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FINAL REPORT

COMMUNITY REVIEW SUPPORT STUDY:
ABERDEEN AREA

Contract No. DAAA15-87-0033

Prepared for

Office of the Program Executive Officer
Program Manager for Chemical Demilitarization
Aberdeen Proving Ground, Maryland

Prepared by

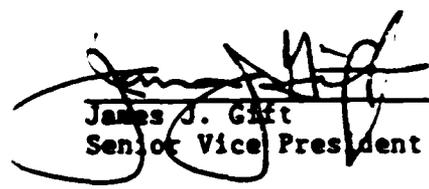
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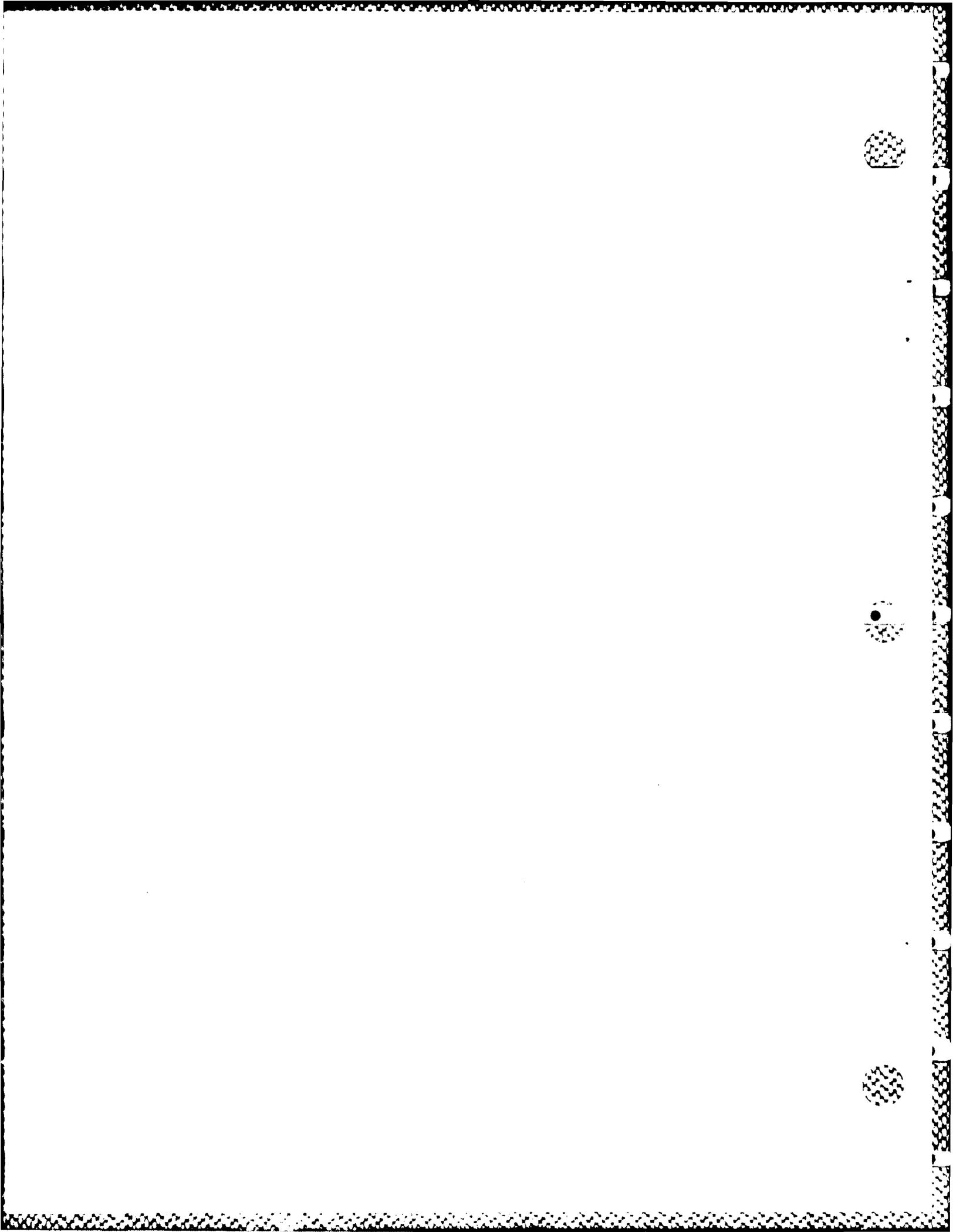
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ACRONYMS

AI	Agent Incinerator
ANAD	Anniston Army Depot
APG	Aberdeen Proving Ground
APSZ	Agricultural Protection and Sheltering Zone
ARI	ARI Engineering
ASC	Allowable Stack Concentration
CAIRAP	Chemical Accident and Incident Response and Assistance Plan
CAMDS	Chemical Agent Munitions Disposal System
CAMPACT	Chemical Ammunition Package Transporter
CASY	Chemical Agent Storage Yard
CCME	Concerned Citizens for Maryland's Environment
CDC	Centers for Disease Control
CONUS	Continental United States
CSDP	Chemical Stockpile Disposal Program
DDI	Decontamination/Detoxification Incinerator
DHHS	Department of Health and Human Services
DOT	U.S. Department of Transportation
DPEIS	Draft Programmatic Environmental Impact Statement
DRE	Destruction and Removal Efficiency
DTE	Dual Technology Evaluation (Program)
DTE-S	Dual Technology Evaluation-Sequenced
EBS	Emergency Broadcast System
EIS	Environmental Impact Statement
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
EPZ	Emergency Planning Zone
ERCP	Emergency Response Concept Plan
FPEIS	Final Programmatic Environmental Impact Statement
GPL	General Population Limit
H, HD, HT	Forms of mustard agent
HCl	Hydrogen chloride (hydrochloric acid)
IDLH	Immediately Dangerous to Life and Health
IRZ	Immediate Response Zone
ISC	Industrial Source Complex air dispersion model

ACRONYMS (Cont.)

JACADS	Johnston Atoll Chemical Agent Disposal System
JI	Johnston Island
JOT	JACADS Operational Testing (Program)
JOT-S	JACADS Operational Testing-Sequenced
LIC	Liquid Incineration Furnace
LASH	Lighter Aboard Ship
LBAD	Lexington Bluegrass Army Depot
LC ₅₀	Lethal dose to 50 percent of those exposed
MBP	Modified Baseline Program
MITRE	MITRE Corporation
MVI	Municipal waste incinerator
NAAQS	National Ambient Air Quality Standards
NDC	National Disposal Center
NEPA	National Environmental Policy Act
NO _x	Nitrogen oxides
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OSTP	Office of Science and Technology Policy
PAH	Polycyclic Aromatic Hydrocarbons
PAZ	Protective Action Zone
PCB	Polychlorinated Biphenyls
PEL	Permissible Exposure Limits
PIC	Products of Incomplete Combustion
POHC	Principal Organic Hazardous Constituents
PVI	Pathological Waste Incinerator
Q*	Carcinogenic potency factor
R and D	Research and Development
RCRA	Resource Conservation and Recovery Act
RDC	Regional Disposal Center
SO ₂	Sulfur dioxide
SOP	Standard Operating Procedure
TCDD	2,3,7,8-tetrachlorodiphenyl dioxin
TEAD	Tooele Army Depot
TRUPACT	Prototype Transportation Container
TVA	Time Weighted Average

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1. EXECUTIVE SUMMARY

EA Engineering, Science, and Technology, Inc. has prepared this report for the Office of the Program Executive Officer, Program Manager for Chemical Demilitarization, Aberdeen Proving Ground (APG), Maryland, as required by the terms of the study contract (Number DAAA15-87-C-0033) which was awarded on 28 April 1987.

STUDY OBJECTIVES/AREAS OF CONCERN

The objectives of the study required EA to perform an independent evaluation of the July 1986 Chemical Stockpile Disposal Program Draft Programmatic Environmental Impact Statement (Dept. of the Army 1986); review and comment on several ongoing additional studies being conducted by the Army and its contractors addressing areas of concern; and to perform independent studies as necessary to address the areas of concern.

SCOPE OF EFFORT

The scope of activities involved review of the DPEIS and the public record containing testimony and comments prior and subsequent to the release of the DPEIS; review of draft documents addressing specific areas of concern; attendance and participation at project review meetings between the Army and its contractors to discuss the draft documents; and interaction with and briefings of a Citizens' Steering Committee organized to guide and assist the EA Study Team in these efforts.

APPROACH AND METHODOLOGY UTILIZED

EA Study Team members were assigned responsibilities to follow progress, attend review meetings, and review documents on specific areas of concern. In total, Study Team members attended approximately 15 review meetings and reviewed 15-20 documents addressing specific study areas. In addition, EA developed an air dispersion model using meteorological

data from the Edgewood Area, and had an emergency evacuation analysis performed by a traffic consultant.

EXTENT OF COMMUNITY INVOLVEMENT

Following publication of notices in all Harford County newspapers, a public informational meeting was held on 21 May 1987. At that meeting, the public was informed about the study scope and approach and was invited to identify additional concerns. Interested persons were invited to apply for membership on a Citizens' Steering Committee to guide the Study Team.

Based on the applications received, a Steering Committee was formed, and met on 4 June 1987. The Steering Committee reviewed the list of community concerns and established the following five priority areas for further analysis by the Study Team:

- . Evaluate the hybrid alternative: water transport from APG to Johnston Atoll
- . Determine the cost and feasibility of an emergency response program at APG
- . Investigate health effects (other than acute lethality) of mustard agent
- . Develop a site-specific exposure assessment for APG
- . Evaluate the alternative selection criteria in light of possible extension of the program completion date

FINDINGS, OBSERVATIONS, AND CONCERNS

- . The Army and its contractors have been cooperative and forthcoming in providing information and assistance.

- . The Study Team supports the Army's decision to develop two additional alternatives (hybrid alternative calling for partial relocation and an alternative to optimize safety/cost considerations).
- . Delayed receipt of some documents and postponement of some review meetings have not allowed sufficient time for thorough integration of all additional study findings. For example, mitigation recommendations are based on earlier risk analysis data.
- . EA's review of the DPEIS revealed the following major deficiencies:
 - Except for lethality, potential health effects were not addressed in the health and risk assessment.
 - The generic approach used, although perhaps reasonable for addressing the impacts of transportation accidents for the regional and national alternatives, does not adequately describe impacts specific to the individual installations.
 - It is possible that some potentially viable alternatives were eliminated prematurely, such as water transport and limited relocation alternatives.
 - In many instances, the information presented in the DPEIS appears insufficient to support the conclusions drawn.
- . Health effects of mustard agent besides acute lethality should be taken into account when determining the population at risk.
- . The Final Programmatic Environmental Impact Statement (FPEIS) needs to include more complete information on incineration chemistry, incinerator design, expected variations in operating conditions, products of complete and incomplete combustion, and scrubber waste products.

- . Data used in the Multiple Stacks Reports are incomplete. The report needs to include a broader list of compounds of concern and substantiation of emission rate calculations.
- . The description of the monitoring program needs to be strengthened to document that the proposed program is capable of detecting potential threats to the general population in a timely fashion, and to identify the actions that will be taken in response to adverse monitoring data.
- . Site-specific emergency response planning should involve adjacent local jurisdictions and should be initiated as soon as possible. Regardless of the disposal alternative selected, a "fixed-site" emergency response plan will be required for the Edgewood Area.
- . The partial relocation alternative involving rail transport of bulk mustard agent from APG to Tooele would involve a limited number of trips. The recommendations included in the transportation, mitigation, and packaging reports appear to reduce significantly the risks associated with rail transport. Revised risk assessment estimates need to be incorporated into the evaluation of the partial relocation alternative. The rail transport option for the APG stockpile appears to be feasible and should receive serious consideration in the FPEIS.
- . The air transport option under the partial relocation alternative should not be considered as a viable transportation option for the APG stockpile. The recommendation for exclusion of air transport from further consideration is based on the difficulty of implementing an emergency response capability and the risk of a catastrophic release of chemical agent during the air transportation phase.
- . The Study Team's overall impression of the risk analysis is that essentially all scenarios with a potential for catastrophic consequences are initiated by external events with extremely low probabilities; however, we do not have a clear picture of the situation with respect to higher frequency events associated with low releases.

The latter could be of concern because of the potential carcinogenicity of mustard. Along the same lines, the Study Team is concerned about the criteria used to screen alternatives.

- . Freezing of mustard agent during transport offers significant improvements in risk mitigation.

- . EA reviewed two reports of chemical incidents that occurred in 1987, one at the Tooele, Utah Chemical Agent Munition Disposal System (CAMDS), and one at Johnston Island. At CAMDS there was leakage of residual agent from a pipeline within the facility at a time when it was not in operation, and a failure of the ventilation and exhaust air filtration systems to contain the release within the facility. No injury or property damage resulted, however. At Johnston Island four workers were exposed to agent GB while they were repackaging a leaking munition; agent vapor had passed through openings in the workers' protective clothing and was absorbed through the skin. Deficiencies in management and quality assurance were cited as factors contributing to the CAMDS incident. The Johnston Island worker exposure was related primarily to limitations of the workers' protective clothing, but departures from standard operating procedures (SOPs) were also noted.

The Army's recommended corrective actions at Tooele included physical changes to the facility, strict attention to existing SOPs, development of additional SOPs, and implementation of an enhanced quality assurance program to provide continuing review of the system so that problems can be prevented. Improved compliance with SOPs was also recommended for Johnston Island, together with acquisition of better protective clothing. The Study Team found both investigations to be thorough, and believes that the recommendations made are appropriate to minimizing the likelihood of similar incidents in the future. Both incidents demonstrate the importance of monitoring in detecting and responding to problems in a timely fashion.

RATIONALE/PRESENTATION OF CONCLUSIONS AND RECOMMENDATIONS

The basis for the following conclusions and recommendations is presented in the report. However, since several of the ongoing studies are still being refined by the Army and its contractors, revisions to these conclusions are quite possible as new information becomes available.

Site-Specific EIS

Although significant progress is being made in generating new information and data to improve the FPEIS the Study Team recommends that a site-specific EIS be developed for the Edgewood Area and that the final decision concerning the APG stockpile be based on the site-specific assessment.

A site-specific EIS is warranted for the Edgewood Area of APG because there are several important site-specific differences between APG and the other seven chemical agent stockpiles. These are:

- . the highest population density is in the vicinity of the proposed incinerator
- . the Edgewood Area is the only site where water transport is feasible
- . the stockpile contains only HD mustard agent in ton containers
- . APG is located adjacent to an important estuarine system.

If new information concerning these unique characteristics emerges during the preparation of the site-specific EIS, then the programmatic alternative should be reevaluated.

Marine Transport of APG Mustard Agent

Transport of mustard agent to Johnston Island by the LASH-lighter system is feasible. The Study Team was not able to evaluate fully this alternative relative to other disposal options because the comparison of alternatives requires access to classified information. The results of the mitigation analysis based on the current transportation plan need to be incorporated into a refined risk assessment for marine transport. It appears that the mitigation proposed for the water transport would significantly reduce the initial projections of risk. If this is true, the water transport option is a feasible alternative and should receive serious consideration in the FPEIS and subsequent site-specific EIS.

Emergency Response Program

- . A site-specific emergency response plan for the Edgewood Area will be required to address any selected disposal alternative. A wider range of accident scenarios will need to be considered, including the low probability/high severity accidents. The major concern in addressing these latter scenarios is streamlining the decision process so that an offsite alert and notification, if required, can be made as rapidly as possible. A more streamlined critical decision path is required for a rapidly escalating major chemical release.
- . The site-specific emergency response plan should include an accident classification system enabling a rapid decision-making process for accidents with moderate to severe consequences. The Edgewood Emergency Operations Center (EOC) should have the authority to implement an offsite alert and notification.
- . The response plan should evaluate the feasibility of a sequential notification and evacuation of the risk area population with priority for the areas within and immediately adjacent to the projected plume trajectory. This will reduce anticipated congestion of the major evacuation corridors. However, such sequential evacuation may prove difficult to implement and control following initial notification.

- . The preliminary evacuation time estimates indicate that if the on-base population is included in any evacuation scenario, significant delays to overall evacuation will be encountered. Where feasible, sheltering of base population or limited evacuation to specified areas on-post and outside of the plume trajectory should be the preferred protective actions for the base population.
- . If the onsite disposal alternative is selected, the site-specific EIS should consider the benefits of relocating the incinerator 3-3.5 mi south of the proposed site on Eagle Point. The location of the incinerator farther down the Gunpowder Neck would greatly reduce the need for protective actions offsite.
- . Sheltering special populations offsite should receive careful attention in the preparation of the site-specific emergency response plan. At a minimum, the feasibility of installing ventilation systems in the public schools in the Edgewood Area should receive serious consideration. Evacuating the school-age population in this area is not a feasible option. Other special populations in the Edgewood/Joppatowne Area include numerous boarding homes, group homes for the elderly, and day care centers.
- . Evacuation or sheltering may not be feasible under the worst-case scenario for the portion of the Edgewood/Joppatowne community living in closest proximity to the installation.

Health Effects

- . The Permissible Exposure Limits (PELs) for the worker and general populations were not derived according to current acceptable guidelines. The Army needs to reassess these limits in light of current standards. This is not to suggest that the chemical demilitarization program be delayed to allow time to conduct additional toxicological studies; rather, the Army needs to consider using methodology developed by Oak Ridge National Laboratory (ORNL) for quantitatively assessing the carcinogenic potency of mustard. Should the EPA

eventually assess mustard's potency on a quantitative basis, the Army would need to take this into consideration as well.

- . The PEL for the general population is a standard that is to be protective of public health based upon a lifetime exposure. Using ORNL's carcinogenic potency assessment, the carcinogenic risk associated with lifetime exposure to this PEL does not fall within acceptable levels. However, the incineration of mustard is to last only 2 years at APG. The risk associated with a 2-year exposure to the PEL falls within a "gray" area of acceptability and would need to be evaluated further with the total population at risk being taken into consideration in order to determine its acceptability. The Army needs to reevaluate the PEL as an acceptable lifetime exposure limit.
- . The PEL for the stack concentration was not based upon health considerations, but rather on analytical detection capabilities. However, on a site-specific basis at APG, it appears to offer an acceptable level of protection which is several orders of magnitude greater than that provided by the general population PEL.
- . The basis of the toxicity values used in the D2PC model to assess the risk of various accident scenarios could not be determined from the references cited in the DPEIS. The Army has indicated that the document from which these values were derived is classified. It would be appropriate for this document to be cited in the FPEIS and to be provided to ORNL staff so that they may evaluate the validity of the numbers and recommend any changes, if necessary, in the use of these values in the D2PC model.
- . The toxicity values used in the D2PC model are for healthy adult males and do not reflect levels for sensitive subpopulations. These populations need to be taken into account in any site-specific risk assessment for APG.

- . Acute lethality is the only toxic endpoint that is considered in assessing the risk associated with different accident scenarios. Acute exposure to mustard, however, can cause a variety of other effects both acute and chronic. These need to be taken into account in any site-specific risk assessment for APG.

Exposure Assessment

Moving the location of the incinerator approximately 3.5 mi south of the proposed location would markedly reduce human exposure. This move would mean that a slightly different population would be at risk, but that the total exposed population would be much smaller. If such a move is made, then careful consideration has to be given to balancing the potentially increased risks of transporting the ton containers a greater distance and the benefits to be gained from reduced human exposure.

Revisions to Alternatives

The revisions to the program completion date and the changes inherent in any of the new options that may be selected are expected to impact the selection of the preferred alternative for disposal of the stockpiled agent at APG as follows:

- . Improve the level of confidence in the JACADS technology
- . Obtain and apply verification or operating data in designing the CONUS facilities
- . Allow more time for verification of transportation plans and packaging concepts
- . Allow more time for developing and testing improved monitoring technologies
- . Allow more time for exploring and devising improvements in emergency response plans

2. INTRODUCTION

The U.S. Department of Defense is required by Public Law 99-145 to destroy the stockpile of lethal chemical agents and munitions stored at eight U.S. Army installations in the continental United States in addition to chemical agents stored at Johnston Island in the Pacific. Public Law 99-145 includes a mandate to destroy all stockpiles by 30 September 1994.

The Chemical Munitions Stockpile Disposal Program has been developed by the U.S. Department of Defense to eliminate the stockpile and reduce any hazards that are associated with the storage, transfer, or disposal of these materials. The U.S. Army, through its Program Executive Officer - Program Manager for Chemical Demilitarization, has prepared a Draft Programmatic Environmental Impact Statement (Dept. of the Army 1986). The programmatic approach was selected because the action is national in scope and involves a number of complex, interrelated actions. Subsequent to selection of a disposal alternative and completion of the Record of Decision, additional environmental documentation will be prepared to address the unique impacts of the selected alternative at each chemical agent stockpile location.

Aberdeen Proving Ground (Edgewood Area) is one of the sites presently used for storage and is a candidate site for onsite incineration, the preferred disposal alternative identified in the DPEIS. The Chemical Agent Storage Yard (CASY) at Edgewood contains only bulk ton containers of mustard agent, representing 5 percent of the national stockpile of chemical agents.

EA Engineering, Science, and Technology, Inc. was awarded a contract to provide an independent evaluation of the DPEIS and additional studies undertaken by the Program Manager in preparation for the Final Programmatic Environmental Impact Statement. The Community Review Support Contract awarded to EA is one of five such contracts the purpose of which is to address the concerns raised by residents of the communities surrounding five of the eight chemical agent stockpiles. EA's approach

to this charge has been to review the DPEIS and supporting documents in light of the particular circumstances surrounding the disposal of mustard agent at APG. Hence, this report does not provide an in-depth evaluation of the onsite disposal or transportation alternatives for nerve agents or munitions.

The DPEIS, released for public comments on 1 July 1986, assessed the health and environmental impacts associated with the proposed approach to disposal of the chemical munition stockpile by each of the following four alternatives:

- . Onsite disposal at each of the existing storage installations.
- . Transportation to regional disposal centers (RDCs) at Anniston Army Depot (ANAD) and Tooele Army Depot (TEAD).
- . Transportation to a national disposal center (NDC) at TEAD.
- . No action/continued storage, an alternative required by the National Environmental Policy Act (NEPA), although ultimately disposal of the stockpile is necessary.

As a result of public comments on the DPEIS, the Program Manager for Chemical Munitions added two additional alternatives for consideration in the Final Programmatic Environmental Impact Statement (FPEIS). These are:

- . Partial Relocation/Disposal option--transport of chemical agent stockpile from APG and Lexington Bluegrass under various transportation modes (air, rail, and barge) to various disposal sites (ANAD, TEAD, and Johnston Island). This is a modification of the onsite disposal alternative with offsite transport considered for the two installations located in urbanized areas and containing limited chemical agent stockpiles.

- . Safety/cost optimized alternative--encompasses several options for evaluating, operating, and adapting the JACADS technology to the other sites and may involve delaying the disposal program from its existing target completion date of 1994.

The involvement of interested residents from Harford and Baltimore Counties was central to guiding EA's work efforts. Section 3 describes the public participation process developed for this study. Section 4 provides a brief overall evaluation of the DPEIS. Section 5 includes our critique of the additional studies, and Section 6 describes the detailed evaluation of the five priority community concerns.

3. PUBLIC PARTICIPATION PROCESS

The involvement of concerned citizens of the Edgewood/Joppatowne area was essential to the successful completion of this report. The purpose of EA's review effort is to address the major concerns of the communities adjacent to the Edgewood Area. The basic approach to public participation involved the establishment of a steering committee to guide and review EA's workscope activities. The short timeframe of the contract and the complexity of the issues involved favored establishing a small working group of concerned and informed residents to prioritize our tasks and review the draft document.

One of the first steps in the public participation process was to review the public record from earlier meetings involving the Edgewood Area communities. Testimony presented at the scoping meeting held on 13 May 1986 and the public hearing on the DPEIS held at Edgewood on 7 August 1986 was reviewed and categorized. Additional testimony from other public hearings on the DPEIS and from congressional hearings was also reviewed. The public record was used to identify the full range of community concerns.

EA staff met in early May with the local community group, Concerned Citizens for Maryland's Environment (CCME), which has been active in following the progress of the Chemical Demilitarization Program at Aberdeen. We briefed the group on the contract workscope and heard their views and concerns.

During the week of 10 May, notices were published in the Harford County newspapers, announcing EA's intent to hold a public meeting to inform the public about the study contract and to identify local concerns. The compilation of community issues identified through review of the public record was presented at the hearing as a starting point for discussion. Attendees provided valuable comments which permitted a refinement of the list of identified concerns. Table 3-1 lists the full range of community concerns including revisions based on public comments from the 21 May

TABLE 3-1 COMMUNITY CONCERNS

Public Health Hazard of Onsite Incineration

- Immediate hazard from accidental release
- Cumulative and long-term health risks from permissible exposure levels
- Increased risks to various age and gender classes
- Cumulative and/or synergistic effects of multiple incinerators
- Generic dispersion models tend to overgeneralize downwind hazard distances
- The varying time period populations are exposed to health hazard should be incorporated into risk analysis

Incomplete Evaluation of Transportation Alternatives

- Water transport from APG to Johnston Atoll was not adequately evaluated
- Packaging and other risk mitigation alternatives for air and rail transport were not adequately evaluated
- Can additional site-specific information overturn the programmatic EIS recommendation for onsite incineration at APG

Technology

- JACADS technology unproven
- JACADS selected because of mandated deadline for disposal
- Inadequate time for monitoring burn efficiency and combustion by-products at full-scale JACADS plant
- DPEIS did not evaluate the fate of the 5 percent stabilizers in bulk mustard gas during incineration
- Inadequate evaluation of alternative disposal technologies
- Potential for incomplete combustion
- Need for real time monitoring capability
- Disposal of waste products, primarily saits with detectable heavy metal contamination

Emergency Response Issues

- FPEIS should address unique characteristics of Edgewood area--population density, limited exit routes, existing emergency response deficiencies
- Population at risk did not include work force and school populations
- Cost and feasibility of developing an adequate emergency response capability

Environmental Impacts to Chesapeake Bay

- From accidental release
- Permissible exposure levels
- Persistence of mustard agent in environment

Operation of JACADS

- Can operating hours be restricted to daylight hours and periods of favorable wind direction?
- Level of work force training
- Need for better coordination with State review agencies
- Can the JACADS facility be located in a more remote location on the Base?

TABLE 3-1 (Cont.)

Fiscal Responsibility

- Potential for cost overruns
- Onsite cost estimates should include improving local emergency response systems
- Can residents seek compensation from U.S. Army or JACADS contractor?

Other Concerns

- Extension of 1994 deadline recommended
- Although the vast majority of residents favor the offsite alternative for APG some residents did recommend onsite incineration
- Recommend site-specific EIS be prepared for APG
- European stockpiles will be transported--why is that not possible for APG?
- Possibility that JACADS facility at APG may be used for other chemical agents
- Status and content of proposed pilot training facility at Edgewood

public meeting. The meeting was also used to solicit applications for membership to the Citizens' Steering Committee. Thirteen applications were received.

The first steering committee meeting was held on 4 June 1987 to prioritize the list of community concerns and to determine which areas deserved an in-depth evaluation by the EA project team. The EA Study Team presented the following five priority areas for further evaluation, which reflected our best prioritization of the community concerns. The overall objective reflects an emphasis on public health hazards over environmental impacts.

- . Evaluate the hybrid alternative: water transport from APG to Johnston Atoll;
- . Determine the cost and feasibility of an emergency response program at APG;
- . Investigate health effects (other than acute lethality) of mustard agent;
- . Develop a site-specific exposure assessment for APG; and
- . Evaluate the alternative selection criteria in light of possible extension of the program completion date.

These priority concerns were discussed with the Steering Committee and consensus was reached that these areas merited further evaluation by EA staff.

The second meeting of the Steering Committee was held on 1 July. EA project staff presented a summary report on the project team's progress in reviewing the additional studies. In addition a detailed approach to investigating the five priority concerns was discussed.

4. EVALUATION OF DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (DPEIS)

The DPEIS is remarkably comprehensive given that little more than 5 months had elapsed between the 28 January 1986 Notice of Intent to prepare the document and its 1 July 1986 completion date; however, the document appears to suffer from several shortcomings which are discussed below. A number of these, but not all, are being addressed in the additional studies reviewed in Section 5.

Although the comments that follow focus primarily on issues specific to the Edgewood Area of the Aberdeen Proving Ground, where chemical demilitarization is to be limited to mustard agent in ton bulk containers, many of the issues raised are also applicable to the other seven installations storing chemical agents.

In general, our concerns fall into four categories:

1. Except for lethality, potential health effects have not been addressed in the human health risk assessment.
2. The generic approach of the DPEIS, although perhaps reasonable for addressing the impacts of transportation accidents for the regional and national alternatives, does not adequately describe impacts specific to the individual installations.
3. It is possible that some potentially viable alternatives (e.g., water transport) were dismissed prematurely.
4. In many instances, the information presented in the DPEIS is insufficient to support the conclusions drawn.

4.1 HEALTH EFFECTS

The DPEIS considers only acute lethality in assessing risk from exposure to mustard during normal operations and accident scenarios. Although nonlethal acute effects, and lethal and nonlethal chronic effects are discussed, they are not factored into the risk assessment. Mustard can cause severe and permanent damage to the eyes, skin, and lungs; it also can cause cancer. These other effects need to be considered in performing a complete risk assessment, taking into account the total population exposed, as well as potentially sensitive subpopulations.

The health effects data used in the DPEIS are based on exposure of military personnel, i.e., healthy young men. The general population at risk encompasses sensitive subpopulations including the young, the elderly, and the infirm.

The toxicity database on mustard agent consists for the most part of old, meager, and, by 1987 standards, inadequate data. The toxicity values cited in the DPEIS often are not well referenced (i.e., primary references not cited), making it difficult to ascertain the scientific and/or experimental basis for some of these values. For example, the basis of the toxicity values used in the D2PC computer model could not be determined from the references cited in the DPEIS nor from the references cited within these references (Section 6.3.2).

EA has identified two apparent contradictions concerning health effects data. The first is between Table 4.2.1 (p. 4-3) and Table 4.7.1 (p. 4-92). The former lists the "ambient standard" for mustard as $0.003 \mu\text{g}/\text{m}^3$ whereas the latter gives a much higher value, $0.0001 \text{ mg}/\text{m}^3$ (or $0.1 \mu\text{g}/\text{m}^3$) as the Army's "permissible exposure limits" for the general population. The origin of the first figure is not specifically referenced, and the document contains no explanation of the difference. The Army, however, has indicated to EA that Table 4.2.1 is incorrect.

The second contradiction is between pages B-12 and B-15 of Table B.2 where the same value (1,500 mg-min/m³ or 150 mg/m³ for 10 minutes) is given as both the human inhalation LCt₅₀ (dose lethal to 50 percent population exposed) and the lowest lethal dose via inhalation. It is inconceivable that the lowest concentration capable of causing death would at the same time be capable of causing 50 percent mortality. The DPEIS again gives no explanation of this discrepancy.

4.2 GENERIC APPROACH

EA questions whether the use of generic communities for comparison of impacts of alternatives is valid. We recommend the use of actual data from the impacted communities so that the comparison of alternatives is real. The generic approach also limits the likelihood of selecting a hybrid alternative, which can only be derived by including site-specific information.

The generic approach breaks down completely with respect to potential effects on surface water quality and aquatic life at APG. The generic model is based on dispersion and dilution in a riverine system; however, this model is not applicable to the estuarine waters surrounding APG where there is minimal freshwater input and where circulation is tidally influenced.

4.3 ALTERNATIVES

It is possible that some potentially viable alternatives have been eliminated prematurely. For example, water-based transport of APG stocks was dropped because of the potential effects of an accident on human population along the Chesapeake Bay, and on the aquatic life of the Bay itself. However, information presented at the June meeting of the risk analysis task force indicates that transport via lighter aboard ship (LASH) vessels is substantially less prone to accidents involving agent release than the DPEIS suggests.

It is possible that even chemical neutralization of mustard could become viable with appropriate research and development. EA recognizes, however, that the time constraints imposed by Congress probably prohibit such an R and D program.

4.4 INSUFFICIENCY OF INFORMATION

EA has noted a number of areas where the DPEIS fails to present key information in support of conclusions.

- . Although the document discusses accident scenarios in considerable detail, there is relatively little coverage of normal operations--it is presumed that normal operations pose no problems. There is no discussion of the products of incomplete combustion that might be expected under less than optimal conditions. What are these products, and what toxicity is associated with them?
- . The monitoring section of the document needs to be expanded significantly and must clearly address how real-time monitoring data will be obtained. Of particular concern is the monitoring of concentrations of mustard agent to protect against the carcinogenic properties of this agent.
- . There is no discussion in the DPEIS of what corrective actions will be taken in the event of system upsets or accidents. Such detail should include a description of procedures for managing a flameout of the incinerator, and what redundancies will be built into the system to prevent accidental releases.
- . The section describing the packaging concept for rail transport needs to be developed in more detail.
- . The Permissible Exposure Limits are listed on page 4-92; however, the rationale for these limits is not discussed.

- . The DPEIS discusses the calculation of distances to no-death, 1 percent lethality, and LCt_{50} concentration from potential accident sites. The concentrations of agent associated with no-death and 1 percent lethality are stated on page B-19; however, there is no indication of how the no-death concentration was derived. For 1 percent lethality, the DPEIS states that the basis for the number was not available, and there is no discussion of what concentration was used for the LCt_{50} .
- . Page 4-21 states that the toxicity of mustard agent to aquatic life is unknown; page 4-27 contains a similar statement concerning the effects of mustard on wildlife.

5. REVIEW OF ADDITIONAL STUDIES

As a result of comments made on the DPEIS and on its own initiative, the Army began a series of "additional" studies designed to investigate and address specific areas of concern. This section of the report discusses briefly the content and status of these studies and also provides the EA Study Team's commentary on the findings of the studies as of the time that draft reports were reviewed and/or review meetings were held.

5.1 MITIGATION STUDY

The purpose of the mitigation study was to identify and consider measures which might reduce the risk to the public that is associated with any of the disposal alternatives under consideration. The accident scenarios from the risk analysis study were screened to identify those which might present an unreasonable public risk. These particular accidents were then analyzed in order to determine what mitigation measures, if any, might be taken. The proposed measures were evaluated based upon technological feasibility, cost, impact on the 1994 program deadline, and the benefits if implemented. The mitigation study also involved the establishment of safety goals for the Chemical Stockpile Disposal Program (CSDP) (Dept. of the Army 1987a). It is currently the Army's intention to assess each site to see if each meets the safety goals.

The mitigation study is not yet complete and, therefore, it cannot be commented on in full. However, major portions of the report have been written in draft form and presented to the community study teams for review. The report is based on the November 1986 version of the risk analysis which is currently being rewritten. The accident scenarios identified in the November version are for the most part remaining as such, but additional scenarios associated with barge transport from the Aberdeen Proving Ground and air transport from APG and Lexington Bluegrass are now being included as well. Therefore, these accidents have not been fully assessed for purposes of mitigation. The revised risk analysis will also contain different probability numbers and consequences which may or may not influence whether any of the original scenarios now

would need to be assessed for mitigation measures. The mitigation report will be redone to reflect the risk revisions, and it is currently thought that this will be done prior to the next PEIS.

5.1.1 Safety Goals

The safety goals under current consideration are similar to those that were developed for the nuclear power industry. These goals, which are based upon risk per site, are presented in Table 5-1.

These limits appear to represent reasonable levels of risk and, in fact are more conservative than the quantitative objectives established by the Nuclear Regulatory Commission, especially when the scope of activities of each program is considered. For example, the NRC objectives cover only reactor accidents and do not include risks associated with the transport of the radioactive materials. The CSDP safety goals would include such risks. It was indicated, however, that the proposed safety goals may be changed in the final mitigation report because the disposal program may not be able to meet them as currently proposed. Since the goals do seem to be quite conservative, some revision might be acceptable. However, any changes will need to be reviewed as to their impact on the level of protection being proposed.

5.1.2 Screening Criteria

In order to focus the mitigation study effort on those accident scenarios which had the greatest potential for making significant contributions to the overall risk of each disposal alternative, several screening factors were used. They are presented in Table 5-2.

The risk posed by an accident consists of two components: the probability of the accident occurring and the consequences of that accident (in this case the no-death distance). Both of these factors were used in the screening process. In addition, there were one or two other accident scenarios with probabilities $<10^{-8}$ which were included in the mitigation

TABLE 5-1 APPROACH TO SAFETY GOALS

<u>Parameter</u>	<u>Recommended for CSDP</u>
Cumulative Upper Bound Accident Frequency Limit That Endanger the Public	$10^{-5}/\text{yr}$
Individual Accident Sequence Frequency Limits That Endanger the Public	$10^{-7}/\text{yr}$
Catastrophic Accident Limits (100 Deaths or More)	$10^{-8}/\text{yr}$
Fatality Limits ^(a) Further Reduction of 100 in Frequency of Harm Credited to Containment and Emergency Response	$10^{-7}/\text{yr}$

(a) A frequency of a fatality of 10^{-7} per year is 0.01% of the frequency of death due to accidents of other causes.

TABLE 5-2 SCREENING FACTORS TO IDENTIFY ACCIDENTS
FOR MITIGATION ANALYSIS

Activity	Screening Factors
Storage ^(a)	Probability $>10^{-8}$ events per storage year and a "no-death, worst case" hazard distance >0.5 km ^(b)
Handling, onsite transport, demilitarization	Probability $>10^{-8}$ events per stockpile and a "no-deaths, worst case" hazard distance >0.5 km
Offsite transport	Probability $>10^{-8}$ events per stockpile and any release of agent if accident occurs offsite

(a) Includes handling related to leakers during storage.

(b) Hazard distance calculated with the D2PC model; "worst-case" meteorology (E stability, 1 m/sec).

study because their consequences were considered of great enough significance. It was unclear how these latter consequences were determined to be "significant enough." The screening process appears to have done a good job of culling out for mitigation analysis those accidents with the potential for posing the greatest risk to the public.

Of the several hundred accident scenarios identified in the risk analysis, approximately 30 were selected by the screening process for the mitigation analysis. Of those accidents reviewed, the study team appears to have done as comprehensive a job as reasonably possible given the time constraints and the fact that there were continual changes (e.g., packaging) being made in the CSDP that impacted the study. However, because the mitigation study is still incomplete, it would be appropriate for it to be reviewed in its final form.

The mitigation measures that have been proposed have also been analyzed based upon technological feasibility, cost, impact on schedule, and benefits. The mitigation report will eventually contain recommendations as to which measures should be considered for implementation. However, the latest version of the report that the community groups have seen does not contain these. Once the recommendations have been made, it is unclear who will be making the final decisions as to which measures will be implemented. It would be appropriate for this process to continue to be monitored by the community groups.

5.1.3 Barge/Air Transport from APG

As mentioned above, the November risk analysis upon which the mitigation study has been based did not include barge or air transport from APG. However, numerous accident scenarios have subsequently been identified and evaluated for the new risk analysis. At the time of the community review meeting, only a few had been considered for mitigation. It is expected that all pertinent accident scenarios associated with these alternatives will have undergone review by the mitigation team and be incorporated into the revised EIS.

5.2 MONITORING

EA reviewed four versions of the monitoring report:

- . A draft received on 12 May 1987
- . A revised draft dated 8 June 1987
- . A revised draft dated 24 July 1987
- . The final report entitled Chemical Stockpile Disposal Program Monitoring Concept Study dated 10 September 1987 (Kuryk et al. 1987)

The document has undergone considerable refinement between successive drafts and is the product of very substantial efforts on the part of both the Army program staff and contractor personnel.

The comments that follow focus primarily on the disposal of ton containers of mustard, the only agent of direct concern for the Edgewood Area of APG.

The document begins with a discussion of the attributes of a proper monitoring program (Section 1):

- . Monitoring instrumentation should measure the proper parameters at correct locations.
- . Intervals between measurements should ensure that useful information will be available in a timely fashion.
- . Instruments should be sufficiently sensitive to measure threshold quantities reliably.

Section 2 of the document compares the capabilities of available technologies with the standards for agent exposure. The four standards established for mustard are:

Immediately Dangerous to Life and Health (IDLH)	0.4 mg/m ³
Time Weighted Average for worker exposure (TWA)*	0.003 mg/m ³
Allowable Stack Concentration (ASC)*	0.03 mg/m ³
General Population Limit (GPL)*	0.0001 mg/m ³

* Also referred to as permissible exposure limits (PEL).

The overall message conveyed by Section 2, however, is that technology capable of detecting concentrations of particular interest to the public (GPL) in a timely fashion does not exist. Instrument response times for the highest standard (IDLH) are from 1 to 2 minutes. Response times for the TWA and ASC are about 8 minutes for Low Level Rapid Response Detectors; however, the best response time of so-called "historical monitors" at the GPL is fully 12 hours plus about 1 hour for analysis, assuming samples are analyzed immediately after collection. Furthermore, the GPL is a 72-hour average, not an instantaneous value.

The monitoring strategy presented in Section 2.6 of the document deals with these limitations and quite properly stresses monitoring of the potential sources of agent release as the key to protecting the general public. Unfortunately, the document does not present enough specific information to support the contention that source monitoring as contemplated will prevent exceedance of the GPL beyond the installation boundaries. For example, the allowable stack concentration for mustard

is 300 times the GPL, but nowhere is it stated that a 300-fold dilution is effected between the stack and the installation boundary. Both the multiple stacks report and modeling conducted by EA, however, indicate that the 0.03 mg/m^3 ASC is in fact protective of off-post populations at APG. Also, the frequency of measurements is not stated (except in such terms as "periodic") for a number of monitoring locations including the storage yard, the mid-bed space between the carbon filters, the filter stacks, and the installation perimeter. The document states that installation perimeter monitoring is not intended as an early warning system--storage area monitoring and disposal plant alarms are to serve that purpose. However, the only specific information on monitoring of the storage area is that there will be monthly low-level monitoring of storage structures. The document implies that there will be continuous monitoring of the storage yard but does not make a definitive statement to that effect.

Section 2 ends with a brief discussion of emergency response monitoring. It is curious that Section 2.6.6 fails to say anything about notifying the public that a release has occurred, nor does it discuss the role of monitoring in responding to a major release. Modeling of agent release based on meteorological conditions is mentioned, but it is not clear how this would be performed or how much time would be involved. For example, consideration should be given to the use of a real-time model that would continuously display plume configuration based on automatic input of current meteorological data.

Section 3 addresses process control and monitoring. Earlier drafts of the document emphasized that real-time, continuous process monitors would most likely provide the earliest indication of potential problems at the disposal plant; i.e., deviations from preset temperatures, pressures, flow rates, etc. would signal a process upset well in advance of agent monitors and in time to take corrective action to prevent a significant release. This concept does not get proper emphasis in the current monitoring report. Section 3 is now so generic that it does not mention what parameters are being measured, where and how often measurements are being taken, and what actions are to be taken in response to measurements

that are out of their normal limits. The document would benefit greatly from specific examples such as the discussion of the liquid incinerator in Appendix B of the June draft.

EA offers the following comment on Section 5, "Organizational Monitoring":

Page 5-5: In addition to the federal and state agencies mentioned in Section 5.7, county agencies should be afforded an opportunity to conduct independent review of the Army's operational data.

5.3 TRANSPORTATION OF CHEMICAL AGENTS AND MUNITIONS

In the transportation of lethal chemical agents, safety to humans is the primary consideration. This section deals with how hazardous materials should be handled and transported in order to ensure this margin of safety.

5.3.1 Offsite Transportation

For the offsite disposal alternatives, there are three transportation modes which can be used: rail, air, and water. In the rail mode, movements from all locations to both regional and national sites are considered. In addition, the partial relocation alternative includes rail movement for only the Aberdeen and Lexington Bluegrass stockpiles. Only two sites are considered for air transportation: Aberdeen and Lexington Bluegrass to Tooele. The water transportation involves the movement of the bulk mustard agent stockpile from Aberdeen to Johnston Atoll in the Pacific Ocean.

The following considerations guided the Transportation Panel (a group of independent experts charged with providing technical oversight to the MITRE consultant team) in the development of criteria for the transportation analysis. A program with a specialized and singular mission would

be created. The packaging system should have a redundancy in its safeguards. Munitions should be packed into containers as early as possible in the transport process. Lastly, zero risk cannot be guaranteed, and accidents may occur. Hence, the benefits of mitigating the impact of accidents by packaging munitions and bulk agents is crucial.

With safety as the main consideration for this project, one is forced to look at each aspect of the plan in detail. Packaging is the key to the safe completion of the transportation of these chemical agents and munitions. If the containers are designed to withstand normal handling, as well as the worst accident imaginable, the people and the environment will not be exposed to these lethal agents.

The operations of this program are covered in great detail in the report. Administrative controls will be in place during all onsite movements. Army personnel utilized will be experienced and knowledgeable in the handling of chemical munitions. There will be an unbroken chain of custody. Monitoring devices will be used throughout the process. Visual inspections will be made to assess any damage. Decontamination and repackaging of leaking munitions will be performed. Individuals will wear protective clothing and will be trained in personal safety. Army standards for these procedures will be followed.

The loading and unloading, holding, packing, and leaker processing areas will all be in an Army exclusion area surrounded by a security fence having anti-intrusion devices. Security guards will be posted 24 hours. The packing area will be inside an enclosed steel and concrete structure. The holding area adjacent to the packing area will have periodic low-level monitoring.

Prior to commencement of the program, a transportation operating plan and safety submission will be prepared for any of the transportation modes proposed. A preoperational survey will be performed as well as a sabotage vulnerability assessment. Medical support and emergency response plans will be developed. Personnel will be selected and trained, and

a central command office will be established. Finally, routes will be selected based on safety factors.

The transportation of chemical munitions by rail has two major alternatives. The first is to ship all the munitions to one site, Tooele, in 75 trainloads. The second is to ship them to Tooele and Anniston in 55 trainloads.

Each munitions train would be preceded by an escort train. Buffer cars would be placed on the munitions train. Current planning envisions the use of gondola cars as the preferred type of rail car for transporting overpacked agent containers. In addition, state-of-the-art detectors of overheated bearings are recommended.

The routing is an important consideration in rail transportation. The most direct route minimizes travel time, reducing risk. The highest quality track minimizes potential for track-caused derailments and accidents. However, routes using these two criteria frequently pass through major metropolitan areas. Routing would necessarily involve tradeoffs between track quality and population density along the route.

The standard crew would be augmented by a railroad officer to serve as crew leader. The crew would be trained by the Army on emergency procedures. The speed should not exceed 50 MPH at any time, and would be 10 MPH less than the maximum permitted. The train would be thoroughly inspected prior to loading and at regular intervals. Crew changes would occur in low population areas. Security guards would be on board at all times, and would provide security exclusion areas around the train during any stops. An 11-member Command and Control Team would ride in the command car of the munition train. Monitoring of the packages would occur periodically at preselected stops along the route.

The rail transport option proposed for the national and regional disposal alternatives would require extensive operational planning and involve complex logistical problems. The requirements and conditions for transport of chemical agents by train together with the large number of

munition trains under consideration for the national and regional disposal alternatives would lead to a significant disruption of passenger and commercial rail traffic. The stringent requirements include recommendations for accident mitigation in addition to emergency response. More significant is the additional risk associated with the large number of transits required.

The partial relocation alternative, however, involves a very limited number of munition trains traveling from Aberdeen and Lexington Bluegrass to Tooele. EA has estimated, strictly on the percent distribution of chemical agent stored at the Edgewood Area (5 percent), that only a limited number of trips would be needed to transport the entire stockpile. The tradeoffs involved in reducing the long-term risks to densely populated areas surrounding these bases compared to the short-term risks involved in this limited rail transport alternative need to be carefully evaluated.

The recommendations contained in the Transportation Concept Plan appear to significantly reduce the risks associated with rail transport. EA understands that revisions are being made to the risk assessment calculations which reflect mitigation recommendations. These revised risk assessment estimates need to be incorporated into the evaluation of a partial relocation alternative. EA recommends that the rail transport of bulk mustard agent from Aberdeen to Tooele be given serious consideration in the FPEIS and in the subsequent site-specific EIS.

As stated before, the air transportation alternative is considered for only Aberdeen and Lexington Bluegrass, with 5 percent and 2 percent of the agent stockpile by weight, respectively. Both are considered because of their close proximity to large populations, and they are only considered due to limited availability of Air Force airlift resources. The flights would go to Tooele Army Depot because of the low population density there and the difficulty of airfield construction at Anniston.

If undertaken, the airlift would be considered a highly specialized mission, and treated as such. The operating requirements and procedures

would be stringent and modeled after nuclear cargo airlift procedures. The flights would be coordinated with the Federal Aviation Administration. Protective suits and continuous air monitoring devices would be used. Movement would cease during taxi and the takeoff roll. An acceleration check would be made in time to abort the takeoff if necessary. Departure, climb, descent, and approach would be under radar control. Radio communications would be maintained with central command and control office. A senior officer will be added to the normal flight crew as mission commander on the flight deck. All other aircraft will be excluded from the airspace of the flight. Weather conditions will be monitored to avoid turbulence. Emergency response teams will be stationed along the route.

The aircraft selected should have a safe history with few problems. They should have had a recent check and be in top condition; upgraded avionics such as collision avoidance and wind shear detection are being considered. The two aircraft under consideration are the C-141 and the C-5. The larger payload of the C-5 means fewer flights, reducing the risk of accident, but will still mean more than 1,000 flights under the national alternative. With this many flights, the chance of accident is high.

The air transport option will require the construction of three new airfields at Aberdeen, Lexington Bluegrass, and Tooele. EA recommends that the air transport option for the APG stockpile not be considered as a viable transportation option owing to the high level of risk involved, the requirement that a new airfield be constructed at Edgewood, and the difficulty in implementing an emergency response capability.

Constructing a new airfield in the lower portion of the Gunpowder Neck would be costly and would have significant adverse environmental impacts. The area proposed for the airfield includes several wetlands protected by state and federal regulations. The Department of Defense has signed a Memorandum of Understanding (MOU) with the Department of Commerce (NOAA) indicating its commitment to comply with the State of Maryland's Coastal Zone Management Program. A major focus of this program is the establishment of the Chesapeake Bay Critical Area Commission which may question

the need to construct a new airport in such an environmentally sensitive area. Past military activities in the proposed area may also increase construction costs significantly.

The water transport option includes shipping the ton containers from Aberdeen to Johnston Island. The nearness of APG to an ocean-connected body of water, as well as its closeness to a major population center, are the reasons for this consideration.

The plan consists of loading the ton containers onto barges, called lighters, which are then stored in the hold of a LASH vessel (Lighter Aboard Ship). The ship will then sail out of the Chesapeake Bay into the Atlantic Ocean, south around Cape Horn of South America, and back up the coast in the Pacific Ocean to a latitude equivalent to Johnston Atoll then due west to the island. The Panama Canal will not be used due to security problems in the confined area of the canal. The ship will remain close enough to the shore to allow helicopter evacuation of personnel, but far enough away to prevent danger to land in case of accidental agent release. A Navy escort ship will accompany the LASH vessel throughout its ocean voyage, and a satellite will monitor the ship's progress once it is in international waters. In the bay, a Coast Guard vessel will escort the ship. One shipload will suffice to transport the entire storage of mustard agent.

In order to load the vessel, either the Bush River or an alternative loading area proposed in the lower portion of the Gunpowder Neck will have to be dredged to 8 ft from the loading pier to the open channel in the bay, and the dredge spoils will have to be disposed of in an environmentally suitable area. Either dredging operation may bring up live projectiles from years of target practice, with the Bush River assumed to contain a higher quantity of unexploded ordnance.

The water transport option has been identified by the Steering Committee as a priority community concern, and EA's recommendations concerning this option are described in more detail in Section 6.1.

5.3.2 Operations for Onsite Destruction

In the onsite destruction alternative, transportation is necessary from the storage location to the demilitarization facility. Operations at the storage location begin with pre-entry monitoring and a subsequent visual inspection of munitions.

Any bulk containers found to be leaking will be treated at the storage location before transfer to the demilitarization facility. This treatment consists of plug and valve replacement. This procedure will be accomplished using a negative pressure glove box device that exhausts through a carbon filter. Versions of this portable device, which also functions as a handling device, are in current use in treating leaking ton containers at the storage location. The apparatus provides complete vapor containment during the plug and valve replacement process. After replacement procedures are complete, the exterior of the ton container will be decontaminated.

When monitoring and inspection indicate the absence of any agent leakage, the ton containers will be moved out of the storage location by a cradle-type forklift and placed in an onsite transportation container. The transportation containers will be loaded into trucks for transport to the incinerator. Trucks will adhere to a 20-mph maximum speed limit and will follow strict administrative controls. Convoys will be used during onsite transport and will include a security escort, a decontamination vehicle, and an emergency support vehicle. The Mitigation Measures report describes in detail the procedures to be employed in the event of accidental spills during loading, off-loading, and transportation operations.

5.4 RISK ANALYSIS

The risk analysis is contained in a massive compilation of documents including:

- . three draft final reports dated August 1987 for the onsite, regional, and national alternatives and three volumes of supporting calculations (GA Technologies 1986a,b,c, 1987a,b,c),
- . "data package" for plant operations (GA Technologies 1987d),
- . "data package" for transportation, materials handling, and storage (GA Technologies 1987e).

None of the documents have been finalized at this writing. Overall the Army and its risk analysis contractors appear to have done a thorough job in dissecting the chemical demilitarization system, identifying events that could initiate releases, and following them through event trees to estimate the probabilities and release quantities for a large number of scenarios. These included both events originating from within the system (e.g., failure of a piece of equipment), and events external to the system over which there is essentially no control (e.g., earthquakes).

Several factors make these documents extremely difficult to interpret for a particular installation, such as APG:

- . In most cases the results are presented in lengthy tables organized by scenario identification code so that it is difficult to pick out scenarios applicable to a given installation.

- . A substantial portion of the final results of the analysis is classified because it is dependent on specific quantities of agent stored at individual installations; without access to classified information, it is virtually impossible to track the risk analysis from individual scenarios to the comparison of program alternatives.

EA's overall impression of the risk analysis is that essentially all scenarios with a potential for catastrophic consequences are initiated by external events with extremely low probabilities; however, we do not have a clear picture of the situation with respect to higher frequency events associated with low releases. The latter could be of concern because of the potential carcinogenicity of mustard.

Along the same lines, EA is concerned about the criteria used to screen alternatives. Page 2-2 of the plant operations data package (GA Technologies 1987a) indicates that if the overall probability of an initiating event combined with failure of plant safety systems is less than 10^{-10} per year, that scenario is dropped from further consideration. A second screen is applied to those scenarios which survive the first test, and this is based on agent vapor release quantities. Page 3-1 (GA Technologies 1987a) states that for mustard, a scenario involving the release of 14 lb or less of agent vapor is dropped from consideration because the consequences of such releases are negligible. The rationale for this second screening step is not contained in the current risk analysis but is to be included in the final. Although this screening criterion may be reasonable with respect to lethality, there is no indication that it is protective against other potential health effects. In fact, modeling conducted by EA (Figure 5.4-1 and Table 5-3) (Turner 1970; Equation 5.21) of an instantaneous release of 14 lb of mustard vapor indicates that 10 minutes after the release, concentrations 0.5 km from the point of release (the generic installation boundary assumed in the risk analysis) are many times higher than the concentration cited in the Army's standard as being Immediately Dangerous to Life and Health (0.4 mg/m^3). The instantaneous release model used by EA may be overly conservative with respect to incineration of mustard agent at APG. Such

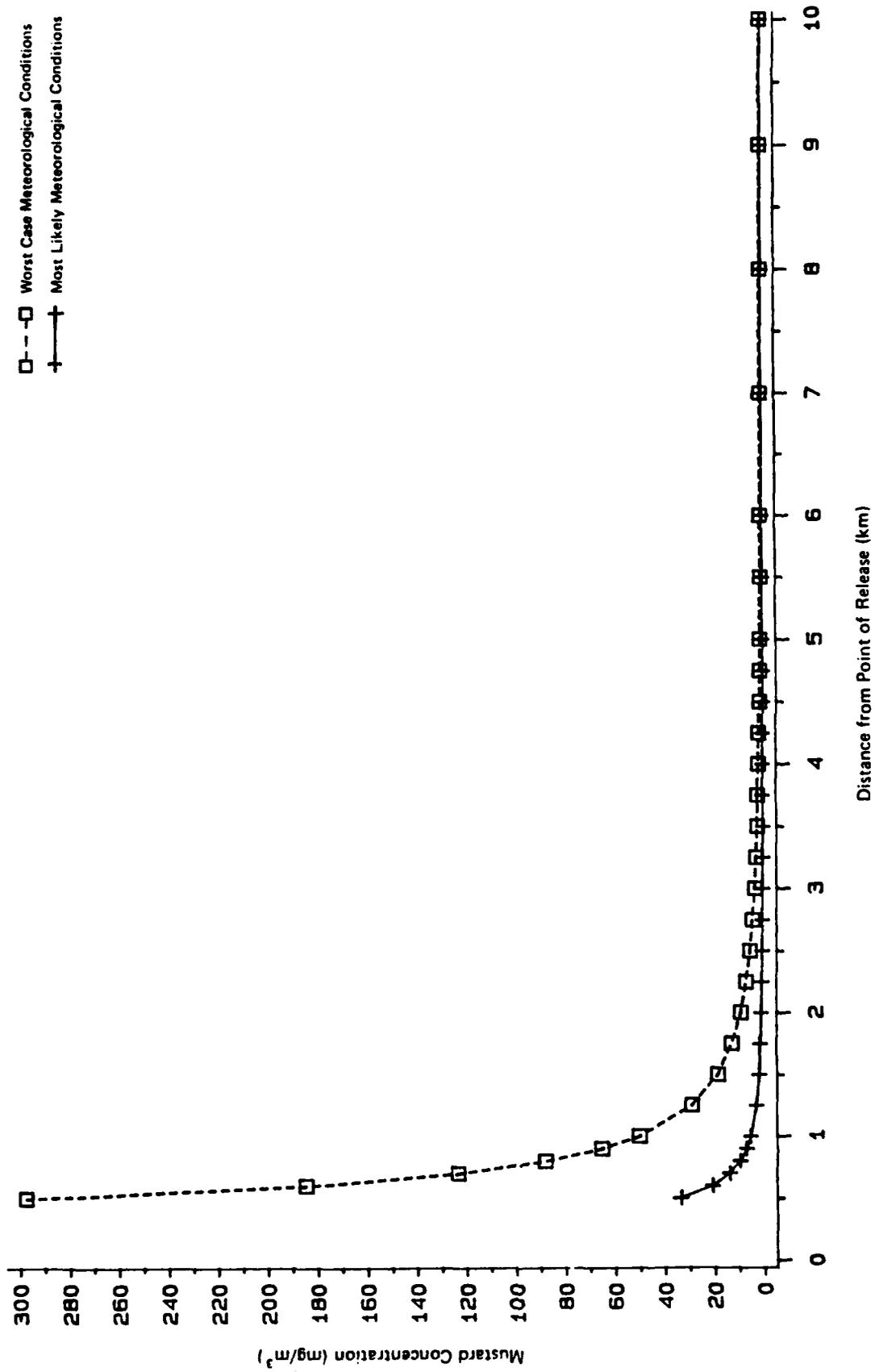


Figure 5.4-1. Concentrations of mustard versus distance from point of release for an instantaneous release of 14 pounds of mustard vapor, 10 minutes after release.

TABLE 5-3 MODEL RESULTS FOR AN INSTANTANEOUS RELEASE OF 14 LB OF MUSTARD VAPOR 10 MINUTES AFTER RELEASE^(a)

Observation	Distance (km)	Mustard Concentration (mg/m ³)	
		Worst Case ^(b)	Most Likely ^(c)
1	0.50	297.558	33.7249
2	0.60	184.610	20.8313
3	0.70	123.344	13.8660
4	0.80	88.165	9.7486
5	0.90	65.577	7.1460
6	1.00	50.332	5.4136
7	1.25	29.093	3.1224
8	1.50	18.601	1.9928
9	1.75	12.749	1.3638
10	2.00	9.194	0.9822
11	2.25	6.963	0.7355
12	2.50	5.432	0.5679
13	2.75	4.340	0.4496
14	3.00	3.536	0.3632
15	3.25	2.948	0.2995
16	3.50	2.492	0.2505
17	3.75	2.131	0.2122
18	4.00	1.841	0.1817
19	4.25	1.604	0.1570
20	4.50	1.409	0.1369
21	4.75	1.247	0.1202
22	5.00	1.110	0.1063
23	5.50	0.895	0.0846
24	6.00	0.735	0.0686
25	7.00	0.519	0.0474
26	8.00	0.387	0.0345
27	9.00	0.298	0.0260
28	10.00	0.237	0.0202

(a) Derived for instantaneous ground-level release from Equation 5.21 of Turner 1970.

(b) Wind speed: 1 m/sec, stability class D.

(c) Wind speed: 2 m/sec, stability class F.

releases are typically due to detonation of burstered munitions which are not present in the APG stockpile. The screening criteria do not appear to have been applied uniformly, however. For example, in the tables of accident frequencies and release quantities, there can be found entries that have lower frequencies and lower release quantities than those stated in the screening criteria. It is not known whether these represent mistakes or whether these scenarios were retained for the sake of conservatism.

EA was pleased to see the inclusion of marine transportation of APG stacks in the transportation, materials handling, and storage data package (GA Technologies 1987b). Unfortunately, EA was unable to obtain a copy of the report on which these data are based. Our general impression of the information made available, however, is that the marine transportation via lighter aboard ship (LASH) vessels appears more promising than was indicated by the DPEIS.

5.5 EMERGENCY RESPONSE CONCEPT PLAN

5.5.1 Summary of Plan

The Emergency Response Concept Plan (ERCP) is a programmatic analysis of the emergency preparedness implications related to the U.S. Army's Chemical Stockpile Disposal Program (Dept. of the Army 1987a). Although the document is not intended to serve as a site-specific emergency response plan for each installation where chemical agents are stored, it does provide a framework for developing site-specific studies. The major emphasis of the report is on the emergency preparedness issues of the preferred disposal alternative--onsite disposal. Twenty-two components of a comprehensive emergency preparedness program are identified and descr. i.

Volume II of the ERCP addresses emergency preparedness issues for the disposal alternatives which involve transportation offsite and include rail, air, and barge/ship transportation modes. The requirement of

offsite transportation for the regional, national, and hybrid alternatives produce several additional considerations not associated with a standard fixed-site emergency response plan. With transportation, the area of focus expands to cover the entire movement area. Each transportation mode presents an unique set of concerns. No single emergency response structure can be developed for the transportation options, and the degree of emergency response capabilities will vary greatly along the transportation routes.

Each transportation option includes two fixed sites: the storage/loading area and the unloading/disposal area. These fixed areas are recommended to receive the same level of emergency response planning as the onsite disposal option. For the in-transit phase, a number of the components for the emergency preparedness program would differ.

The ERCP states that the occurrence of an accident during the in-transit phase creates a fixed-site accident which essentially requires the same requirement and responses as an onsite accident scenario. However, the framework of the in-transit response planning is vastly different because the potential accident site cannot be anticipated and can occur at any point along the transportation corridor.

The draft ERCP includes an Appendix which describes the existing emergency preparedness program at each of the eight chemical agent stockpile sites. These individual assessments provide a general overview of the current status of emergency response planning and capabilities at the military installations and in the adjacent communities.

The following summary briefly describes the 22 components that were identified in the ERCP as being necessary to develop an effective emergency response plan at each installation.

1. Emergency Planning Zone (EPZ)--Three emergency planning zones are proposed. The Immediate Response Zone (IRZ), the innermost one, extends to a radius of 10 km. The Protective Action Zone (PAZ) reaches a maximum 35-km

radius which includes the IRZ and is the maximum area in which some protective action could be required by the public. For the case of the Edgewood Area where only bulk mustard agent is stored, the PAZ and the IRZ will most likely be the same. The Agricultural Protection and Sheltering Zone (APSZ), the outermost zone, includes the area where there is potential for contamination of the environment and the food chain.

2. Protective Action Options--Three basic options are available: evacuation, sheltering, and individual and collective respiratory protection. Evacuation may not be feasible within the IRZ due to the short warning time. Sheltering may only be feasible for institutional land used within the IRZ such as schools or housing for the elderly.

3. Management of Emergency Response--The Army's primary management role is limited to the onsite response. The initial response to an accident will be the responsibility of the local government. Secondary response involving medical care, sheltering, and environmental assessment will most likely include state agencies. Long-term response--addressing the enduring impacts of chemical agents on populations, food-chain implications, and water and soil contamination--will involve appropriate federal agencies.

4. Accident Assessment--The primary role of the Emergency Operations Center (EOC) staff at the installation is to determine the type and nature of the accident and to predict its potential impact.

5. Protective Action Decision-Making--This is the key element of an emergency response plan. The decision to implement an offsite protective action rests with chief

elected official in the affected jurisdiction. In most cases, the authority is delegated to the civil defense or emergency management coordinator.

6. Command and Control--The effective coordination of decision-making, involving onsite and offsite responding organizations, is essential. The ERCP recommends that all neighboring jurisdiction(s) establish an EOC. Harford County's EOC is located in Hickory, just north of Bel Air.
7. Communications--Direct, reliable, and effective communications with back-up systems are essential to the overall coordination of an emergency response action.
8. Public Alert and Notification--This involves two separate components: alert and notification. Although a combination of sirens and Emergency Broadcast System (notification phase) is the standard approach utilized, a more effective alert and notification system may be needed, such as alert radio receivers.
9. Special Population Groups--Additional attention to special population groups is needed in preparing an emergency response program. In the Edgewood Area, special population groups include school students (6,400 children with 150 being of pre-school age), elderly, hearing-impaired, and mobility-impaired. No hospitals or nursing homes are located within the assessment area, but a personal care facility and a senior citizens complex were identified.
10. Transportation--The evacuation of the public from the EPZ is an integral part of any fixed-site emergency response

program. Evacuation routes must be identified and the response plan must address the transportation-dependent subpopulations.

11. Emergency Worker Protection--Any civilian or military workers assigned tasks within the EPZ should be provided with personal protective equipment.
12. Emergency Medical Services (EMS)--This component includes pre-hospital emergency care and hospital-based emergency care. The ERCP recommends that all communities potentially affected by a chemical agent should have an EMS system in-place.
13. Access and Traffic Control--Local emergency management officials should have policies and a plan in-place to designate access control points around the EPZ in order to limit access into an affected area. Policies regarding who is permitted to enter a restricted area should be formalized.
14. Monitoring and Decontamination--Ideally, agent-monitoring systems should be able to detect and measure agent concentrations below the threshold level for physical symptoms on a real-time or near-real-time basis. The ERCP recommends that each storage/disposal site should have the capability to rapidly deploy a decontamination team.
15. Evacuee Support--Emergency response plans for each installation should include advance planning on establishing reception centers along main evacuation routes. The American Red Cross would have responsibilities for mass care requirements. Coordination of reception and mass care centers would rest with the local emergency

management agency. One note regarding the unique characteristics of a mustard agent release: its effects are delayed and may become manifest hours after exposure. Exposed individuals, not realizing the severity of their situation, may not seek protection and treatment. Procedures established for reception of evacuees need to acknowledge this difficulty in determining the medical needs of evacuees.

16. Public Information--This element includes involving the public in the development of an emergency preparedness program providing direct and indirect (through media) information about emergency preparedness and providing continuous information to the public in the event that an accidental release should actually occur.
17. Training--This includes both onsite and offsite emergency response personnel.
18. Drills and Exercises--The ERCP recommends both tabletop/ emergency operations simulation exercises and an annual field exercise.
19. Resources--The time constraints involved with responding rapidly to a chemical agent accident mandate that all resource needs (both of equipment and manpower) be identified, acquired, and--in the case of manpower-- committed.
20. Reentry/Recovery--The key element here is the capability to determine, through monitoring and sampling the time when reentry to an affected area is possible. Standards need to be prepared to address permissible levels of contamination which pose no chronic health effects to the affected community.

21. Implementing Procedures--These procedures spell out the functional roles of all organizations with responsibilities for emergency response. They need to be related to the emergency classification level system developed as part of the local emergency response plan.

22. Program Implementation--The ERCP recommends that regardless of the disposal alternative selected, the Army should initiate additional emergency preparedness efforts at each of the eight installations in the near future.

5.5.2 Comments

The most recent draft of the ERCP (July 1987) represents a very thorough evaluation of the emergency response requirements for the Chemical Stockpile Disposal Program (Dept. of the Army 1987a). The recommendations of the Schneider consultant team, if approved by the Army, will require an intensive effort by each of the eight military installations and adjacent communities to implement the recommended level of emergency response capabilities. The emphasis of the ERCP on "fixed-site" emergency response capabilities is warranted because these concepts apply to all of the alternatives including continued onsite storage. EA supports the ERCP recommendation that site-specific emergency response planning be initiated as soon as possible because currently, risks are present at stockpile locations. Any of the selected alternatives will require a "fixed-site" emergency response plan.

The consequences of a major release of chemical agent mandate a streamlined decision-making process. The time required to reach a decision whether or not to alert and notify offsite populations is the most critical part of an emergency response program. Four discrete steps are involved in this process: identification of release; assessment of its magnitude and potential impacts; notification of the responsible

authorities; and the time required by authorities to decide on evacuation or other protective action. Development of site-specific, emergency response plans should ensure rapid characterization of an accident occurrence and the earliest notification of offsite authorities.

The initial assessment of a chemical agent release can be based upon the specific parameters of a "real-time" accident, or it can be based on an accident classification scheme prepared from classes of accident scenarios derived from the risk assessment studies. The categories of accidents reflect their potential impacts onsite and offsite. EA prefers the latter approach, especially for accidents with potentially serious offsite impacts because it permits a more rapid decision to be reached regarding protective action. Concurrently, assessment of the particular accident, including inputting current meteorological conditions into the dispersion model and estimating the volume of release, should parallel the use of the preestablished accident classification scheme. The results of an accident-specific dispersion modeling effort should not be required to make a decision on protective action, but should complement a predetermined accident classification scheme and provide valuable information concerning the protective action selected.

EA acknowledges that Army emergency officials cannot presently compel protective actions for the general public. However, it is strongly recommended that for accidents with potentially serious offsite impacts, the Army have the authority to initiate the alert/notification phase offsite. This preauthorization would remove one additional step from the decision-making process and improve response time under a rapidly escalating accident scenario. Negotiations with local jurisdictions concerning Army implementation of immediate protective action decisions under specified conditions should be included in each site-specific response plan. EA supports the ERCP recommendation that an Army Liaison Officer be assigned to an offsite EOC at any time it is activated for a chemical agent response.

The decision-making criteria need to include the quality of information available at the onset of a chemical agent incident. If the quality of

information is poor and the severity of the accident is low, additional time to investigate and evaluate is permissible. However, if the severity of the accident is potentially high, a conservative approach dictates that offsite protective actions be implemented even if the available information is incomplete. Care must be taken to address accident scenarios that fall into the moderate range for severity and quality of information.

The most recent version of the ERCP acknowledged the difficulties inherent in each of the three major types of protective actions: evacuation, sheltering, and individual respiratory protection. The types of protective action selected will depend on the site-specific emergency response plan and may differ depending on meteorological conditions and the nature of a chemical agent release. Evacuation is most effective as a precautionary action. However under several of the more severe accident scenarios there would not be adequate time to evacuate nearby communities. Sheltering is effective for some institutional settings in the IRZ (e.g., schools, nursing homes, and hospitals) where modifications to ventilation systems can be made.

In most cases, sheltering should be the preferred alternative for special population groups. Improving all single family residences in the IRZ was found to be impractical. For several of the site-specific emergency response plans, the only effective protective action may be the distribution of individual respiratory protection to residents living in close proximity to the installation. The provision of respiratory protection to residents will greatly increase the protection afforded by the sheltering option and provides the flexibility of additional protection if evacuation is subsequently required.

The ERCP states, that "Emergency response programs cannot be as effective in mitigating accidents that occur during the transportation of chemical agents as they can for accidents that occur onsite at a chemical storage

site." Elements of an emergency response plan that are especially difficult to implement for offsite transportation include alert and notification, aid to special populations, and the provision of emergency medical services.

The conceptual approach proposed for the train option calls for a mobile emergency management capability to escort the munitions train to the disposal site. The response group will have accident assessment capabilities including computerized plume plotting, communication links to local and state EOC offices, route alert, and traffic control teams. One positive aspect of this proposal is that it would provide for rapid deployment of the emergency response team--as opposed to the inherent delays of assembling the civilian emergency response team in an onsite accident scenario with offsite impacts.

The national and regional disposal options would require approximately 75 and 55 trains, respectively. The large number of train trips would complicate emergency response planning in addition to the increased probabilities of a rail accident. If transportation by rail from APG to Tooele is considered separately, only a few train trips would be required. The effectiveness of emergency response capabilities is clearly reduced under the train option; however, it is feasible to implement an emergency response capability.

The air transport mode presents the greatest difficulty in providing emergency response capabilities. Expanded "fixed-site" planning would be conducted for the approach and takeoff zones at existing or proposed airfields at the storage facility, at emergency airfields designated along the route, and at the destination (Tooele). There is no economically feasible or realistic way to provide emergency response capabilities along the flight corridor. Should an accident occur, the potential for a significant release of agent is very high.

The water transport mode presents the greatest complexity for developing an adequate emergency response plan because such a plan would involve air, land, and water components. The LASH approach involves numerous

barges (lighters) which would be transported from the shore to the LASH ship waiting in the deep-water channel. This approach is described in more detail in Section 5.3. One ship would be capable of transporting the entire stockpile of mustard agent.

EA does not support the ERCP alternative of considering the entire Chesapeake Bay a "fixed-site" and preparing detailed emergency response plans for this region. It may be feasible, but it is not practical. As an alternative, the "fixed-site" boundaries for the Edgewood Area (onsite option) should be expanded to include a 10-km radius from along the axis of two points--the storage facility to the LASH vessel loading area. This would include the area where an accident is most likely to occur.

A more limited state and local planning effort would be required for the 10-km corridor to the mouth of the Chesapeake Bay. Once the LASH vessel is in the open waters of the Atlantic Ocean, there appears to be a much lower probability of an accident as well as minimal potential for exposure of the public. Therefore, advance planning for states along the Atlantic coastline and South America does not appear to be justified. If an accident were to occur in deep-water transit, adequate time to prepare an ad hoc response would be available before a civilian shore population became at risk.

EA recommends that the Edgewood Area EOC be considered the base center of operations for overseeing the transit of the LASH vessel down the Chesapeake. Other military installations such as the Naval Academy, Patuxent Naval Air Station, and Norfolk Naval Base could function as satellite EOCs as the ship moves down the bay. Prepositioned emergency preparedness teams could be located on the eastern and western shore and coordinated by an air-based escort team. On the rural eastern shore, helicopters would be useful in alert/notification, monitoring, and access control functions.

Although the water transport option presents many complexities in the development of an adequate emergency response plan, it appears feasible and has the additional benefit of requiring only a single shipment.

5.6 PRODUCTS OF INCOMPLETE COMBUSTION (PICs), PRINCIPAL ORGANIC HAZARDOUS CONSTITUENTS (POHCs), AND CHEMICAL AGENT INCINERATION

During public meetings held to scope and then to discuss the Draft Programmatic Environmental Impact Statement (DPEIS), the public expressed concerns about compounds which would be emitted from the incinerator stacks, especially during periods of incomplete combustion. This report was prepared to support the DPEIS and to address these public concerns (Flamm 1987).

The report is a step in this direction, but misses the larger questions being asked by the public. The public would like to know the basic principles of incinerator design and chemistry. Given the fuel to be used and the agent and bulk stabilizers to be incinerated, and assuming that the incinerator complex is working efficiently, the public would like to know what will be emitted through the stack, and in what quantities. Variations in operating conditions will occur during incinerator operation. If they do not occur at any other time, these variations will certainly occur as the system is brought up and down for general maintenance. If the incinerator complex is operating less than optimally, then the public would like to know what is emitted under these conditions and in what quantities? In the case of less-than-optimal operations, the concern is not with accidents (this concern should be addressed elsewhere), but with such factors as temperature excursions, changes in the feed rate, too brief a burn time, and turbulence in an incinerator. Variations during normal operation of the incineration system, a major concern of the public, is dealt with in a cursory manner in Section 4.2.1 of the report.

While the probability of a major accident occurring to the incinerator may be small, the probability of suboptimal operation occurring sometime during the approximately 2 years it will take to dispose of the APG mustard stockpile is almost a certainty. By not fully addressing this possibility, the Army gives the impression of ignoring this possibility and not being adequately prepared to take action when suboptimal operations occur.

There are other concerns of the public about the incineration process. One concern is the nature and amount of waste products produced by incineration and how and where these waste products will be disposed. Another concern is with formal and informal coordination between the Army (both base operations and the Chemical Stockpile Disposal Program) and the contractors building and operating the incinerators. Neither of these concerns is strictly a PICs or POHCs issue; however, they are concerns of the public about incineration.

All aspects of incineration need to be addressed in the FPEIS. A suggestion would be to expand the PICs and POHCs report to address all the generic concerns about incineration including incineration chemistry, incinerator design, expected variations in operating conditions, disposal of waste products, and coordination between the Army and the contractors building and operating the incinerators.

5.6.1 Compounds of Concern

The DPEIS (1986) (Table 4.2.1) lists emission products (excluding contributions from fuels) regulated by National Ambient Air Quality Standards (NAAQS) or appropriate state standards. These compounds include nitrogen oxides (NO_x), particulates, sulfur dioxide (SO_2), hydrochloric acid (HCl), hydrofluoric acid (HF), polychlorinated biphenyls (PCB), and the agents themselves.

The PICs and POHCs report defines principal organic hazardous constituents (POHCs) as RCRA Appendix VIII compounds (40 CFR 261). Appendix VIII lists several hundred specific chemicals, including mustard, which are regulated under RCRA. POHCs are compounds which are fed into the incinerators, and RCRA requires that the incineration process reduce these by 99.99 percent.

PICs are defined as products of incomplete combustion (Section 1.0(a)) and are generally considered to be what comes out of the stack. Later, in Section 4.1 of the report the definition is restricted, and PICs are defined as Appendix VIII compounds in exhaust gases, whereas products

of incomplete combustion are any organic compounds, other than H₂O and CO₂, which might be emitted. The public does not make this distinction between PICs and products of incomplete combustion. Technically, PICs by any definition are not regulated. EPA did propose a regulation to limit hazardous combustion by-products (i.e., Appendix VIII compounds) to 0.01 percent of the total mass of POHCs fed into the incinerator (46 Fed. Regist. 7684). The Army feels that test burns demonstrate that this limit is met.

The public concern is well served by, but is broader than, the six compounds covered by NAAQS, the few compounds covered by state regulations, or the several hundred compounds regulated by RCRA. The Army is of course concerned with regulated compounds, but the public would like some assurance that serious consideration has been given to all compounds going into the incinerators, including the fuels, the range of agents, the containers, the sulfur impurities in mustard, stabilizers and other additives with nerve agents, propellants and explosive components for those munitions having them, and all compounds coming out of the stacks. The proposed incinerator at APG would burn only ton containers of HD mustard agent and would not include explosive component or bulk stabilizers.

5.6.2 Health Effects

Health effects of PICs are discussed in Section 4.1(c) of the report which is brief. This report states that PICs do not present a public health risk. It is not clear but is assumed that the minimal health risk attributed to PICs refers to optimal incineration conditions of commercial hazardous waste incinerators (Oppelt 1986). This report does not address combustion by-products and possible health risks under conditions of problem operation. There is an increasing concern with the production during incineration of dibenzo-p-dioxins and dibenzofurans. This concern applies to all incineration and is not specific to the incineration of chemical agents.

5.6.3 Incinerator Design

Section 2.2.2 of this report briefly describes the Chemical Stockpile Disposal Program incineration system. This section includes one paragraph, one schematic diagram, and one process flow diagram for each of the four types of incinerators. Other than the diagrams, there is no information which is not included in Appendix C of the DPEIS, which itself did not address the subject in sufficient detail.

5.6.4 Incineration Waste Products

Another aspect of incinerator chemistry which is of concern to the public is the nature and amount of waste products produced by the incineration process. While not strictly a matter of PICs or POHCs, the products coming out of the bottom of the process are a concern as well as the products coming out of the stack.

The volume of these waste products is substantial and therefore requires a major disposal effort. For example, the combustion of mustard will yield sulfur dioxide (SO_2) and hydrogen chloride (HCl). Both of these compounds react with the caustic soda scrubber solutions. Absorption of SO_2 results in 2.2 lb of sodium sulfate for every pound of SO_2 . The reaction of HCl and caustic soda results in 1.6 lb of sodium chloride for every pound of HCl .

In addition, the nitrogen found in ambient air can readily oxidize to NO and NO_x when combustion zone temperatures reach and exceed 1800 F. The use of a liquid incinerator unit with a primary combustion zone temperature of 2500 F, followed by an afterburner zone combustion stage operating at 2000 F will surely produce NO and NO_x . The absorption of NO and NO_x gases in caustic soda solution will produce sodium nitrite and even more sodium nitrate. The amount produced is estimated to be 1.9 lb of sodium nitrate for every pound of NO_x .

A further waste product may be produced because alkaline solutions have an affinity to absorb reformed organic compounds produced downstream of

the combustion zone. If such materials are produced, they have to be stripped from the scrubber solutions and disposed.

5.6.5 Trial and Demonstration Burns

Sections 3.2 and 3.3 of this report briefly discuss the proposed trial burns. The need for trial burns is mandated by RCRA, which requires that the trial burn demonstrate a Destruction and Removal Efficiency (DRE) of at least 99.99 percent. RCRA requires that the trial burn be conducted on Appendix VIII compounds. Since no agents except mustard are on this list, surrogate compounds will have to be used for the trial burns of the nerve agents. After trial burns are successfully completed, then demonstration burns will be conducted with the actual chemical agents and munitions. The public and the Army are really interested in these burns, and these plans need to be more fully described.

Section 3.3 of this report states that completed tests have demonstrated DREs in excess of 99.99 percent, the RCRA standard. This report needs to go further and answer the following questions: How many tests have been conducted? What are the numeric results? How much was burned? What were the emissions? Did these tests involve surrogate compounds or the actual agents and munitions?

5.6.6 Minor Problems with the Report

Some information is extraneous, such as the map of CAMDS (Figure 3-1), and the explanation as to why the chemical stockpile is not hazardous waste, and hence not regulated by RCRA, until it is delivered to the disposal facility (Section 3.1). This discussion, together with other sections focusing on RCRA, leaves the impression that the Army would not be concerned about PICs and POHCs if the POHCs were not regulated by RCRA.

Section 3.2(d) of this report presents some interesting information. Other than the first item, however, these are not reasons why the agents themselves will not be used in trial burns. The second item on this list is confusing and may be missing some words.

Table 4-4, referenced near the top of p. 4-11, does not list shut-off limits as stated in the text. This list, together with a discussion of monitoring, is of major public interest and, while covered in other reports, needs to be discussed here.

5.7 MULTIPLE STACKS REPORTS

While the PICs and POHCs report discussed in the previous section deals with incineration in general and therefore applies to all sites, the multiple stacks reports are site-specific and apply only to APG. There are two reports entitled "Evaluation of Multiple Incinerator Air Quality Impacts, Edgewood Area, Aberdeen Proving Ground, Maryland" dated December 1986 and May 1987. The latter updates emission rates but is less detailed and does not completely replace the former. The reports need to go into more detail in order to convince the public that the problem has been adequately studied and that there is no unacceptable risk from emissions from the multiple incinerators in the Edgewood Area of APG.

5.7.1 Purpose of Reports

The purpose of the reports is very clearly stated. It is to examine the long-term additive health impacts of emissions from the four incinerators operating, under construction, or proposed for the Edgewood Area of APG. The four incinerators are listed in Table 5-4.

The authority letters for these reports mention only the first three incinerators. The Army is to be commended for including the fourth incinerator and evaluating the complete incineration picture. It is assumed that there will be a total of four incinerators on the Edgewood Area peninsula.

TABLE 5-4 INCINERATORS IN THE EDGEWOOD AREA, APG

<u>Incinerator</u>	<u>Abbreviation</u>	<u>Status</u>
Agent Incinerator	AI	Proposed
Harford County Municipal Waste Incinerator	MWI	Under construction
Medical Research Institute for Chemical Defense Pathological Waste Incinerator	PWI	Operating
Chemical Research, Development, and Engineering Center Decontamination/ Detoxification Incinerator	DDI	Operating

The only health effect considered in the reports is carcinogenesis. Although carcinogenesis is usually the first concern, a complete assessment should also consider noncarcinogenic effects, especially chronic respiratory effects since the source of concern is incineration. The assessment is limited to additive effects of carcinogenesis. It is difficult enough to consider additive effects and this approach is consistent with EPA's guideline on cancer risk assessment (51 Fed. Regist. 33992).

5.7.2 Selection of Compounds of Interest

The DPEIS (1986) discusses pollutants covered by National Ambient Air Quality Standards (NAAQS) and states that there will be no significant air quality impacts due to these pollutants. It is necessary to consider the NAAQS, but since only six conventional pollutants have NAAQS, it is not sufficient to consider only these standards. The multiple stacks reports consider broad classes of potentially toxic air pollutants including dioxins, furans, polychlorinated biphenyls (PCB), chlorobenzenes, and chlorophenols. Each of these classes contains related compounds. Within each class there is a wide range of toxicity potencies. Some compounds of each class are carcinogenic. In these reports, all of these classes of compounds are grouped and referred to as chlorinated organics.

The PCBs are selected as a surrogate for all the compounds in order to quantitate the risk. Selecting a surrogate is done because of the lack of data on many of the compounds. However, in this case no rationale is given for the selection of the surrogate. No data are presented to show the expected distribution of the classes within the chlorinated organics. Another approach is to select the most toxic compound as the surrogate to ensure a conservative calculation of risk. In these reports a form of dioxin, 2,3,7,8 tetrachlorodiphenyl dioxin (TCDD) is said to be considerably more toxic than PCBs but will comprise a very small proportion of emissions. In fact, 2,3,7,8 TCDD is five orders of magnitude more toxic than PCBs, so 1/100,000 of the amount of PCBs presents the same order of

risk. The carcinogenic potency factor for PCBs is $4.34 \text{ (mg/kg/day)}^{-1}$; the potency factor for 2,3,7,8 TCDD is $1.56 \times 10^5 \text{ (mg/kg/day)}^{-1}$ (U.S. EPA 1986b).

There may be other general classes of compounds which should be considered in this assessment such as the polycyclic aromatic hydrocarbons (PAHs). These compounds, some of which are carcinogenic, are produced, among other ways, by the combustion of hydrocarbon fuel and can be a concern with incineration.

The reports also consider mustard emissions from the AI. A consideration of incinerator chemistry would give the combustion products of mustard, and some of these also may require an assessment of risk. Because the containers are also being heat treated, some metals may be of concern.

5.7.3 Methodology for Dispersion Modeling

The Army uses the Industrial Source Complex (ISC) (U.S. EPA 1986) computerized dispersion model to estimate annual average ground level concentrations given the emission rates of the incinerators. EPA recommends this model, and EA uses it for dispersion modeling. The Army had hourly meteorologic data for 1 year and used the short-term version of the model. EA did some modeling for comparison. EA had 10 years of meteorologic data from Phillips Field for 1955-1964 summarized according to wind speed, wind direction, and stability class, and therefore, used the long-term version of the model. Both model versions estimate annual average concentrations. Using the same emission rates, results obtained with the long-term model were very similar to those obtained by the Army using the short-term model, as shown in the Table 5-5. Receptor locations are defined in the December 1986 multiple stack report. The short-term model results are from Table 3 of the May 1987 report.

5.7.4 Source Term Calculations for Mustard

The reports consider mustard emissions from the AI to emanate from two sources: the liquid incineration furnace and metal parts furnace

TABLE 5-5 ESTIMATED ANNUAL CONCENTRATIONS OF HD
AT SELECTED RECEPTOR SITES

<u>Receptor</u>	<u>Army Short-Term Results Concentration (ng/m³)</u>	<u>EA Long-Term Results Concentration (ng/m³)</u>
1	0.013	0.019
2	0.021	0.016
3	0.023	0.021
4	0.026	0.017
5	0.033	0.024
6	0.018	0.027
7	0.037	0.033
8	0.026	0.026

as one source, and the ventilation from the Demil Building as the other. Different methods are used to calculate the emission rates from the two sources. Both methods are based on the figure 0.03 mg/m^3 as the concentration in the stack. Note that this quantity is based on detection limits and not on health limits. This is the concentration which if present for 10 minutes would set off the alarm in the stack. Using this concentration is taking a conservative approach, because the actual concentration in the stack is expected to be lower than this. Using this concentration as the basis for the emission rate means that the resulting concentrations will be upper bound estimates, i.e., the actual concentrations will likely be lower than those calculated by the model if the actual stack concentration is less than 0.03 mg/m^3 .

The emission rate from the Demil Building stack is based on design specifications of the ventilation system discharging at a rate of $40,000 \text{ ft}^3/\text{min}$ (Vocelka 1987). Using this rate and a stack concentration of 0.03 mg/m^3 , the emission rate given in Table 1 of the May 1987 report is calculated as follows:

$$40,000 \text{ ft}^3/\text{min} \times 0.02832 \text{ m}^3/\text{ft}^3 \times 1 \text{ min}/60 \text{ sec} \times \\ 0.03 \text{ mg/m}^3 \times 1 \text{ gm}/1,000 \text{ mg} = 0.00057 \text{ gm/sec}$$

The emission rate from the liquid incinerator and metal parts furnace stack is based on stack and stack gas characteristics (Vocelka 1987). The emission rate is the concentration in the stack times the cross-sectional area of the stack times the velocity of the gas from the stack. The rate given in Table 2 of the December 1986 report is calculated as follows:

$$0.03 \text{ mg/m}^3 \times \pi \times (0.35 \text{ m})^2 \times 17 \text{ m/sec} \times 1 \text{ gm}/1,000 \text{ mg} \\ = 0.00020 \text{ gm/sec}$$

In the May 1987 report this figure is adjusted to account for a 40-hour per week operation of the incinerator rather than round-the-clock operation. Round-the-clock operation would be for 24×365 or 8,760 hours in

a year. Forty-hour per week operation would be approximately 40 x 50 or 2,000 hours per year. This adjustment is made as follows:

$$(0.00020 \text{ gm/sec} / 8,760) \times 2,000 = 0.00005 \text{ gm/sec}$$

as given in Table 1 of the May 1987 report. This adjustment is valid, but applies only if the incinerator operates 40 hours per week. If hours of operation increase, then the emission rate increases as do the resulting ground level concentrations.

Either of these two methods for the calculation of the emission rate is valid. However, the second method cannot be used with the stack and stack gas data given for the Demil Building to obtain an emission rate which agrees with the rate calculated by the first method. Only one approach should be used, and the stack and stack gas characteristics, which are used in the model, should be compatible with the design specifications of the ventilating system. In other words, both methods for the calculation of emission rates should give approximately equal results.

5.7.5 Source Term Derivation for Chlorinated Organics

Emission rates for chlorinated organics for the MWI and the DDI were derived from an article by Ozvacic et al. (1985) on a study of emissions of chlorinated organics from a municipal incinerator. The emission rate calculation assumed the makeup of the incinerator feeds would be similar for the MWI and the DDI as for the studied municipal incinerator. The calculations took into account the maximum design feed rates for each incinerator. The calculated emission rates were 0.0011 gm/sec for the MWI and 0.00001 gm/sec for the DDI. This low emission rate for the DDI resulted in low concentrations relative to concentrations from the MWI. Chlorinated organic concentrations resulting from the DDI were therefore considered negligible, and further consideration of these emissions from the DDI was dropped in the May 1987 report. This is a valid action if the concentrations from the MWI are shown subsequently to pose very low risk.

The chlorinated organic emission rate for the PWI was based on EPA guidance for compiling emission rates (U.S. EPA 1977). The emission rate for the PWI was judged to be negligible. The figure is not given, but it is assumed to be substantially less than the emission rate of 0.00001 gm/sec given for the DDI.

In the December 1986 report, it was assumed that because of the chlorine in mustard, incineration of mustard in the AI would produce some chlorinated organics. The emission rate "was assumed to be 1 percent of the nonmethane hydrocarbon emission rate given for mustard incineration. This percentage was based on the general assumption that the emission products of this incineration were similar to that for MWI." In the December 1986 report the emission rate for chlorinated organics from the AI based on the assumptions above was estimated to be 0.0005 gm/sec, approximately half the chlorinated organics emission rate for the MWI.

In the May 1987 report, the chlorinated organics emission rate from the AI is considered to be negligible and, therefore, the MWI is the only incinerator anticipated to emit chlorinated organics. The assessment of the AI emission rate as negligible is based on the fact that "The incinerator designer has recently completed an analysis which indicates, that, for HD incineration at design operating conditions, negligible amounts of chlorinated organics are formed as products of incomplete combustion." Details of this analysis need to be presented to ensure confidence in the conclusion that there are negligible chlorinated organics emitted from the AI. Numbers need to be presented which show that the amount emitted results in concentrations so low that even the high carcinogenic potency of 2,3,7,8 TCDD does not pose a risk.

5.7.6 Plume Overlap

This is the one area where the multiple stacks reports completely miss the point. The reports state that, depending on how far plumes from the AI and the MWI are considered to extend, the plumes overlap 5 percent of the time or less. The concern is not with the amount of time that a receptor will be simultaneously under the influence of both plumes, but

what is the cumulative effect of being first under the influence of one plume and then under the influence of the other. The concern is with the cumulative additive effects of the multiple incinerators. If the PWI and the DDI are dismissed as insignificant compared to the other incinerators, then what are the cumulative annual average concentrations from the AI and the MWI.

Figure 5.7-1 shows the pattern of emissions from the AI. Each dotted line is an isopleth of concentration, i.e., concentrations along this line are equivalent. As isopleths move away from the source, the concentration of each isopleth is two-thirds of the concentration of the isopleth closer to the source. This figure shows that, as stated in the multiple stacks reports, the effect of the AI stretches toward the southeast. In fact the AI plume is triangular and reaches almost as far to the northeast and to the southwest.

Figure 5.7-2 shows the pattern of emissions from the MWI. Again isopleth concentrations are two-thirds of the isopleth concentration nearer the source. Assuming equal emission rates of whatever pollutant is being modeled, isopleths on the two figures drawn with the same type of line represent equivalent levels of concentration. If emission rates are not equal, then the isopleths of the same line type are not equal on the two figures. The figures do not show the expected concentration at any one point, but rather illustrate the expected patterns of the plumes from the AI and the MWI. The figures further show that over time most areas of the Edgewood Area peninsula will be affected by both incinerators.

The multiple stacks reports are headed toward the conclusion that different compounds of concern are emitted by the two incinerators. If this proves to be the case, then a receptor may have one effect from the pollutants of one incinerator and a different effect from the other incinerator. Health effects from either or both incinerators may be negligible. The reports have to demonstrate that all pollutants of concern have been included, that all effects including noncarcinogenic effects have been considered, and that conservative estimates have been used for the emission rates. If the resultant modeled concentrations are

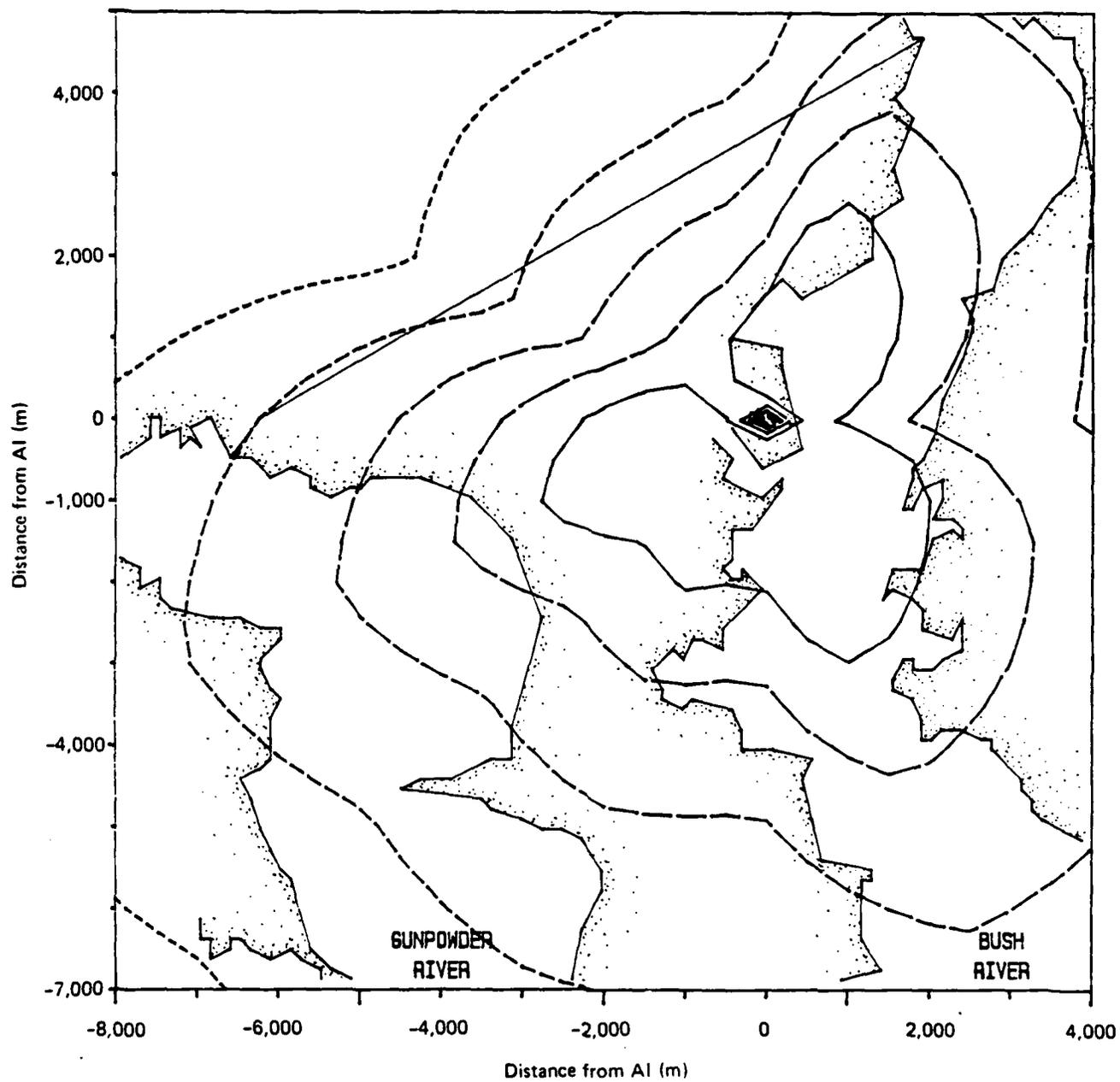


Figure 5.7-1. Pattern of emissions from the agent incinerator.

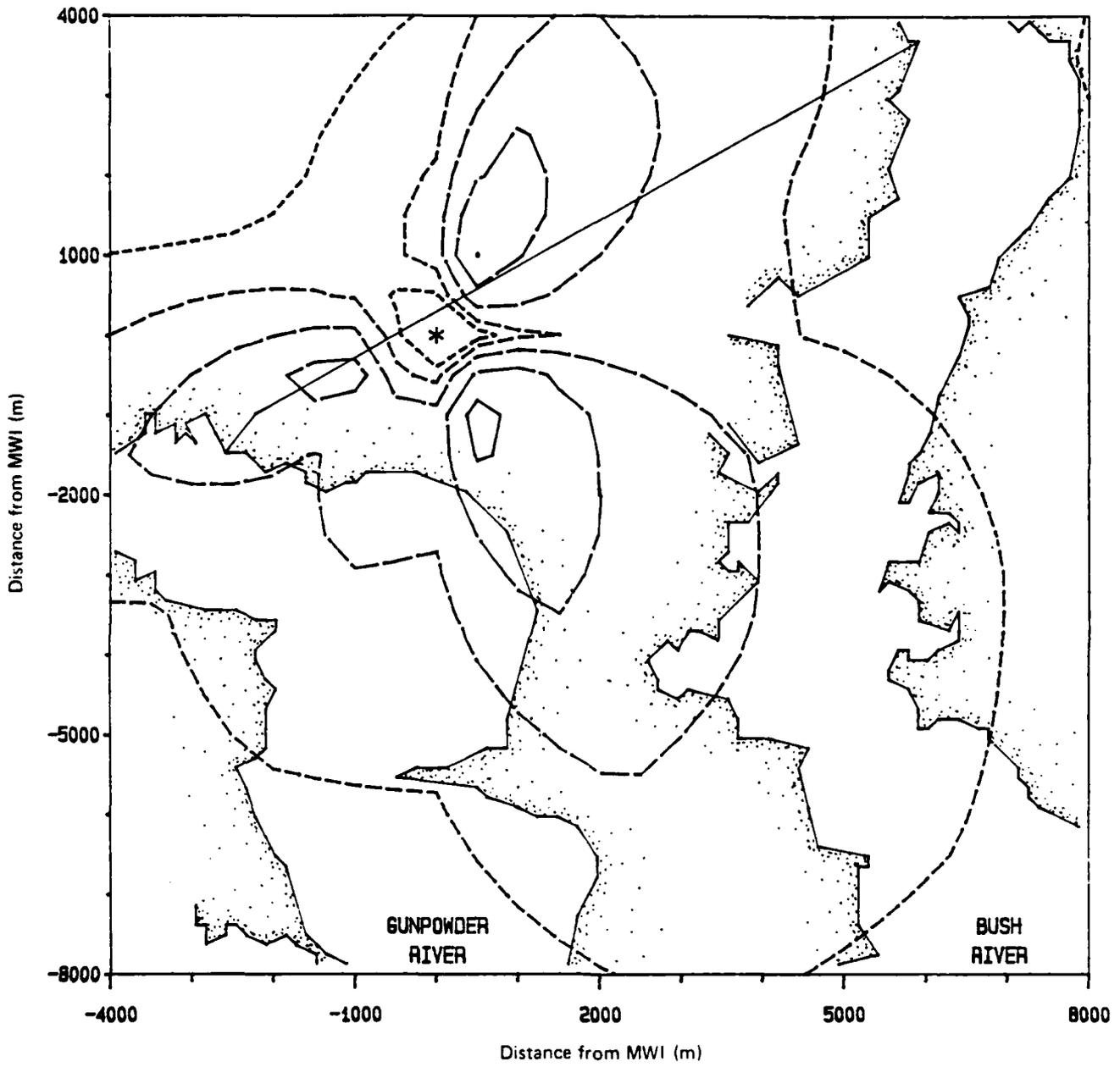


Figure 5.7-2. Pattern of emissions from Harford County's municipal waste incinerator.

compared with carcinogenic potency factors or reference doses and result in risks of 10^{-6} or 10^{-7} or lower, then even the additive risks from the multiple incinerators will be acceptable. Otherwise the overlap of the incinerator plumes over time cannot be ignored.

5.7.7 Cancer Risk from Exposure to Mustard

The methodology for the risk calculation for carcinogenic effects is that recommended by EPA (49 Fed. Regist. 46294) and is succinctly described in the May 1987 report. The carcinogenic potency is denoted in the report by Q^* and is expressed in units of the reciprocal of mg/kg/day, i.e., Q^* is in units of $(\text{mg/kg/day})^{-1}$. Another way to express this is that the potency factor units are the reciprocal of the dose units (U.S. EPA uses the notation q_1^* for carcinogenic potency).

Risk is then calculated using this potency factor by:

$$\text{Risk} = Q^* \times \text{dose}$$

Dose or daily intake is calculated from the modeled concentration assuming reference values. These values include 70 kg as the weight of an adult and 20 m^3 as the daily breathing rate of an adult (U.S. EPA 1986b). Reference values for children are lower (10 kg and $5 \text{ m}^3/\text{day}$) and result in a higher calculated risk.

The highest concentration of mustard modeled in the multiple stacks reports is 0.037 ng/m^3 at Receptor Site 7. The adult daily intake at this site is:

$$\begin{aligned} &0.037 \text{ ng/m}^3 \times 20 \text{ m}^3/\text{day} / 70 \text{ kg} \\ &= 0.011 \text{ ng/kg/day} \\ &= 1.1 \times 10^{-8} \text{ mg/kg/day} \end{aligned}$$

There is no carcinogenic potency factor for mustard. Oak Ridge National Laboratory (ORNL) has developed a relative potency comparing mustard to benzo(a)pyrene (BaP) (Watson 1987a; Jones et al. 1985; Jones in press).

The carcinogenic potency factor for BaP is 6.1 (mg/kg/day) (U.S. EPA 1986b). ORNL calculates the relative potency of mustard to BaP as 3.2. Therefore the lifetime risk of an individual developing cancer from a lifetime (70 years) exposure to 0.037 ng/m³ of mustard is:

$$6.1 \text{ (mg/kg/day)}^{-1} \times 3.2 \times 1.1 \times 10^{-8} \text{ mg/kg/day} = 2.1 \times 10^{-7}$$

Since the incineration at Aberdeen will last approximately 2 years, this lifetime risk is further reduced. The risk for a 2-year exposure to mustard at the highest modeled concentration is:

$$2.1 \times 10^{-7} \times (2/70) = 6.1 \times 10^{-9}$$

By any standards this is a very low risk. The actual risk will likely be even lower because the modeled concentrations are based on a stack concentration of 0.03 mg/m³, a higher concentration than is expected to occur.

5.7.8 Cancer Risk from Exposure to Chlorinated Organics

The same risk calculations are used as in the previous section and are based on the maximum modeled concentration for chlorinated organics of 0.328 ng/m³ at Receptor Site 2.

The adult daily intake is:

$$\begin{aligned} 0.328 \text{ ng/m}^3 \times 20 \text{ m}^3/\text{day} / 70 \text{ kg} \\ = 9.4 \times 10^{-2} \text{ ng/kg/day} \\ = 9.4 \times 10^{-8} \text{ mg/kg/day} \end{aligned}$$

Using PCBs as the surrogate for all chlorinated organics incorporates the PCB carcinogenic potency factor of 4.34 (mg/kg/day)⁻¹ (U.S. EPA 1986b) and calculates the lifetime cancer risk from the modeled exposure to chlorinated organics as follows:

$$4.34 \text{ (mg/kg/day)}^{-1} \times 9.4 \times 10^{-8} \text{ mg/kg/day} = 4.1 \times 10^{-7}$$

The risk for a 2-year exposure to the maximum modeled chlorinated organics concentration would be:

$$4.1 \times 10^{-7} \times (2/70) = 1.2 \times 10^{-8}$$

This risk is also very low, but to have confidence in this figure, confidence is needed in the emission rate for chlorinated organics and the use of PCBs as a surrogate for all chlorinated organics. There is no PCB carcinogenic potency factor for the inhalation route of exposure and there is little evidence that PCBs are carcinogenic via this route. In addition directly using the oral potency factor for the inhalation route ignores relative absorption via the two routes.

Another approach is to use the most carcinogenic member as the surrogate for the class. The most potent dioxin for which a carcinogenic potency factor has been derived is 2,3,7,8 TCDD with a potency factor of 1.56×10^5 (mg/kg/day)⁻¹ (U.S. EPA 1986b). It is not possible to quantify the risk in a realistic manner using this potency factor because no dose calculation for TCDD is possible. The dose calculation depends on the proportion which TCDD is expected to be of the total chlorinated organics. While this proportion is expected to be small, the risk could still be of concern because of the high potency of this compound. Therefore, it is important to consider even the expected small contribution of this compound to ensure that the risk is acceptable.

5.7.9 Conclusions

The multiple stacks reports use recommended air dispersion modeling techniques to calculate maximum concentrations of mustard from the AI and chlorinated organics from the MWI. These modeled concentrations result in cancer risks of less than 10^{-6} , the de minimis or acceptable level of risk. Usually if a concentration results in a low cancer risk, this concentration is below reference doses for threshold effects and there is little concern for other chronic noncarcinogenic effects.

In order to have complete confidence in the low risks presented in the multiple stacks reports, there needs to be complete confidence in all assumptions. The public must be assured that:

- . All compounds of concern have been identified. This includes mustard, products of complete and incomplete combustion including all conventional pollutants, the chlorinated organics especially the dibenzo-p-dioxins and the dibenzofurans, and other classes of compounds including metals and PAHs.
- . All health effects, both carcinogenic and noncarcinogenic, have been considered.
- . Emission rates of mustard are valid. In the multiple stacks reports, mustard emission rates are based on a stack concentration of 0.03 mg/m^3 . This figure is derived from analytical detection capability and is not health-based. However, since the actual stack concentration is expected to be lower than this level, which will set off alarms, modeled concentrations based on this figure are upper bound concentrations. If these concentrations pose an insignificant risk, then the expected lower concentration will pose no significant risk.
- . Emission rates for other compounds of interest are valid. Additional explanation concerning derivation of emission rates of compounds of interest other than mustard needs to be presented. Risk calculations depend on modeled concentrations which in turn depend on emission rates. Confidence in low risk numbers depends on confidence in the emission rates.

- Incineration is carried out for only 40 hours/week and is completed within 2 years. If these assumptions change, then emission rates, concentrations, and risks have to be recalculated.

5.8 TECHNOLOGY ADDENDUM

The "Technology Addendum" is a summary of the U.S. Army's experience with chemical agent and munition disposal (Flamm and McNulty 1987), including both incineration and chemical neutralization.

With regard to mustard agent in ton containers, approximately 3,000 tons were incinerated in Phase I of Project Eagle at the Rocky Mountain Arsenal between August 1972 and February 1974. The document states that despite occasional exceedance of particulate emissions standards, this incineration "had no significant impact on ambient air quality" based on data generated from stack and work area monitoring, and from a network of nine monitoring stations at the installation perimeter. These data are not contained in the Technology Addendum, but presumably are available in documents referenced by Flamm and McNulty (1987).

No industrial-scale chemical neutralization work with mustard agent appears to have been attempted. Neutralization work with agent GB was beset with various problems related to slow reaction rates and incomplete mixing. The document states (p. 3-71) that chemical neutralization of mustard does not appear attractive because of the limited solubility of mustard, the imperfect characterization of reaction products, and the need for high temperatures and pressure to achieve practical reaction rates.

The document indicates that draining of ton containers of mustard agent was troublesome (p. 4-12). Containers that had stored agent HD had a solid residue or "heel" that averaged 100 lb, or 6 percent of the capacity of the container. For agent H, the heel averaged 600 lb, or 33 percent of the capacity. For some containers there was as much as 1,400 lb (78 percent) in the heel. Furnace modifications were necessary

to accomplish thermal decontamination of the drained containers with large residue heels (p. 4-14).

5.9 APPROACH FOR SELECTING THE ENVIRONMENTALLY PREFERRED ALTERNATIVE FOR THE CHEMICAL STOCKPILE DISPOSAL PROGRAM: FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Following is a summary of an undated draft report, received by EA on 11 June 1987, that recommends a systematic approach for selecting the environmentally preferred alternative(s) for the FPEIS. The approach is intended to: (1) compare the impacts of various alternatives, for both normal operations and unplanned releases (i.e., accidents) of chemical agent, for each site; (2) identify the environmental trade-offs associated with each alternative at each site; and (3) reach a decision. As the trade-offs are identified, the approach allows interested parties to note points of disagreement in the decision process. In this manner, although the interested parties may not agree on the preferred alternative(s), the rationale for selecting the alternative is apparent, points of disagreement are obvious, and the preferences and rationale for making trade-offs can be clearly defined.

5.9.1 Alternatives Considered

In addition to the four alternatives evaluated in the DPEIS (i.e., onsite disposal, regional disposal, national disposal, and continued storage), two new alternatives have been identified and will be evaluated. These are: (1) safety/cost optimized alternative and (2) partial relocation and disposal. A brief description of each of the new alternatives follows:

- . Safety/cost optimized alternative will identify one or more disposal alternatives that would optimize the disposal program in terms of safety and cost. This new alternative encompasses several options for evaluating, operating, and adapting the JACADS technology to the other sites and may well involve delaying the disposal program from its existing target completion date of 1994. (For a more

detailed discussion of this alternative, see Report AMCPM-CD-FR-87109--Chemical Stockpile Disposal Plan Supplement, March 1987).

- . Partial relocation and disposal will analyze combinations of transporting inventories of chemical munitions at selected installations to other locations for disposal as follows: (1) LBAD to ANAD by train; (2) LBAD to TEAD by air; (3) APG to ANAD by train; (4) APG to JI by barge; and (5) APG to TEAD by air.

The alternatives will be examined against expected impacts in categories as follows:

1. Impacts on human health are the most important. No other impact is judged equal to this one.
2. Impacts on living systems other than human health including terrestrial, aquatic, and socioeconomic resources.
3. Impacts on other environmental resources (i.e., air and water quality), apart from their impacts on human health and other ecosystem resources.

The next steps in the process will involve screening of the alternatives by using criteria for normal operations and for accident impacts under each of the three categories. Following the screening step, a matrix will be developed showing all activities associated with each alternative and each site along with potential accident scenarios unique to each activity and each site. Each cell in the matrix will have information regarding the size of the release, the modes of release, the duration of time that releases could occur, and the location(s) of potential release. In this fashion, separate matrices will be developed for each site showing the alternatives for that site and their impacts. No numerical scheme is suggested for ranking alternatives; instead, a simple ranking

of large, clearly defined differences between alternatives at each site, for both normal operations and unplanned releases, will be used.

The final step is to screen the alternatives starting with the most important category of impacts (i.e., human health). If an alternative is clearly preferred for a site on the basis of this category, then it is unnecessary to consider the lower-ranked categories. The preferred alternative with respect to the most important category is accepted, regardless of the results that would occur from screening with the less important categories. For those sites where the preferred alternative for unplanned releases is different from the preferred alternative for normal operations and routine releases, the risks and impacts between the two alternatives must be weighed. Such weighting will more than likely produce controversy among interested parties, but it is viewed as unavoidable.

5.9.2 Expected Fundamental Trade-offs

The above approach is expected to yield fundamental trade-offs, as listed below, which must be resolved by interested parties based on individual perceptions and preferences:

- . Onsite disposal versus continued storage
- . Onsite disposal versus national and regional alternatives
- . Partial relocation and onsite disposal versus onsite disposal including:
 - LBAD to TEAD by air versus onsite disposal at LBAD
 - Onsite disposal at LBAD versus LBAD to ANAD by train
 - APG to JI by barge versus onsite disposal at APG
 - Onsite disposal at APG versus APG to ANAD by train
 - APG to TEAD by air versus onsite disposal at APG
- . Safety/cost optimized alternatives versus other alternatives

5.9.3 Comments

Clearly, identification and inclusion of the two new alternatives in the evaluation process is responsive to the concerns raised during the comment period for the DPEIS and should enhance the FPEIS and the Army's decision-making process. The methodology described for evaluating the various elements of each alternative appears reasonable and should be carried out. However, we expect that it will be very difficult (and perhaps unrealistic) to have differences "resolved" by interested parties. In any event, we recommend that subsequent documents include an actual demonstration of the various matrices and scenarios including the "weighting" factors.

5.10 PACKAGING

One of the primary methods used to reduce potential risk should an accident occur during movement of chemical munitions, is the development and use of improved packaging. MITRE Corporation examined various packaging concepts and on 17 June 1987 presented a "Status Report." Following is a summary of that Status Report:

- . The basic criteria (recommended by a panel of transportation experts) to be met by any packaging concept were:
 - redundant protection against agent release during normal transport,
 - prevention of agent release during specified transportation accidents,
 - compatibility with standard cargo handling and transport equipment,
 - monitoring during transport, and
 - early loading of munitions into transportation container.

- . The panel of experts further outlined accident conditions and variables to be used as performance standards as shown in Tables 5-6 and 5-7.
- . A survey of existing containers revealed that most of them are used for transport of nuclear material, hazardous material, or explosives, and are controlled by regulations/standards issued by the U.S. Department of Transportation (DOT), the Nuclear Regulatory Commission, or various international conventions.
- . DOT regulations have evolved from transportation experience (i.e., what works) and currently contain design criteria (e.g., steel thickness, burst pressure, etc.) for tanks, drums, and other containers.
- . Using the accident conditions and accident variables outlined above, MITRE designed a munitions transport container which is basically a "double container" with outside dimensions of 20 ft x 8 ft-6 in. x 8 ft. It can be used for rail or air offsite transport of all of the chemical munitions. A modified design would be developed for marine transport of the mustard bulk containers if this alternative is selected in the FEIS.
- . Current plans call for design and development of prototype units so that full scale tests can be performed in 1989. A total of 400 units will be needed and are estimated to cost about \$200,000 each.

5.10.1 Comments

The concept, as presented, appears to address the major concerns that must be considered in designing the containers for offsite transport of the chemical munitions. However, as indicated during the presentation, the container to be used during the marine transportation phase has not

TABLE 5-6 ACCIDENT CONDITIONS

Accident Condition	Transport Mode		
	Rail	Air	Marine
Crash Impact Puncture Crush	Accordion-type derailment at 50 mph	Controlled crash during takeoff or landing	Collision with bridge, pier, or bow of ship
Fire	Locomotive fuel and LPG truck spill	Jet fuel	LASH vessel fuel
Water Immersion	100 ft		100 ft 600 ft

Note 1: Under the accident conditions stated no leakage of agent from the shipping container shall occur.

Note 2: Crash and fire can occur separately or in sequence, with crash occurring first.

TABLE 5-7 ACCIDENT VARIABLES

Accident Condition	Descriptor Units	Transport Mode		
		Rail	Air	Marine
Crash	Deceleration (g)	--	30	30
Impact	Free Drop (ft)	40	--	--
Puncture	V/R ^(a) sec ⁻¹	200	--	--
Crush	Static (lb)	600,000	--	--
Fire				
Temperature	Exterior (F)	1,850	1,850	1,850
Time	Transient (hour)	2	2	2
Temperature	Interior (F)	250 ^(b)	250	300
Water Immersion	Depth (ft)	100	100	100
Ballistic Penetration	Areal Density (PSF)	10	10	--

(a) V/R = Velocity of impact over end radius of probe.
 (b) Container wall = 400 F.

yet been designed. We recommend that such a design be developed and presented in subsequent documents. Additionally, a packaging system to be used during onsite transport (i.e., from the storage area to the incinerator) should be developed and described in subsequent documents.

5.11 TRANSPORTATION OF CHEMICAL MUNITIONS AT REDUCED TEMPERATURE

As a method of mitigating the public safety risks during all movement of the stockpile of chemical munitions, the Army is considering the possibility of cooling the munitions. This would reduce the effects of accidental release of chemical agents during both onsite and offsite movement. MITRE Corporation examined methods for reducing the munitions' temperature and keeping it low during transport, then analyzed the effect of low temperature on hazards incurred during handling, onsite transport, and offsite transport by rail, air, or barge. A draft report was issued in June 1987 and is summarized below:

- . HD was used to represent all compounds in the mustard family because HD is present in the inventory in larger quantities than the other mustard compounds.
- . HT, H, and HD freeze between 58 F and 32 F. A temperature of 0 F was selected to provide an additional margin of safety and because it would take a little longer for HD to melt when exposed to ambient temperatures. Also, most conventional refrigerated containers are designed to maintain temperatures at about 0 F.
- . The modes of offsite transportation that were considered were rail, air, and barge (from APG only). The onsite transportation mode was assumed to be truck.
- . All major activities expected to occur during a low temperature transportation option were considered. They included:

- chilling and refrigeration,
 - handling and onsite transportation,
 - offsite transportation, and
 - warming to ambient temperature at the disposal site.
- . The effects of reduced temperature during transportation were examined for the two main classes of accidents:
- Detonation or fire and
 - Spills.
- . Costs were estimated for the most promising methods of chilling munitions and for maintaining the munitions at reduced temperature during movement.
- . Maintaining reduced temperatures during transportation would be accomplished by filling the shipping container with insulation which would keep the HD bulk container frozen for about 4 weeks. However, large cargo containers cannot be conveniently carried on barges. For movement of bulk containers by water out of APG, it should be possible to install a refrigeration unit on each barge. The barges would be insulated and sealed, and the barge-carrying ship equipped with a generator to supply power to the refrigeration unit.
- . Identifying the effect of reduced temperatures on accidents resulting in detonation or fire would require extensive research and development. The expected hazard reduction is expected to be small, and consequently, no net benefits for reducing the temperature during such accidents were identified.

5.11.1 Findings and Recommendations

- . There are both advantages and disadvantages to transportation at reduced temperatures, depending on the agent, the type of munition, and the transportation mode.
- . Since HD can be readily solidified, the greatest benefit from reduced temperatures is realized for munitions containing HD.
- . There is a significant reduction in the effects of offsite transportation accidents involving bulk containers using reduced temperatures. The effects of spills resulting from rail and air accidents are greatly reduced. In a possible barge accident, the evaporation of agent to the air from mustard floating on the water surface is eliminated. However, any hazard caused by the agent sinking to the bottom will remain.
- . Munitions in open storage (e.g., APG) would be moved to a refrigerated building designed and built for this purpose and chilled prior to movement of the munitions.
- . The downwind distance to a "no-deaths" dosage for an onsite transportation accident involving an HD bulk container spill is reduced from 0.8 km to 0.1 km by chilling the HD. Thus, reduced temperatures greatly reduce accident hazards at sites (e.g., APG) where onsite transportation activities may be performed at distances less than 0.8 km from the area site boundaries.
- . The cost of low-temperature transportation of the GB and mustard stockpile is estimated to be about \$23.6 million above the cost of nonrefrigerated transportation. Included in this estimate is approximately \$1.8 million for constructing and operating a refrigerated storage structure

at APG and approximately \$2 million for refrigerated barge transport.

5.11.2 Comments

The concept and approach demonstrate that significant advantages are possible if mustard is transported in a frozen state. Since freezing occurs at relatively high temperatures, such a state can be reached and maintained relatively quickly and inexpensively. We recommend that the concept be incorporated into all of the alternatives being explored for the offsite transportation and disposal of the stockpiled mustard agent.

5.12 A COMPILATION OF CHEMICAL WEAPONS MOVEMENT HISTORY

Two of the alternatives being considered for the disposal of the stockpile of chemical munitions involve transportation of significant quantities of munitions over long distances. In response to questions about its past record, the Office of the Program Manager for Chemical Demilitarization has compiled a "movement history" report. A draft of this report was issued on 12 June 1987 (Brankowitz 1987b). The report concedes that Army records on chemical movement operations are incomplete. This is because such records were not kept or were destroyed during some periods, or because movements were not viewed as "special" during other periods. In any event, a significant body of records does exist--primarily for a 40-year period from 1946 to 1986--which provides a base of data from which the following conclusions were reached:

- . The Army has moved large quantities of chemical weapons over many years with relatively few problems.
- . The Army has learned lessons from the problems encountered.
- . There has never been a fatality from exposure to a chemical agent released during an incident associated with a movement.

The report is essentially a compilation of abbreviated descriptions of "moves" by year from 1946 to 1986 that contains the following information:

- . From: The location from which the shipment originated
- . To: The location to which the shipment was sent
- . Dates: Duration of move where available or approximate dates of moves
- . Type: Designation of movement types, i.e., sea, rail, air, or truck
- . Cargo: Various types/forms of munitions, e.g., rockets, bombs, mines, bulk or cylinder, projectiles, etc.
- . Quantity: Whatever information was available, e.g., number of railcars, aircraft, or trucks; name of the cargo ship; quantity in pounds, tons, or numbers each, etc.
- . Incidents: Either the word "none" appears, signifying that there is documentation to support that no incident occurred, or a number appears (1-43). The numbered incidents are described in another section of the report.

5.12.1 Recommendations and Conclusions

From the 43 recorded incidents, the report draws some lessons and offers recommendations which are to be incorporated in several of the other studies including: the Transportation Concept Plan (TCP), the ERCP, the Mitigation Study, the Monitoring Plan, the Packaging Plan, and the Reduced Temperature Study. Specific areas include the following:

- . Overpacking--Over a period of many years, both bombs and 1-ton containers have repeatedly shown a tendency to leak during movement. Although rockets have not been moved for a number of years, their storage history is particularly well known to include leakage problems. Overpacking during movement is strongly endorsed.

- . Refrigeration--The movement history documents several key incidents where transportation during warm weather, combined with other factors, resulted in leakage of munitions. Some of these incidents were:
 - the leakage of captured German mustard bombs aboard the cargo ship Francis L. Lee in the summer of 1946;
 - the leakage of captured German mustard bombs being transported from Theodore Naval Magazine, Alabama to Pine Bluff Arsenal, Arkansas (the Nazi War Gas Train) in the summer of 1946; and
 - the leakage of M70 mustard bombs during transportation moves for the Ralston sea dump.

The use of refrigeration as a mitigation technique is analyzed in depth in the reduced temperature study.

- . Maintenance--In the past, munitions destined for disposal were left unattended for prolonged periods. Consequently, leakages occurred during transportation and could have been prevented with relatively minor but regular maintenance. Funding and personnel manpower for inspection and maintenance must be provided and continued up to and including the period of any movement.

- . Explosive Disassembly and Downloading--Historically, prior to any movement, projectiles had all fuses and propellant material removed. These items were incinerated locally and projectile bodies were moved to the disposal locations. Apparently, rockets and land mines were always moved in a full explosive configuration. This issue needs further study and evaluation and is being addressed in the TCP and in the Packaging Plan.

- . Use of Contract Carrying Services--The documented incidents repeatedly reveal failures by contract carriers (air, rail, ship, or truck) to fully understand and comply with the Army's safety procedures. A related issue was the inability of the Army's Technical Escort personnel to stop such behavior when it was discovered. These are issues of (1) command and control of movement operations; (2) use of military versus contract personnel for certain key tasks; (3) training of contractors; and (4) writing of contracts to maximize Army control. All of these issues are to be addressed in the TCP.

- . Emergency Response: During past moves, where incidents occurred and required emergency response actions, the Army's technical escort teams typically needed from 24 to 72 hours in order to mobilize staff and equipment in sufficient strength to deal effectively with the incident. Inadequate advance planning and briefing of local officials invariably led to "stand-off" situations while lines of authority and responsibility were being debated and resolved. Recognition of these issues is being reflected in the planning requirements being incorporated into the ERCP.

- . Communications: The recorded incidents reveal several situations where communication at the person-to-person and organizational levels were often poor or nonexistent

and led to some embarrassing and potentially dangerous conditions. For example, in May 1968, while executing a rail movement, escort personnel realized that two railcars were being left at the rail yard as the train was leaving. Because of lack of communication with the engine crew, the train could not be stopped and the cars were not retrieved for several hours.

The TCP and the ERCP will be addressing and developing specific plans for proper and effective communications during movement operations.

5.12.2 Comments

The report concedes that not all information concerning the Army's history of "moving" chemical munitions is available. However, the documentation that is available and was compiled illustrates, by highlighting certain incidents, that several lessons can be learned from these experiences. These lessons are being applied by incorporating such concepts as packaging and refrigeration during transport; improved communications; continuous availability of escort personnel; and advance planning/briefing of local officials.

5.13 CHEMICAL INCIDENT REPORTS

EA is aware of two incidents of exposure to chemical agents that occurred in 1987: one at the Tooele Army Depot (TEAD) on 28 January and one at Johnston Island on 4 March.

5.13.1 Tooele Army Depot

The Tooele incident involved the Chemical Agent Munition Disposal System (CAMDS), a prototype chemical agent incinerator intended to develop new demilitarization technology, to develop technical data for the design of other similar plants, and to process unserviceable chemical stocks at TEAD.

Investigative reports (Technical Investigation Board 1987; Dept. of the Army 1987b) found that a release agent GB (non-persistent nerve agent) had resulted from the failure of three systems at CAMDS:

- . the agent piping system
- . the ventilation system, specifically the features designed to provide containment of an agent release
- . the chemical filtration system which was designed to remove residual agent from the air being exhausted from the facility

Problems were also noted in the areas of management and quality assurance.

Prior to the 28 January 1987 incident, the CAMDS facility was last operated in August 1986. At the conclusion of operations, the pipeline carrying agent from storage tanks in the Explosive Containment Cubicle to the liquid incinerator storage tank was allowed to drain by gravity and all valves were closed. Some agent apparently remained in the line, adhering to the interior walls of the pipe, and in the intervening months this residue accumulated in a vertical run of pipe above one of the valves. On 28 January, liquid began to drip from this valve to the top of the liquid incinerator agent storage tank and triggered an alarm. Alarms in the corridors surrounding the liquid incinerator also sounded, indicating a failure of the louvers supplying air to the liquid incinerator to close and contain the contamination. Within 35 minutes of the first alarm, the filter stack alarm sounded in response to a failure of the carbon filters. A backup filter was immediately brought on line. The source of the leak was found within 3 hours and the area affected by liquid agent was decontaminated; however, some alarms continued to sound periodically until 31 January.

There was no injury to personnel and no damage to buildings or equipment.

Mechanical defects cited in the investigation reports include (among others):

- . failure of one louver to close completely because of a design defect
- . failure of another louver to close completely because a thermocouple wire had been routed through it
- . use of carbon that did not meet design specifications for particle size
- . absence of a seal around a duct where it passed through the wall of the liquid incinerator room

The more significant management and quality assurance recommendations listed in the report call for

- . better attention to detail with respect to public concerns, correction of known or suspected problems, review of system modifications, and instruction of personnel on the interdependence of subsystems
- . improved preventive maintenance and in-process testing
- . establishment of procedures for purging lines
- . periodic review of plans and standard operating procedures
- . verification of the adequacy of ventilation and filtration systems in non-operational as well as operational modes

The Army's investigation of the Tooele incident appears quite thorough in identifying the cause of the release, as well as the weaknesses in the management of the facility that were significant contributing factors.

The recommended corrective actions are appropriate both for CAMDS and for the chemical demilitarization program as a whole.

5.13.2 Johnston Island

Johnston Island is the site of the prototype of the system proposed for the National Chemical Stockpile Disposal Program, and is also a major storage area for chemical munitions and agents. Munitions include M55 rockets, 500- and 750-lb bombs, land mines, 4.2-in. mortars, and artillery projectiles. Filler agents include GB (non-persistent nerve agent), VX (persistent nerve agent), and HD (blister agent, mustard). The inventory also includes ton containers of all three agents.

The incident involved maintenance of stored munitions and was not related to the JACADS facility (Jones 1987). Routine air sampling of a storage igloo on 2 March 1987 indicated the presence of GB at concentrations greater than the Permissible Exposure Limit (0.0001 mg/m^3) for unprotected workers. Initial efforts to locate the source were unsuccessful; filter units were installed on the building stacks as a precaution against agent release and additional alarms were deployed inside the building.

Subsequent air sampling on 3 March confirmed the continued presence of GB.

On 4 March, four workers identified the source as a leak from an overpack in which a leaking M55 rocket had been placed. They immediately transferred the rocket to a new overpack and decontaminated the affected area.

Medical surveillance showed that all four workers exhibited depressed cholinesterase levels indicative of agent exposure, and that the most probable route of exposure was absorption through the skin resulting from a "bellows effect," i.e., entry of vapor through openings in the workers' protective clothing.

The incident involved departures from the established standard operating procedures in that two additional workers should have been present, and that the workers remained in the contaminated area for a period larger than permitted for the type of protective clothing they were using.

This incident is not directly applicable to APG because the APG inventory does not include agent GB or M55 rockets. However, it is indicative of the importance of monitoring to protect against the hazards associated with continued storage of the nation's chemical stockpile. The incident also emphasizes the need for attention to SOPs to ensure the safety of workers, both for their own well being and for prevention of agent release.

6. PRIORITY COMMUNITY CONCERNS

During the initial phase of EA's work activities, five major issues were selected for in-depth evaluation. These issues were presented to the Edgewood Area Citizens' Steering Committee as our best prioritization of the community concerns. Following discussion with Steering Committee members, consensus was reached that these areas merited further evaluation by the Study Team. Section 6 presents the results of our analysis of these priority community concerns.

A thorough evaluation of the five priority areas is limited by several constraints, not the least of which is the limited timeframe for this review effort. Another constraint relates to the nature of the priority areas--they required an integration of the results of two or more of the additional studies. The problem that this presents is one of timing--several of the deadlines for the additional studies have slipped and it has proved difficult to integrate the results of additional studies that are interrelated.

6.1 EVALUATION OF MARINE TRANSPORT ALTERNATIVE

The partial relocation alternative under consideration for the FPEIS includes shipment of the bulk mustard agent inventory at Aberdeen Proving Ground to Johnston Island in the Pacific Ocean. The marine transport alternative was identified early in the public participation process as a priority area of concern. The marine transport of bulk mustard agent is also discussed in Section 5.3 Transportation and Section 5.5 Emergency Response.

The DPEIS evaluated rail, truck, air, and barge transportation modes for the movement of chemical stockpiles in the Regional and National Disposal Center alternatives. Based on considerations of public safety, environmental impact, security, and operating requirements, all but the rail transport option were rejected for in-depth evaluation. In response to comments on the DPEIS, the Chemical Demilitarization Program staff added a fifth disposal alternative including marine transport to be addressed

in the FPEIS. The barge transport mode was initially judged environmentally unsound because of the sensitivity of the Chesapeake Bay and the catastrophic consequences of a barge accident in the region.

The additional disposal alternative will actually be a consideration of mixed alternatives, i.e., partial relocation/onsite disposal, depending on the optimization of safety and cost factors. The partial relocation and disposal alternative includes barge/air/train transport modes for APG, and train and air modes for the Lexington, Kentucky site (LBAD). This section evaluates the feasibility of the marine transport option.

6.1.1 Development of the Marine Transport Option

The status of the marine transport option is still conceptual in nature. If this site-specific alternative is chosen, a detailed operational plan will be required. A critical factor in the operational plan will be the design and cost considerations of the marine transport containers.

Unlike the other disposal alternatives, the marine transport of bulk mustard agent involves a single shipment. The total number of overpack containers would be equivalent to the number of ton containers stored at APG. While the exact number of ton containers is classified, this represents a considerable cost (McKinney 1987). The overpacking requirements for marine transport should not have to meet the stringent requirements for shipment of nerve agent munitions. Several options for reducing the overall cost of packaging while maintaining adequate levels of safety during the high-risk portions of the transportation phase should receive additional scrutiny. The ton container provides a structural integrity greater than several of the munition types; a "double" redundancy may not be required. The overpacking should provide protection for the accidents likely to occur during loading and offloading of the lighters. The feasibility of placing two or more containers in a single overpack should be considered. Finally, freezing of the agent prior to loading lighters or choosing the time of year to transport agent to Johnston Island to optimize safety along the entire route may provide an additional level of safety.

The consultant team evaluated various methodologies for marine transport of the mustard agent stockpile and decided upon the LASH shipping system. In this system, barges (called lighters) are loaded with the marine transport containers and are towed through shallow waters to a large, ocean-going LASH vessel securely anchored in deeper water nearby. The loaded lighters are lifted aboard the LASH vessel from the stern by a shipboard crane and stored in the hold. The LASH vessel would transit the Bay, proceed to Johnston Island, and unload for eventual destruction at the JACADS facility. The LASH ship and lighters are depicted in Figures 6.1-1 and 6.1-2.

EA evaluated other marine transportation options and discussed these with the project manager for the TCP. These options included alternatives that would not require any dredging of the waters in the Bush River or adjacent to the alternative loading area near Boone Creek, located further down the Gunpowder Neck. These options included the use of the amphibious landing craft (LAC-30 and LAC-60) which ride on a cushion of compressed air, other types of landing craft, and the use of temporary bridging equipment used by the Army to cross rivers and streams. Each of these alternatives appeared to have higher levels of risk associated with the loading and unloading of the ocean-going vessel. The benefit of the LASH system is that the lighters are carried aboard the LASH vessel, significantly reducing the risk associated with loading and off-loading the individual mustard agent containers. EA concurs with the selection of the LASH-lighter system as the most feasible marine transport system.

Two candidate lighter loading areas have been selected and are depicted in Figure 6.1-3. The initial loading area is in close proximity to the Chemical Agent Storage Yard and will require approximately 3,000 ft of dredging to reach 8 ft of water. The alternative loading area near Boone Creek will require approximately 2,000 ft of dredging, but requires an additional 3 mi of land transport to the loading area. Both areas are located outside of current firing ranges (Figure 6.1-4); however, there is a distinct possibility of unexploded ordnance which would require removal before dredging. The possibility of unexploded ordnance presents an additional complication to the marine transport option, yet

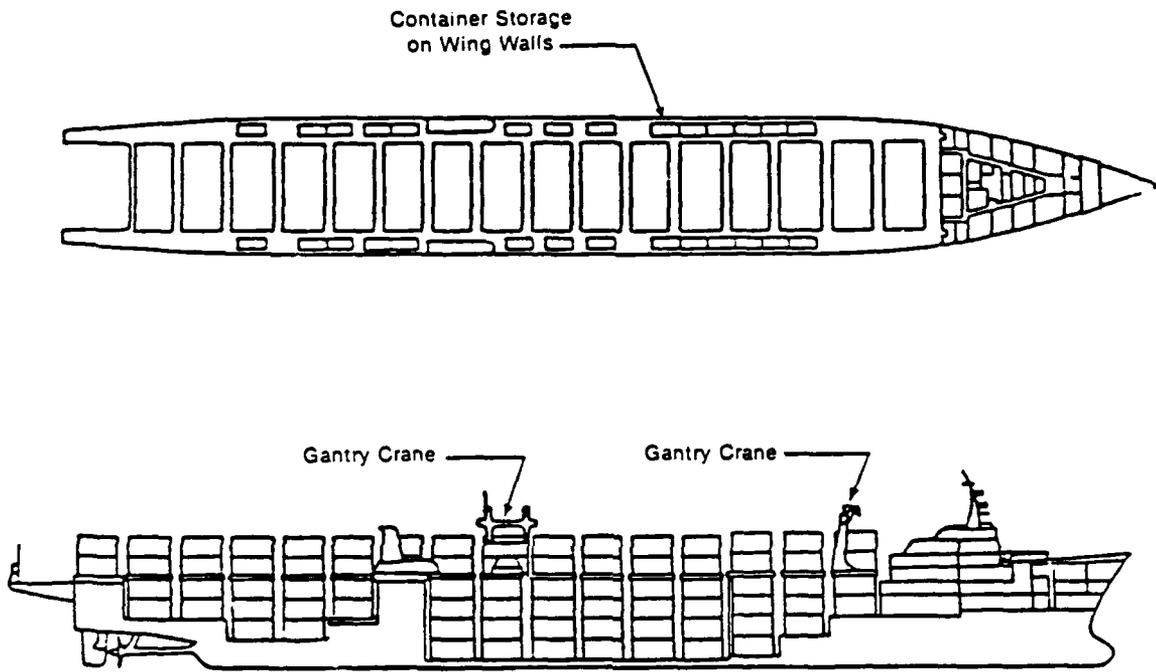
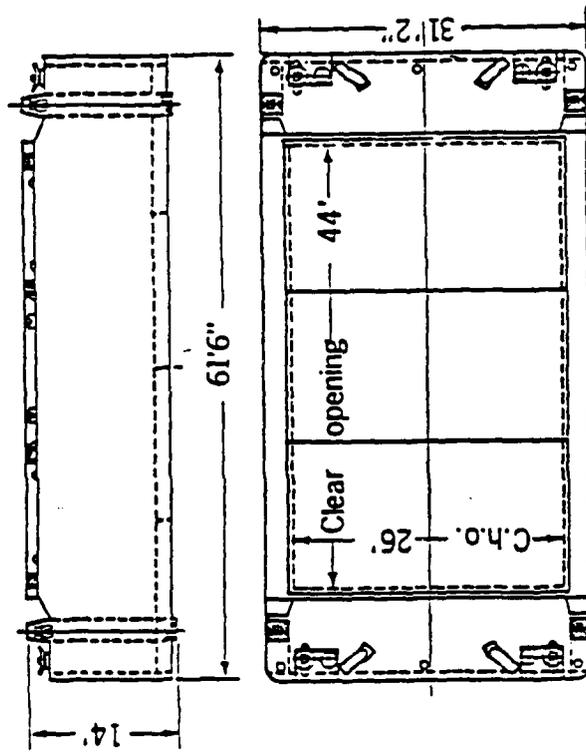


Figure 6.1-1. Plan and profile of a lighter aboard ship (LASH) vessel.
(Mitre Corporation 1987)



PRINCIPAL CHARACTERISTICS OF LASH BARGES

Length	61'6"
Width	31'2"
Height Overall	14'0"
Hatch Opening	44' by 26'
Draft of Empty Barge	1'6"
Draft, Maximum	8'8"
Weight of Empty Barge	80 Long Tons
Cargo Capacity	368 Long Tons
Bale Capacity	19,600 Cu. Ft.
Grain Capacity	20,100 Cu. Ft.

Figure 6.1-2. Typical lighter for use with lighter aboard ship system.
(Mitre Corporation 1987)

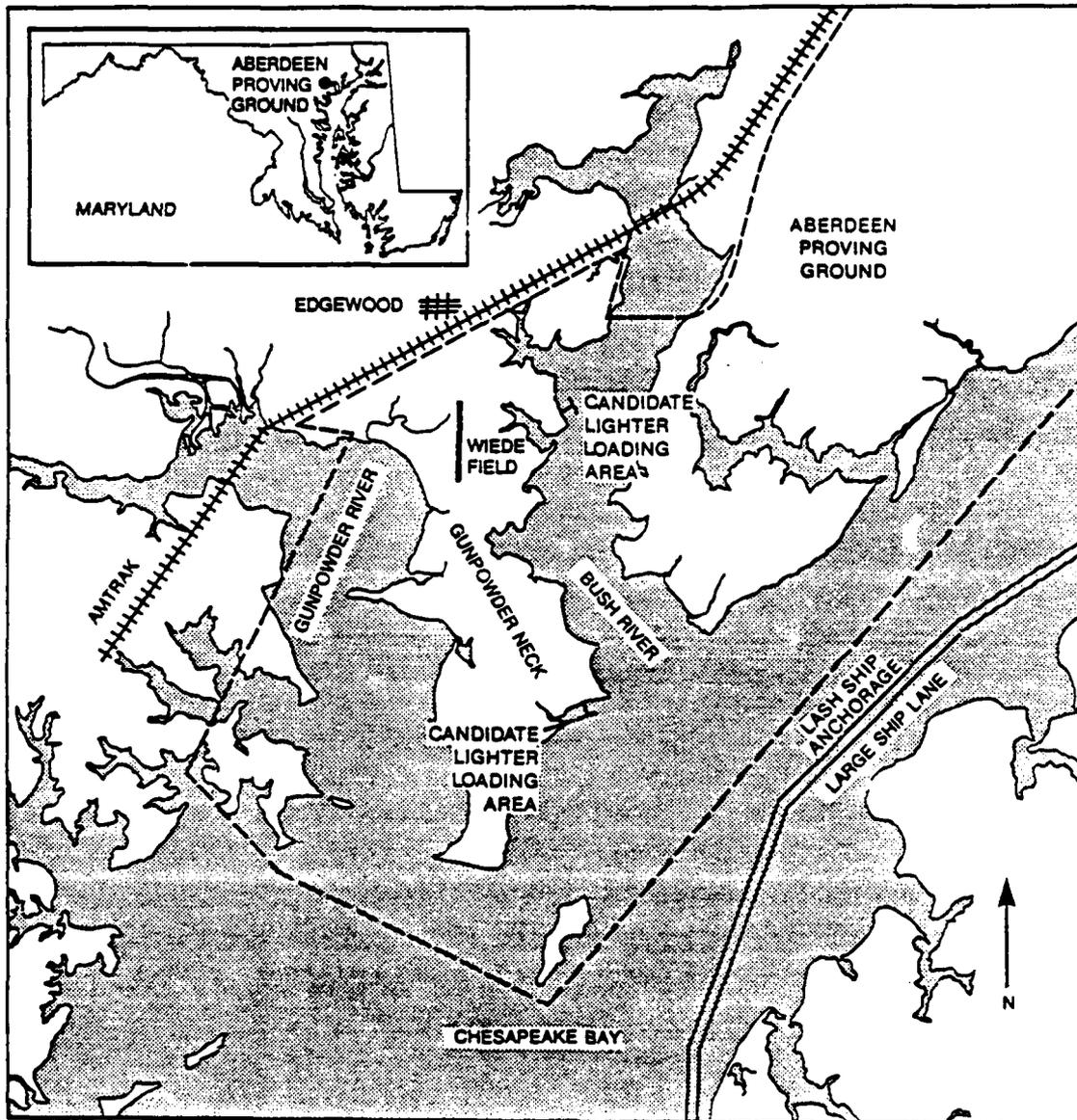


Figure 6.1-3. Proposed alternative locations of lighter loading area at Aberdeen Proving Ground, Maryland. (Mitre Corporation 1987)

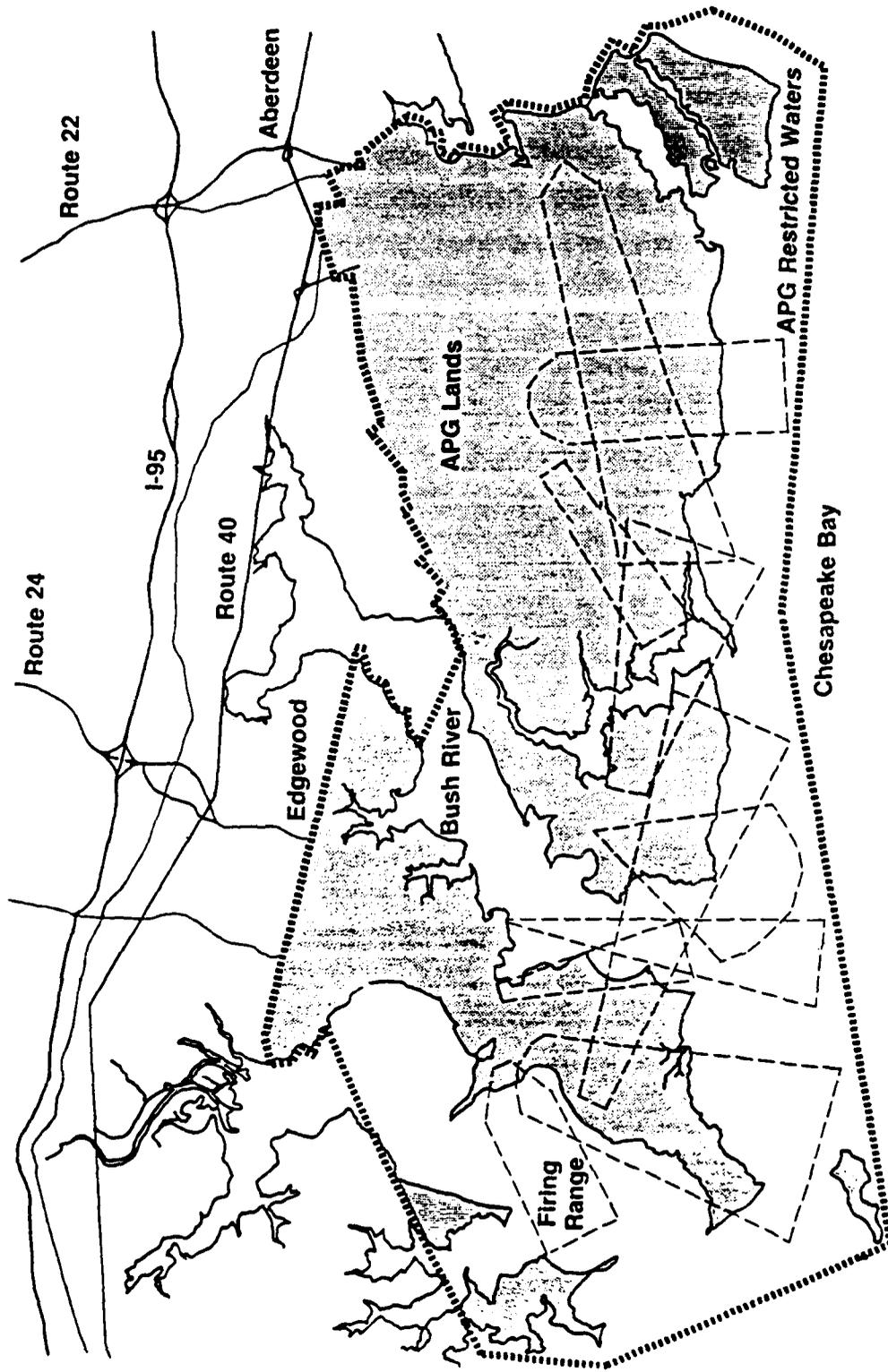


Figure 6.1-4. Aberdeen Proving Ground (APG) firing ranges.
(deJong 1985)

it is not felt to be a fatal flaw. The technology exists to locate the unexploded ordnance and special Navy teams have the experience to remove them safely. If the marine transport alternative is selected, both sites should be studied in detail to determine which site is most suitable.

In the 1 May version of the TCP, LASH vessel is proposed to remain anchored south of the Bay Bridge near Annapolis, making periodic travels to the mouth of Bush River to load ten lighters. This suggestion was omitted in the revised report. This condition was originally proposed because it was not considered feasible to block the main channel to the Chesapeake-Delaware Canal for the period of time it would take to load the LASH vessel (2-4 weeks). This condition would increase risks associated with the movement of the partially loaded LASH vessel to an anchorage south of the Bay Bridge and make emergency response planning extremely difficult. Further investigation since the May draft indicates that an area outside the channel has enough depth to "berth" the LASH vessel during loading. Mooring piles would be required to ensure the LASH vessel would remain at the mooring position during a major storm event.

At the storage yard, ton containers will be loaded into the shipping containers after ultrasonic testing to determine susceptibility to leakage. Overpack containers will be packed and sealed, and then assembled for loading. Trucks will be used for transporting overpack containers to either of the two lighter loading areas.

Security will be provided during each phase of the marine transport operation. The Coast Guard and APG security vessels will provide armed security during the loading phase and a Coast Guard escort will travel with the LASH vessel to international waters. During the entire loading process and transit down the Chesapeake Bay, the LASH vessel will be accompanied by a tug to provide steerage if the LASH vessel is disabled. A naval escort vessel will accompany the LASH vessel to Johnston Island.

Once the LASH ship, with its escort, has reached international waters, its progress will be monitored by satellite to ensure that its position is known at all times. The LASH vessel will proceed to Johnston Island along the route shown in Figure 6.1-5. Security reasons and a vulnerability assessment do not permit the use of the Panama Canal.

6.1.2 Conclusions

EA's assessment of the marine alternative indicates that transport of mustard agent to Johnston Island by the LASH-lighter system is feasible. EA is not able to evaluate this alternative fully relative to other disposal options because risk assessment data for the marine transport are currently not available. The results of the mitigation analysis based on the current transportation plan need to be incorporated into a refined risk assessment for marine transport. It appears that the mitigation proposed for the water transport would significantly reduce the initial projections of risk (2×10^{-5} to 3×10^{-6}). If this is true, the water transport option is a feasible alternative and should be considered in the site-specific EIS.

6.2 FEASIBILITY OF DEVELOPING AN EMERGENCY RESPONSE PLAN FOR THE EDGEWOOD AREA

6.2.1 Site-Specific Considerations

This section evaluates the feasibility of developing adequate emergency response capabilities in the Edgewood/Joppatowne area. In order to evaluate the fixed-site emergency response capabilities, EA reviewed several drafts of the ERCP, and reviewed the current Chemical Accident and Incident Response and Assistance Plan for the Edgewood Area (Dept. of the Army 1985). In addition, EA staff met with Dr. Charles Brown, Director of the Department of Emergency Services Coordination, Harford County, and were given a tour and briefing of the Edgewood Arsenal Emergency Operations Center (EOC) by base personnel responsible for implementing the CAIRAP. EA also obtained the services of ARI

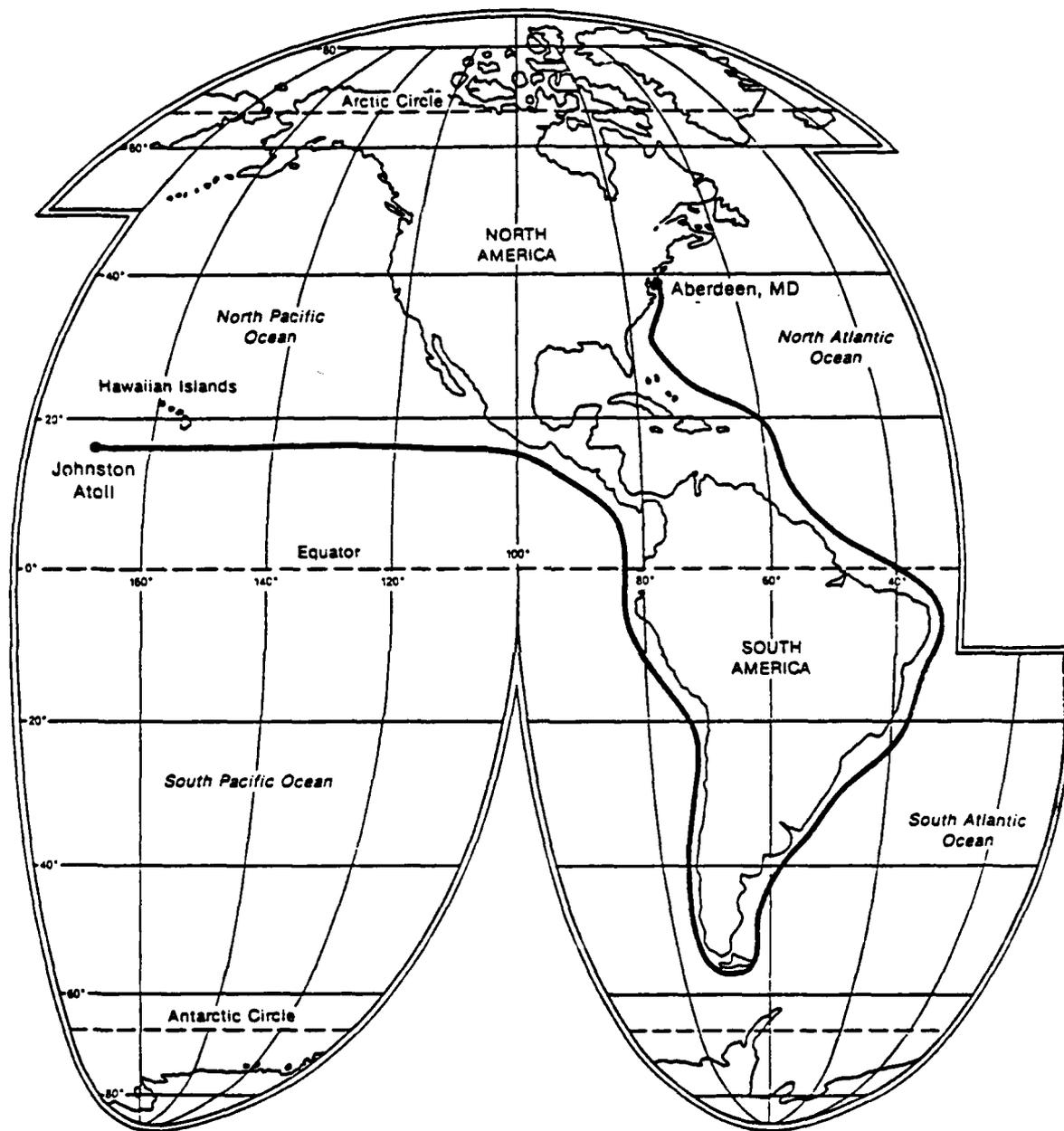


Figure 6.1-5. Route of the LASH Vessel from Aberdeen Proving Ground, Maryland to Johnston Atoll.
(Mitre Corporation 1987)

Engineering as a subcontractor to prepare evacuation time estimates for the Edgewood/Joppatowne area.

The ERCP designates a 10-km Immediate Response Zone (IRZ) as the priority area for emergency response planning. In the specific case of the Edgewood Area where only mustard agent is stored and which does not disperse as readily as other chemical agents, the Protection Action Zone (PAZ) would not extend beyond 10 km.

The designated IRZ for the Edgewood Area is a densely populated area, averaging about 1,660 people/mi². Unfortunately, the population density increases in proximity to the Edgewood Arsenal. The 10-km zone includes a small, sparsely populated area of Baltimore County including the communities of Harewood and Chase. As depicted in Figure 6.2-1, the IRZ includes the following residential developments: Edgewood Area, Joppatowne, Willoughby Beach, Van Bibber, Constant Friendship, Boxhill, Long Bar Harbor, and Riverside. The total population in the IRZ was estimated to be 40,870 in the DPEIS. A conservative population projection for the Harford County portion of the IRZ would be 45,000 by 1990. The majority of the Harford County portion of the IRZ lies within the County's development envelope and substantial residential construction is currently underway in the Riverside, Boxhill, and Constant Friendship developments. The Edgewood/Joppatowne area, however, is primarily built-out and is projected to grow at a more modest rate.

Several major transportation corridors cross the IRZ in a southwesterly to northeasterly alignment including Interstate 95, Route 40, the Baltimore and Ohio Railroad (freight), and Conrail line (freight and AMTRAK passenger). It is crucial that these interstate transportation corridors be considered in the site-specific emergency response plan.

The geography of the region surrounding Edgewood Arsenal places major constraints on the ability to respond quickly to an accident requiring offsite evacuation. The area immediately adjacent to the base is bounded by the Gunpowder River and the Bush River limiting the number of evacuation routes. The road network in the Edgewood/Joppatowne area consists

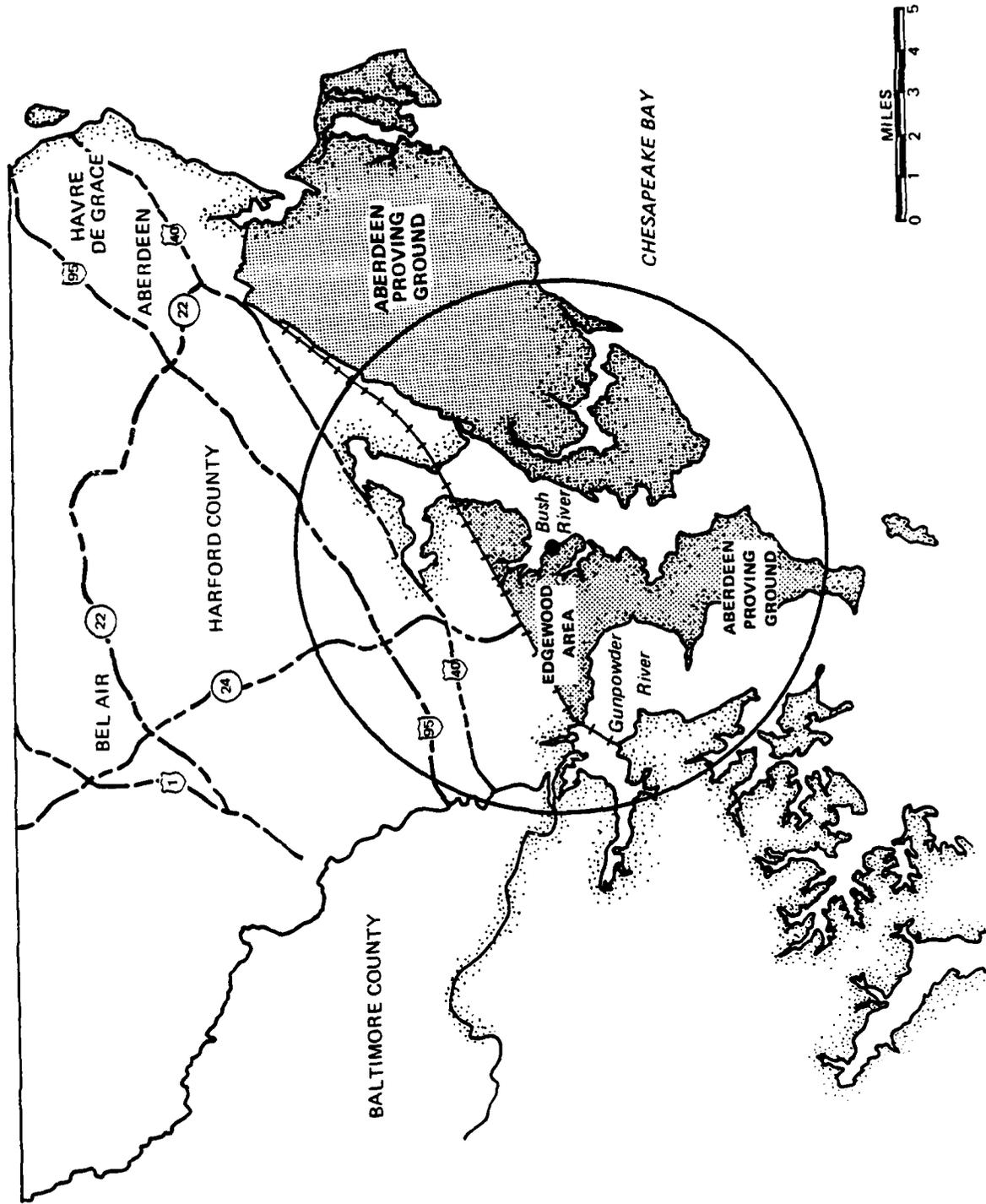


Figure 6.2-1. 10-kilometer Immediate Response Zone.

of four major routes that could function as evacuation corridors. These are:

- . Route 755 and Route 24
- . Route 152
- . Joppa Road/Trimble Road
- . Joppa Farm Road

Harford County does have an Emergency Preparedness Plan and an EOC located in Hickory just north of Bel Air. The plan is out of date and needs to be revised to address types of accidents involving hazardous materials. The County has recently signed a Memorandum of Understanding with APG outlining basic coordination activities. No alert and notification system is currently in place in the Edgewood/Joppatowne area. In a letter dated 24 March 1987 to Dr. Vernon Houk, CDC, the County has estimated the cost to install and maintain a siren alert system at \$3 million (Browne 1987). The ERCP recommends that the siren/Emergency Broadcast System alert and notification system be complemented by a radio-tone or telephone-alert system in areas of high risk. Such redundancy may well be appropriate in the Edgewood/Joppatowne area.

The ERCP outlines three major categories of protective action responses to a chemical agent release--evacuation, sheltering, and individual respiratory protection. Evacuation is the preferred protective action when adequate time is available. An Evacuation Time Analysis for the Edgewood/Joppatowne area was prepared by ARI traffic consultants to evaluate the feasibility of evacuation. Figure 6.2-2 summarizes the evacuation time estimates for the resident population with automobiles. The figure reveals that 40 percent of the auto-owning population can evacuate within 75 minutes following notification, 70 percent within 105 minutes, and 100 percent within 2 hours. The flattening of the S-shaped "Exit" curve represents traffic congestion at four critical intersections which commences approximately 1 hour after notification. The ARI report is provided in Appendix A.

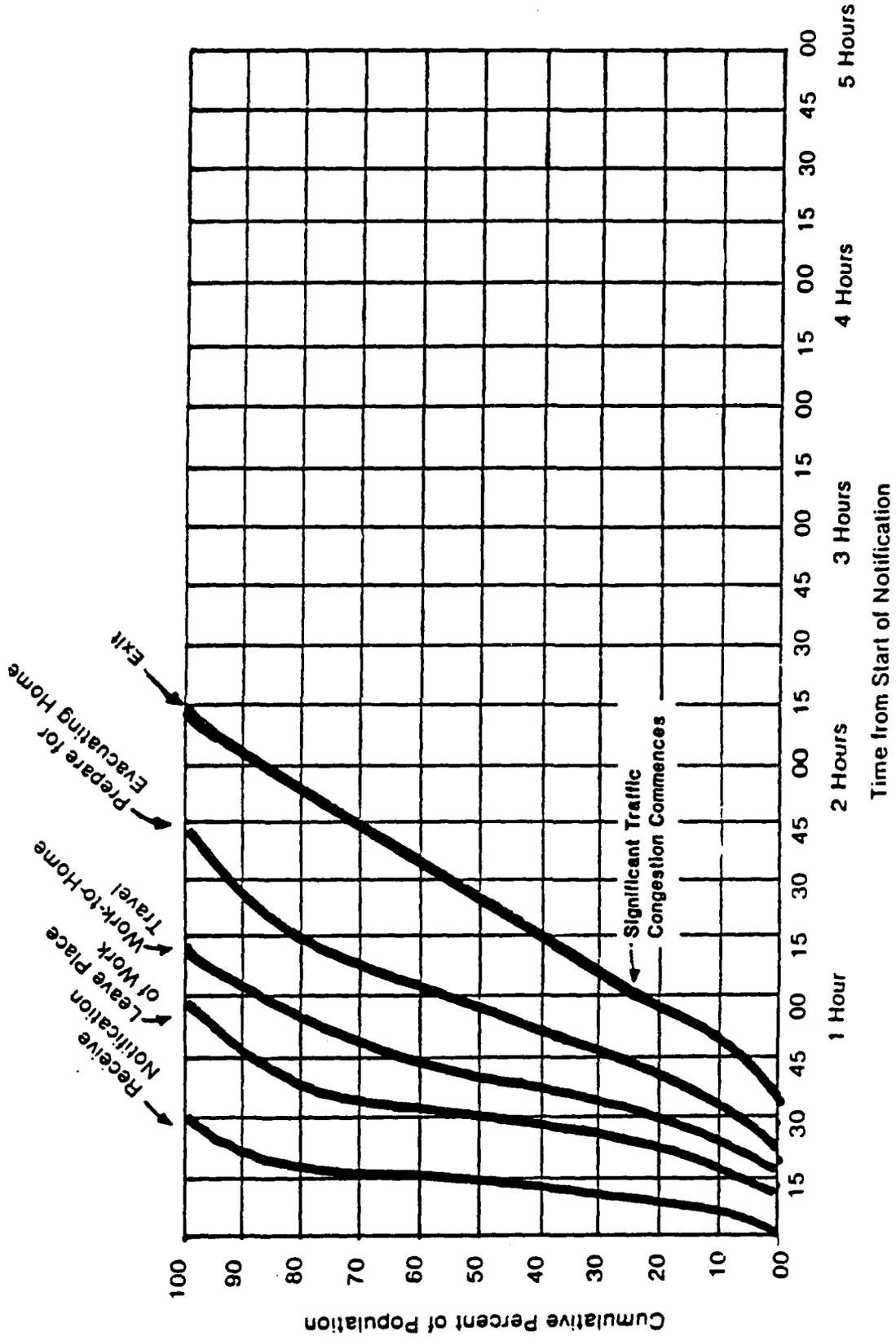


Figure 6.2.2. Evacuation times for the permanent resident population (auto-owning).
 (ARI Engineering 1987)

Table 6-1 illustrates estimated travel time for an agent plume from a major release assuming little dispersion along the axis of the wind direction. Included are the worst-case meteorological conditions (inversion with low wind speed) and conservative most-likely conditions (2 m/s). If alert and notification was activated immediately after a release occurred, a portion of the population in the Edgewood/Joppatowne area would still be at risk during the evacuation phase.

The majority of accident scenarios involving accidental release of mustard agent would have no impacts off-base. An explosion or fire involving a number of ton containers would be required to achieve a plume that would carry the agent offsite. The term mustard gas is a misnomer owing to the low volatility of this agent. It is the low probability accidents, however, that have the most serious consequences and need to be considered in the emergency response plan.

The CAIRAP for the Edgewood Area appears to be more than adequate for the accident scenarios considered probable during continued storage. The U.S. Army has expended significant resources in developing the CAIRAP and maintaining onsite emergency response capabilities. The maximum credible event being considered for a chemical agent spill is a valve failure or shear of a ton container. Under such a scenario, air dispersion modeling predicts a limited downwind hazard zone and no impact off-base. The CAIRAP does not address the extremely low probability/high severity releases included in DPEIS risk assessment studies.

6.2.2 Conclusions

A site-specific emergency response plan for the Edgewood Arsenal area will be required to address the selected disposal alternative. A wider range of accident scenarios will need to be considered including the low probability/high severity accidents. The major concern in addressing these latter scenarios is streamlining the decision process so that an offsite alert and notification, if required, can be made as rapidly as possible. Under the existing CAIRAP, the decision process leading to an offsite evacuation involves far too many steps considering the critical

TABLE 6-1 ESTIMATED PLUME TRAVEL TIME

<u>Distance (miles)</u>	<u>Location</u>	<u>Worst Case 2.2 mph (hour)</u>	<u>Most Likely 4.4 mph (hour)</u>
1.5	Perimeter boundary	0.68	0.34
2	Edgewood schools	0.90	0.45
3	Centroid Edgewood	1.3	0.68
4	Route 40	1.8	0.9
5	Centroid Joppatowne	2.2	1.1
6	10-km boundary	2.8	1.4

element of time in determining the success of any selected protective action. Currently, an offsite evacuation cannot be recommended by the Edgewood Area EOC, but must first be forwarded to the APG EOC who notifies the Harford County Civil Defense Office. Included in this critical decision period are delays in determining the severity of release, running the dispersion model, and briefing the Chemical Accident/Incident Commander. In addition, once the decision is made to recommend an offsite evacuation, time will be needed to notify the Harford County Civil Defense office, describe the accident, and initiate the offsite alert and notification phase. Clearly, a more streamlined critical decision path is required for a rapidly escalating major chemical release.

The Evacuation Time Analysis prepared by ARI Engineering and the additional evaluation by the EA project team have led to the following conclusions and recommendations:

- . The site-specific emergency response plan should include an accident classification system enabling a rapid decision-making process for accidents with moderate to severe consequences. The Edgewood Area EOC should have the authority to implement an offsite alert and notification.

- . The response plan should evaluate the feasibility of a sequential notification and evacuation of the risk area population with priority for the areas within and immediately adjacent to the projected plume trajectory. This will reduce anticipated congestion of the major evacuation corridors. Any sequential evacuation proposal must consider the potential for a "mass psychology" syndrome creating panic following the initial alert and notification. It may prove exceedingly difficult to implement sheltering as a protective action in one sector of the IRZ and evacuation in an adjoining sector. This "shadow effect" has been observed in past evacuations where

residents outside the affected zone added to the congestion created by residents evacuating the affected zone.

- . A sequential or tiered evacuation will require a refined version of the D2PC model which includes topographic considerations. EA understands that an updated air dispersion model is under development. Continuous modeling capability using real-time meteorological data would be beneficial.
- . The preliminary evacuation time estimates prepared by ARI indicated that if the on-base population is included in any evacuation scenario, significant delays to overall evacuation are encountered. The results are two-fold: traffic congestion on the local road systems occurs earlier and overall evacuation time of the resident increases by approximately 45 minutes. Where feasible, sheltering of base population or limited evacuation to specified areas on-post and outside of the plume trajectory, should be the preferred protective actions for the base population. On-post buildings with positive pressure ventilation systems should be considered for sheltering base personnel.
- . If the onsite disposal alternative is selected, the site-specific EIS should consider the benefits of relocating the incinerator 3-3.5 mi south of the proposed site on Eagle Point. The location of the incinerator farther down the Gunpowder Neck would greatly facilitate the implementation of protective actions offsite. The added risk of moving mustard agent to the incinerator would need to be considered; however, it does not appear to be significant, and the convoy traffic can be carefully controlled on-base. Both the primary incinerator site and an alternate site located on the lower Gunpowder Neck involve the same level of risk in loading or unloading. The alternate site would involve an additional 2-3 mi of travel by truck convoy.

If the incinerator should be located lower on the Gunpowder Neck, emergency response planning for the western portion of Kent County would have to be considered. The reduced costs and risk associated with implementing emergency response capabilities at an alternate incinerator on the lower Gunpowder Neck must be balanced against the added risk of a longer truck transport on the base. If onsite incineration is selected in the the FPEIS for APG, the option of relocating the incinerator merits consideration in the site-specific EIS.

- . Sheltering special populations offsite should receive careful attention in the preparation of the site-specific emergency response plan. At a minimum, the feasibility of installing ventilation systems on the public schools in the Edgewood Area should receive serious consideration. Evacuating the school-age population in this area is not a feasible option.
- . Evacuation of special populations also requires special consideration in the preparation of a site-specific emergency response plan. Although there are no large hospitals or other institutions for the sick or elderly in the IRZ, there are a number of smaller boarding homes, group homes, and day care centers which must be addressed in the development of any evacuation plan.
- . Movement of the chemical agent stockpile to the incinerator should not occur under meteorological conditions that could lead to offsite impacts to the Edgewood/Joppatowne area. If the onsite disposal option is selected for APG the site-specific EIS should consider the trade-offs involved with nighttime operation of the incinerator and the difficulty of implementing an emergency response plan at night. The incinerator at Edgewood Area would not have to run three shifts to completely dispose of the agent stockpile within

the 1994 deadline. Incinerators often operate at peak efficiency if run continuously and suspending operations at night needs to be evaluated in light of its effects on the operational efficiency of the plant.

- . Evacuation or sheltering may not be feasible under the worst-case scenario for the portion of the Edgewood/Joppatowne community living in closest proximity to the installation.
- . While a more thorough evacuation analysis will be required, the ARI recommendations should be considered in the development of the site-specific response plan.

6.3 INVESTIGATION OF THE HEALTH EFFECTS ASSESSMENT OF MUSTARD AGENT

Mustard agent, also known as bis(2-chloroethyl)sulfide, is a chemical agent which was used primarily in World War I. It is classified as a vesicant or blistering agent and can cause severe incapacitation as well as lethality. There are three forms of mustard: H, HD, and HT. H is mustard agent made by the Levinstein process and is approximately 70 percent pure with 30 percent sulfur impurities. HD is H that has been purified and is approximately 92 percent pure. HT is 60 percent mustard and 40 percent T (bis[2(2-chloroethylthio)ethyl]ether) which has been added to create a more toxic, stable agent. The form of mustard stored at APG is HD.

Reaction to mustard agent usually does not occur for several hours after exposure, unless exposure is to very high concentrations. Therefore, individuals may not know they are being exposed and, thus, fail to take appropriate measures. Exposure to mustard can result in both acute and chronic effects. Major target organs include the skin, eyes, and lungs, with the eyes being the most sensitive. Acute symptoms may range from mild reactions, such as reddening of the skin and tearing of the eyes, to severe skin blistering, inflammation and swelling shut of the eyes, and lung congestion. High exposure levels may result in nausea, vomiting,

diarrhea, and injury to hemopoietic tissues (e.g., bone marrow) which results in depression of the white blood cell count. The severity of these effects and the time it takes for recovery (days to months) are dependent on the level of exposure and the sensitivity of the exposed individual. If the damage is severe enough, secondary infections may set in. Permanent effects, such as chronic bronchitis, visual impairment, and skin damage, may also result. Repeated exposure to mustard gas can cause skin sensitization resulting in a more rapid and severe response to subsequent exposures. There is also evidence that mustard gas causes developmental/reproductive toxic effects as well.

Mustard agent is both mutagenic and carcinogenic in animals and is considered a human carcinogen by the International Agency for Research on Cancer (IARC, 1975) and the National Toxicology Program (NTP) (U.S. DHHS 1985a). Mustard agent was used in World War I and studies of individuals exposed during the war indicate that there was a small increase in the number of respiratory cancers over what would be expected. Other evidence of an increased risk of respiratory cancer comes from studies of factory workers in Japan who were exposed during the manufacturing of the agent between 1929 to 1944 (Wada et al. 1962, 1968). A significant increase in the number of cancers was found in exposed individuals as compared to those who were not exposed and as compared to the expected number of deaths from respiratory cancer.

In reviewing the toxicity data presented in the DPEIS as well as pertinent references cited in a literature search performed for EA, it is clear that there is a lack of quantitative data and that the data which do exist are for the most part quite dated and not of very high quality by today's standards. Most of the toxicity information on mustard comes from studies performed between the 1920s and the 1950s. Another problem with the data presented in the DPEIS is that much of it is not well-documented. Often a particular piece of data, such as an LC_{50} (the dose that results in lethality of 50 percent of the population), is cited from one Army document to another, but the experimental basis for this number is never presented. This has made it impossible to assess the validity of these data. As discussed below, these problems with the data call

into question the validity of the Permissible Exposure Limits (PELs) set by the Army as well as the data used in assessing the risk posed by mustard during various accident scenarios.

Because of the types of acute and chronic effects caused by mustard and the quality and quantity of data available for assessing the risk posed by the Chemical Stockpile Disposal Program, concern has been raised by the community over a number of issues including the following:

1. What is the basis for the Permissible Exposure Limits (PELs) and are these limits protective of the public's health?
2. What are the toxicity values used in the D2PC model for assessing the size of the population at risk and the consequences of various accident scenarios? What is the basis for these values?
3. Are there sensitive sub-populations to mustard? If so, are they taken into account in assessing the risk posed by mustard?
4. What are the complete and incomplete combustion products of mustard and what is the toxicity associated with these? What risk is posed to the community by these?

6.3.1 Permissible Exposure Limits

The PELs have been established for mustard and are listed below (expressed as time weighted averages [TWAs]):

General Population (72 hour TWA)	Worker Population (8 hour TWA)	Stack Effluent (1 hour TWA)
0.0001 mg/m ³	0.003 mg/m ³	0.03 mg/m ³

These limits were developed by the Dept. of the Army (McNamara et al. 1975) and then reviewed and approved by the Centers for Disease Control's Center for Environmental Health, the Department of Health and Human Services' (DHHS) designee (U.S. DHHS 1985b). The PELs for the worker and general population are based upon health concerns and represent levels of chronic exposure considered to be protective of human health. The stack effluent PEL is based upon the lowest reliably detectable level (taking into account a short monitoring time) (Ovens 1987).

6.3.1.1 Methodology Used to Calculate PELs for Worker and General Populations

The limits for the general and worker populations were based upon an Army study published in 1975 (McNamara et al. 1975). Several animal species were exposed to mustard at two different concentrations via inhalation. Exposure lasted up to 52 weeks with animals being sacrificed and necropsied at various time points. The authors found no detectable effects at the lower exposure concentration of 0.001 mg/m^3 for 24 hours/day, 5 days/week, but observed cancer at the higher combined exposure concentrations of 0.1 mg/m^3 for 6.5 hours/day plus 0.0025 mg/m^3 for the remaining 17.5 hours/day, 5 days/week. Based upon these findings, the 0.001 mg/m^3 concentration was used to derive the exposure limits for the worker and general populations. The 0.001 mg/m^3 exposure had been for 24 hours and was, therefore, converted to a level of 0.003 mg/m^3 for workers based upon an 8 hour workday. Because workers are considered to be a healthier and more homogeneous population than the general population, the worker limit was divided by a factor of 30 to yield the limit of 0.0001 mg/m^3 for the general population. The 30X factor consisted of two components: a factor of 3 to convert back to a 24-hour exposure and a factor of 10 to account for the increased variability in sensitivity of the general population.

6.3.1.2 Appropriateness of Methodology Used to Calculate PELs for Worker and General Populations

While the methodology for deriving the population limits as described above might have been acceptable at the time of the report, it is not in keeping with the current recommended methodologies as practiced by a number of federal agencies and national organizations, including the Environmental Protection Agency (U.S. EPA 1986a), the Food and Drug Administration (Hutt 1985), the Occupational Safety and Health Administration (Hutt 1985), and the National Academy of Sciences (NAS 1986). Current scientific consensus holds that there is no level of exposure to a carcinogenic compound that is not without some level of risk of developing cancer, albeit that risk might be extremely small. Noncarcinogenic effects of a compound, however, are considered to be threshold effects whereby there is a threshold level of exposure below which there is expected to be little or no risk of such effects occurring. Based upon these distinctions, the quantitative methodologies employed in assessing risks of carcinogenic and noncarcinogenic effects of compounds are different.

Because carcinogenic effects are often as sensitive as, if not more so, than noncarcinogenic effects (i.e., appear at equal or lower levels of exposure), the methodology used to derive an acceptable level of exposure to a compound which causes both types of effects is most often that which is appropriate for quantifying carcinogenic risk. The result of a quantitative assessment of a carcinogenic agent is the characterization of the dose-response curve. This is often expressed by a number known as the carcinogenic potency factor which represents the slope of the dose-response curve as well as the lifetime risk of developing cancer at a dose of 1 mg/kg body weight/day for a lifetime exposure (i.e., 70 years). The level of risk associated with other levels of exposure may also be calculated from this number.

Because mustard agent is a carcinogen, it would be appropriate to quantitate the cancer risk and use this to set an acceptable exposure limit. As indicated above, however, this is not how the PELs were

derived. In fact, the method used was similar to the methodology employed in the case of noncarcinogenic effects, which involves the identification of a No-Observed-Effect-Level (NOEL) and the division of this number by an appropriate safety factor. The safety factor used should reflect the various uncertainties associated with using the particular data. The NOEL identified in the McNamara study was 0.001 mg/m³ (McNamara et al. 1975). The use by the Army of a 10X factor to account for the variability within the general population was in keeping with current practice (Dourson and Stara 1983). (Note that the 30X factor used by the Army to convert the worker PEL to a PEL for the general population consisted of two components: a 3X factor to convert from an 8 hr/day exposure for workers to a 24 hr/day exposure for the general population and a 10X factor, discussed here, to account for variability within the general population (Section 6.3.1.1). It is also common practice, however, to use another 10X factor when extrapolating from animals to humans to account for interspecies variability (Dourson and Stara 1983). Therefore, the appropriate safety factor for noncarcinogenic effects would be 100 instead of 10 as used by the Army. The resulting number needs then to be multiplied by a factor of 1.4 in order to account for the difference in dosage (mg/kg body weight) received by a human versus a rat when exposed to the same ambient concentration. This difference is due to the differences in breathing rate and body weight of each:

$$\text{Dosage adjustment factor (from rat to human)} = \frac{0.2 \text{ m}^3/\text{day} + 0.5 \text{ kg}}{20 \text{ m}^3/\text{day} + 70 \text{ kg}} = 1.4$$

where

Rat -		
Breathing rate	0.2 m ³ /day	
Body weight	0.5 kg	

Human -

Breathing rate 20 m³/day
Body weight 70 kg

Once these adjustments are made to the NOEL, the resulting PEL is 0.000014 mg/m³ for the protection of noncarcinogenic effects:

$$\begin{aligned} \text{PEL} &= 0.001 \text{ mg/m}^3 \div 100 \times 1.4 \\ &= 0.000014 \text{ mg/m}^3 \end{aligned}$$

where

0.001 mg/m³ = NOEL based on 1 year exposure

100 = Safety factor to account for animal to human extrapolation (10X) and variability within the human population (10X)

1.4 = Adjustment factor to account for the difference in dosage received by human versus rat exposed to same ambient concentration

As indicated previously, the methodology for quantitatively assessing carcinogenic effects differs from that used for noncarcinogenic effects. There are times, however, when the carcinogenic risk of a compound cannot be calculated due to the nature of the scientific data available. When this is the case, one could consider using the methodology for noncarcinogenic effects and then adding an additional safety factor due to the severity of the carcinogenic effects. In fact, the FDA, prior to acceptance and use of the current methodology for carcinogenicity assessment, used this approach (Hutt, 1985). It would be appropriate that the size of this additional factor be at least 10X. This would yield a total safety factor of 1000X and a PEL for carcinogenic as well as noncarcinogenic effects of 0.0000014 mg/m³.

6.3.1.3 Quantitative Assessment of Mustard Agent Carcinogenicity

As for being able to quantitatively assess the carcinogenic potency of mustard, unfortunately, neither the animal laboratory data nor the human epidemiological data are of very high quality. For example, if an animal bioassay were being performed according to the current criteria of such groups as EPA (U.S. EPA 1986b) and the National Toxicology Program (Office of Science and Technology Policy 1986), there would be 50 animals of each sex per dose and exposure would be for the majority of the test species' lifetime (e.g., 24 months for rats) (OSTP 1986; U.S. EPA 1985). In the McNamara study, however, the longest exposure in rats was for 1 year followed by different lengths of time post-exposure before the animals were sacrificed (McNamara et al. 1975). In the experiment that was specifically designed to study carcinogenicity, the longest post-exposure time at the lower concentration (0.001 mg/m^3) was 10 months for 12 male and 5 female rats. In the higher concentration group (0.1 mg/m^3), the longest post-exposure time was 18 months for 4 male rats. Why the lower dose group was not carried up to 18 months post-exposure was not indicated. As is evident, neither the length of exposure nor the number of animals used would meet current bioassay guidelines.

Scientists at both EPA and Oak Ridge National Laboratories (ORNL), while keeping in mind the limitations of the available data, have been involved in trying to derive a carcinogenic potency factor for mustard. Opinions have been expressed by individuals in both groups that the epidemiological data cannot be used to derive this number (ORNL 1987; U.S. EPA 1987). ORNL staff have also decided that there are not sufficient data to perform directly a quantitative risk assessment according to standard accepted methodology. However, they do believe that by using a relative potency scheme which involves comparing mustard carcinogenic data with data on the well-characterized carcinogen benzo[a]pyrene (BaP), the relative potency of the two compounds can be estimated. Using this methodology which was developed by scientists at ORNL (Jones et al. 1985, in press), they have estimated that mustard is 3.2 times more potent than BaP (Watson, 1987a). EPA has estimated the carcinogenic potency of BaP via inhalation and via ingestion to be $6.1 (\text{mg/kg/day})^{-1}$ and 1.15×10^1

(mg/kg/day)⁻¹, respectively (U.S. EPA 1986b). This difference between the inhalation and oral potency of BaP is probably due to absorption differences in the lung and the gut. Because there is no basis to assume that mustard would have the same difference, both factors will be used to delineate a potency factor range for mustard. Applying the relative factor of 3.2 to both of BaP's potency factors yields a potency factor range for mustard of $1.95 \times 10^1 \text{ (mg/kg/day)}^{-1}$ (i.e., $6.1 \text{ (mg/kg/day)}^{-1} \times 3.2$) to $3.68 \times 10^1 \text{ (mg/kg/day)}^{-1}$ (i.e., $1.15 \times 10^1 \text{ (mg/kg/day)}^{-1} \times 3.2$).

As indicated, ORNL scientists are of the opinion that the mustard data were such that a quantitative assessment of the carcinogenic potency of mustard could not be determined according to currently acceptable guidelines. However, they are of the opinion that the relative potency methodology developed at ORNL (Jones et al. 1985; Jones et al. 1987 in press) could be used to give a rough estimate of mustard's carcinogenic potency. EPA's Carcinogen Assessment Group (CAG) has not yet derived a potency factor for mustard, but it would be of interest to any future site-specific risk assessment for APG to see CAG's methodology as well as their estimate of mustard's potency and how these compare to ORNL's work.

Neither the Army Surgeon General, EPA, nor DHHS has endorsed the methodology used by ORNL for deriving a carcinogenic potency factor for mustard (Brankowitz 1987b). However, the methodology has been published in peer reviewed literature (Jones et al. 1985) and, as indicated below, has been endorsed and/or used by various programs in different branches of the Armed Services (Watson 1987b):

1. The Air Force has endorsed this methodology for use in their Installation Restoration Program and accepted it as a valid method for use in the Defense Priority Model for prioritizing Air Force hazardous waste sites;
2. The Department of the Defense's Deputy for the Environment has indicated that the Armed Forces intend to use this methodology; and

3. It has been used by ORNL to evaluate both a Navy and an Army hazardous waste site (Watson 1987b).

6.3.1.4 Estimation of Carcinogenic Risk Associated with the General Population PEL

Based upon ORNL's relative potency methodology, one can estimate the risk posed by various ambient levels of mustard. Using both the inhalation and oral potency factors of BaP, the risk posed by exposure to the general population PEL of 0.0001 mg/m^3 is calculated to range from 5.58×10^{-4} (or one in 1,793) to 1.05×10^{-3} (or one in 952) excess cancer cases based upon a lifetime exposure of 70 years:

$$\text{Daily Intake} = \frac{0.0001 \text{ mg/m}^3 \times 20 \text{ m}^3/\text{day}}{70 \text{ kg}}$$

$$= 2.86 \times 10^{-5} \text{ mg/kg/day}$$

$$\begin{aligned} \text{Range of} \\ \text{Lifetime Risk} &= 2.86 \times 10^{-5} \text{ mg/kg/day} \times 1.95 \times 10^1 (\text{mg/kg/day})^{-1} \\ &\quad \text{to} \\ &= 2.86 \times 10^{-5} \text{ mg/kg/day} \times 3.68 \times 10^1 (\text{mg/kg/day})^{-1} \end{aligned}$$

$$= 5.58 \times 10^{-4} \text{ to } 1.05 \times 10^{-3}$$

$$= \frac{1}{1,792} \text{ to } \frac{1}{952}$$

$$\text{Two Year Risk} = 5.58 \times 10^{-4} \div 35 \text{ to } 1.05 \times 10^{-3} \div 35$$

$$= 1.59 \times 10^{-5} \text{ to } 3.00 \times 10^{-5}$$

$$= \frac{1}{62,893} \text{ to } \frac{1}{33,333}$$

where

Air intake/day = 20 m^3

Adult = 70 kg body weight.

Mustard potency factor = 1.95×10^1 to 3.68×10^1 (mg/kg/day)⁻¹

This level of risk would be considered unacceptable by current standards. However, the incineration of mustard at APG is to last 2 years rather than 70. If the population were exposed to the PEL for this length of time, the range of the risk level would be 1.59×10^{-5} to 3.0×10^{-5} . This level of risk falls within a "gray" area of acceptability in that it is not considered to be clearly acceptable (de minimis) or clearly unacceptable (de manifestis) regardless of other considerations (Travis et al. 1987). In order to determine the acceptability of this level, it would need to be compared to the total population at risk in order to assess the absolute magnitude of the risk, i.e., the number of excess cancers in the exposed population. In general, the greater the size of the exposed population, the lower the risk level must be to be considered acceptable (Travis et al. 1987).

6.3.1.5 Estimation of Carcinogenic Risk Associated with Stack PEL

While, based upon the above calculations, the level of risk posed by exposure to the PEL concentration of 0.0001 mg/m^3 for two years falls within a "gray" area of acceptability, the actual concentration to which the general population is expected to be exposed under normal operating conditions should be, according to the Army's calculations, at least several orders of magnitude lower, thereby reducing the level of risk accordingly. In fact, the Army has estimated for APG that if the concentration of mustard in the agent incinerator stack and in the ventilation stack for the Demil building were 0.03 mg/m^3 , which is the PEL for the stack concentration, and if mustard were burned 2000 hours per year out of a possible 8760 hours (i.e., 8 hours/day, 5 days/week), the highest annual average ambient concentration would be $3.7 \times 10^{-8} \text{ mg/m}^3$ (Dept. of the Army (EHA) 1986, 1987). EA has also performed air dispersion

modeling based on a stack concentration of 0.03 mg/m^3 and attains comparable ambient concentrations.

An ambient concentration of $3.7 \times 10^{-8} \text{ mg/m}^3$ is well below the PEL of 0.0001 mg/m^3 (or $1 \times 10^{-4} \text{ mg/m}^3$). Using the potency factor derived by ORNL scientists, this translates into a lifetime (70 years) risk of excess cancer cases, based upon daily exposure, of 2.07×10^{-7} (or one in 4,837,929) to 3.9×10^{-7} (or one in 2,564,103), which is considered acceptable by today's standards. The risk when adjusted for a 2-year exposure is even lower, 5.91×10^{-9} to 1.11×10^{-8} .

$$\text{Daily Intake} = \frac{3.7 \times 10^{-8} \text{ mg/m}^3 \times 20 \text{ m}^3}{70 \text{ kg}}$$

$$= 1.06 \times 10^{-8}$$

$$\text{Range of Lifetime Risk} = 1.06 \times 10^{-8} \text{ mg/kg/day} \times 1.95 \times 10^1 (\text{mg/kg/day})^{-1}$$

to

$$= 1.06 \times 10^{-8} \text{ mg/kg/day} \times 3.68 \times 10^1 (\text{mg/kg/day})^{-1}$$

$$= 2.07 \times 10^{-7} \text{ to } 3.90 \times 10^{-7}$$

$$= \frac{1}{4,830,918} \text{ to } \frac{1}{2,564,102}$$

$$\text{Two-Year Risk} = 2.07 \times 10^{-7} + 35 \text{ to } 3.90 \times 10^{-7} + 35$$

$$= 5.91 \times 10^{-9} \text{ to } 1.11 \times 10^{-8}$$

$$= \frac{1}{169,204,738} \text{ to } \frac{1}{90,090,090}$$

The above calculations are based upon the incinerator operating only 2,000 hours per year. It is uncertain, however, just how many hours the incinerator will operate during the 2 years. This would depend upon the amount of mustard stored at APG, but this information is classified data. If the incinerator, however, were to operate more than 2,000 hours per year or longer than two years, the risk would need to be reassessed.

As indicated the above calculations are based upon a concentration of 0.03 mg/m^3 in both the incinerator stack and the Demil building ventilation stack. This concentration, however, would trigger the monitoring alarm. Therefore, the actual level of exposure under normal operations should be even lower than that estimated for a stack concentration of 0.03 mg/m^3 . Unfortunately, because the JACADS facility has not been completed, there are no test data on just what the actual emission and/or ambient levels of mustard might be.

The Army's PEL for the stack effluent (0.03 mg/m^3) was not based upon health considerations, but rather the lowest detectable limit (Owens 1987). However, based upon the analysis presented above, the PEL for the stack effluent appears to be much more protective of human health than the PEL for the general population, i.e., 5.91×10^{-9} to 1.11×10^{-8} versus 1.59×10^{-5} to 3.0×10^{-5} risk of excess cancer cases, respectively, for a two-year exposure.

It is important when considering the risk numbers presented in this analysis, to keep in mind that these are rough estimates, their accuracy being influenced by the methodology and the quality of the data used by ORNL to calculate the carcinogenic potency of mustard.

6.3.1.6 Summary of Permissible Exposure Limits

The PELs for the worker and general populations were not derived in a manner that would be acceptable by today's standards. The Army needs to reassess these limits and take into consideration the methodology used by ORNL for assessing the carcinogenic potency of mustard. Hopefully, EPA in the near future will also have quantitatively assessed mustard's

potency and the Army should then compare EPA's assessment with that of ORNL. Even if the Army were to decide not to use either EPA's or ORNL's assessment and continue to use the McNamara study as the basis for the PELs (McNamara et al. 1975), the limits should be derived based upon application of appropriate safety factors. Based upon a minimum safety factor of 1,000 for protection of carcinogenic as well as noncarcinogenic effects, the PEL would be 0.0000014 mg/m^3 (see Section 6.3.1.2). Interestingly, when the carcinogenic risk associated with this level is assessed using the potency factor derived by ORNL, the lifetime risk based upon lifetime exposure ranges from 7.80×10^{-6} to 1.47×10^{-5} which would fall within the "gray" area of acceptable level of risk. If the risk were adjusted for a two year exposure, it would be even lower at 2.23×10^{-7} to 4.2×10^{-7} and considered acceptable.

At APG, the stack effluent PEL appears to be significantly more protective of human health even though it was not based upon human health considerations, but rather on detection limits. Because it offers a greater degree of protection, it, rather than the worker and general population PELs, should be relied upon for monitoring purposes.

6.3.2 Toxicity Values Used in the D2PC Model

In order to estimate the risks associated with individual accident scenarios, a model called the D2PC was used. This model contains a number of parameters necessary for making the appropriate calculations, including: amount of agent released, mode of release, wind speed under worst-case conditions and under most likely conditions, and several toxicity values. These values represent human toxicity values and are the following:

LCt ₅₀ (estimated)	1,500 mg-min/m ³
1% Lethality Dosage	150 mg-min/m ³
No-Death Dosage	100 mg-min/m ³

For each accident scenario, the D2PC calculated the distances from the accident site to the point where the ambient concentrations of agent would be equal to the toxicity values. These distances were called the LCt_{50} , the 1 percent Lethality, and the No-Death distances. Estimations of the population size falling within these areas were made, then the number of fatalities were estimated. Therefore, the toxicity values play an important role in assessing the lethal consequences of the various accident scenarios. Unfortunately, the scientific and/or experimental basis for these numbers could not be determined from the references cited in the DPEIS or from the references cited within the DPEIS references. After numerous attempts by EA to ascertain the basis of these values, the Army eventually determined that they were derived from a classified document entitled "Minutes of Research Laboratories Human Estimates for GB, VX, H, EA 1724(Q), Isopropylamine, CS and EA 3834, 4 December 1969." Due to time constraints, EA did not view this document and, therefore, was not able to evaluate the data contained in it. The document, however, should be referenced in the FPEIS. It would also be appropriate for ORNL staff to be provided with a copy of the document (which they have indicated that they do not have), since they are responsible for evaluating the toxicity data on mustard.

In order to demonstrate the difficulty encountered in EA's attempt to track the origins of the toxicity values used in the D2PC model, each will be discussed individually.

6.3.2.1 LCt_{50}

The estimated LCt_{50} for humans is listed in Table B.2 in Appendix B of the DPEIS as $1,500 \text{ mg-min/m}^3$. Although it is not discussed in the text as being the value used in the D2PC model, ORNL has confirmed that it is the concentration used. This number represents the concentration-time value at which 50 percent of the exposed population would be expected to die. It is expressed as concentration X time because it is believed by some researchers that HD exposures are cumulative with time and the lethal dose (i.e., concentration X time) changes little with variations

in exposure time, as long as exposure times are relatively short. The reference for this toxicity value is the Chemical Agent Data Sheets: Vol. 1 (Dept. of the Army 1974). When this reference is examined, this value is indeed listed as the LCt_{50} estimate for humans. However, there is no reference for the basis of this number. When this estimate is compared with the LCt_{50} s for other species that are listed in Table B.2 of the DPEIS, it is on the higher end of the range.

There is also an apparent contradiction of values involving the LCt_{50} as listed in Table B.2. Not only is $1,500 \text{ mg-min/m}^3$ listed as the LCt_{50} , but it is also listed as the lowest lethal dose (via inhalation). The actual listing is 150 mg/m^3 for 10 minutes which multiplies out to $1,500 \text{ mg-min/m}^3$. How the same dose can represent a 50 percent lethal dose as well as a minimum lethal dose is not addressed. The reference for the minimum lethal dose was a report prepared for the Department of Transportation entitled Reclassification of Materials Listed as Transportation Health Hazards (Back et al. 1972). In this document, the dose was simply listed as being lethal (as opposed to being of minimal lethality) with the cited reference being a book entitled Chemicals in War which was published in 1937 (Prentiss 1937). When this book is examined, one finds that this value is indeed listed as a minimum lethal dose. The discussion in the text regarding this number was found to be as follows:

Mustard gas is lethal in concentrations varying from 0.006 to 0.200 mg. per liter, depending upon the time of exposure. Generally speaking, when inhaled, 0.15 mg. per liter is fatal on 10 minutes' exposure and 0.07 mg. per liter on 30 minutes' exposure.

Once again, there are no scientific and/or experimental studies presented as a basis for these values.

6.3.2.2 One Percent Lethality Dose

The 1 percent lethality dose used in the D2PC is 150 mg-min/m^3 . It is discussed in Appendix B of the DPEIS as being the same value cited in an Army document entitled Safety Regulations for Chemical Agents H, HD, and

HT (Dept. of the Army 1979). In this document, the 1 percent lethality distance is discussed as being the distance at which the dosage would be 150 mg-min/m^3 . A Department of Defense report is referenced in this discussion: Methodology for Chemical Hazard Prediction (U.S. Dept. of Defense 1980). In this document, it is stated that this dose represents a dose at which there is no permanent skin damage and that in the absence of more definitive data, this value will be used in place of a 1 percent lethality dose for calculating 1 percent lethality distances. The scientific and/or experimental data upon which this value was based was not referenced.

6.3.2.3 No-Death Dose

The no-death dose is given as 100 mg-min/m^3 . There is no reference cited for this dose in Appendix B of the DPEIS. The value, however, is considered by the Army and ORNL (as are the no-death doses for the nerve agents) to be the no-death dose for healthy males and, therefore, not a dose protective of lethality within sensitive subpopulations, such as children and the elderly (ORNL 1987). Viewing this limit as not being protective of sensitive subpopulations is a conservative approach and appropriate for risk analysis.

6.3.2.4 Analysis of Sensitive Subpopulations Using an Adjusted No-Death Concentration

Because of the view that the 100 mg-min/m^3 value is not protective of sensitive subpopulations for lethality, ORNL is currently performing a site-specific analysis of the potentially sensitive subpopulations at two sites: APG and Lexington Bluegrass (ORNL 1987). The approach being taken is to determine the distance where the dose is 1/5 of the no-death dose, i.e., 20 mg-min/m^3 , during the worst-case accident and then assess the size of the subpopulations of concern and, thus, the increased potential for fatalities. It is expected that no deaths would occur below this dose. The use of this 5X factor is considered to be conservative for scaling from adult dose levels to dose levels comparable for children. While this is true, it does not take into account that

children (or other subpopulations) are potentially more sensitive for a variety of reasons (e.g., disease, stage of development), even if the dose level has been appropriately scaled based on size and breathing rate. The procedure used by the EPA and FDA when attempting to estimate a dose protective of sensitive subpopulations is to use a safety factor of 10 (as compared to the 5 fold factor being used by ORNL). It would be more appropriate that a 10X factor be used for this analysis, thereby yielding a no-death dose of 10 mg-min/m^3 . Once again, it must be pointed out that the basis for the no-death dose has not been identified.

This analysis of the sensitive sub-populations is being kept separate from the original accident fatality analysis and will not be used to revise those fatality estimates. The identification of sensitive sub-populations is being based on residential population numbers. It is unclear whether institutional population sensitivity will also be considered (e.g., schools, nursing homes, hospitals) in the analysis. This analysis using the 20 mg-min/m^3 no-death distance will be used for emergency response planning purposes as well. Just how it will be used, however, is still unclear (see Section 5.5 Emergency Response). Assessing the population at risk for purposes of emergency response planning, however, should not be based on just the population at risk of lethality, but on the population at risk to any type of mustard toxicity.

6.3.2.5 Risk Assessment of Other Toxic Effects

While the DPEIS discusses other toxic effects of mustard besides acute lethality, such effects are not considered in the risk assessment. In determining the population at risk, only those exposed to the no-death dose or higher are counted. However, a significantly larger population would be at risk to all toxic effects of mustard. In order to evaluate the significance of this, EA has performed air dispersion modeling in order to demonstrate the inappropriateness of only considering the population within the no-death distance. The scenario that was modeled consisted of the no-death distance (where the ambient concentration is 100 mg/m^3) being at 0.5 km from the proposed incinerator site with a continuous emission from ground level for 10 minutes. Both most likely

and worst-case weather conditions were modeled. The extent of the plume out to the no effect level was evaluated. The no effect level for all acute toxic effects which was used for this was 2 mg-min/m^3 . This dose was taken from Table B.2 in Appendix B of the DPEIS. Figure 6.3-1 and Table 6-2 show the results of this exercise. The no effect distance falls approximately between 6-7 km depending on the weather conditions. This would be 3-4 km past APG's boundary which includes a significant population. It is clear that the population at risk to all toxic effects of mustard needs to be considered in a site specific risk assessment for APG.

6.3.2.6 Summary of the Toxicity Values Used in the D2PC Model

The references cited in the DPEIS for the toxicity values in the D2PC model do not contain the scientific and/or experimental basis for these values. The Army has indicated that the basis for these numbers is contained in a classified Army document. It would be appropriate for this document to be cited in the FPEIS and to be provided to ORNL staff for evaluation as to the validity of these values.

The toxicity values used in the D2PC model are for healthy adult males and do not reflect levels for sensitive sub-populations. These populations need to be taken into account in any site specific risk assessment for APG.

Acute lethality is the only toxic endpoint that has been assessed for purposes of comparing the five disposal alternatives with each other. However, a much larger population is at risk to all the toxic effects of mustard. Any site-specific risk assessment for APG needs to take this into account. While it would be very difficult to quantitatively assess the actual number of people who might be expected to show other types of effects, such an analysis would identify the total population at risk, i.e., the number of people who could be exposed to potentially toxic levels. This information should also be considered during emergency response planning.

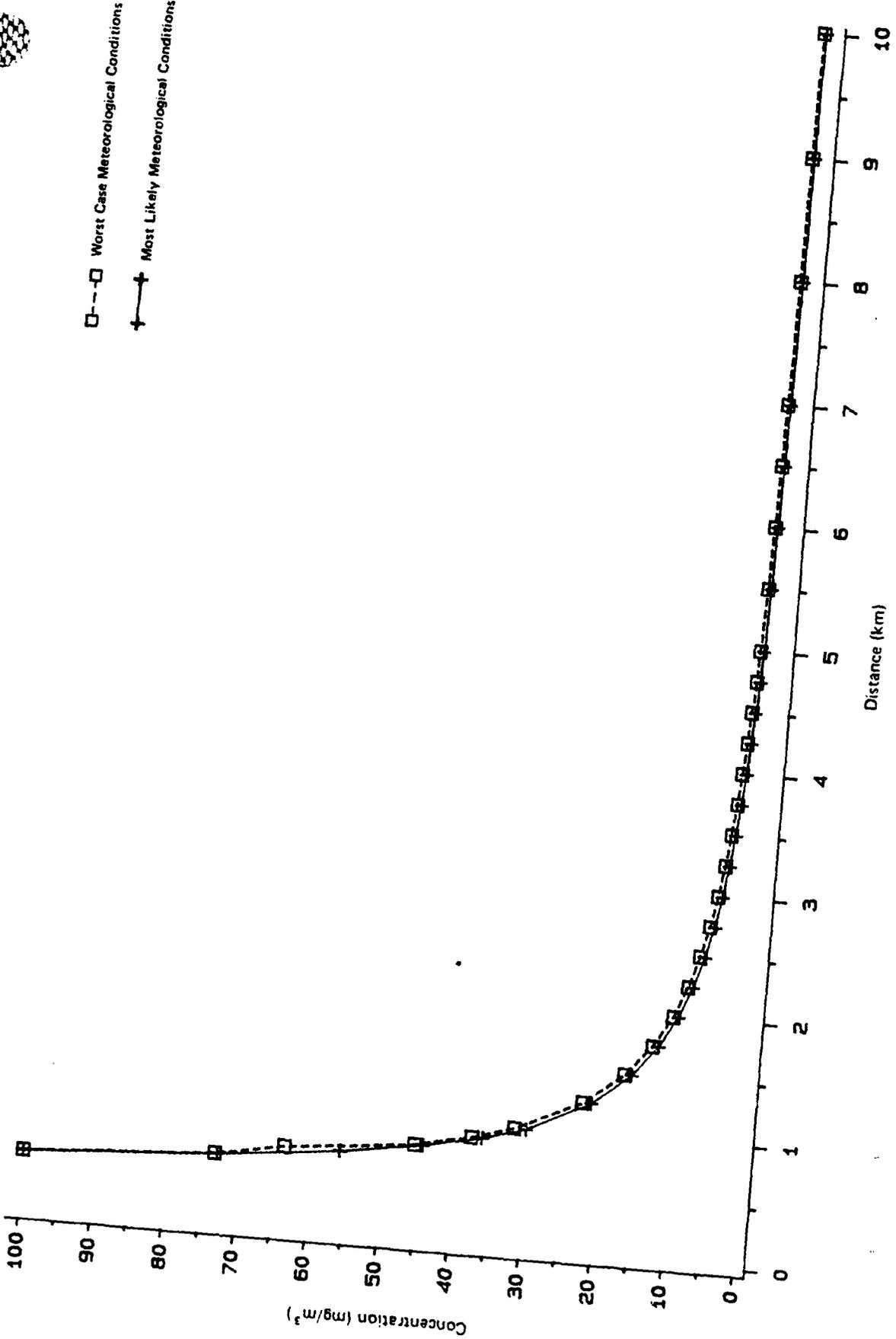


Figure 6.3-1. Concentration of mustard versus distance from source for a ground level emission which results in the no death distance at 0.5 km from the source.

TABLE 6-2 AMBIENT AIR CONCENTRATIONS PAST A NO-DEATH DISTANCE OF 0.5 KM

<u>OBS</u>	<u>Worst-Case Concentration (mg/m³)</u>	<u>Distance (km)</u>	<u>Most Likely Concentration (mg/m³)</u>
1	100.000	0.50	100.000
2	73.333	0.60	72.991
3	63.676	0.70	55.942
4	45.575	0.80	44.435
5	37.753	0.90	36.270
6	31.903	1.00	30.249
7	22.604	1.25	21.380
8	17.062	1.50	16.106
9	13.454	1.75	12.679
10	10.953	2.00	10.307
11	9.231	2.25	8.587
12	7.923	2.50	7.294
13	6.900	2.75	6.294
14	6.083	3.00	5.501
15	5.452	3.25	4.876
16	4.926	3.50	4.361
17	4.483	3.75	3.930
18	4.105	4.00	3.566
19	3.779	4.25	3.255
20	3.495	4.50	2.987
21	3.246	4.75	2.754
22	3.027	5.00	2.550
23	2.832	5.25	2.369
24	2.658	5.50	2.210
25	2.502	5.75	2.067
26	2.361	6.00	1.939
27	2.233	6.25	1.824
28	2.117	6.50	1.719
29	2.011	6.75	1.625
30	1.914	7.00	1.539
31	1.607	8.00	1.260
32	1.378	9.00	1.056
33	1.200	10.00	0.902

6.3.3 Toxicity of Combustion Products

The DPEIS briefly discussed the products that could be expected from complete combustion of mustard, and stated that those compounds for which there were federal or state emission standards would not exceed those standards. Products of incomplete combustion and those for which there are no federal or state standards were not evaluated. Further discussion of what the Army has done to address this issue is discussed in Section 5.6 PICs, POHCs, and Chemical Agent Incineration.

Since the Army had not identified all the possible combustion products of mustard, there was no analysis of the potential toxicity associated with these products. Any discussion of this area would be based mostly on theoretical considerations and on test burns at facilities dissimilar to the proposed JACADS incinerator. The Army has yet to burn mustard in the CAMDS test program upon which the JACADS facility is based. The Army, however, needs to collect all relevant data during not only the test burn at CAMDS, but also at the JACADS facility on Johnston Island, once it is built and test burns are conducted. This would then allow a more realistic evaluation of any potential problems associated with combustion products of mustard.

ORNL has begun addressing the issue of what the combustion products might be and what is known about the toxicity associated with each. Their report will be added to the FPEIS. Hopefully, it will provide a useful basis for assessing the potential risk from mustard combustion products once the Army has actual test data.

6.3.4 Conclusions

The PELs for the worker and general populations were not derived according to current acceptable guidelines. The Army needs to reassess these limits in light of current standards. This is not to suggest that the chemical demilitarization program be delayed to allow time to conduct additional toxicological studies; rather the Army needs to consider using ORNL's methodology for quantitatively assessing the carcinogenic potency

of mustard. Should EPA eventually assess mustard's potency on a quantitative basis, the Army would need to take this into consideration as well.

The PEL for the general population is a standard that is to be protective of public health based upon a lifetime exposure. Using ORNL's carcinogenic potency assessment, the carcinogenic risk associated with lifetime exposure to this PEL does not fall within acceptable levels. However, the incineration of mustard is to last only two years at APG. The risk associated with a two year exposure to the PEL falls within a "gray" area of acceptability and would need to be evaluated further with the total population at risk being taken into consideration in order to determine its acceptability. The Army needs to reevaluate the PEL as an acceptable lifetime exposure limit.

The PEL for the stack concentration was not based upon health considerations, but rather on analytical detection capabilities. However, on a site-specific basis at APG, it appears to offer an acceptable level of protection which is several orders of magnitude greater than the general population PEL.

The basis of the toxicity values used in the D2PC model to assess the risk of various accident scenarios could not be determined from the references cited in the DPEIS. The Army has indicated that the document from which these values were derived is classified. It would be appropriate for this document to be cited in the FPEIS and to be provided to ORNL staff so that they may evaluate the validity of the numbers and recommend any changes, if necessary, in the use of these values in the D2PC model.

The toxicity values used in the D2PC model are for healthy adult males and do not reflect levels for sensitive sub-populations. These populations need to be taken into account in any site specific risk assessment for APG.

Acute lethality is the only toxic endpoint that is considered in assessing the risk associated with different accident scenarios. Acute exposure to mustard, however, can cause a variety of other effects both acute and chronic. These need to be taken into account in any site specific risk assessment for APG.

The toxicity of combustion products of mustard was not thoroughly assessed in the DPEIS. ORNL is apparently preparing this type of assessment for the FPEIS. This evaluation should be considered in any site-specific risk assessment for APG.

6.4 SITE-SPECIFIC EXPOSURE ASSESSMENT AT APG

The DPEIS did not emphasize site-specific conditions because the approach in the document was programmatic. The concern of residents living near the Edgewood Area is that site-specific issues need to be considered before a programmatic decision on agent disposal is made. The possibility that a programmatic decision at the conclusion of the DEIS process would preclude a different site-specific determination for the APG chemical agent stockpile is of major concern to the Edgewood Citizens Steering Committee.

The use of generic meteorologic data for air dispersion modeling in the DPEIS is an example of how generic data may not be applicable to each installation. Because of proximity to the Chesapeake Bay, meteorologic conditions at APG are not likely to be similar to conditions at any other site. In addition, the location for incineration at each site was assumed near the existing agent storage location. Since the mustard is stored only 3 km (1.9 mi) from the boundary of Edgewood Area, an onsite incineration location farther down the peninsula would reduce substantially the exposure to the civilian population.

The population at risk considered in the DPEIS did not take into account sensitive populations such as the school age population which is adjacent to the Edgewood Area boundary. A site-specific EIS for APG needs to consider additive or synergistic effects of the agent incinerator with

a solid-waste incinerator under construction, an existing pathological waste incinerator, and an existing decontamination/detoxification incinerator all located within 1-4 km of the proposed site of the agent incinerator.

The issue of multiple incinerators is discussed in Section 5.7 reviewing the multiple stacks reports. The location of the incinerator on the Edgewood Area peninsula and the population at risk will be explored briefly here.

6.4.1 Location of the Incinerator in the Edgewood Area

If the final decision is to incinerate the mustard onsite, then the location of the incinerator on the Edgewood Area peninsula becomes an issue in controlling the exposure to the population. The programmatic plan is to build the incinerators at the location where the agent currently is stored. At Edgewood Area the ton containers of mustard are stored on the eastern shore of the Edgewood Area peninsula between *Lauderick and Kings Creeks*. This location is only 3 km (1.9 mi) from the APG boundary with the town of Edgewood Area. There is a campus consisting of elementary, middle, and high schools situated on this boundary at the point nearest to the AI.

Figure 6.4-1 shows the pattern of emissions if the AI is located at the Chemical Agent Storage Yard (CASY). The prevailing direction of the plume is to the southeast and over water, hence minimizing human exposure in this direction. However, the heavily populated northern portion of the Edgewood Area as well as the communities located along the installation boundary are also under the influence of the incinerator plume.

Figure 6.4-2 shows the pattern of emissions should the location of the AI be moved farther down the Gunpowder Neck. We have arbitrarily selected a location approximately 5.6 km (3.5 mi) south of the CASY between *Swaderick and Watson Creeks* on the western shore and *Coopers Creek* on the eastern shore of the Edgewood Area peninsula. This alternate location is situated on an existing road network. Figure

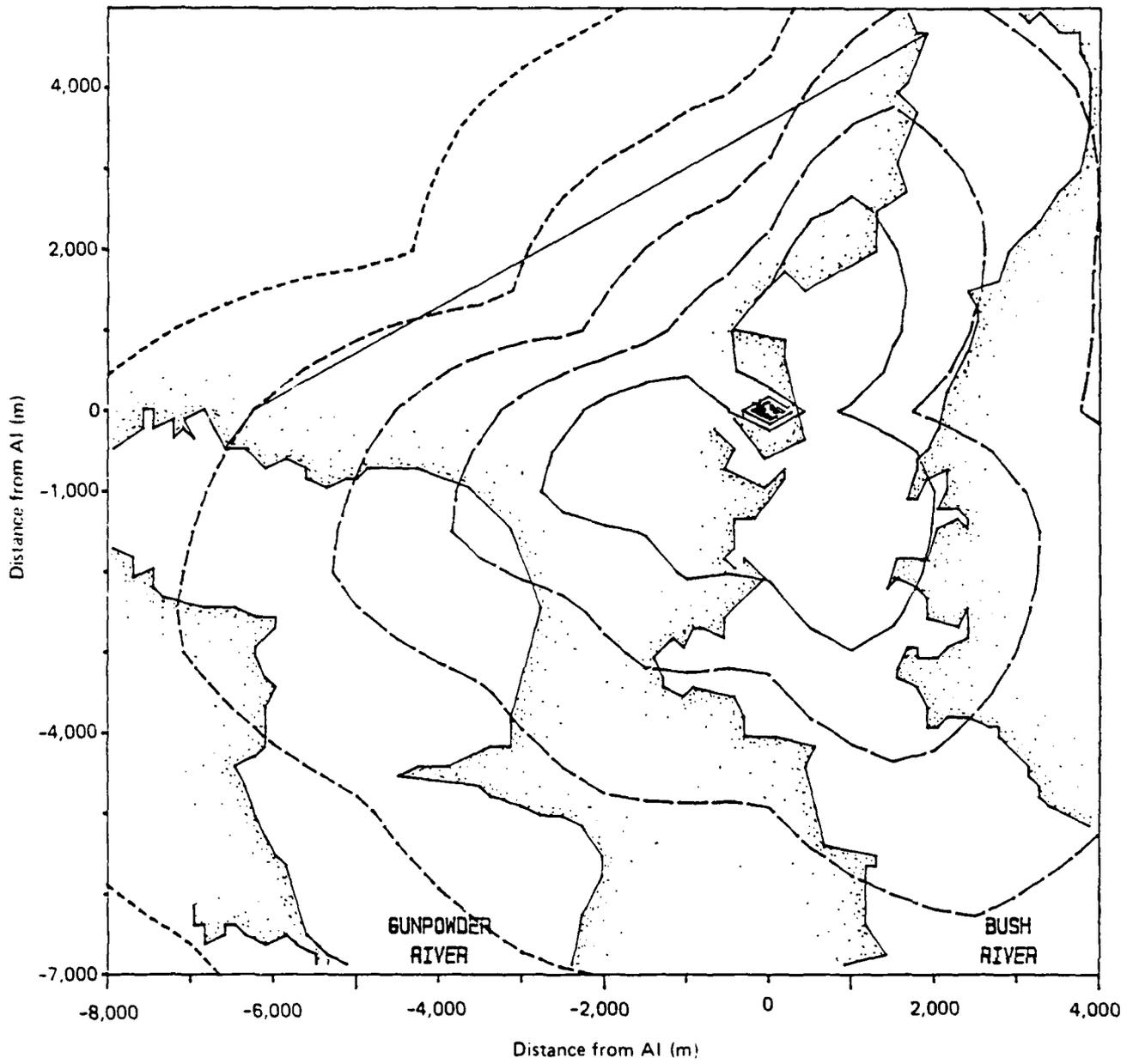


Figure 6.4-1. Pattern of emissions from the agent incinerator.

6.4-2 shows that if all factors are held constant except the location, the resulting incinerator plume covers much less of the populated areas on both sides of the installation boundary on the north of the Edgewood Area. A much larger portion of the plume is now over water. The added risk, however, of moving mustard agent by convoy over a longer distance to the alternate incinerator site would need to be considered (see discussions in Section 6.2.2).

6.4.2 Population at Risk

Approximately 4,000 people work on base in the northern section of the Edgewood Area within a few kilometers of the AI. A large school age population, a sensitive population, is located just over 3 km from the proposed incinerator site. About 26,500 people live in the area between the Edgewood Area boundary and Highway U.S. 40 (ARI 1987). This area is solidly suburban with the principal towns being Edgewood Area and Joppatown. A circle with the center at the AI and a radius of 10 km encompasses approximately 45,000 people, even though more than half the area within this circle is covered by water or marsh.

6.4.3 Conclusions

If the mustard has to be incinerated at Edgewood Area, then Figure 6.4-2 illustrates that human exposure can be markedly reduced by moving the location of the incinerator to the south. This move would mean that a slightly different population would be at risk, but that the total exposed population would be much smaller.

If the decision is made to incinerate onsite, then careful consideration has to be given to balancing the perhaps increased risks of moving the ton containers a greater distance and the benefits to be gained from reduced human exposure.

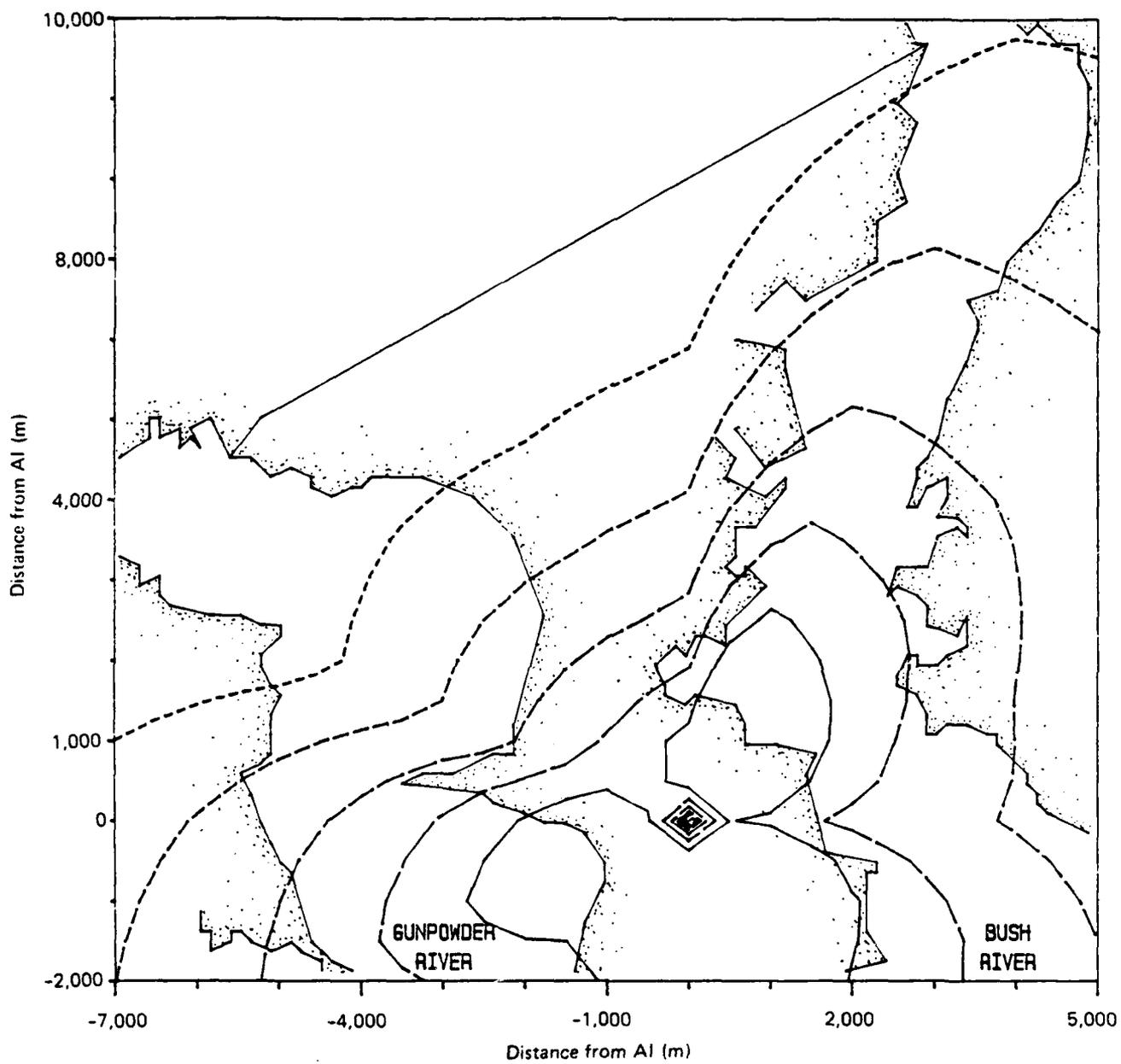


Figure 6.4-2. Pattern of emissions from the agent incinerator if the incinerator were located 3.5 miles south of the present proposed locations.

6.5 EVALUATION OF ALTERNATIVE SELECTION CRITERIA

The Fiscal Year 1987 Defense Authorization Act (P.L. 99-661) directed the Department of Defense to prepare a report describing alternative approaches for destruction of the chemical stockpile that would optimize safety considerations and cost-effectiveness implicitly without the constraints of the September 1994 program completion target (i.e., the "Baseline Program"). In March 1987, the report Chemical Stockpile Disposal Plan Supplement (AMCPM-CD-FR-87109) was submitted to the U.S. Congress and described technical concepts, implementation schedules, and life-cycle cost estimates for the following five technical options to the baseline program:

Option 1--The Modified Baseline Program (MBP) in which JACADS designs are optimized to reduce the program life-cycle costs.

Option 2--The JACADS Operational Testing (JOT) Program in which the JACADS plant is operated at full scale for an 18-month period to verify the safety and operability of the plant before the design of CONUS facilities is completed.

Option 3--The JACADS Operational Testing--Sequenced (JOT-S) Program in which CONUS plants are constructed and operated in sequence after the JACADS verification using the same construction crews and plant work force for each of the plants.

Option 4--The Dual Technology Evaluation (DTE) Program in which the JACADS operation is completed at Johnston Atoll while a full-scale prototype cryofracture/thermal destruction plant is constructed at Tooele Army Depot and operated for an 18-month period to verify this technology. A technology decision for implementation at CONUS sites would then be made.

Option 5--The Dual Technology Evaluation--Sequenced (DTE-S) Program in which the technology selected in Option 4 is applied

to a series of CONUS sites utilizing the same construction crews and plant work forces in the same manner as Option 3.

The life-cycle costs and program completion dates for the options are summarized in Table 6-3 along with the revised baseline program.

The five options were compared using six criteria as follows: Safety, Program Cost, Technological Risk, Schedule, Public Confidence, and Stockpile Storage Time. Presumably, Congress, in enacting the Fiscal Year 1988 appropriations budget, will also select one of the five options with the attendant change in the program completion date. At that point, the approach described under Section 5.9 of this report will be used to select the environmentally preferred alternative.

6.5.1 Conclusions

The revisions to the program completion date and the changes inherent in any of the five options that may be selected are expected to impact the selection of the preferred alternative for disposal of the stockpiled agent at APG as follows:

- . Improve the level of confidence in the JACADS technology
- . Obtain and apply verification or operating data in designing the CONUS facilities
- . Allow more time for verification of transportation plans and packaging concepts
- . Allow more time for developing and testing improved monitoring technologies
- . Allow more time for exploring and devising improvements in emergency response plans.

TABLE 6-3 LIFE-CYCLE COSTS AND COMPLETION DATES FOR CSDP OPTIONS
(costs in millions of constant FY 1986 dollars)

Option	Onsite Destruction		Regional Destruction		National Destruction	
	Cost	Completion	Cost	Completion	Cost	Completion
Revised Baseline	2,184	MAY 1994	2,075	SEP 1994	2,147	SEP 1994
1. Modified Baseline	2,234	JUN 1996	2,069	OCT 1995	1,989	OCT 1995
2. JACADS Operational Testing	2,507	MAY 1999	2,153	OCT 1998	2,242	JAN 1999
3. JACADS Operations Testing - Sequenced	2,749	SEP 2008	2,354	FEB 2003	2,261	APR 1999
4. Dual Technology Evaluation						
A. Cryofracture/Thermal	2,359	MAR 2000	2,277	DEC 1999	2,202	NOV 2000
B. Disassembly/Thermal	2,641	JUL 2001	2,306	NOV 2000	2,322	OCT 1999
5. Dual Technology Evaluation - Sequenced						
A. Cryofracture/Thermal	2,464	NOV 2005	2,397	MAR 2003	2,202	NOV 2000
B. Disassembly/Thermal	2,795	APR 2008	2,428	AUG 2003	2,340	NOV 1999

Source: Report AMCPM-CD-FR-87109

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APPENDIX A

STUDY REPORT

EVACUATION TIME ESTIMATES

EDGEWOOD ARSENAL

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I. INTRODUCTION

The study program described in this technical memorandum was conducted to evaluate the evacuation of the general population in the vicinity of the Edgewood Arsenal in Harford County, Maryland. For evaluation purposes two basic alternatives were considered: 1) that only the general population in the area would be evacuated, and 2) the evacuation would include the base personnel.

Study Area

The study area considered for purposes of this evaluation is identified in Figure 1 and includes that area between the base and U.S. Route 40 from the Gunpowder River in the west to Bush River in the east. For this work phase the study area was limited to the population south of U.S. Route 40 to conduct a preliminary assessment of evacuation feasibility for the population segment most proximate to the base and the site of potential release of hazardous agents.

Study Area Population Characteristics

Households and Population

The study area comprises a moderate level of residential and commercial development. Population and various other statistics were obtained primarily from two sources, the (1) State Report on Transportation, MDOT, 1987, and the (2) Maryland Statistical

Abstract 1986-1987. The total resident population, excluding the base, is estimated to be 26,500, based on 8,700 dwelling units and an average household size of 3.05 persons per dwelling unit.

The geographic distribution of the area population provides a generally dispersed pattern focused for general services on a number of small communities such as Edgewood and Joppatowne.

Employment

The employment opportunities in the study area are predominately of the service type and of moderate intensity. The total employment level in this study area is estimated to be about 3100. The character of these employment opportunities indicate that most of the employees are either are residents or residents from the immediate environs, as opposed to longer distance commuters.

Labor Force

Nearly fifty percent (48.8) of the Harford County population is in the labor force. Based on these county-wide statistics the total labor force in the study area is estimated to be 11,600. With an estimated 3100 persons employed within the area there exists a daily out commuting of about 8500 workers on the average weekday.

Car Ownership

No area specific information on car ownership was available for incorporation in the analysis. Statewide averages indicate that

car ownership in the area will be at least equal to or exceed 1.75 autos per household. High auto ownership in the study area would, of course, be consistent with the substantial level of area labor force commuting.

Special Populations in the Study Area

For purposes of evacuation analysis and logistics of an evacuation, special population groups in the area will require specific evacuation instructions and/or assistance. No large special groups were identified in the study area. For example, there are no hospitals in the study area, nor is there a large transient population.

The most significant special population group is children of school age that attend the several schools in the study area. It is estimated that the school age population in the study area is in the order of 6400. This includes both elementary and high school groups for the area.

Future Development

The entire Harford County area is recognized as one of the most active growth areas within the state. This regional growth is projected to impact the study primarily in terms of increased residential development. Examples of such growth are evidenced by the current developments south of U.S. Route 40 and east of Route 152.

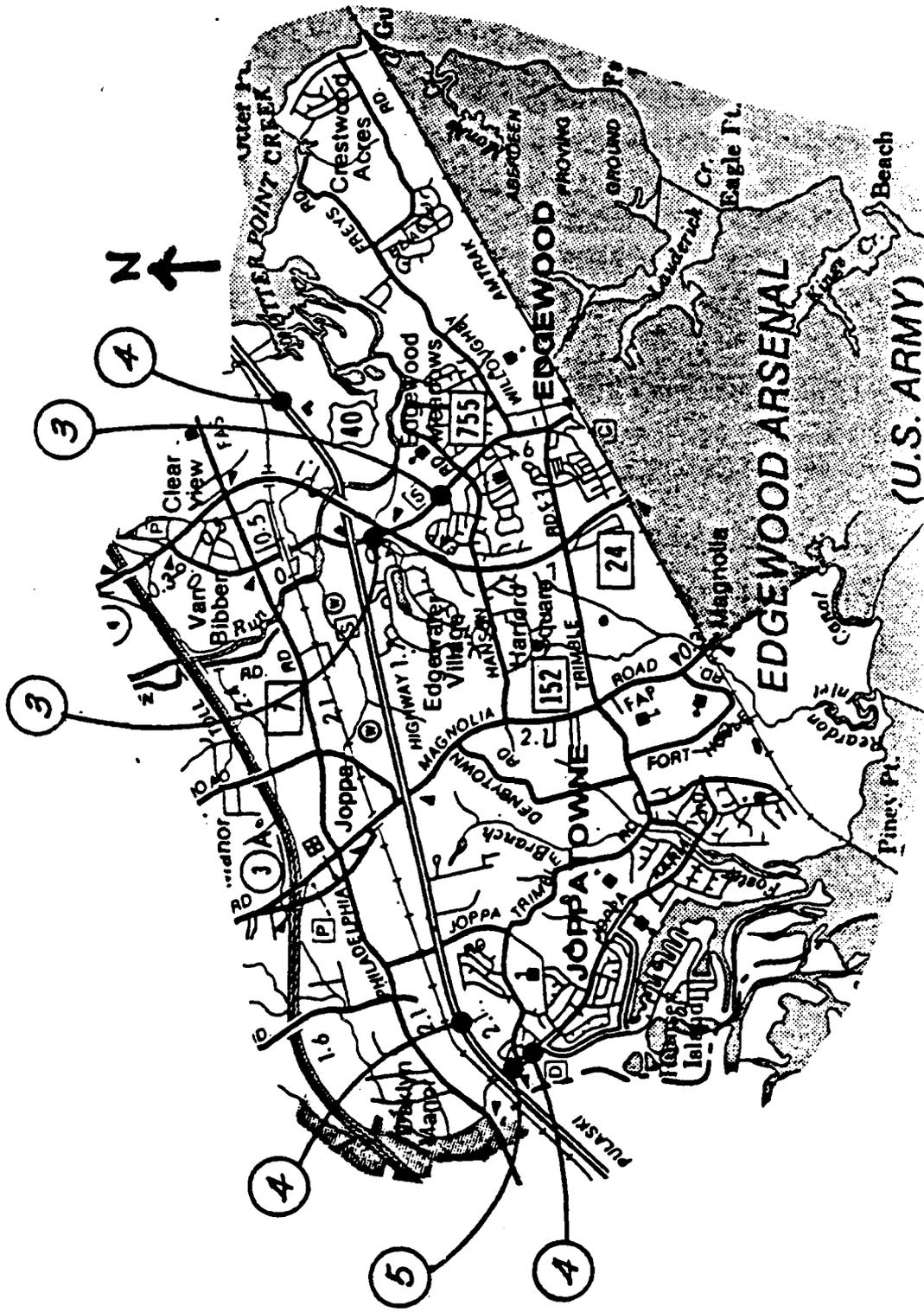
Any area evacuation plan or strategy must have provisions for

regular update and adjustment, especially in projected growth areas.

Transportation System in the Area

From a transportation point of view the study area has the characteristics of a shore line community with the major travel facilities oriented along a southwesterly to northeasterly alignment. Both Interstate 95 and U.S. Route 40 follow this general alignment pattern. Local roads in the area tend to be primarily two lane facilities linking I-95 and U.S. Route 40 with the communities in the study area.

A number of these facilities terminate at either the Gunpowder or Bush Rivers, or alternately terminate, for public access purposes, at the gates leading to the Edgewood Arsenal. The primary network of public road facilities is illustrated in Figure 2.



(X) INDICATES NUMBER OF TRAVEL LANES;

TWO LANES IF NO DESIGNATION

PRIMARY ROAD NETWORK
FIGURE 2

II. EVACUATION SCENARIOS

Two fundamentally different evacuation strategies can be adopted and each will produce radically different results and consequent impact on the safety and well being of the general population in the risk area. These two strategies are:

1. Simultaneous notification and evacuation of the entire predesignated risk area population.
2. Sequential notification and evacuation of the risk area population with controlled priorities for those areas within and immediately adjacent to the projected plume trajectory of the hazardous agent.

Both strategies involve all the steps and actions required of various public agencies and individual members of the public.

The number of individuals involved in the evacuation process at any one time is significantly different under the different strategies.

The advantages of prioritized evacuation process can be summarized as follows:

1. The population in the high risk areas can be evacuated more effectively when not impeded by evacuation activities from persons from lower risk areas. Although some voluntary evacuation (or shadow effect) may occur in adjacent lower

risk areas, the volumes may not be sufficient to create an impediment to the high risk area evacuees.

2. A staged evacuation, prioritized in accordance with the level of risk, will tend to preclude the degree to which the area population may become entrapped in traffic queues with the attendant hazards of irrational behavior or the potential for more extensive exposure to the hazardous agent.
3. With the provision of high risk area definition, the resources of public and/or military agencies can be highly focused to provide assistance in the evacuation of special population segments and families that do not have a private automobile available to effect their own evacuation.
4. The smaller the area required to be evacuated the more effective the necessary controls and evacuation compliance can be implemented and assured. For example, small area cordon controls can be established rapidly and effectively. Public notification and evacuation compliance can be confirmed in a prioritized evacuation program but becomes almost impractical in the case of simultaneous evacuation order for a larger area.

The evacuation of an area population must recognize the fact that different needs and circumstances exist for a number of population groups. As a minimum, five different population groups must be considered:

- o Resident Population with Private Auto Availability
- o Resident Population without Private Autos
- o School Children During Periods of School Activity
- o Transient Population in the Area
- o Residents of the Area with Special Needs (sick, hospitalized, etc)

For evacuation purposes, the latter four groups can, under certain circumstances, be aggregated since all members of this group are generally in need of transportation assistance in the event of an evacuation. For purposes of reviewing the sequence of events of an evacuation two basic categories are considered: those who have private transportation available, and those who are transportation dependent.

III. EVACUATION TIME ESTIMATES

Evacuation for Auto-Owning Population

The evacuation sequence for the permanent resident auto-owning population includes five steps: (1) Receive Notification; (2) Leave Place of Work; (3) Work-to-Home Travel; (4) Prepare for Evacuating Home; and (5) Drive Out of the Risk Area. The time required to complete each of these steps is established. Then, a total evacuation time for the auto-owning population is obtained by combining the time required for each of the five action steps.

Receive Notification

Some of the auto-owning permanent resident population receives the broadcast information almost immediately; for example, 10 percent of this population is assumed to receive broadcast information in 5 minutes (Table 1). These are individuals who immediately comprehend the notification and promptly tune into the EBS broadcasts. This group also includes individuals already listening to radio and television broadcasts, and are therefore informed immediately of the emergency and the need to evacuate the area.

TABLE 1 TIME DISTRIBUTION FOR
"RECEIVE NOTIFICATION" STEP

Time After Start of Notification	Estimated Percentage of Population Receiving Notification
5 Minutes	10
10 Minutes	15
15 Minutes	30
20 Minutes	30
25 Minutes	10
30 Minutes	5

A large fraction of the population of the area is estimated to receive the broadcast information between 10 and 20 minutes after the start of notification. These individuals require several minutes to comprehend the notification, and then several more minutes to tune into the EBS broadcasts.

At the high end of the range, some of the population (10 percent of the total) are assumed to require 30 minutes to receive the broadcast information. These are mainly persons not reached by the initial notification system, not understanding the significance of the siren warning, or without access to a radio or television set.

It is estimated that all of the population receive the broadcast information within 30 minutes of the start of notification.

Leave Place of Work

It is estimated that a sizeable portion of the permanent resident auto-owning population can leave work within 10 minutes after receiving the broadcast information, or after this information is conveyed to them by their employer (Table 2). In general, these are workers not having managerial responsibility or whose jobs do not require shutdown time.

TABLE 2. TIME DISTRIBUTION FOR
"LEAVE PLACE OF WORK" STEP

Time After Receipt of Notification	Estimated Percentage of Workers Leaving Place of Work
10 Minutes	50
15 Minutes	30
20 Minutes	10
30 Minutes	10

Another large group of workers (an estimated 40 percent of the total) will need between 10 and 20 minutes to leave their place of work. These are employees whose jobs require some shutdown time, and managers who remain until other employees have left.

At the high end of the range, an estimated 10 percent of the workers require 30 minutes to prepare for leaving work. These individuals are mainly managers, persons responsible for securing cash or property, and persons needed to shut down industrial processes.

All employees complete preparation to leave their place of work

within 30 minutes of receiving the broadcast information.

Work-to-Home Travel

The time needed for this step is similar to that needed for the daily trip home during the afternoon peak hour. This time depends primarily on the distance from work to home. This distribution of estimated travel-to-home time is for only those workers having their residence and place of work in the area. At the low end of the range, an estimated 50 percent of the workers can complete the trip home within 5 minutes (Table 3). The remainder of the area workers are projected to return home in 10 to 15 minutes.

TABLE 3. TIME DISTRIBUTION FOR
"WORK-TO-HOME TRAVEL" STEP

Time After Workers Begin to Leave Place of Work	Estimated Percentage of Workers Arriving at Home
5 Minutes	50
10 Minutes	30
15 Minutes	20

Some employees working outside the area, particularly at locations near the risk area boundary, may return home before the perimeter is closed to entering traffic and will evacuate in the same manner as auto-owning households. However, employees who work at some distance outside the area will not be able to enter the area since all roads will be barricaded to incoming traffic as soon as possible after the start of the evacuation.

Prepare for Evacuating Home

The time needed to prepare for evacuating the home depends on three factors: (1) whether or not an adult member of the household is home at the time of notification; (2) the number of dependents in the household; and (3) the amount of household property to be secured prior to evacuation.

At the low end of the range, an estimated 20 percent of all of the auto-owning population can prepare for evacuating their households within 20 minutes after the arrival of the workers from their jobs (Table 4). These are generally household with an adult member present at home, with few dependents, and no property to be secured.

TABLE 4. TIME DISTRIBUTION FOR
"PREPARE FOR EVACUATING HOME" STEP

Time After Workers Arrive Home	Estimated Percentage of Auto-Owning Population Leaving Home
5 Minutes	10
10 Minutes	10
15 Minutes	15
20 Minutes	25
25 Minutes	25
30 Minutes	15

An estimated 60 percent of the auto-owning population can prepare

to leave home within 30 minutes of the arrival at home of the household workers. These are likely to be households with dependents at home and a typical single-family residence to secure.

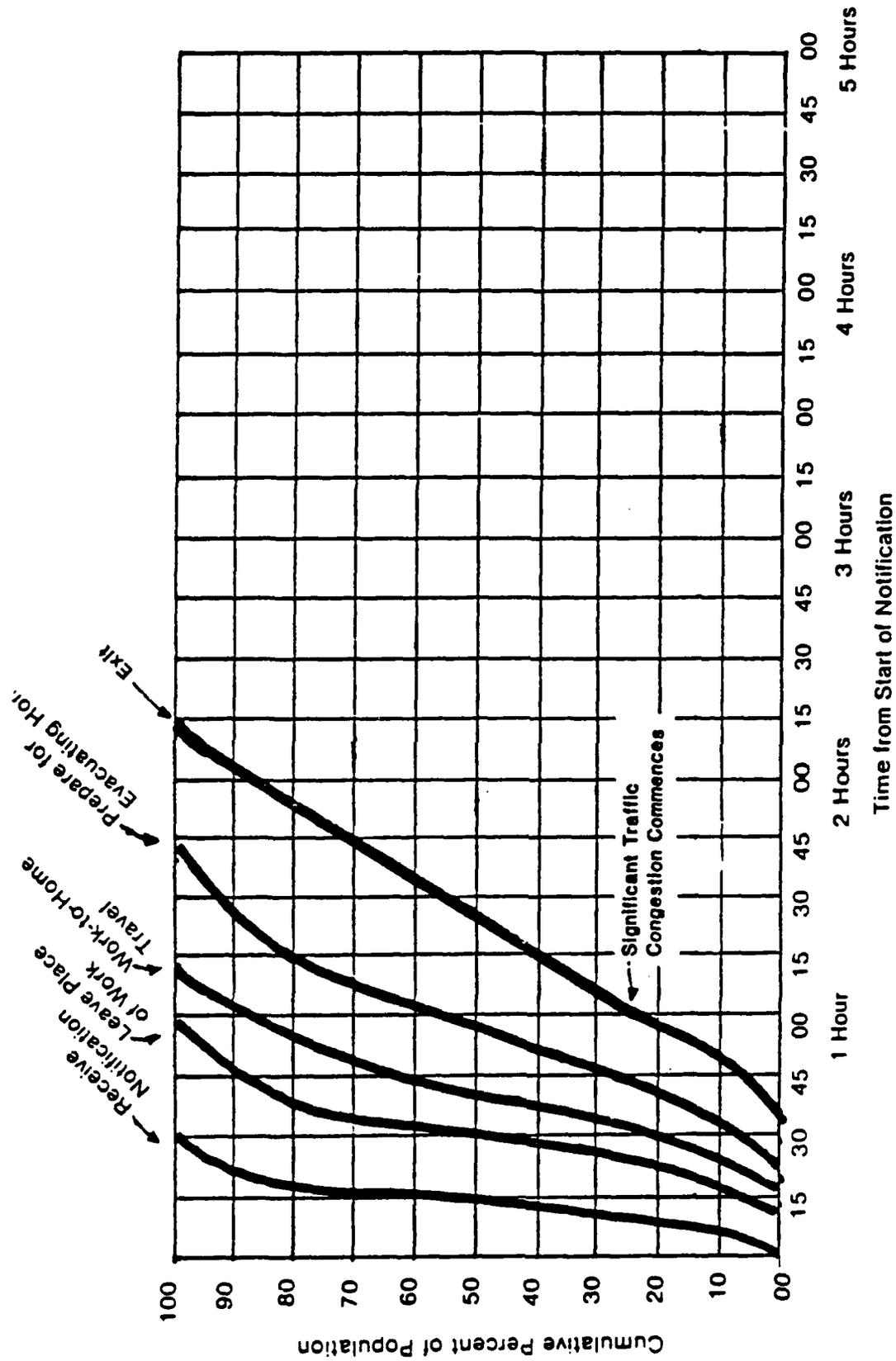
At the upper end of the range, an estimated 15 percent of the population requires up to 40 minutes to prepare for evacuating their homes. Generally, these are households with more than one dependent and extensive property to be secured (for example, a farm).

Final Departure Curve

Figure 3 illustrates the distribution of time needed by the risk area population to complete each of the evacuation steps. The final departure curve (that is, the time needed to complete all action steps including the final driving from the area) is completed at 2 hours after the start of notification.

Possible Levels of Traffic Congestion -- Three possible conditions of traffic congestion are analyzed in Figure 4. In the instance with no traffic congestion (Type "A" in Figure 4), the departure from the risk area depends solely on the rate at which people prepare to leave their households and drive, in a free-flow manner, out of the area. At no point in the evacuation period does traffic congestion slow this progress out of the area.

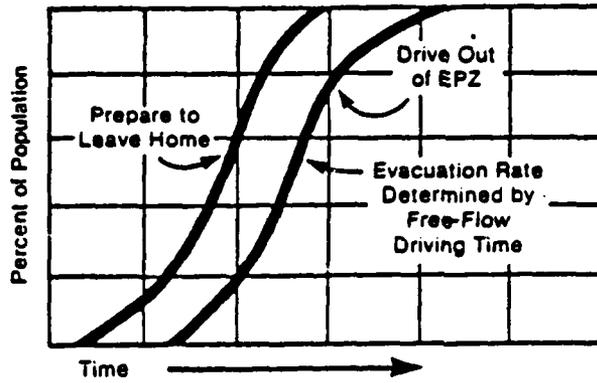
On routes where traffic congestion occurs (Types "B" and "C" in Figure 4), traffic congestion begins when the rate of vehicles



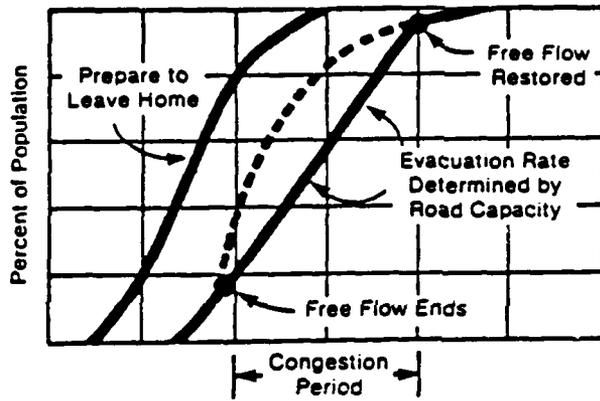
Evacuation Times for the Permanent Resident Population (Auto-Ownng)

FIGURE 3

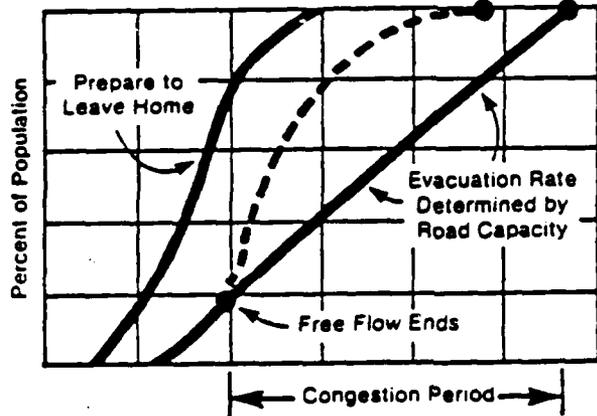
A. FREE TRAFFIC FLOW, NO CONGESTION



B. CONGESTION OCCURS AND ENDS BEFORE ALL POPULATION LEAVES HOME



C. CONGESTION CONTINUES AFTER ALL POPULATION LEAVES HOME



Possible Levels of Traffic Congestion
FIGURE 4

entering the street exceeds the capability of the street to carry them. Congestion continues to build as long as the rate of vehicles entering the street system continues to exceed the vehicular capacity of the evacuation route.

At some point in the evacuation process, the rate at which vehicles enter the street system reaches a maximum and begins to decrease.

Congestion begins to diminish as the rate of vehicles entering the street system begins to fall below the capacity of the evacuation route to carry them. This decrease in traffic congestion continues until the queues disappear, and free traffic flow is restored on the evacuation route.

In the less severe instances of congestion (Type "B" in Figure 4), this occurs before the population has finished preparations to leave home. From the point at which congestion is dissipated onward until the completion of evacuation, the rate of evacuation is once again determined by the rate at which households complete their preparation to leave home and enter the street system.

In the more severe instances of congestion (Type "C" in Figure 4), the traffic backups continue even after all the population has completed preparations to leave home. In this type of congestion, the backups are too large to be discharged prior to the time that all population has completed preparation to leave home. In this case, evacuation times are no longer dictated by the time at which preparations for leaving home plus a free-flow

driving time, but rather by the traffic capacity of the evacuation route.

Congestion in the Study Area

Based on the characteristics of the area enumerated in previous chapters the total number of vehicles used during an evacuation by the resident population is estimated to be 8500. This is an average one vehicle per household, but does not suggest that one vehicle will be available for every household. Larger households with multiple auto-ownership may use more than one auto in the event of an evacuation. Based on a number of evacuation studies conducted throughout the country, analysis have shown that projected auto usage during an evacuation will on average be very nearly one auto per household.

As indicated in the previous section, the traffic flow conditions depend on the departure rate of the evacuees and on the capacities of the specific routes used by evacuees to leave the area.

Because of the transportation network character of the area, there are essentially four routes or corridor that lead from the risk area to Route 40 and/or I-95. These four corridors are:

- (1) Route 755 and Route 24
- (2) Route 152
- (3) Joppa Road/Trimble Road
- (4) Joppa Farm Road

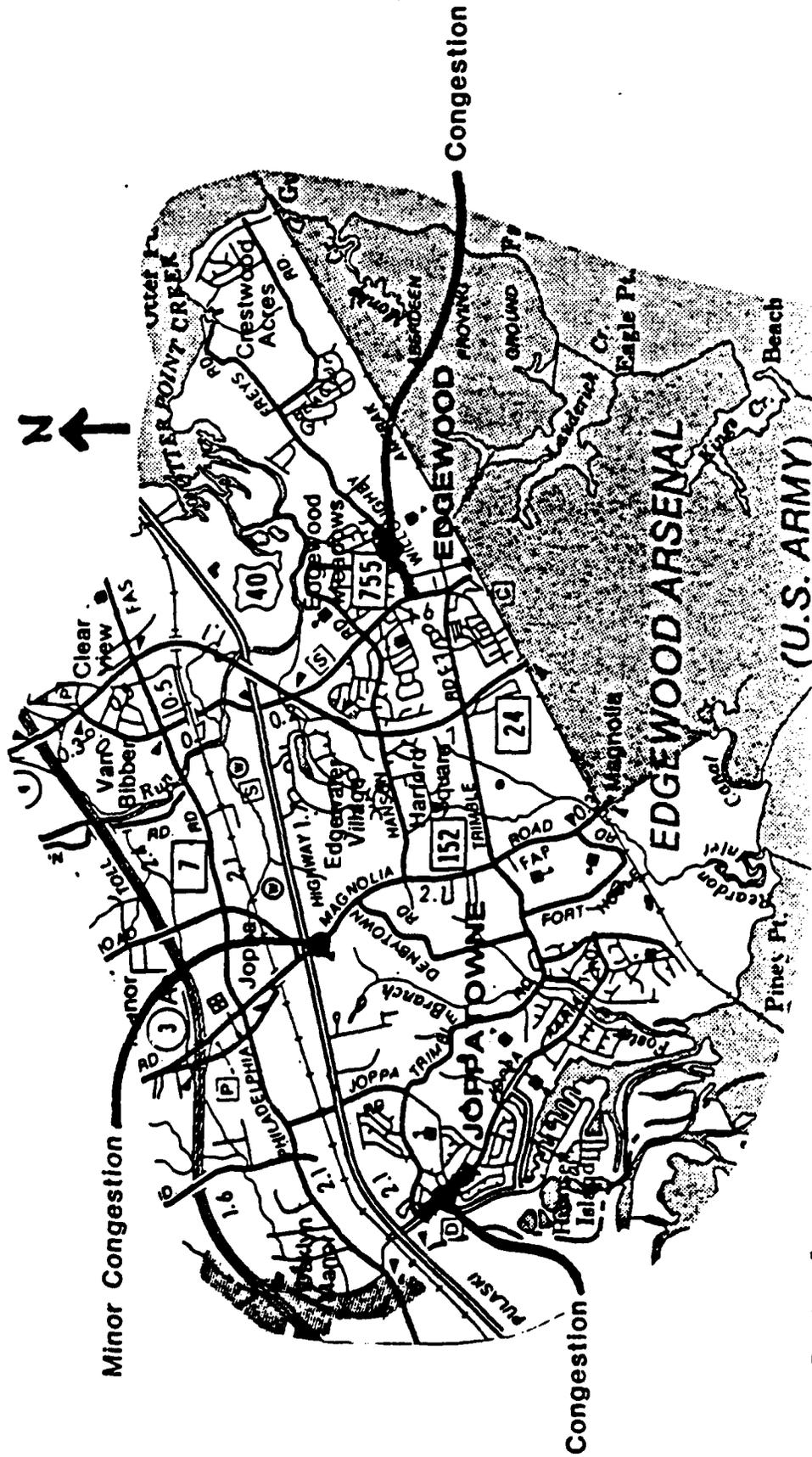
Logical travel sheds for the area population were assumed in allocating evacuation traffic to these four corridors. Based on the departure rate shown in Figure 3, the evacuating traffic was loaded onto the network and compared with the available capacity within each corridor to estimate the degree of congestion and the duration for the evacuees to leave the area.

Substantial congestion is estimated to commence about 45 minutes to one hour following notification to evacuate. At this time, approximately 20 to 25 percent of the evacuees will have left the risk area. Areas of congestion are illustrated in Figure 5. At about 1 hour and fifteen minutes following notification the rate of auto departures will diminish and the traffic queues will begin to disipate but free flow conditions are not expected to be recovered before all evacuees have left the area, at about 2 hours following the time of notification.

These time estimates are based on the various assumptions noted, and on the provision of traffic control and specific lane assignments as noted below.

Intersection of Willoughby Beach Road and Route 755

At this location traffic on Willoughby Beach Road will become congested and the traffic queue may extend from 1/2 mile to 3/4 mile during maximum congestion. Traffic control at the location would require police officer or guard control to direct motorists to use the center lane on 755 north for northbound travel to allow a continuous flow of traffic from Willoughby Beach Road onto 755, as illustrated in Figure 6a.



CONGESTION AREAS
FIGURE 5

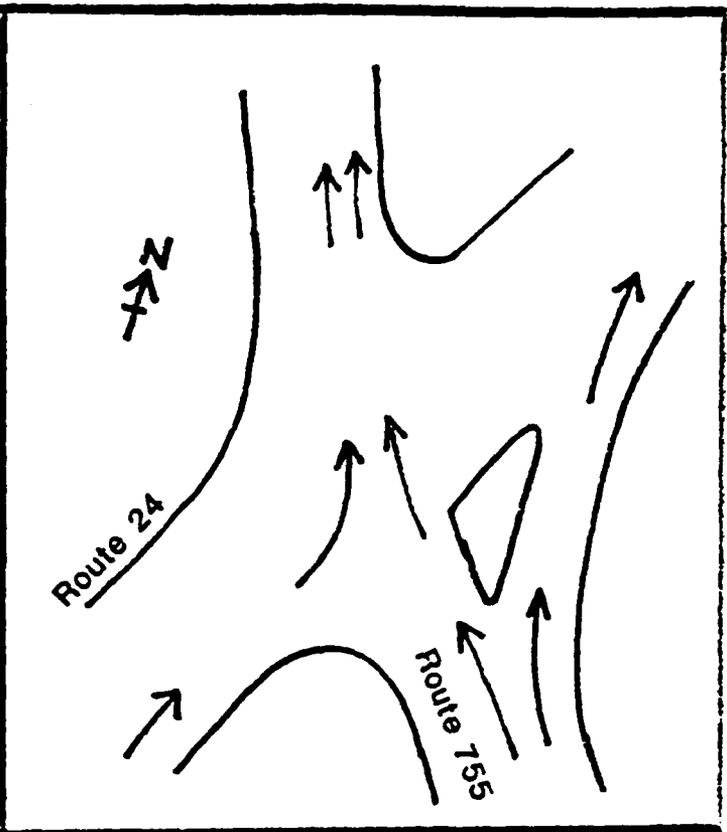
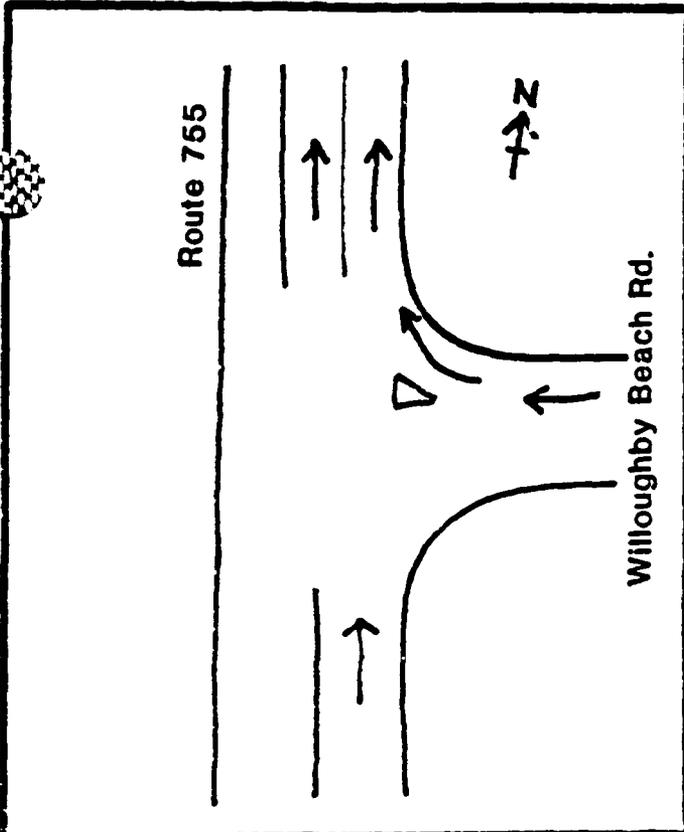


FIGURE 6A. TRAFFIC OPERATIONS

FIGURE 6B. TRAFFIC OPERATIONS

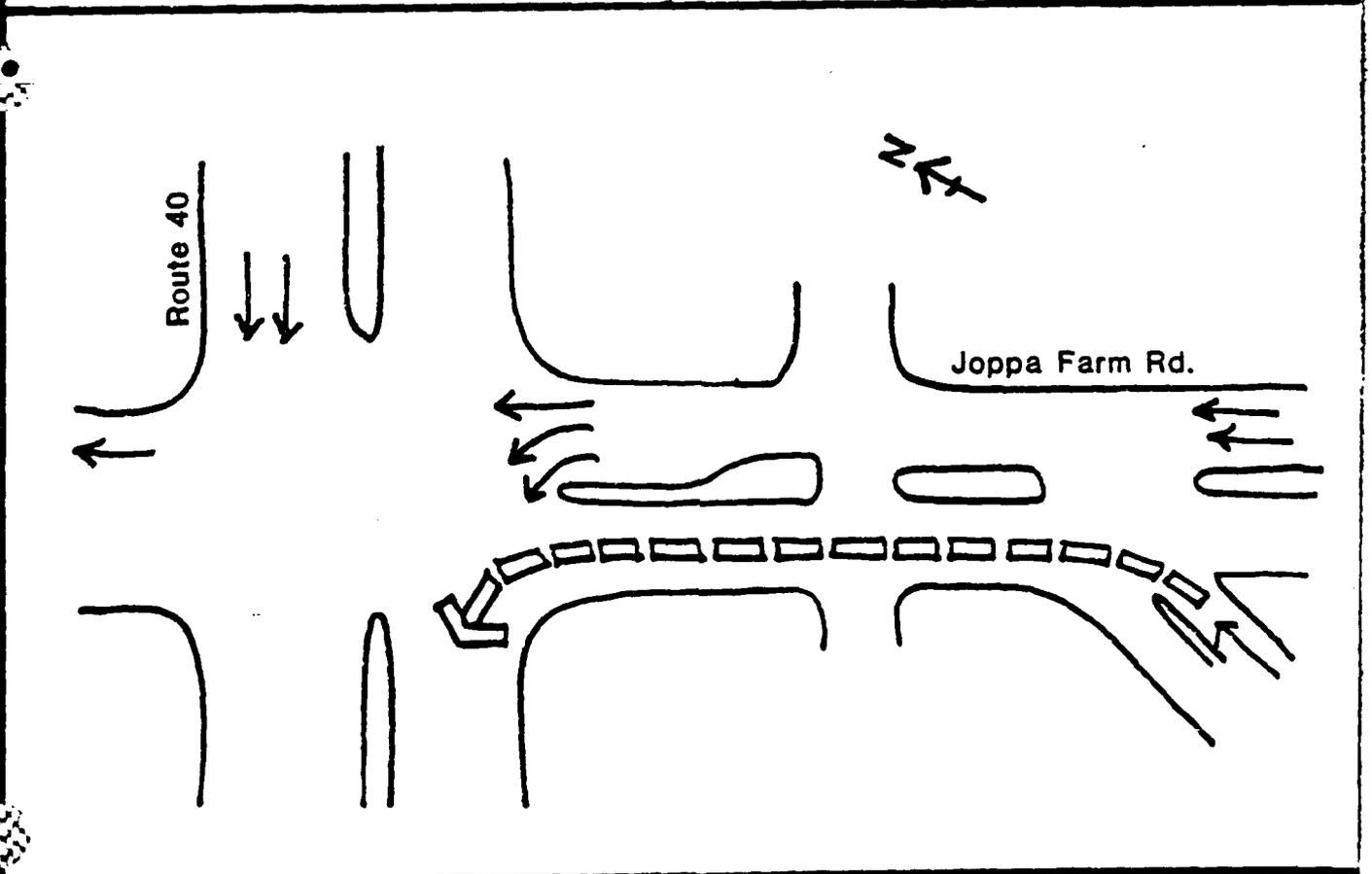


FIGURE 6C. TRAFFIC FLOW ALTERNATIVE

Intersection of Route 24/755

This intersection will require officer or guard control to direct traffic in predesignated lanes as shown in Figure 6b. Little or no congestion is expected at this location, primarily due to the metering of traffic at the Willoughby/Route 755 intersection.

Intersection with Route 40

All intersections with Route 40 will require police or guard control to provide priority access of evacuees to Route 40.

Intersection of Local Subdivision Streets onto Route 40

Subdivision street access to Route 40 West of Route 755 is not projected to generate congestion or queueing problems.

Intersection of Route 152 with U.S. Route 40

Significant congestion is expected at this location. Diversion of traffic via Trimble Road to Joppa Road would need to be considered to reduce the projected traffic queues. With such diversion in place the traffic congestion will be lessened to the point of near free flowing conditions.

Intersections Along Joppa Farm Road

The exit facilities for Joppatowne are constrained and diversions to Trimble Road are to be considered to reduce the traffic load.

Even with such diversions in place traffic queues in the order of 1/2 mile to 3/4 mile during the peak evacuation period can be expected. Extensive traffic control is required in the Joppatowne area and at the intersection of Joppa Farm Road and U.S. Route 40. A traffic operations plan involving one contra-flow lane on Route 40, as illustrated in Figure 6c, would facilitate traffic flow in this area. This operations plan would be especially desirable in the event the evacuation departure rates of the population can be reduced through effective and detailed preparedness plan development. With a steeper departure rate curve the rate of vehicle arrival at this critical location would be greater than that assumed in the analysis.

Special Routing Considerations

In view of the fact that the travel facilities between Route 40 and I-95 are relatively narrow and have physical constraints, such as the narrow railroad underpasses, it is deemed advisable to direct evacuees both easterly and westerly onto Route 40 as the primary exits from the risk area. Extensive dependence on narrower road facilities may generate special problems in the event of vehicular breakdowns and/or accidents.

Evacuation Time Estimates for Non-Auto Owning Population

As indicated earlier, there are two significant population groups in the study area that are likely to be transportation dependent during an emergency if it occurs on an average weekday.

The first group are members of a household whose primary wage-

earner commutes out of the area and the family members at home do not have a car available in the absence of the wage-earner. The second group are school age children at school during an average weekday.

Both these population groups would need to be provided with transportation to allow evacuation from the area. Based on a number of studies conducted to transport such population groups from a risk area, it is recognized that the initial time factor in evacuating transport dependents is the time required to mobilize and dispatch the necessary buses or other vehicles to collect the evacuees. Based on the premise that the necessary vehicles are available, either within the risk area or within close proximity of the risk area, the mobilization and dispatch is likely to involve in the order of 30 to 45 minutes. Public familiarization with collection points would be required to effect evacuation of the transport dependents.

The evacuation time of transport dependents is, as noted, substantially dependent on equipment availability and mobilization time. Based on the foregoing assumption evacuation of the transport dependents is estimated to require 45 minutes longer than the evacuation of the auto-owning population, i.e. a total time of 2 hours and 45 minutes.

Impact of Base Population Evacuation on Total Evacuation Time

The preceding evacuation times did not include the evacuation of the base population. During an average weekday, the base population is in the order of 4000. With a normal level of

carpooling for large institutions it is estimated that this labor force uses about 3300 vehicles to commute to and from work.

The departure rate for this population group will be significantly different than that for the residential area population. For example, notification time is expected to be considerably less than the 30 minutes assumed for the general population. In addition, this labor force will evacuate immediately upon their departure from the work place. Therefore, departures of the base labor force will commence as much as 15 minutes earlier than the general population and the departure rate will be much more rapid and is estimated to be completed at the end of 30 to 45 minutes following initiation of notification.

Assuming that each of the three exit facilities will carry approximately similar volumes, traffic congestion can be expected to commence at about 20 to 30 minutes following notification. This is significantly earlier than for a general population evacuation only and impacts the logistics of perimeter security and other preparedness actions that must be effected prior to widespread traffic congestion.

The impact of the base population evacuation is two-fold: (1) it will induce traffic congestion on the local road system earlier; and (2) it will increase overall evacuation time of the resident area population by 45 minutes.

Summary of Evacuation Times

The estimated evacuation for the various population groups are

summarized below:

Resident Area Population and Transportation Owning Transient Population (Without Base Population)	2 hrs.
Transportation Dependents (Without Base Population)	2 hrs. 45 min.
Total Area Evacuation (Including Base Population)	3 hrs. 30 min.