EMERGENCY PLANNING FOR CHEMICAL AGENT RELEASES

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Abstract. Because of the potentially catastrophic consequences associated with accidental releases of chemical agent, emergency planning for the Chemical Stockpile Disposal Program became the central mitigative measure of the Final Programmatic Environmental Impact Statement. Emergency response capabilities become a central part of the National Environmental Policy Act (NEPA) process when (1) the principal negative impacts identified are associated with accidents, (2) the consequences of accidents are potentially catastrophic, and (3) the probability of accidents is high enough to be considered credible. However, using emergency planning as a mitigative measure presents burdens that communities are often ill-equipped to meet. Even though emergency planning reduces the overall risk, uncertainty makes it difficult to quantify these reductions. In addition, emergency planning itself may present socioeconomic impacts when it is implemented. This paper summarizes the Army's efforts to provide maximum protection to the public and examines the issues associated with using emergency planning as a mitigative measure in the NEPA process.

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INTRODUCTION

Emergency planning for the Chemical Stockpile Disposal Program (CSDP) is the central mitigative measure of the Final Programmatic Environmental Impact Statement (FPEIS) (U.S. DA, 1988a). The Draft Programmatic Environmental Impact Statement (DPEIS) characterized the stockpile and its hazardous potential, concluding that the concept of "no risk" was inappropriate (U.S. DA, 1986). The average maximum fatalities estimated under conservative most likely meteorological conditions exceeded 500 deaths and ranged from a low of 1 to a high of over 1400 within 20 km of the facilities.

Response plans at the Army installations predate the DPEIS, but emphasize on-site response to relatively small releases with limited or no off-site consequences. The DPEIS (Appendix L) also raised a series of issues about both on- and off-post emergency preparedness for accidental chemical agent releases, including:

- How long will it take to recognize the nature of the accident?
- Who will be notified of an emergency?
- What means of communication will be used?
- What emergency operations center will be established?
- Who will decide when or whether to warn the public?
- How will the warnings be communicated?
- What protective actions will be considered?
- How will the decisions be made concerning what protective actions will be considered?
- Who is in charge of emergency response?

The DPEIS clearly indicated that accidental releases could reach off-site locations and underscored the lack of existing emergency preparedness to mitigate such events.

The complexity of the disposal program, the potential hazards associated with storage and disposal, and the adequacy of emergency response all contribute to the uncertainty about what is needed. The public was asking about the specifics of an emergency response program; yet even on such key issues as warning, the uncertainty was evident. Some people and emergency managers were concerned about the specifics of a warning system that they felt was clearly needed, but others felt no warning system was needed.

EMERGENCY RESPONSE CAPABILITIES AND NEPA

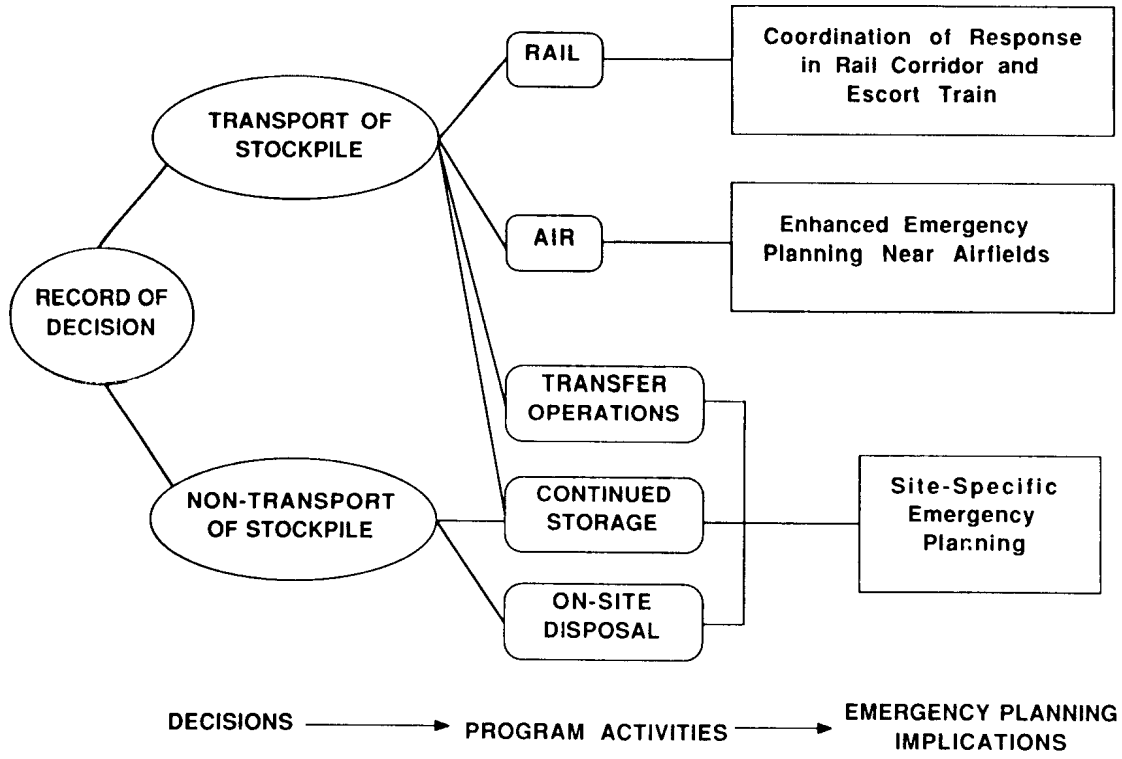
Emergency response capability became a central part of the National Environmental Policy Act (NEPA) documentation and decisionmaking process for the CSDP when the principal impacts identified in the FPEIS were those associated with accidents, the consequences of accidents were estimated to be catastrophic, and the probability of accidents was considered credible (i.e., $\geq 10^{-8}$). Although the impacts associated with accidents are not a necessary condition for using emergency response capability to mitigate potential impacts, the credible potential for catastrophic off-site consequences that would overwhelm existing response resources is sufficient to lead to emergency planning as a mitigative measure. The FPEIS commits the Army to implementing a comprehensive emergency response program at each of the stockpile locations regardless of the disposal alternative selected. Carnes (this issue) discusses these alternatives in detail.

Disposal alternatives involving transportation of chemical agents pose additional emergency response requirements for potential accidents occurring in transit, which require unique considerations beyond the fixed-site program requirements for the stockpile locations. Emergency response concepts for each transportation alternative were considered unique and were independently presented in the *Emergency Response Concept Plan* (ERCP) (U.S. DA, 1987). The implications of disposal alternatives on program activities and emergency planning are summarized in Figure 1. The FPEIS concludes that if the selected disposal alternative involves off-site transport of chemical agent, it is impossible, due to logistical and financial factors, to develop emergency response capabilities along the corridors that are commensurate with those at fixed-site locations (U.S. DA, 1988a, pp. 4-166).

Emergency response programs may not mitigate the effects of chemical agent releases in transit and because of the large geographical areas potentially affected by such accidents, the emergency response programs cannot be as effective as those for a fixed location. The Under Secretary of the Army James R. Ambrose concluded that even though the risk of catastrophic accidents is relatively low for all programmatic alternatives, on-site disposal is the safest alternative; it was therefore selected as the environmentally preferred alternative. The statistical usefulness of the FPEIS analysis is limited somewhat by the fact that the accident events considered have low probability of occurrence, but have potentially large adverse consequences. The risks of these events are never entirely absent from the installation population and surrounding area despite the alternative chosen, whereas they could be avoided completely along the transportation corridors if the on-site alternative was selected (Ambrose, 1988).

Although the Record of Decision to dispose of chemical agents was consistent with the environmentally preferred alternative, "the hazards and risks analyses presented in the FPEIS were a contributing but not determining factor" in the decision (Ambrose, 1988, p. 4). Ambrose found the

Figure 1. Implications of Disposal Alternatives for Emergency Planning



logistical complexity of security from terrorism, safety, and emergency response more important aspects of the decision: emergency response to protect people along transportation corridors is far more difficult and less effective than for the people near fixed locations.

Because impacts of potential accidents can be reduced through emergency preparedness and the affected communities generally have inadequate preparedness capabilities, communities will need to upgrade their preparedness capabilities for response to accidental releases and will be affected by the expenditures required for these upgrades. Moreover, the Army committed to fulfill its responsibility in the event of an accident/incident that exceeds the capabilities of local and state governments to respond. The Army also committed to immediate improvements in (1) local off-site planning and response capabilities and (2) coordination, communication, and decisionmaking by the installation and off-site officials. These improvements will include:

- developing an improved technical basis for planning;
- developing a streamlined decision and communication command structure for off-site notification in an emergency;
- developing improved operating procedures, monitoring, and accident assessment and decision support systems;
- developing improved exercise design criteria for evaluating emergency preparedness;
- conducting emergency exercises involving off-post participation and having an independent review and evaluation of exercises to determine needed improvements; and
- establishing an oversight review board to coordinate planning among the sites and to ensure that guidelines specified in the ERCP are being implemented on schedule.

The Army is also pursuing other means to mitigate the costs of emergency preparedness enhancements to local governments. First, the Army is providing assistance to improve existing emergency response plans, coordination, communication, and decisionmaking. Second, the Army is developing site-specific emergency response concepts and implementation plans conforming with the programmatic ERCP, including exploring alternative ways of funding the emergency response planning efforts. The Army informed Congress on March 15, 1988, that the implementation of emergency response concepts for each site will cost an estimated $100 million (U.S. DA, 1988b).

THE EMERGENCY RESPONSE CONCEPT PLAN

The ERCP (U.S. DA ED, 1987) was a programmatic analysis of emergency preparedness implications of the CSDP. It was not intended to provide a detailed, site-specific analysis of emergency preparedness measures or to represent definitive criteria for the development of an emergency response program. Rather, the ERCP identified emergency preparedness issues common to the CSDP, discussed alternative strategies by which they are addressed, and provided emergency response concepts that can be implemented to protect the public. The ERCP established the concepts for the subsequent development of emergency response programs. It addresses accidental chemical agent releases during all phases of the CSDP and for all disposal alternatives.

The emergency response concepts for the on-site and transportation alternatives are based on established principles of emergency management. Sound models for these programs exist in the Radiological Emergency Preparedness Program currently implemented for fixed nuclear facilities by the Federal Emergency Management Agency (FEMA) and the Nuclear Regulatory Commission, in the Chemical Emergency Preparedness Program of the U.S. Environmental Protection Agency, and in the Hazardous Materials Emergency Planning Guidance of the National Response Team. The emergency response concepts developed vary among stockpile disposal alternatives in that each alternative poses a unique set of problems and circumstances that must be considered in fashioning appropriate response programs. Planning for accidents at fixed, defined sites can be accomplished in greater detail and with much greater assurance of an effective response capability than planning for accidents during transportation. However, the fixed-site programs do not provide complete assurance that loss of life can be prevented.

The emergency response concepts presented in the ERCP include a general description of how such programs could be implemented. An important process of cooperative interaction involving local, state, and federal agencies and organizations must be accomplished for these emergency response concepts to be effectively implemented. For fixed-site emergency response planning, the relationship between the U.S. Army command at each stockpile site and the surrounding community organizations is central to development of programs for the protection of the surrounding population. Further guidance regarding site-specific emergency planning will be developed and reported in the site-specific NEPA documentation. Even though the transportation alternatives were eventually eliminated, the associated emergency response planning involved a broad range of local, state, and federal agencies. The complexity and logistics of planning for accidents that could occur across a potentially expansive area affecting literally thousands of jurisdictions, agencies, and populations were specifically mentioned by Under Secretary Ambrose in the Record of Decision as a significant factor in selecting the on-site disposal alternative.

EMERGENCY PLANNING ZONE CONCEPTS

Emergency planning zone (EPZ) concepts were identified to support the development of emergency response concepts for fixed-site and transportation alternatives. The EPZ is made up of three subzones depicted in Figure 2: the immediate response zone (IRZ), the protective action zone (PAZ), and the precautionary zone (PZ). EPZs are developed in consideration of the risk analysis, available response time, distance, and protective action options. The EPZs reflect the differing emergency response requirements associated with the potential rapid onset of an accidental release of agent and the amount of time that may be available for warning and response. They were developed in recognition of the importance of comprehensive emergency response planning and support systems for rapidly occurring events and the critical nature of such programs in areas nearest the release point (Table 1).

The EPZs are intended to guide the development of emergency response concepts and should not be applied mechanically or inflexibly to specific sites or alternatives or to a specific accident scenario. The development of actual EPZs takes into account the unique political, social, geographical, and stockpile characteristics at each site. Conceptually, the criteria for establishing the EPZs are applied consistently across the program; however, specific configurations and associated distances may vary from site to site. The subzones discussed in the FPEIS were based on the types of accidents identified at each site and the amount of time available to pursue appropriate protective actions. The EPZs currently being developed are based on the hazards posed by a given stockpile and meteorological, topographical, and demographic conditions at each site.

PRECAUTIONARY ZONE

The PZ is based on the usual maximum no-deaths distance of approximately 35 km for worst-case accidents involving nerve agent releases (U.S. Army, 1988a, Sec. 4.2). Worst-case accidents having lethal effects beyond 35 km provide sufficient warning and response times to preclude the need for detailed local emergency response planning.

The worst-case meteorological condition is a wind speed of 1 m/s (Miller and Kornegay, this issue). The time required for such a worst-case release to travel 35 km from the stockpile location is nearly 10 h, a sufficient time to implement protective actions without prior comprehensive and detailed local planning efforts. Under conservative most likely (CML) meteorological conditions (wind speed of 3 m/s), the time required for a chemical agent release to reach 35 km is slightly more than 3 h; however, under these

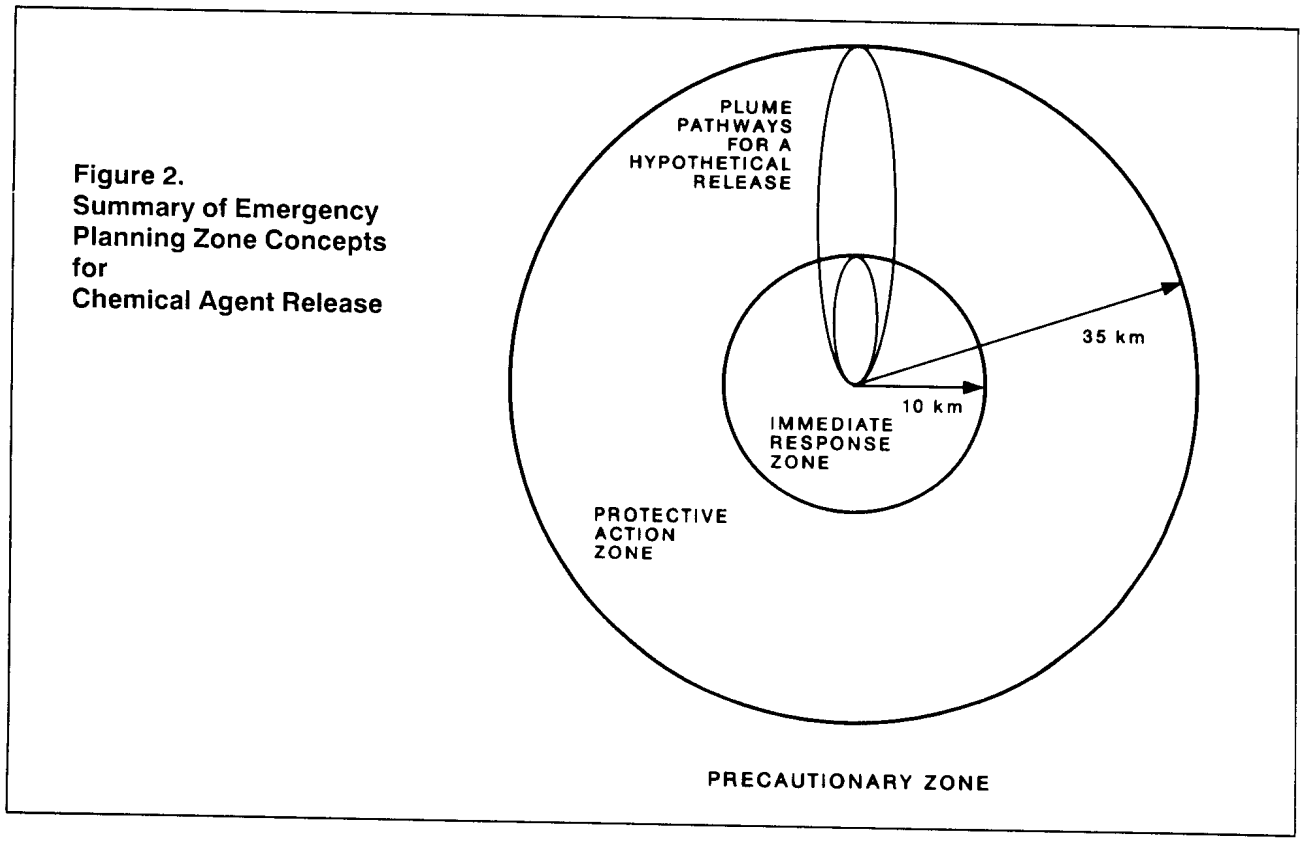


Figure 2.
Summary of Emergency Planning Zone Concepts for Chemical Agent Release

conditions, substantially greater mixing takes place. The maximum no-deaths distance for most accidents would be substantially less than 35 km under CML meteorological conditions. Hence, precautionary actions outside 35 km are planned via wide-area information dissemination mechanisms for all disposal alternatives.

Given substantial warning and response times for areas beyond 35 km, precautionary measures can be planned and implemented at a state or regional level, although coordination of local emergency managers may prove useful. The PZ is the outermost EPZ and extends theoretically to a distance where no adverse impacts to humans would be experienced in the case of a maximum potential release under any conditions. This distance may vary substantially, based on the circumstances of an accident occurrence and would be determined on an accident-specific basis.

Protective action considerations in the PZ are limited to precautionary measures and actions to mitigate the potential for food-chain contamination as a result of an agent release. Precautionary sheltering in the PZ would reduce the potential for exposure to non-lethal concentrations of chemical agent. A precautionary evacuation could also be implemented in the PZ. The means for implementing the agricultural protection and other precautionary activities can be based principally on broad-area dissemination of emergency public information at the time of an accidental release of agent.

PROTECTIVE ACTION ZONE

The PAZ defines an area in which the primary emergency response is evacuation although other options are considered. Hence, the available emergency response times and the hazard distances associated with them are sufficiently large to allow most people to respond to an emergency effectively through evacuation. Operationally, a 35-km PAZ is an appropriate basis for emergency response planning. The comprehensive range of programs and support mechanisms described in the ERCP is applied within the PAZ.

Evacuation, the principal emergency response, must be considered carefully to ensure effective implementation and enhance protection of public health and safety. Evacuation is likely to be the most effective emergency response in the PAZ if time is sufficient to permit orderly egress. However, evacuation, like other protective actions, requires warning. Because time is limited in the PAZ, effective warning systems are required to both alert people to the potential for harm and notify them of the most appropriate actions to take. Available time for protective action varies with agent type, accident, and meteorological conditions at the time.

The capacity to implement timely emergency response is critical in the PAZ. Some areas in the innermost areas of the PAZ will require detailed planning for emergency

Table 1. Summary of Emergency Planning Concepts (With Emphasis by Zone)

Emergency Planning Concept Description	Emergency Planning Zone: Immediate Response Zone	Protective Action Zone	Precautionary Zone
Character of Zone	Prompt response critical; limited response time (<60 min); heaviest concentrations; public protective measures possible.	Primary response evacuation; response time adequate (1-3 h); potentially lethal concentrations; responder protection required.	Sheltering and precautionary evacuation for non-lethal exposures; abundant (3-10 h); agricultural response possible.
Recommended Implementation Area	<10 km	10-35 km	>35 km
Emergency Response Management			
Coordination	+++*	++	+
Command and Control	+++	++	+
Communications	+++	+	
Accident Assessment	+++	++	+
Protective Action	++	+	
Decisionmaking	+++	++	+
Protective Actions and Responses			
Protective Action Options	+++	++	+
Public Alert And Notification	+++	++	+
Access And Traffic Control	++	++	
Special Populations	+++	++	
Emergency Worker Protection	+++	++	
Resource and Information Management			
Emergency Medical Services	+	++	+++
Transportation	++	+++	
Community Resources	+++	+++	++
Public Information	+++	+++	+++
Evacuee Support		+	+++

*A general indicators of the importance each emergency management function has in each zone. Triples (+++) indicate the function is critically important in the zone and is characterized by intense program emphasis. Doubles (++) indicate more general importance and will be characterized by significant program emphasis. Singles (+) indicate general importance, and these functions will receive adequate attention but with limited program focus.

response; other areas near the PZ will require less resource concentration. However, the degree of needed emergency response capabilities depends on specific agent type; geographical configurations such as transportation routes, terrain affecting dispersion, choke points such as bridges, and available egress; and social characteristics such as the location and type of schools, hospitals, and other institutions.

IMMEDIATE RESPONSE ZONE

Those areas nearest to the stockpile locations require special consideration because the warning and response times available may be very limited within those areas. An IRZ is defined for the development of emergency response concepts that make immediate response possible in areas nearest the site. Because of the potentially limited warning and response time available in the event of an accidental release of chemical agent, the IRZ extends to a distance of approximately 10 km from the storage/disposal site. This area usually encompasses the no-deaths distances associated with non-external events and has less than 1-h response time for most accidents under CML meteorological conditions. This area is most likely to be affected by an accidental release of chemical agent. These impacts occur within the shortest period of time and result from the heaviest concentrations of agent.

The full range of available protective action options and response mechanisms is considered appropriate for the IRZ. The principal protective actions (sheltering and evacuation) will be considered carefully, along with supplemental protective action options that can significantly enhance the protection of public health and safety. Sheltering may be the most effective principal protective action for the IRZ because of the potentially short period of time before the effects of agent exposure may be expected. In-place protection is particularly important in areas within the IRZ nearest to the release point because the time to complete an evacuation may not be available for people within downwind areas of the IRZ. The suitability of sheltering depends on a number of other factors, including the type(s) and concentration(s) of agent(s); expedient or pre-emergency measures taken to enhance the various capacities of buildings to inhibit agent infiltration; the availability of individual protective devices for the general public; the accuracy with which the particular area, time, and duration of impact can be projected; and the ability to alert and communicate instructions to the public quickly and effectively.

The capability to implement the most appropriate protective action(s) very rapidly is critical within the IRZ. A thorough analysis of the IRZ specific to each storage/stockpile location should be conducted, and a precise methodology for determining the appropriate protective action(s) under various accident scenarios will be established to ensure that time to make decisions is minimized at the time of a chemical agent release. This analysis should identify certain areas within the IRZ that would implement sheltering for most accident scenarios, evacuation being available as a precautionary measure before a release occurs. Subzone areas may be defined to accommodate the selective implementation of different protective actions within portions of the IRZ. Given a reasonably effective capability to project the area of impact and to predict levels of impact at the time of a release, it may be appropriate to implement sheltering in areas close to the release point within the plume and evacuation in areas not immediately affected.

PROTECTIVE ACTIONS AND RESPONSES

The emergency response program should establish the systems, resources, and response capabilities needed to implement appropriate actions for protection of the civilian population. Capabilities should be established for three principal methods of public protection: evacuation, sheltering, and individual protection. Evacuation may be implemented when sufficient time is available to move people without exposing them to lethal concentrations of chemical agent. Sheltering may be implemented when sufficient time for evacuation is not available; however, because sheltering alone does not provide adequate protection from lethal concentrations of chemical agent, additional measures that provide a high degree of protection will be considered for populations in close proximity to the stockpile sites. Measures should be taken to improve the sheltering protection of certain buildings near each site that house sensitive populations or that may be difficult to effectively evacuate, such as schools, hospitals, and nursing homes. Protective equipment is another means of protection available for populations in close proximity to the storage and disposal locations. Protective equipment can include civilian face masks and mouthpiece respirators, hooded jackets for young children, and protective infant carriers. Individual protective measures have the added benefit of being useful in combination with other protective actions, such as evacuation or sheltering.

A number of support systems and capabilities should be put in place to ensure that the means for implementing various protective actions are available (Sorensen, 1988). Most significant is the installation of a public alert and notification system to alert civilian populations to an accident and notify them of the actions they should take to protect themselves. Although none of the specific alert and notification systems has been defined, systems should be established using a combination of alerting devices to provide the most effective capability for each site. Outdoor warning sirens and indoor warning devices, including tone-alert radios and automated telephone alerting systems, should be installed and supported by the Emergency Broadcast System, cable television override systems, and other public information mechanisms to provide good

overall coverage in both indoor and outdoor alerting and notification. At greater distances, one or more of the alerting systems or mechanisms can be used to provide sufficient warning time for the public to take appropriate protective action(s).

Evacuation of the civilian population requires comprehensive planning and a number of support mechanisms. Detailed traffic and access control plans will be developed to facilitate the implementation of evacuation. Emergency plans should be developed for all special facilities such as schools, hospitals, and nursing homes. These plans should include the transportation resources required to evacuate the facilities identified, and agreements should be obtained for their use in an emergency. So that special assistance can be provided, a survey can facilitate the identification of individuals within the general population that have special needs, such as the handicapped, hearing and sight impaired, and medically disabled people, and those without a means of personal transportation. Protective equipment may also be offered to all civilian emergency workers who have a role in emergency response to ensure that they are protected from exposure to chemical agent while performing their duties. This equipment includes full protective clothing and respiratory protection, as well as auto-injectors for self-administration of agent antidotes if necessary (Chester, 1988).

ASSESSING SOCIOECONOMIC IMPACT

A survey of existing emergency preparedness was conducted in February and March 1987. The resulting assessments are summarized in Table 2. On-site emergency preparedness was generally found to be adequate, and preparations for the most likely events were usually organized reasonably well. However, the coordination with off-site authorities and the preparations for supplying off-site authorities with the information they would need to make decisions and to respond effectively were generally found to be lacking. Although capital investments in equipment and facilities may be needed less at the installations than in the communities, facility and equipment improvements are urgently needed; and while there is considerable variation among sites, capital upgrades are badly needed in three areas: emergency operations centers (EOC), communications equipment, and warning systems.

The organizational element of emergency preparedness was found to be seriously deficient. The Army organization on-site typically has a well-organized chain of command and authority, but it generally lacked community awareness. On-site officials were not fully aware of the kinds of information and assistance the surrounding communities would need to make decisions, to warn the public, and to respond effectively to emergencies. Some installation personnel seemed to nurture the sentiment that accidents affecting off-site populations were improbable. To some extent, this sentiment was shared by off-site officials; at one site, the local official indicated in a FEMA hazard assessment survey that no fixed-site chemical hazard existed in the area. From the community's perspective, however, there were additional problems: Recognizing the hazard, what kind of emergency response capability could be established with the limited existing resources? The perceived futility of detailed planning in the face of extremely limited warning and response capacity discourages the development of a sound planning and preparedness program with existing resources.

The problem of estimating the costs of upgrading the emergency response capabilities at each site is multidimensional. For some elements of effective emergency response, the cost for individual elements is reasonably well known. For example, a mouthpiece respirator costs about $13; if it is determined that 100,000 people require this kind of protection, the total cost would be $1.3 million. The problem with estimates of this kind is the criteria used to determine who needs this kind of protection. Even though these determinations are made, some people will prefer other kinds of protection. To ensure that some protective action is taken, even though a more desirable alternative exists, officials will yield to these preferences.

Another genre of estimation problems involves less-definitive cost elements, such as the cost associated with an EOC. The costs of an EOC can be arbitrarily estimated, but these estimates may not adequately take into account the degree of renovation of existing facilities and local variations in the cost of land, construction materials, and labor. When these estimates are then multiplied by the number of jurisdictions affected to obtain a program estimate, the original estimation problems are further compounded because this kind of estimation fails to consider the potential for shared facilities or political constraints.

Another set of problems associated with cost estimates involves the interpretation of the estimates. Table 3 presents the Army's cost estimates for each installation and compares them with the number of people likely to benefit most from emergency planning at each site (i.e., within 35 km). On the average, emergency planning upgrades are estimated to cost about $50 per person; however, emergency planning upgrades at one site are estimated to require less than $20 per person, whereas costs at others are about $500 per person. It remains unclear at this time whether the levels of protection obtained over the range of costs are equivalent, although this is certainly the goal. Although the costs at the remaining sites fluctuate less dramatically, the fact remains that upgrading the emergency planning at some sites will require more investment than others. When the costs associated with some aspects of establishing/upgrading emergency response capabilities are estimated, cost per person will vary to some degree, but substantial variations highlight the potential for perceived

Table 2. Summary of Emergency Preparedness at CSDP Sites* (as of February/March 1987)

ANAD	APG	LBAD	NAAP	PBA	PUDA	TEAD	UMDA
Plans and Procedures							
I**: Adequate C***1: Defines operating concepts C2: None	I: Well organized C1: General; update required C 2: General	I: Designed to protect I mainly C: Draft not coordinated	I: No continuity, quick access, and none C needs C: None identified	Detailed plans; no decision criteria; limited coordination	I: Adequate C: Not clearly defined or organized	I: No continuity, and quick access C: Not TEAD/CSDP specific	I: Adequate; but contradictions C: Not complete/ coordinated with I
Facilities							
I: Equipped EOC; weak link with C C1: Adequate EOC C2: Very modern EOC	I: EOC well equipped and dedicated link with C C1: EOC C2: EOC exceptional	I: EOC excellent C mobile EOC C: EOC weak dual-use and small	I: EOC equipped; No dedicated link with C: no EOC identified	I: EOC excellent C: Command post concept	I & C EOCs adequate; no dedicated I-C communications	I: EOC well equipped; linked via I-command to C C: Dual-use EOC	I & C EOCs well equipped; dedicated I-C link; no alternate EOC
Organization							
I: Clear C1: Not well defined C2: Personnel identified	I: Clear C1 & C2: Legal authority defined	I: Clear with alternates C: Complete but no alternates	I: Identified structure C: EMS, police, and fire not coordinated	I & C: Well defined and staffed	I: Not clearly defined C: Exceptionally well organized	I: Not clearly defined C: Not defined; I & C not coordinated	I: Clearly defined C: General, not specific authorities
Accident Assessment							
Agent presence; monitoring teams verify real-time air dispersion model	No procedures specified; plume models and met available	No real-time assessment, plume models, or agent monitoring	Nonreal-time lethal/nonlethal dose monitors	Lethal dose detection MCE criteria used	Real-time monitoring not linked to plume models	Lethal-dose real-time monitoring plume models	Real-time hazard monitoring; no plume prediction
Decisionmaking							
I: Authority identified C1 & C2: Based on I recommendations	I: Authority and procedures identified; C1 & C2: Unclear	I: Authority but no procedures — "intuitive" C: Reluctant	I: Authority but no procedures C: Unclear	I: No criteria C: Will accept recommendations	I:No clear criteria C: Limited to accept/reject	I: Authority identified; no criteria C: No procedures	I: Authority identified C: Limited to accept/reject
Emergency Classification							
I: 2 Level; code-names similar C1: May share w/I C2: None	I: 4 level linked with I response C1 & C2: None	I: General 3 level; limited guidance C: None	I: Two 3-level; no guidance to C C: None	Accident, incident minor leak, occurrence	I: 4 level/one off-site C: 4 level not shared with I	I: 3 level; not guide C: Response C: None	I:4 level/one off-site C: Potential and actual releases
Accident Notification							
Conduct assigned contacts listed with C1, but not C2	Authority and conduct assigned dedicated link; C1 notifies C2	No procedures or responsible dedicated link	Authority, but not conduct assigned; no dedicated link to C	Addressed, but not well defined	No clear procedures; contradictory authority; 911	Authority and conduct assigned but separated; no alternates	Procedures and responsibilities defined; radio, 911 backups

Accident Notification							
Conduct assigned contacts listed with C1, but not C2	Authority and conduct assigned dedicated link; C1 notifies C2	No procedures or responsible dedicated link	Authority, but not conduct assigned; no dedicated link to C	Addressed, but not well defined	No clear procedures; contradictory authority; 911	Authority and conduct assigned but separated; no alternates	Procedures and responsibilities defined; radio, 911 backups

Table 2, Continued. Summary of Emergency Preparedness at CSDA Sites (as of February/March 1987)

ANAD	APG	LBAD	NAAP	PBA	PUDA	TEAD	UMDA
Public Alert/Notification							
Local EBS yields partial coverage and tone-alerts to institutions	Limited sirens, route alerting, and EBS; some protocols exist	EBS, weather alert radios, route alerting, limited sirens	EBS, media contacts listed; protocols calm, not alert public	Route alerting	EBS, route alerting, tone alerts to schools and hospitals	EBS, route alerting some protocols exist	Limited sirens, EBS and route alerting; no procedures
Protective Actions Implementation							
Traffic access and control, evacuation and mass-care resources identified by C1	C1: Evacuation routes assigned C1 & C2: Have no procedures	No traffic access and control; evacuation resources not well identified	No procedures or planning identified	Ad hoc; no designated mass care or access control	Exceptionally well developed	Traffic access and control, evacuation and mass-care resources identified	Responsibility assigned, but no procedures or specifics
Health/Medical							
I & C coordinated; I will supply and train; no decontamination	I & C coordinated to handle non-agent injuries; no decontamination	No training or supplies; no coordination, no training	I & C limited coordination and supplies provided	I & C coordinated training and supplies adequate	I & C coordinated some supplies and decontamination provided	I: Being built; personnel available C: Not addressed	I & C coordinated training and supplies C: No decon
Special Populations							
None identified; no hospitals/ nursing homes known; schools identified	None identified; day care/schools procedures exist; but no transport	Institutions and disabled identified; no procedures	Not systematically identified; some known; institutions unknown	Some identified; no special plans	Some identified; exceptions are: day care and nursing homes	None identified; no institutions in close proximity	None identified
Public Information							
I: Preplanned news releases; media contacts C1 & C2 not joint	I: Responsibility C1 & C2: Rumor control; not joint with I	Joint release; center designated joint operations unclear	No procedures; none except hearings	Joint activity agreements; no location or procedures	I: Preplanned news releases; media linked C: Not joint with I	I: Procedures not identified; no location C: None	I: Preplanned news releases; media contacts C: Not joint with I
Training, Drills, and Exercises							
I: Regular C1: Periodic C2: Annual no joint	I: 4 years; C1: REP C2: EOC every 5 years C1 & C2 not CSDP; no joint	I: 6 years C: Limited joint annual	I: Regular C: Unknown no joint	I & C annual joint; I response focus	I & C adequate; no joint	I: Regular C: None; no joint	I: Frequently; table-top exercise in 1980 with C

*ANAD - Anniston Army Depot; APG - Aberdeen Proving Ground; LBAD - Lexington-Blue Grass Army Depot; NAAP - Newport Army Ammunition Plant; PBA - Pine Bluff Arsenal; PUDA - Pueblo Depot Activit; TEAD - Tooele Army Depot; MDA - Umatilla Depot Activity

**I refers to installation or Army emergency preparedness.

***C refers to preparedness characteristics of nearby communities; C with numbers are used to designate one community from another.

inequality. In addition, once site estimates are released, local officials may expect that money to be allocated directly to them. One local official indicated to reporters that his county would be getting the total amount allocated for that site, even though other jurisdictions in the area have emergency response needs and their program costs have to be deducted from the total amount.

EMERGENCY PLANNING AS MITIGATION

Emergency management mitigates the risks of accidents to the nearly 1.9 million people living within 35 km of the facilities, but the degree of mitigation is difficult to assess. A quantitative estimation of the benefits associated with the emergency response program is not possible because of the numerous individual circumstances that affect human behavior in emergencies. Although there is some certainty that emergency preparedness programs will improve survival chances and thereby mitigate the effects of potential accidents, the improvements are not quantifiable in terms of potential lives saved or protected.

Hence, a qualitative approach to assessing the benefits of enhancing emergency preparedness is summarized in Table 4. Accidents were characterized in terms of agent, mode of release, and wind speed. Agent was classified as being VX, GB, or HD; mode of release is characterized as instantaneous, semicontinuous, or a spill; and wind speeds were hypothesized as slow (1 m/s), moderate (3 m/s) or fast (6 m/s). For all kinds of chemical agent under all modes of release, the benefits of emergency response programs were found to be the greatest under relatively slow wind speeds. Similarly, benefits were assessed as greater under moderate wind speeds than under fast wind speeds. This general assessment reflects the nature of emergency response: more time allows greater response, and one of the key elements of enhanced response with additional time is available warning time. Rogers and Sorensen (1988) examined the impact of limited warning time on receipt of warning and found that even with combinations of advanced warning systems under rapidly moving events, people near the source would likely be exposed to the hazard before receiving the warning.

PROGRAM DIRECTIONS

The Under Secretary of the Army James R. Ambrose was briefed on the status of emergency response planning in August 1987. At that briefing, he committed the Army to immediate upgrades not requiring capital expenditures to enhance emergency planning at all eight sites. As a result, the Army is providing assistance to communities for enhanced emergency preparedness in the vicinity of the eight locations. In addition, site-specific concept studies are under way for each site. These concept studies are expected to be released in the fall of 1989 and will examine the

Table 3. Estimated Costs of Emergency Response Upgrades by Location

Locations	Estimated Costs* (10^6 $)	Population within 35 km** (10^3)	Cost per Person ($)
ANAD***	9.98	192.4	51.87
APG	22.15	1175.1	18.85
LBAD	18.29	128.2	142.67
NAAP	8.98	101.8	88.21
PBA	8.97	113.0	79.38
PUDA	6.72	116.2	57.83
TEAD	10.62	20.4	520.59
UMDA	14.29	28.9	494.46
Total	100.00	1876.0	53.30

* Constant FY 1988 dollars as adopted from U.S. DA, 1988b.,
** Adopted from the U.S. DA, 1988a.
*** ANAD - Anniston Army Depot
APG - Aberdeen Proving Ground
LBAD - Lexington-Blue Grass Army Depot
NAAP - Newport Army Ammunition Plant
PBA - Pine Bluff Arsenal
PUDA - Pueblo Depot Activity
TEAD - Tooele Army Depot
UMDA - Umatilla Depot Activity

Table 4. Qualitative Benefits of Fixed-Site Emergency Response Programs for Nerve Agent Accidents

Accident Scenario	Wind Speed: Slow (1 m/s)	Wind Speed: Moderate (3 m/s)	Wind Speed: Fast (6 m/s)
Moderate instantaneous release (100 kg VX)	Fatalities possible to 33 km; potential for multiple fatalities is high within IRZ; lower in PAZ. **High reduction in fatalities at all distances at greater distances**	Fatalities possible to 10 km; potential for multiple fatalities is high within 2 km; lower to 10 km. **Low reduction in fatalities to 2 km; higher at greater distances**	Fatalities possible to 15 km; potential for multiple fatalities is high within 4 km; lower to 15 km. **Low reduction in fatalities to 5 km; higher at greater distances**
Small instantaneous release (10 kg VX)	Fatalities possible to 7 km; potential for multiple fatalities is high within 2 km; lower to 7 km. **High reduction in fatalities at all distances**	Fatalities possible to 4 km; potential for multiple fatalities is moderate within 1 km; low to 4 km. **Low reduction in fatalities to 2 km**	Fatalities possible to 6 km; potential for multiple fatalities is moderate within 2 km; lower to 6 km. **Low reduction in fatalities at 5 km**
Large semicontinuous release (1000 kg VX)	Fatalities possible to 100 km; potential for multiple fatalities is very high within IRZ; lower in PAZ and PZ. **High reduction in fatalities at all distances**	Fatalities possible to 25 km; potential for multiple fatalities is high within IRZ; lower in PAZ. **Low reduction in fatalities to 2 km; high at greater distances**	Fatalities possible to 15 km; potential for multiple fatalities is high within IRZ; lower in PAZ. **Low reduction in fatalities to 5 km; high at greater distances**
Moderate semicontinuous release (100 kg VX)	Fatalities possible to 45 km; potential for multiple fatalities is very high within IRZ; lower in PAZ, and very low in PZ. **High reduction in fatalities at all distances**	Fatalities possible to 8 km; potential for multiple fatalities is moderate within 2 km; lower to 8 km. **Moderate reduction in fatalities at 2 km; greater to 8 km**	Fatalities possible to 7 km; potential for multiple fatalities is high within 2 km; lower to 7 km. **Low reduction in fatalities at 2 km; moderate reduction to 5 km**
Large spill (900 kg GB)	Fatalities possible to 12 km; potential for multiple fatalities is moderate within 3 km; lower to 12 km. **High reduction in fatalities at all distances**	Fatalities possible to 8 km; potential for multiple fatalities is moderate within 2 km; lower to 10 km. **High reduction at distances**	Fatalities possible to 8 km; potential for multiple fatalities is moderate within 2 km; lower to 8 km. **Moderate reduction in fatalities to 2 km; greater to 8 km**
Moderate instantaneous-release (900 kg HD)	Fatalities possible to 7 km; potential for multiple fatalities is high within 2 km; lower to 7 km. **High reduction in fatalities at all distances**	Fatalities possible to 2 km; potential for multiple fatalities is moderate within 5 km; low to 2 km. **Low reduction in fatalities to 2 km**	Fatalities possible to 1 km; potential for multiple fatalities is low. **Potential for precautionary measures is low**
Small instantaneous release	Fatalities possible to 1 km; potential for multiple fatalities is low. **High potential for taking precautionary measures**	Fatalities possible to 0.2 km; potential for multiple fatalities is very low. **Low potential for precautionary measures**	Fatalities possible to 0.15 km; potential for multiple fatalities is very low. **Precautionary measures unlikely**
Large semicontinuous release (4000 kg HD)	Fatalities possible to 100 km; potential for multiple fatalities is very high within IRZ; lower in PAZ and PZ. **High reduction in fatalities at all distances**	Fatalities possible to 10 km; potential for multiple fatalities is high within 2 km; lower to 10 km. **Low reduction in fatalities to 2 km; high at greater distances**	Fatalities possible to 7 km; potential for multiple fatalities is high within 2 km; lower to 10 km. **Low reduction in fatalities to 5 km; high at greater distances**
Moderate semicontinuous release (100 kg HD)	Fatalities possible to 8 km; potential for multiple fatalities is very high within 2 km; lower to 8 km. **High reduction in fatalities at all distances**	Fatalities possible to 2 km; potential for multiple fatalities is moderate within 5 km; lower to 2 km. **Moderate reduction in fatalities at 2 km**	Fatalities possible to 1.5 km; potential for multiple fatalities is high within 5 km; lower to 1.5 km. **Low reduction in fatalities at 1.5 km**
Large Spill (900 kg HD)	Potential for fatalities is very low. **High likelihood of successful precautionary measures**	Potential for fatalities is very low. **High likelihood of successful precautionary measures**	Potential for fatalities is very low. **High likelihood of successful precautionary measures**

generic recommendations contained in the ERCP in light of site-specific data and information.

Technical support studies on such critical topics as hazard assessment, public information, emergency worker training, and protective action are being undertaken. The Army also has signed a comprehensive Memorandum of Understanding with FEMA to "take the lead in working with state and local governments in developing off-site emergency plans" and provide "liaison, coordination and oversight between the Army and federal, state and local governments in developing off-site emergency preparedness plans" (Becton and Shannon, 1988, p. 4). FEMA also has agreed to take the lead in developing planning standards and evaluation criteria, providing training, developing and conducting exercises, and providing public information. The Army has agreed to provide technical assistance and to take the lead in developing exercise design and criteria, conducting site-specific hazard analyses for emergency preparedness plans, and reviewing FEMA assessments of preparedness. FEMA and the Army have agreed to pursue jointly the determination of emergency preparedness funding requirements by fiscal year to facilitate the Army's request for necessary funding. In addition, a FEMA/Army Joint Steering Committee has been established to review the status of the joint emergency preparedness programs; to discuss, consult on, and resolve major policy issues; and to provide direction in meeting the overall goals of the program.

The purpose of the memorandum was to draw on FEMA's expertise and experience with state and local governments in developing and implementing emergency preparedness programs and to integrate that capability with the Army's considerable technical expertise with these extremely dangerous chemical agents. The Memorandum of Understanding exemplifies the need for cooperation and understanding between all parties to ensure a successful program. The need for an integrated approach to emergency management has never been more apparent than in the CSDP.

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