S.L., Schmidtlein, M., McCarn, R., Duhe, S.,(2005) ,"Evacuation Behavior in Response to the Graniteville, South Carolina, Chlorine Spill", *Research Lab, Department of Geography, and Hazards Research Lab, Department of Journalism and Mass Communications*, University of South Carolina, Quick response Research Report 178

"Tool Kit for Managing the Emergency Consequences of Terrorist Incidents", Interim Planning Guide for State and Local Governments. Federal Emergency Management Agency (2002).

"Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries". FM 8-285/NAVMED P-5041/AFJMAN 44-149/FMFM 11-11. Headquarters Department of the Army, The Navy, and The Air Force and Commandant Marine Corps. 22 December 1995. http://www.public.navy.mil/surfor/Documents/P_5041.pdf

Publications

"Shelter-in-Place Protective Action Guidebook", Chemical Stockpile Emergency Preparedness Program, Chemical and Nuclear Preparedness and Prevention Division Department of Homeland Security and Department of the Army, www.cseppportal.net

LandscanTM Global population database. 〈http://www.ornl.gov/sci/landscan/〉 , Oak Ridge National Laboratory, Oak Ridge, Dobson, Jerome E., et al. "LandScan: a global population database for estimating populations at risk." Photogrammetric engineering and remote sensing 66.7 (2000): 849-857.

"2012 Emergency Response Guidebook" U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration

"Risk Assessment of Using Firefighter Protective Ensemble with Self-Contained Breathing Apparatus for Rescue Operations During a Terrorist Chemical Agent Incident" U.S. Army Soldier and Biological Chemical Command, August 2003, http://www.ecbc.army.mil/downloads/cwirp/ECBC_ffpe_scba_rescue_ops.pdf

Reports

(2014), US Department of Homeland Security, Department of Health & Human Services, USA, *"Patient Decontamination in a Mass Chemical Exposure Incident: National Planning Guidance for Communities*," Cibulsky, Susan M.; Kirk, Mark A; Ignacio, Joselito S.; Leary, Adam D.; Schwartz, Michael D

(2000) Los Alamos National Laboratory, *"Determination of the Spatial and Temporal Distribution of Population for Air Toxics Exposure Assessments,"* McPherson, T.; Ivey, A.; Brown, M., Streit, G. website: https://ams.confex.com/ams/pdfpapers/80347.pdf

Web Sites

Wind Rose data, http://www.wcc.nrcs.usda.gov/ftpref/downloads/climate/windrose

Cameo suite (ALOHA, MARPLOT, CAMEO), http://www.epa.gov/cameo/what-cameo-software-suite

Chemical Toxicity data, http://toxnet.nlm.nih.gov, http://www.atsdr.cdc.gov

Landscan population database (requires subscription), http://web.ornl.gov/sci/landscan

How to create a cross functional chart in Microsoft Visio, https://support.office.com/en-us/article/Create-a-cross-functional-flowchart-4a403033-9787-454f-b87e-b88452c47a21

Center for Disease Control Chemical Emergencies Overview, http://emergency.cdc.gov/chemical/overview.asp

Appendix B, Response Risk Assessment Scenario Selection

Develop a set of plausible scenarios

Identify possible sources of release

Information on toxic chemicals at industrial facilities in the community can be obtained from the Local Emergency Planning Committees (LEPC) required by the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. This act requires the community to develop an emergency response plan, review the plan at least annually, and provide information about chemicals in the community to citizens. To find your LEPC, contact your State Emergency Response Commission (http://www.epa.gov/epcra/local-emergency-planning-committees).

Transportation routes through the community where toxic chemicals may be carried are truck routes, nearby major highways, rail lines (particularly through lines and those feeding industrial facilities), and barge/ship channels.

Identify possible threat chemicals

The EPCRA law requires facilities using and storing hazardous chemicals to provide EPCRA Tier II Emergency and Hazardous Chemical Inventory Forms which provide details on chemicals and quantities to state and local governments. State regulations can be found on the following website: http://www.epa.gov/epcra/state-tier-ii-reporting-requirements-and-procedures.

Small quantities of toxic chemicals stored at industrial facilities do not normally pose a mass casualty threat. If there are no large storage facilities in the community, a source for scenario development should come from transportation through the community.

Local HAZMAT and the state Department of Transportation may be able to provide information on hazardous chemicals routinely trucked or transported by rail through your community. The railroad company can also provide the routine chemical shipments.

In the absence of actual transportation information, two generic examples can be used. For a truck accident, a tanker truck carrying anhydrous ammonia (a common industrial and agricultural chemical) would be involved in an accident. The tank contains 8500 gallons – 20 tons of liquid ammonia, and has a four inch diameter hole six inches above the tank bottom. This will cause a release duration of about three minutes. For a rail accident, the actual Graniteville railroad accident would serve as a model. A 90 ton railcar carrying 80 tons of liquid chlorine would be involved in a collision where the tank car is punctured with a 4 inch by 34 inch split, three feet above the bottom of the tank.

A selection of possible scenario chemicals is contained in Appendix C. These are common toxic substances and can be used for assessment in the absence of actual chemicals possible in the community. It's important to select at least one respiratory and one dermal threat to adequately challenge the response system.

A source of chemical information for analysis is CDC's Agency for Toxic Substances & Disease Registry (ATDSR) toxic substance portal. **http://www.atsdr.cdc.gov/substances/index.asp**

Identify population targets

This step identifies where large numbers of people may be exposed to the chemical plume. Downtown business districts and residential areas are sources of dispersed population, however concentrations should also be identified such as outdoor gathering places, outdoor concerts, and street fairs.

Concentrated population locations should also be identified such as arenas, convention centers, and sports facilities.

Select release point, chemical, and quantity

This is the creative step that brings together possible sources, chemicals, and determines what targets are at risk. The simplest method is to select a potential source (chemical facility or transport) along with the appropriate chemical, select the hazard distance from the Emergency Response Guide, and orient the protect box in the downwind direction selected from the wind rose. If it covers a population concentration, it is a plausible scenario for examining the response system.

If there is a specific target of interest (sports arena, for example), a preclusion-oriented process can be used to determine possible release points that will cause the plume to reach the target. To do this, the protect box is based on the target and the wind is direction is modified by 180 degrees from the wind rose – looking upwind. Toxic chemicals released at any point within the protect box will reach the target, and thus will form another useful scenario.

Choose test scenarios

Scenarios are compared against all of the major tasks performed by the emergency response and medical. One or more are selected that provide either a major or possibly overwhelming challenge to each of the major tasks. This is a judgement call that compares the current capability/capacity with the scenario. A matrix is useful to illustrate where each selected scenario provides these challenges (figure 10).

Detection	Identification	Warning	Evacuation	SIP	Source Reduction	Gross Decon	Technical Decon	Treat	Triage	Transport	ER	Bed Space	Med Equip/meds
Observe release	ID Chemical	Warn population	Execute & control	Execute	Suppress release	Initiation & Throughput	Resources & Throughput	EMS	Delayed Symptoms	Resources & Routes	Capacity and Throughput	Capacity	Resources

Figure 10, Scenario comparison matrix

Appendix C, Sample Chemicals for Scenario Selection

Scenarios can be developed using toxic chemicals that are commonly found in the United States, either at industrial facilities or being transported by road, rail, or barge. Chemical warfare agents must be considered common, as a terrorist organization could develop or purchase them and use them anywhere. Figure 11 lists common chemicals that could be used in scenarios.

	Chemical	Source	10 minute AEGL values	ERG day/night distance
Respiratory				
	Anhydrous Ammonia	TIC - vapor	AEGL3 2700 ppm AEGL2 220 ppm	0.5/1.3 miles
	Chlorine	TIC - vapor	AEGL3 50 ppm AEGL2 2.8 ppm	1.9/4.9 miles
	Hydrogen Cyanide	TIC - vapor	AEGL3 27 ppm AEGL2 17 ppm	0.9/2.4 miles
	Phosgene	TIC - vapor	AEGL3 8.9 ppm AEGL2 0.12 ppm	1.9/6.7 miles
	Sarin	CWA - vapor	AEGL3 0.011 ppm AEGL2 0.003 ppm	1.3/3.0 miles
Dermal				
	Sulfur Mustard	CWA – liquid or vapor	AEGL3 0.59 ppm AEGL2 0.09 ppm	0.2/0.3 miles
	Lewisite	CWA – liquid or vapor	AEGL3 0.46 ppm AEGL2 0.15 ppm	0.3/0.6 miles
	Methyl Parathion	TIC – liquid or vapor	AEGL3 0.54 ppm AEGL2 0.18 ppm	2.4/5.9 miles
	VX	CWA – liquid or vapor	AEGL3 0.0027 ppm AEGL2 0.00065 ppm	0.2/0.2 miles

Figure 11, Possible toxic chemicals

Appendix D, Example of Response Risk Assessment Scenario Selection

This example considers phases 1-3 in the RRA flowchart (figure 12).

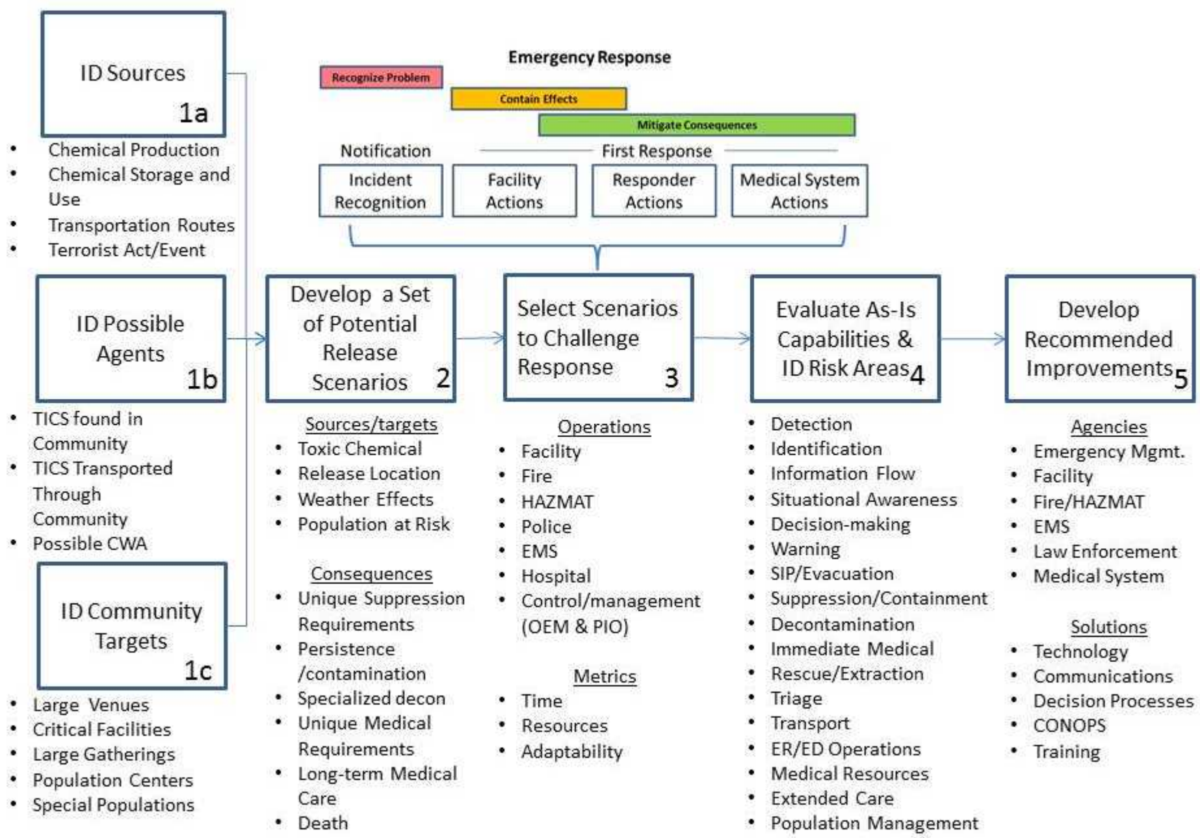

Figure 12, RRA flowchart

1a. ID Sources

Sources include: truck traffic on interstate highway 52, highways 32 and 76, and city streets; barges in the Hybernia basin; petrochemical plants and chemical storage locations along the riverside in Hybernia; and possible terrorist actions.

1b. ID Possible Agents

Hybernia contains a large number of chemical plants and storage facilities. The top toxic chemicals from their Risk Management Plans are:

Based on number of facilities employing the chemical:

41 facilities	Chlorine
20 facilities	Ammonia (anhydrous)
8 facilities	Sulfur dioxide (anhydrous)
7 facilities	Ammonia (20% concentration or greater)
6 facilities	Propane

5 facilities	Cyclohexylamine [Cyclohexanamine]
4 facilities	Ethylene [Ethene]

Based on chemical quantity employed in processes:

19,305,300 pounds	Chlorine
6,142,032 pounds	Toluene 2,4-diisocyanate [Benzene, 2,4-diisocyanato-1-methyl-]
5,582,680 pounds	Vinyl acetate monomer [Acetic acid ethenyl ester]
5,310,000 pounds	Carbon disulfide

The Hybernia emergency management community is concerned with the large quantities of liquid chlorine shipped by rail, as well as chemicals with unique management problems, such as anhydrous hydrogen chloride and silicon tetrafluoride.

Hybernia is surrounded by agricultural areas. Discussion with agricultural experts revealed that there are stockpiles of methyl parathion readily available in the area as a potential terrorist chemical. Other agricultural chemicals are more benign and not considered.

Chemical warfare agents could possibly be employed by terrorists, however with the large numbers of existing toxic chemicals in the area, they were not considered. Chemicals providing the threat in proposed scenarios are chemicals considered dangerous in the Department of Homeland Security documents “Appendix to Chemical Facility Anti-Terrorism Standards, 6 CFR Part 27, 20 Nov 2007” and “(U) 2012 Chemical Terrorism Risk Assessment CSAC 12-006 (S),” and fall within the community information discussed above.

1c. ID Community Targets

Hybernia is a large community, containing many “targets” (areas where a chemical release could cause a large number of casualties). The downtown area contains approximately 250,000 people on any given day, and over 100,000 vehicles. It is immediately adjacent to major rail, river, and highway corridors where chemicals are transported daily, and is at risk from releases in nearby chemical facilities.

In addition, the downtown area contains several large public venues including the Major League Baseball facility, a National Football League outdoor stadium, and the Hybernia Convention Center.

Other community target areas include the urban population centers surrounding the downtown area and extending along the Hybernia riverside chemical complexes. These areas contain over 400 schools and large numbers of assisted living facilities, both with vulnerable populations.

Develop plausible scenarios

Potential scenarios include transportation scenarios where an accident results in a toxic chemical release near potential targets, an accidental release from a chemical plant, an accidental release from a barge in the barge basin, an intentional (terrorist) release from a chemical plant or storage facility, an indoor intentional (terrorist) release of a chemical warfare agent in one of the large venues, an outdoor spray (terrorist) of a chemical warfare agent over a stadium or other outdoor venue, and an outdoor spray (terrorist) of a toxic pesticide over a stadium or other outdoor venue.

Select Test Scenarios

There are two dominant factors affecting the selection. Hybernia community officials expressed a concern over the large quantities of toxic chemicals transported daily by rail through the city and requested a railroad scenario. This overarching requirement was then overlaid on the list of potential scenarios, with released chemicals and locations selected to provide possible challenges to the response system. Additional scenarios were then added to obtain a more complete assessment.

Figure 13 illustrates the pre-analysis assessment of the impact of the different scenarios on the response system. Many other possible scenarios were discarded as not providing sufficient challenge to the system.

The columns reflect the most serious response system components (not including communications, decisions, or situational awareness components). The rows list the selected scenarios along with the toxic chemicals to be considered. An inference was then made to evaluate the comparative level of challenge a particular scenario/chemical would provide to the response system component. Low implies no significant challenge, medium is a major challenge, and high means a possible overwhelming challenge.

		Detection	Identification	Warning	Evacuation	SIP	Source Reduction	Gross Decon	Technical Decon	Treat	Triage	Transport	ER	Bed Space	Med Equip/meds
		Observe release	ID Chemical	Warn population	Execute & control	Execute	Suppress release	Initiation & Throughput	Resources & Throughput	EMS	Delayed Symptoms	Resources & Routes	Capacity and Throughput	Capacity	Resources
Downtown	*Railcar* Chlorine	Medium	Medium	High	Low	Medium	Medium	Low	NA	Medium	High	High	Medium	High	High
Port	*Storage Tank* Cyclohexylamine	Low	Medium	High	Low	High	High	Medium	NA	Medium	High	Medium	High	Medium	High
Stadium	*Crop Duster* Parathion	Low	High	Low	High	Low	NA	High	High	High	High	Medium	Medium	High	High

Figure 13, Scenario Challenge Considerations

Appendix E, Analysis: Determining Exposure

Airflow approximation is necessary to determine where a toxic cloud will go and how fast it will move. An external release is dominated by the prevailing wind that will push the cloud across the city which will affect both the distributed and concentrated populations. An internal venue or building will draw the toxic chemical in through open doors and the HVAC system. An internal release is dominated by the normal airflow within the facility due to the HVAC system.

External airflow prediction

The first step: develop wind direction and speed

1. One source is wind rose data from the Department of Agriculture National Weather and Climate Center http://www.wcc.nrcs.usda.gov/ftpref/downloads/climate/windrose/, which provides historic wind direction data for most large cities on a monthly basis. The wind rose shows on a graph both the directions as well as speeds from historic data.

   An example for Hartford Connecticut in Feb (figure 14) shows a wind from either the northwest or north would be most common, and a reasonable choice would be from the northeast at 8 meters/second

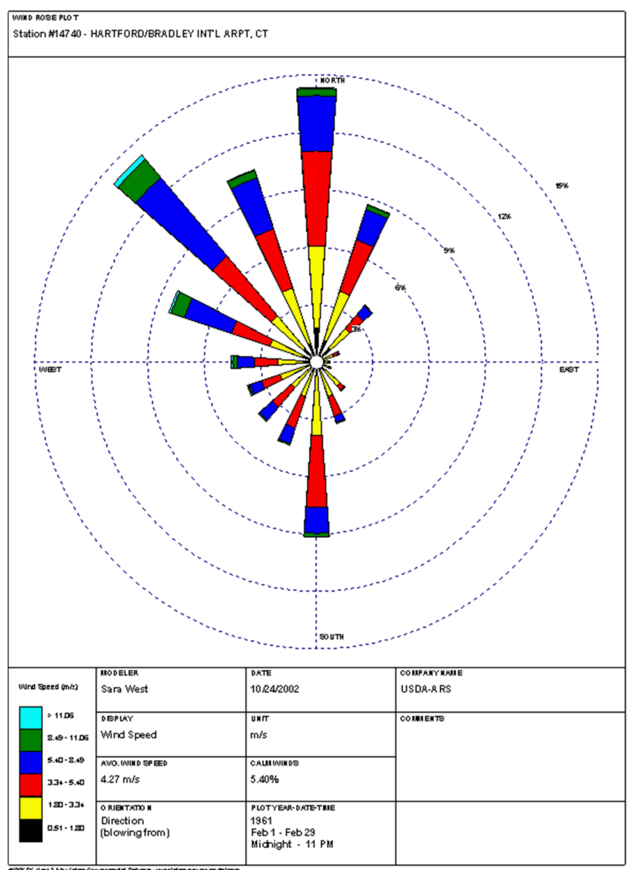
,

Figure 14, February Wind Rose for Hartford, Connecticut

Internal airflow approximation

It is difficult to determine the exact airflow inside an arena, as it is highly dependent on the details of the HVAC system. Airflow mapping may be available from the facility engineer office; however a simplification will serve to generate a reasonable exposure approximation. With normal air handling, assuming two to three air turnovers per hour, an airflow of sixteen to twenty feet per minute can be assumed. This is the speed with which a plume will travel from the release point out over the audience.

Population distribution

External populations are provided within the Aloha plume model when displayed on a MARPLOT map of the area. Clicking on the edge of the AEGL3 curve will bring up the population under the curve from census data (see example in figure 15). The same is true for the AEGL2 and AEGL1 curves. If we assume that roughly 10% are outside, this puts 925 at risk.

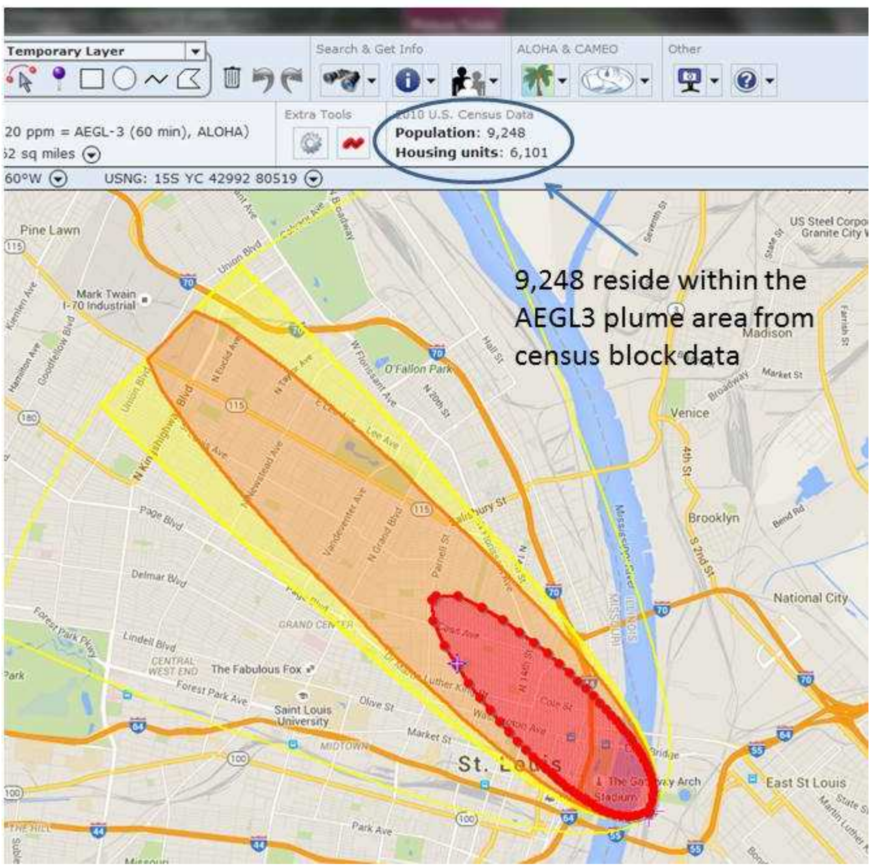

Figure 15, Population under the AEGL3 plume

The CAMEO software suite is available for free download from the EPA at:

http://www.epa.gov/cameo/what-cameo-software-suite

The software suite contains:

ALOHA – the plume model
MARPLOT – the map model which the plume will be displayed on
CAMEO Chemicals – chemical data sheets

Internal populations are obtained from seating maps of the facility, or capacity of convention center halls.

Exposure vs. time

An easy way to estimate exposure versus time for an external release is to also use the ALOHA/MARPLOT software. Click on a point approximately halfway downwind in the plume area and then select that as a threat location (shown in figure 16)

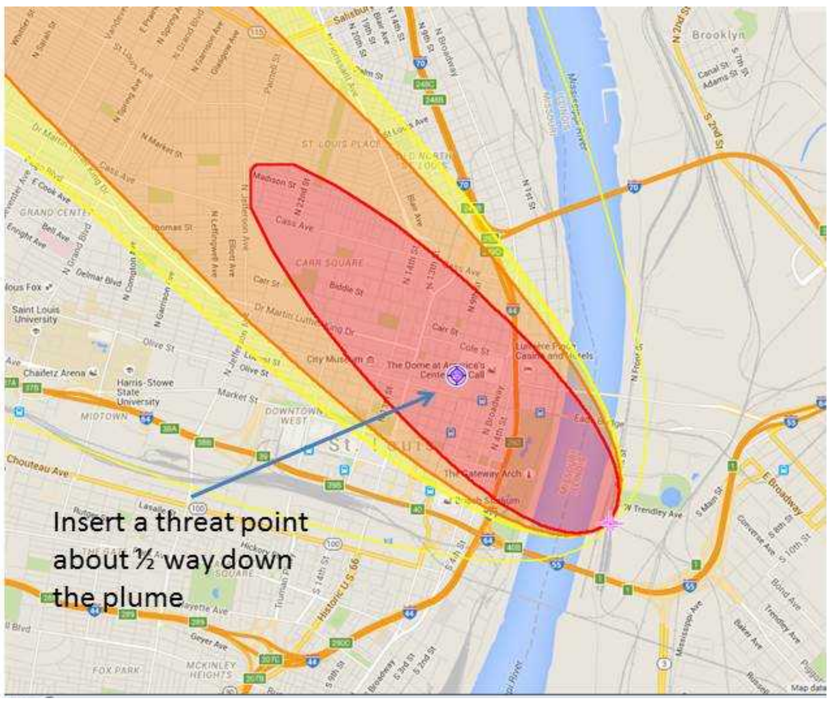

Figure 16, Selecting a threat point

Right clicking on the threat point will then provide the time versus concentration curve at that point. This is shown in figure 17.

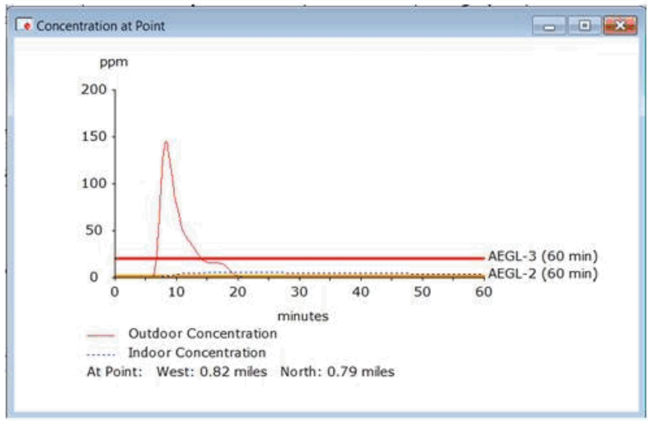

Figure 17, Plume arrival and concentration at threat point

In this example, the plume arrives at the halfway point in about 6 minutes and the concentration is well above the AEGL3 level. As we know from figure 26 that there were 925 people outside within the AEGL3 area, a simplifying assumption is that the number of AEGL3 exposures increases by 77 people per minute up to a total of 925.

Note: in the examples, the AEGL values for a 60 minute exposure were used. A more realistic exposure time would be 10 minutes, and those AEGL values should be used in the ALOHA software.

A similar procedure is used for an indoor venue. If we have a venue containing 12000 patrons and 250 feet long, we can use a 20 foot per minute airflow assumption to calculate a rough time based exposure number.

20 feet per minute means the plume would cross the length of the venue in 12.5 minutes. If we assume the patrons are uniformly distributed (a simplifying approximation), the number exposed would increase by 960 per minute up until the plume had reached the entire 12,000.

Appendix F, Analysis: Agency Actions and Interactions

Determining agency tasks and capabilities is best done through interviews with each agency. Figure 33 lists some typical tasks for the agencies; however the agencies should add tasks that they see as important for the test scenarios. Figure 18 is a form that could be used for the data collection.

Agency	Task	Execution Time	Capacity	Throughput (where applicable)	Source of information
Facility	Evacuate				
	Shelter in Place				
EOC	Situational Awareness				
	Alert & warning messaging				
Fire Department	Suppress				
	Rescue				
	Establish IC/UC				
	Gross decon				
	Technical decon				
HAZMAT	ID chemical				
	Establish Hot/Warm zones				
	Provide PPE guidance				
Law Enforcement	Traffic control				
	Perimeter control				
EMS	Triage				
	Treat				
	Transport				
Medical	Hospital Decon				
	ER/ED operations				
	Capacity expansion				
	Cross hospital coordination				

Figure 18, Agency task data collection form.

Mapping the decisions and tasks each agency performs is a major step in identifying the cumulative time for when each task takes place. A simple form like figure 19 can be used to produce a cross-functional task/decision map (a "swim lane analysis"). This can be done on a white board or using the swim lane function in Visio (see Appendix A for a Visio how-to reference).

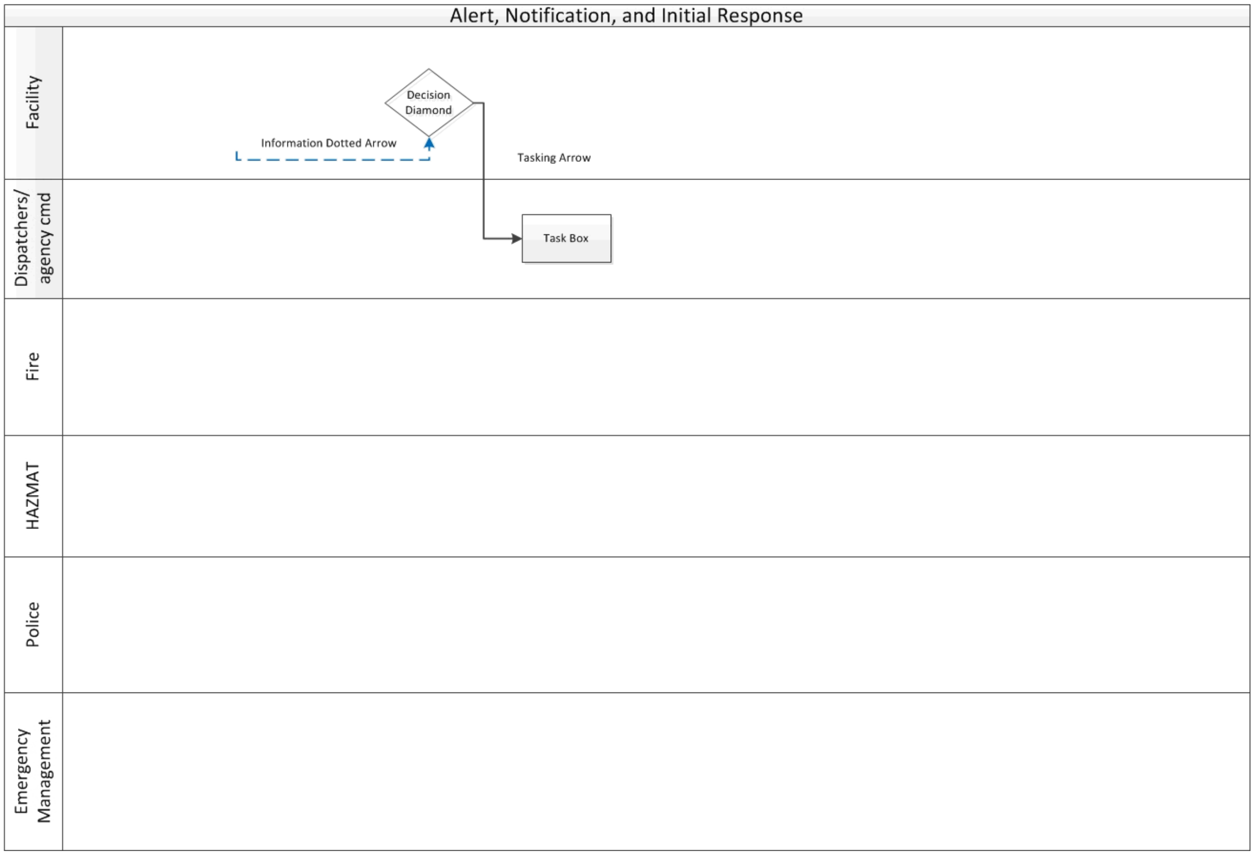

Figure 19, Cross-functional chart

Normally tasks are displayed in boxes, decisions in diamonds, direction or orders with a solid line, and information as a dotted line. An example is shown in figure 20 for the fictional city of Hybernia with a railroad release of chlorine. This particular example covers the alert and initial response phases, with initial release identification boxes colored in salmon, and IC/UC decisions highlighted in gold.

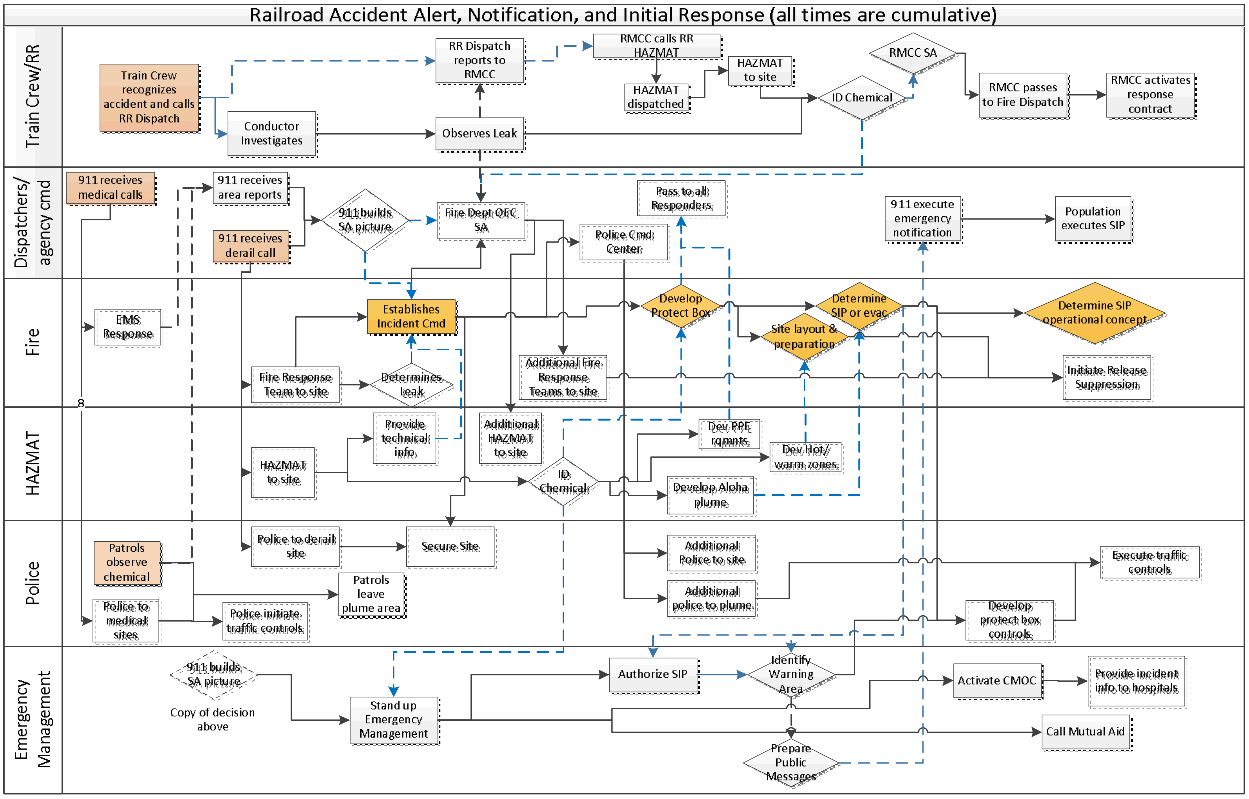

Figure 20 Example cross-functional map for a Hybernia scenario

After the cross-functional map is developed, the times for initiating each task can be placed on the chart. These times are cumulative, beginning at zero when the release occurs and adding the time required for each task along the paths. As an example from figure 35, in the dispatcher lane, 911 receives the derail call 3 minutes after the release, dispatches fire response which arrives 6 minutes later (total of 9 minutes), fire determines there is a leak 2 minutes after arrival (total of 11 minutes) and so forth. This allows determining when each task is initiated.

Appendix G, Analysis: Casualty Flow

A simple block diagram is a useful tool for examining casualty flow. Blocks are constructed for each major activity and linked in the order in which they will take place. A suggested method is to build the block diagram on a Microsoft Powerpoint slide using the shape tools built into Powerpoint.

Every scenario and community emergency response system may have a slightly different block diagram as each will probably require different activities. Figure 21 is an example of a possible diagram for inhalation casualties dispersed over a wide area.

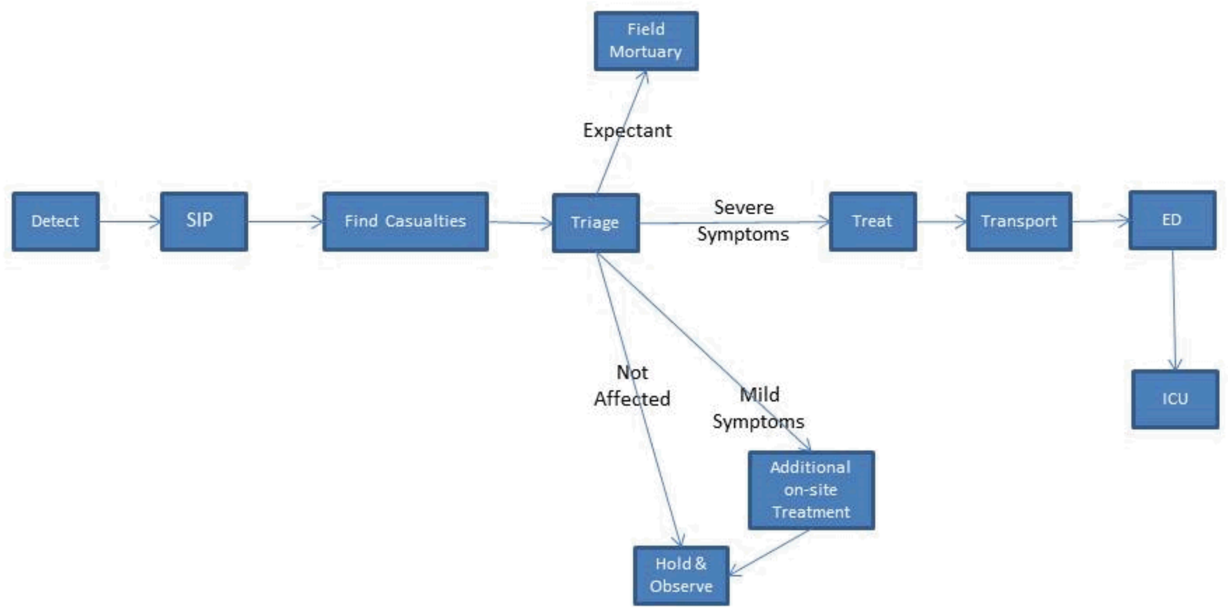

Figure 21, Block flow diagram for dispersed inhalation casualties

In this example, a critical activity is getting everyone to shelter in place as the chemical plume passes over the area. This then requires the responders to find the individual shelters holding casualties throughout the area – this becomes an activity in the block diagram.

Figure 22 is a more complex example of a release within a venue of a toxic material causing dermal casualties where the chemical is an organophosphate (which will require atropine).

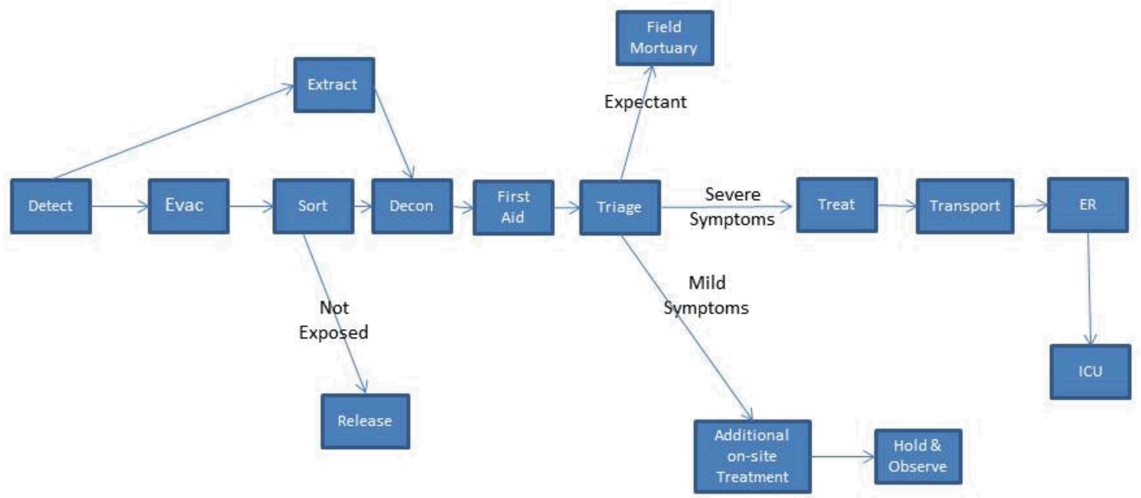

Figure 22, Block flow diagram for venue dermal (organophosphate) casualties

Here the critical activities include evacuating the venue and decontamination. As organophosphate casualties require atropine when they show symptoms, and as this may occur while awaiting triage, this requires an additional "first aid" activity.

There are many supporting activities that are not shown on the block flow diagram (such as acquiring and transporting atropine to the site). These supporting activities impact the capabilities in each activity but do not change the casualty flow path so they are not included.

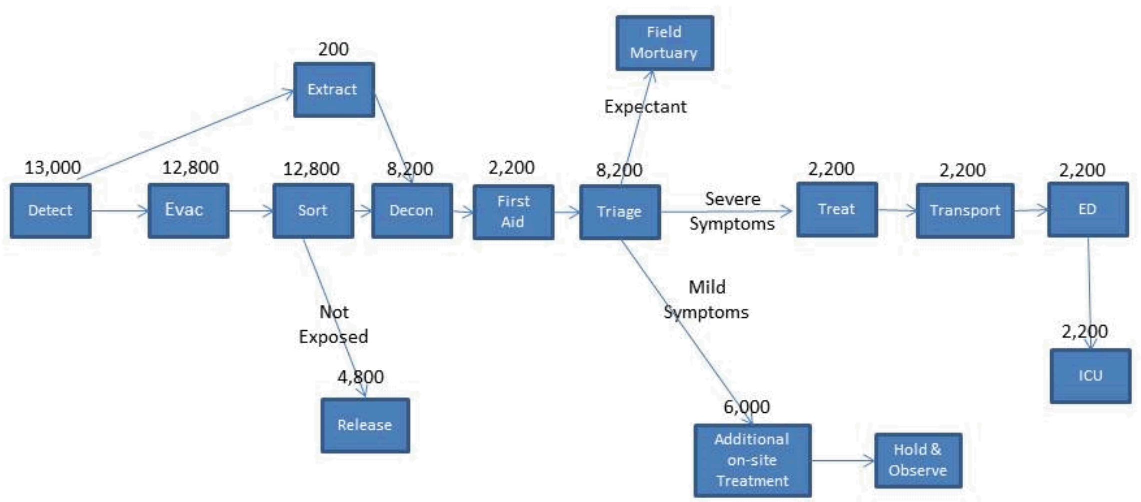

Figure 23 Block flow diagram with numbers for venue dermal (organophosphate) casualties

After developing a block flow diagram, the next step is to establish the casualty flow. In figure 23, there were 13,000 potential casualties when the release was detected. 200 became severe casualties and incapacitated before being evacuated and will have to be extracted (this is based on airflow across the venue and how many the plume covered before evacuation was ordered – it's a rough estimate, as some will be overcome during evacuation).

After evacuation, the toxic chemical plume had not reached 4,800 so they were not exposed and can be released. The remaining 8000 plus the 200 that have to be extracted must be decontaminated.

A simple rule of thumb is anyone with skin or clothing contamination that has not been decontaminated within 30 minutes can be assumed to have acquired a dose causing severe injury. If decontaminated within 30 minutes, the acquired dose only produces mild symptoms (though some will later exhibit severe injury symptoms – this will not be considered). Again, this is a rough estimate, but will serve to determine shortfalls.

Based on decontamination capacity, this produced 2,200 that took longer than 30 minutes and became severe casualties -- showing symptoms that will require first aid atropine while awaiting triage. The full 8,200 will undergo triage, however those first to be decontaminated (under 30 minutes) will only exhibit mild symptoms. This means that 6,000 have mild symptoms and 2,200 are severe.

All 2,200 will require continuous treatment (repeated atropine) until transported. All 2,200 must be transported, receive ED processing, and eventual hospital bed space.

In this example, expectant and field mortuary numbers are not considered, as they do not affect casualty handling capacity.

This example illustrates the thought process and how assumptions are applied developing the casualty flow numbers. Rough approximations are appropriate, as the goal is to simply compare possible numbers with emergency response capacity (covered in Appendix H).

Appendix H, Analysis: Shortfall Determination

After the casualty flow has been placed on the block flow diagram, each action is compared with the capability and capacity of the emergency response action agency. These capabilities and capacities were determined during the analysis of agency actions (Appendix F), but should be verified with the appropriate agencies after the casualty flow is established. Blocks are then color coded based on the level of shortfall – for simplicity, yellow for a serious shortfall, red if it is critical. These assessments are not absolute but showcase the areas for possible improvement.

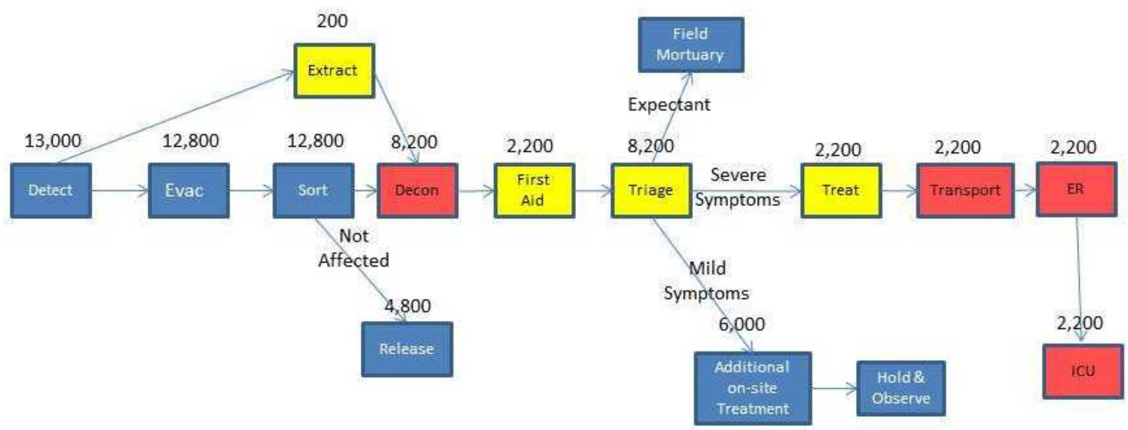

Figure 24 Color coded block flow diagram with casualties for dispersed inhalation casualties

Working across the flow diagram, if it takes 10 minutes for the responders to arrive on scene, and then 5 minutes for a fireman in his bunker/turnout gear to rescue/extract one person, it will take 20 rescuers to extract the incapacitated within 20 minutes of exposure (times from the cross-functional flow diagram). This will require 20 dedicated rescuers at the same time that fire crews are establishing a gross decontamination capability, which is a serious shortfall in capability.

In the same manner the decontamination task capacity is compared with the requirement. If decontamination lines can be established within 15 minutes of exposure (from cross-functional flowchart) and each has a throughput of 30 casualties/minute, it will take over 18 decontamination lines to handle all casualties within 15 minutes (within 30 minutes of exposure). Any not decontaminated within this time become serious casualties. This is a critical shortfall.

In a similar manner all of the other activities are assessed. Transport, ED, and ICU functions are almost universally critical shortfalls as the medical system is not sized to handle mass casualties on this scale. Transport, for example, must consider ambulance turnaround times based on distance to hospitals and ambulance load capacity. In this case, if capacity is four and turnaround is 30 minutes there is a requirement for 1025 ambulance trips.

Appendix I, Typical Critical Response Action Shortfalls

A useful crosscheck is to compare shortfalls with those identified in the detailed analysis of the test cities. These are listed by Operational Framework phases.

Alert and Assessment

Rapidly recognize release and initiate response

Immediate Actions

Early decision and actions to minimize exposure – cannot wait for definitive answers

Outside release: shelter in place

If inside release: Evacuate venue/building

Emergency Response

Rapid rescue/extraction in reduced PPE

Rapid decontamination

Quantity and speed of deployment of critical medical countermeasures (chempacks, oxygen, etc.)

Insufficient EMS personnel for triage, continuous monitoring, and treatment

Providing rapid EMS access to dispersed shelters within the plume area

Medical Treatment

Rapid transport to medical treatment facilities

Decontamination at hospitals

Hospital capacity expansion

Receipt of additional medical equipment, supplies, and medications

Appendix J, Critical Decisions

Every decision has consequences and the magnitude of a mass casualty incident can magnify those consequences. Several factors influence decision consequences:

- Making the "correct" vs incorrect decision (picking the optimal choice)
- Making a timely decision vs delay in decision (waiting for better information can increase the consequences)
- Every decision is dependent on information inputs (reliability of the information driving a decision)

It is impossible to pre-decide the actions to be taken during a mass casualty chemical incident as there are too many situation-dependent variables. It is possible, however, to identify those time sensitive decisions that will have significant impact on casualties (if either delayed, or if an incorrect action is directed). Each critical decision should be thought through in advance and its components recorded in the response plan. As no incident can be completely predicted in advance modification is expected to be necessary – however decisions can be made much quicker if there is an existing plan. A possible model for planning consists of 5 steps:

1. Identify possible options: what are the different actions that could be taken (shelter, evacuate, do nothing)
2. Consequence balance – For each option identify:
   - If correct: what's the benefit, if incorrect: what's the regret
   - Identify time criticality of the decision and how it affects benefits and regrets
   - Compare benefits and regrets to predetermine the best action
3. Identify the decision trigger point: the information/indicators that will require making a decision
4. Determine the Minimum Actionable Information (MAI): the information sufficient to select the best action
5. Identify information sources that may provide MAI

It is important to as best as possible identify and list the possible actions (the options) for each decision along with their potential consequences.

After identifying the critical decisions and action options, the next step is to pre-identify possible trigger information, and the minimum actionable information necessary to take action. The table in figure 25 is one possible method to record pre-identified triggering and actionable information along with the information sources. The example shown is for a decision recognizing that a problem exists.

Recognize Problem			
Incident type	Trigger	MAI	MAI Source
Indoor release	Observed people in distress	Number distressed expanding	Facility staff
		Identify symptoms	Medical staff
	Visible cloud	Observed people in distress	Facility staff
	Chemical detector alarm	Observed people in distress	Facility staff
	911 calls	Observed people in distress	Facility staff
	Aid Station casualties	Symptom based assessment	Medical staff
		Increased number of distressed people	Facility staff
External release			
	Chemical vehicle accident	Visible cloud	Citizens, police patrols
		Observed people in distress	Citizens, police patrols
	Chemical vehicle venting	Observed people in distress	
	Chemical facility alert	Trusted report	Facility staff
		Visible cloud	Citizens, police patrols
		Observed people in distress	Citizens, police patrols
	Visible cloud	Observed people in distress	Police patrols
	911 calls of symptoms	Number of distress calls increasing	911 supervisor
		Police observe people in distress	Police dispatch
	Chemical detector alarm	Observed people in distress	Emergency responders
		Visible Cloud	Emergency responders

Figure 25, Incident triggering information and MAI

The following example shows the decision planning process for an identified critical decision to shelter in place.

Example: Decision to Shelter in place

Options: 1. Provide immediate shelter in place warning, 2. delay until identify chemical

Consequence Balance: timely action can save 1000s, if wrong, may be political fallout inconvenience, and financial loss – consequences too grave, cannot delay awaiting more complete information

Trigger Point: recognition of chemical plume

MAI: location of population at risk

Information Sources: Emergency responder observation, Emergency Response Guide (ERG), Aloha model

A technique for preplanning is to develop a decision table for each critical decision applying the 5 step process to the Observe, Orient, Decide, and Act model which includes assessment of information sources and observations that impact the decision and decision timing. A sample decision table illustrating this is shown in figure 26 for the decision to shelter in place.

Information Source	Observation	Time	Orient	Decision	Action/Impact
Emergency responder	Plume leaving railcar and heading to city	5 min	Threat to city from unknown chemical plume	Delay to determine possible affected population	Trigger point – must quickly determine who's at risk
Emergency Response Guide	Protection box location	10 min	Approximate area to protect	Pass to OEM to disseminate warning	Minimal actionable information – expedite warning
Aloha model	Extended plume	20 min	Plume goes farther than protect box	Extend SIP warning area	Expedite updated warning

Figure 26, Decision Table example

Appendix K, Library of Typical Critical Decisions

Alert and Assessment

1. Recognize attack/release – venue or building. Delay during the first few minutes can cause thousands of additional casualties.

Who: Venue/building security
911/dispatch or emergency management
Incident Command

Options: 1. Do nothing and await more information, 2. Call security office for instructions (venue/building staff) or alert supervisor (emergency management), 3. Recognize and declare potential toxic chemical

Consequence balance: early recognition of potential problem can significantly reduce casualties. Delay for additional information or instruction will delay application of any protective measures. Assuming potential toxic chemical can result in facility or community disruption. – the consequences are too grave, however, cannot delay recognition/notification while awaiting additional information.

Trigger point: observation of people in distress or chemical plume

MAI: observation that number of people in distress is increasing or plume increasing

Information sources: direct observation by arena staff, or outside observers

Immediate Actions

1. Provide warning and necessary actions – external release, indoor venue or building. Removing people from harm quickly is important to minimize severity of casualties. Several actions to do this require decisions.

Who: venue/ building security manager

Options: 1.Await instructions from fire or HAZMAT 2. Shelter in place and close off venue/building by shutting doors and shutting down HVAC.

Consequence balance: Timely action can save thousands in the arena but may doom people outside, if wrong may be political fallout, inconvenience, financial loss, and potential casualties from panic reaction. – Consequences too grave, cannot delay awaiting more information/instructions. The good of the many must predominate.

Trigger: observation of people in distress outside and an approaching white cloud or 911 call

MAI: observation of people in distress, or smelling chemical

Information sources: arena staff at entry point, 911 dispatch

2. Provide warning and necessary actions – internal release, indoor venue/building. Removing people from harm quickly is important to minimize numbers and severity of casualties.

Who: venue/building security manager

Options: 1.Await instructions from fire or HAZMAT 2. Evacuate building and shut down HVAC system

Consequence balance: Timely action can save thousands in the venue/building, if wrong may be political fallout, inconvenience, financial loss, and potential casualties from panic reaction. – Consequences too grave, cannot delay awaiting more information/instructions.

Trigger: observation of people in distress

MAI: observation of people in distress are increasing

Information sources: venue/building staff

3. Provide community Shelter in Place warning. Delay during the first few minutes can cause thousands of additional casualties.

Who: 911/dispatch, Incident Commander

Options: 1. Provide immediate shelter in place warning, 2. delay until incident commander makes on-scene assessment

Consequence Balance: timely action can save 1000s, if wrong, may be political fallout inconvenience, and financial loss – consequences too grave, cannot delay awaiting more complete information until the Incident Commander arrives at the scene

Trigger Point: recognition of chemical plume or chemical company report of chemical release

MAI: location of population at risk and sensitive populations

Information Sources: Chemical company report, 911 reports, Emergency Response Guide

Emergency Response

Widespread airborne toxic chemical

1. Determine suppression approach. Normally, suppression applies water to the source. Some chemicals such as oleum react strongly with water, making the problem worse

Who: Incident command, advised by facility and HAZMAT

Options: 1. Do not suppress until chemical is verified 2. Carefully position fire equipment to put a water mist downwind from the chemical source/pool into the air to wash out the toxic chemical 3. Put water directly on the chemical source and a mist into the air. Cease suppression if a chemical reaction increasing the plume is observed.

Consequence Balance: By not suppressing the chemical source and the plume its producing, the continuous release will significantly delay EMS access to sheltering casualties – consequences are very situationally dependent. If water is placed on certain chemicals, it will make the problem far worse by generating a larger and longer acting plume. For the majority of chemical materials, water is the best choice and will significantly reduce the airborne plume. If the chemical is suspected to be one that reacts with water, if it is possible to maneuver fire equipment where a water mist can reach the plume without putting water on the pool option 2 should be selected. If water-reactive chemicals are not suspected, option 3 should be selected to minimize downwind plume.

Trigger Point: chemical plume reaching populated area

MAI: continuous chemical release, identification of the chemical

Information Sources: Chemical company, HAZMAT

2. Determine PPE requirements for rescue. Current guidance for operating in the hot zone requires level A PPE. There will be casualties that had been outside and received high doses before gaining shelter, people in the streets that were unable to reach shelter before being incapacitated, and people inside venues/buildings that cannot evacuate under their own power.

Rescue is a short-term entry and withdrawal for life saving, or short term transit of the hot zone to enter shelters in order to provide medical support where rescuers will not spend much time in the contaminated environment

Who: Incident Commander

Options: 1. Require full level A PPE for all responders entering the hot zone, 2. direct rescue operations using a lower level of PPE

Consequence Balance: The limited numbers of level A qualified and equipped personnel along with short operational times in level A could result in increased severity and lethality for casualties. Operating with reduced PPE levels can cause injury to responders operating too long in hot zone – consequence is too grave to rely only on level A equipped responders and option 2 should be employed, however rescue must minimize responder exposure – consequence is too grave to rely only on level A equipped responders. Rescue operations must be closely monitored and must minimize responder exposure.

Trigger Point: report that sheltering casualties have received significant exposure, or that casualties outside shelters are incapacitated but still alive.

MAI: location of casualties, guidance from HAZMAT on acceptable PPE and any operating restrictions.

Information Sources: 911 reports, direct observation, HAZMAT guidance, SME (poison center)

3. Strategy for provision of EMS care. Current guidance for operating in the hot zone requires level A PPE, or waiting until the chemical plume has dropped to a safe level. There will be casualties in shelters in urgent need of medical care. Delays in reaching them will significantly increase severity of casualties and numbers that become deceased.

Who: Incident Commander with advice from EMS Chief/Supervisor and the HAZMAT Chief

Options: 1. Delay entry until the plume has cleared the area 2. Employ HAZMAT survey teams along streets into the hot zone, closely followed by EMS teams to enter shelters as they are reached (skirmish line technique)

Consequence Balance: Onset of respiratory distress within shelters requires immediate medical care. Failure to provide care will cause death. A risk to responders remains, however from residual chemicals and wind shifts – consequences to the sheltering casualties is too grave to wait dispersion of the plume and option 2 should be implemented.

Trigger Point: report of worsening casualties in shelters

MAI: location of casualties, increasing numbers of 911 calls from shelters reporting severe problems. HAZMAT assessment of shrinking/moving plume

Information Sources: 911 reports, HAZMAT survey reports

Liquid toxic chemical contamination

1. Separate exposed from unexposed, and move from contaminated area. Delay during the first few minutes can cause thousands of additional casualties from secondary contamination.

Who: Facility manager

Options: 1. Wait for instructions from fire department commanding officer, 2. Evacuate stadium to concourse area, separating those contaminated from uncontaminated

Consequence Balance: timely action can save 1000s, if wrong, may be political and commercial fallout– consequences too grave, implement option 2 as cannot delay awaiting more complete instruction

Trigger Point: recognition of a chemical contamination

MAI: some spectators as well as exposed seating area are contaminated, other areas and spectators are not

Information Sources: reports from facility staff and spectators

2. Cause immediate disrobing. Immediate disrobing will remove approximately 60% of the contaminant from spectators. Over time, chemical will penetrate clothing and reach the skin surface.

Who: Incident Commander in route

Options: 1. Leave spectators clothed, 2. direct immediate disrobing of contaminated spectators, 3. Wait until arrival and incident assessment

Consequence Balance: There are severe political and financial consequences to requiring disrobing in the absence of a threat. Leaving clothing on will drive all contaminated spectators into a severe casualty state, with a high level of lethality. Delay in making the decision allows more and more chemical agent to reach the skin increasing severity. – consequence is too grave, implement option 2.

Trigger Point: recognition of a liquid chemical contamination

MAI: indication that liquid contaminant is on the spectator skin and clothing

Information Sources: facility manager/staff and on-site EMTs

2. **Execute immediate gross decontamination process.** Immediate flushing through a hasty decontamination process will remove a large portion of the contaminant from the skin surfaces. This will significantly slow absorption and reduce the number of critical casualties. As time is so critical, setting up technical contamination lines is far less effective than immediately providing a water flush from expedient methods. The short time window where this will be effective requires a decontamination decision before responders have detailed information. This must be followed by detailed decontamination, but an initial hasty decontamination provides more time to establish and operate a deliberate decontamination process

   Who: Incident Commander

   Options: 1. Delay a decontamination decision until the nature of the agent is identified, 2. Direct establishment of detailed decontamination lines, 3. Immediate decision to direct hasty decontamination to flush spectators as they leave the stadium

   Consequence Balance: Decontamination has political and financial consequences in the absence of a threat. It also requires significant response resources. Delay in making the decision allows more and more chemical agent to penetrate the skin increasing severity. Establishing a detailed decontamination process will remove all significant contaminant, but will take a longer time to process all affected spectators. – the consequence from selecting either option 1 or 2 if the agent is toxic is too grave, assume toxic and implement option 3 upon arrival

   Trigger Point: recognition of a chemical contamination

   MAI: indication that liquid contaminant is on the spectator skin, very large number of contaminated spectators

   Information Sources: facility manager/staff and on-site EMTs

4. Quickly mobilize atropine stocks Methyl parathion casualties require multiple doses of atropine. The large number of casualties will require large quantities of atropine to be provided on site in a very short time after exposure. This will exceed immediate available stocks, requiring authorization and transportation of atropine from across the city, region, and state.

Who: Incident Commander with advice from the EMS Chief/Supervisor

Options: 1. At the first indication of a nerve agent, order large quantities of atropine, 2. Await identification of the toxic chemical and determination of quantities required.

Consequence Balance: Casualties will require initial atropine injections followed by re-injections at approximately 15 minute intervals. This will rapidly exhaust locally available stocks. As out of area stocks require transportation to the site, any delay will cause an atropine shortage until they can arrive. Delay will cause much higher lethality. Ordering out of area atropine if it is not required will cause political and financial consequences. – execute option 1, the consequences of delay are too severe.

Trigger Point: initial identification of nerve agent symptoms

MAI: initial identification of nerve agent symptoms

Information Sources: EMS

Medical Treatment

1. **Mass casualty transportation augmentation.** Available ambulances are insufficient to move casualties to hospitals in a timely manner.

Who: Incident Commander with advice from the EMS Chief/Supervisor

Options: 1. Using available ambulances 2. Augment ambulances with buses

Consequence Balance: Using available ambulances is the normal method to transport casualties to hospitals; however transport is inadequate for a mass casualty incident leaving large numbers of casualties with only the emergency medical care available at the incident site. Augmenting with buses requires removing them from normal routes with possible political and economic impact – consequences of delaying transporting casualties is too grave to only employ ambulances.

Trigger Point: report of number of casualties requiring transport

MAI: location of casualties, increasing numbers worsening casualties.

Information Sources: medical monitoring reports, EMS ambulance status reports