RISK STANDARDS FOR ORDNANCE AND EXPLOSIVES REMOVAL

Paul M. LaHoud, P.E.

ABSTRACT

The U.S. Army Engineering and Support Center, Huntsville (USAESCH) provides central program management, safety, and special engineering expertise for the Corps of Engineers to identify, evaluate, and clean up Formerly Used Defense Sites (FUDS) contaminated with Ordnance and Explosives (OE). Inherent in this process is the need for risk-based site evaluations and clearance standards. There are currently no widely accepted procedures to define acceptable OE risk. The USAESCH has developed and continues to improve such a risk based methodology. This paper discusses the basis of this methodology and the extension of its use to include comparative risk data and consequences effects. The intent is to provide a clear means to relate OE hazards to common activities the public is exposed to regularly and for which comparative risk data are extensively collected.

INTRODUCTION

The purpose of this paper is twofold. The first objective is to present to the reader the current process utilized by the Corps of Engineers to ***define risk*** resulting from historical Ordnance and Explosive (OE) contamination at Formerly Used Defense Sites (FUDS). The second is to discuss changes to the methodology which can provide a basis for establishing risk reduction standards which can be compared to other common types of public activity. This revised method would significantly improve the determination and reduction of OE risk to a level which does eliminates ***"imminent and substantial endangerment"*** to the public**.**

BACKGROUND

The 1986 Superfund Amendments and Reauthorization Act (SARA) amended various elements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Some of these changes directly applied to (OE) contamination. The Defense Environmental Restoration Program (DERP) was one of the products of these changes. A primary objective of DERP is the correction of environmental damage resulting from the

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presence of unexploded ordnance, leading to the identification and removal of OE which creates an ***"imminent and substantial endangerment"*** at sites which were owned by, leased, or otherwise controlled by the Department of Defense at the time of contamination.

The National Contingency Plan (NCP) identifies nine criteria which must be considered by the DOD and coordinated openly with stakeholders in the consideration of risk reduction alternatives at OE sites. Since several of these criteria deal with risk management, the ***definition of risk*** associated with the presence of OE is an important public policy and program execution issue.

OE VIEWED AS A CONTAMINANT

To begin to assess risk there must be an understanding of the physical and chemical characteristics of OE. OE has both similarities and differences when conceptually compared to contaminants and hazardous substances encountered in traditional environmental remediation. A few of the significant comparisons follow:

<u>Similarities</u>. It is a surface or subsurface contaminant which is located in relatively discrete pockets or areas (Burial pits, trenches, and target areas). In burial pits or trenches remediation can be 100%. In the case of Target areas from former training activities, the OE density (contamination level) decreases as the distance from the target (conceptually analogous to a point source) increases. As with traditional environmental contaminants it is usually technically impossible to reduce contamination to zero.

<u>Differences</u>. OE consist of a dispersion of individual munitions items which are generally self-contained and physically robust. As a result, the potential pathways to the public differ from conventional contaminants. They are not passed through an intermediate medium such as the food chain, groundwater or released as vapor emissions. The exposure pathway for OE involves direct interaction between a person and an intact OE item.

<u>Risk</u>. The risk resulting from an OE exposure is a consequence of immediate physical trauma rather than an increase in cumulative long term health risks. These trauma result from fragmentation, blast pressure, intense heat, and in some cases chemical agent. The types of health risk ***consequences*** resulting from these exposures more closely align themselves with accidental injuries such as vehicular accidents, aircraft crashes, home accidents, explosion, fire, or falls. Injury severity to those in close proximity to OE initiations can range from immediate death to loss of limbs or extremities, partial or complete loss of sight or hearing, burns, puncture wounds, or cuts. The severity of the injuries is dependent on the explosive capacity of the OE item and its intended function (blast, fragmentation, chemical release).

THE GENERALIZED RISK ASSESSMENT PROCESS

The FUDS Program risk assessment process has many similarities when compared to traditional environmental contamination assessments. These include a review of historical property use leading to contamination, a site investigation program to define the nature and scope of contamination, and use of defensible analytical and statistical procedures to quantify the probable risk. OE geophysical field sampling procedures can be viewed as roughly analogous to the use of well fields to define groundwater contamination plumes. Like the data from a groundwater well field, the integration of data from an OE subsurface geophysical sampling program using advanced Geographic Information System (GIS) technology and statistical analysis software allow the estimation of OE contamination. This analysis method can then be used to define exposures and related to consequences in a complete risk model.

THE FUDS PROGRAM RISK ASSESSMENT PROCESS

The current risk modeling process uses a two-phase approach. The first phase is a qualitative risk assessment based on the results of an analysis of the historical use of the site. This process leads to a Risk Assessment Code (RAC). The method was developed in Accordance with MIL-STD 882C and AR 385-10. This model generates a risk matrix based on two factors paraphrased as follows:

1. HAZARD SEVERITY. A qualitative measure of the worst credible event resulting from personnel exposure to different types and quantities of explosives.
2. HAZARD PROBABILITY. A qualitative measure of the probability that a hazard has or will be created due to the presence of OE, the expected exposure environment and future land use of the FUDS property.

The methods include additional factors which amplify or attenuate risk based on area, extent, and accessibility of the potential OE hazard. The method has been presented previously at this Seminar and is described in Corps of Engineers Technical Letter (ETL) 1110-1-165. The results of the RAC are entered into the following Table to define the basis for action at the site under consideration. Below the Table are the paraphrased definitions of actions which are taken for each RAC outcome.

Once a site has been prioritized throughout the RAC process, and any RAC 1 TCRA efforts completed, further actions are evaluated through a CERCLA equivalent process requiring and Engineering Evaluation / Cost Assessment (EE/CA). This process includes site specific geophysical sampling, OE density estimates, statistical estimates of current risk and possible risk reduction associated with alternative courses of action and recommendations for public comment and consideration.

HAZARD SEVERITY TABLE

PROBABILITY SEVERITY	FREQUENT	PROBABLE	OCCASIONA L	REMOTE	IMPROBABLE
CATASTROPHIC I	**1**	**1**	**2**	**3**	**4**
CRITICAL II	**1**	**2**	**3**	**4**	**5**
MARGINAL III	**2**	**3**	**4**	**4**	**5**
NEGLIGIBLE IV	**3**	**4**	**4**	**5**	**5**

RAC 1 Requires immediate response such as a Time Critical Removal Action (TCRA)
RAC 2 High Priority site with near term action.
RAC 3 - 4 Further action required through orderly planing and further evaluation
RAC 5 Negligible Risk and No Further Action Required (NOFA)

COMPARATIVE RISK ANALYSIS

Because of the differences between OE and traditional environmental risks,   OE exposure analysis has little meaning to policy makers and stakeholders alike. As a means to enhance communication, a comparative risk model is utilized. The model currently consists of three parts. The first is a statistical estimate derived from field sampling that defines the degree of OE contamination. Using this parameter, combined with local demographic data (expected population growth, future land use), an analysis is generated by the model which projects the number of people who will be exposed to OE risk annually. The annual exposures for each area are then converted to a ***comparative risk*** projection that estimates the probability of "***exposures***" over some future period, say 20 years. At this time the comparative statistical risk analysis does not address whether an exposure leads to an accident, but rather conservatively equates “exposure” to accident. This phase of the model is in essence a quantitative extension of the initial qualitative RAC code assessment conducted earlier. Table 1 shows an example of the results of such a comparative risk assessment.

POPULATION BASE = 455 THOUSAND   20 YEAR PROJECTION

ACCIDENT SOURCE	RISK OF EXPOSURE	
In the Home	256,444	
Motor Vehicle	141,092	
Fires or Burns	6,129	
Students on School Buses	358	
Hunting	42	
All Aviation	34	
Commercial Aviation	6	(0.61×10^{-6})
Lightning	2.5	(0.28×10^{-6})
OE Site (Example)	0.4	(0.04×10^{-6})

TABLE 1. COMPARATIVE RISK OF ACCIDENT OCCURRENCE

Although this analysis has not considered the reduction in risk associated with the likelihood of "exposures" leading to accidents, it is evident that the risk of exposure alone is very low compared to other common risks for the expected future population and land use. A recommendation to propose for stakeholder discussion for this site based on the comparative risk data would be No Further Action (NOFA). Higher levels of OE contamination would require some type of risk standard to determine further action.

CONSEQUENCES AND RISK ASSESSMENT

In the most traditional safety sense, risk is the product of ***probability of occurrence*** and the ***severity or consequence*** of the event. Probability of the event includes two components; proximity of the OE to people and the presence of conditions which would lead to initiation. Severity of the event includes the nature of the OE item. At this point in our evolving risk assessment process for OE, we conservatively assume that both an initiator is always present given an exposure and that all exposures incidents are considered accidents (neglect severity of event).

There exists at least an initial basis for the classification of OE in a manner that recognizes both the probability and consequences (severity) of the accidental functioning of the item in relation to the expected exposure scenario in the comparative risk analysis model. This basis is considered qualitatively in the initial RAC assignment. For example, OE items such as large explosive filled bombs and projectiles were designed as area damage weapons. They represent a severe threat to human life over a fairly large area. The severity of such an incident might be comparable to an aircraft crash. If the analysis of land use would lead to a projection of frequent human exposure coupled with the severity described, The degree of remediation (risk mitigation) could then be defined to achieve for instance at least the same ***tolerance of risk*** as one accepts for commercial air travel. At the other end of the spectrum, are OE items such as practice bombs and ammunition, which may contain a very small amount of energetic material to create a smoke marker of the impact location during training. An encounter with this type of OE might lead to results such as a burn, or at worst eye injury. Such a risk might be mitigated to a ***standard of risk*** comparable to accidental fires or burns. For the two examples suggested, the range of acceptable risk might be 1 in a million (1×10^{-6}) for the former, to one a thousand (1×10^{-3}). The Table below is a version of the earlier table which substitutes ***hypothetical*** risk goals which might be acceptable to mitigate the initial RAC values.

Risk values such as this based on an order of magnitude ranging may be suitable for OE blast effects definition. An approach such as this could provide a complete risk standard since both probability of occurrence, and the consequences of the event are considered. It would be consistent to link these quantitative risk standards to the qualitative definitions utilized in the initial risk assessment process used to arrive at the RAC. At each stage of site activity, the progress of risk definition can be compared with the initial assessment and the standard. When a level of risk suitable to all stakeholders (or accepted standard is reached) clearance efforts would be completed and documented. All Geophysical data used to derive risk model results are now captured in permanent digital form by USAESCH to allow future analysis if required by land use changes or revised standards.

RISK MITIGATION GOALS

PROBABILITY		**FREQ.**	**PROB.**	**OCCASION.**	**REMOTE**	**IMPROB.**
SEVERITY						
CATASTR.	**I**	10^{-6}	10^{-6}	10^{-5}	10^{-4}	10^{-3}
CRITICAL	**II**	10^{-6}	10^{-5}	10^{-4}	10^{-3}	**0**
MARGINAL	**III**	10^{-5}	10^{-4}	10^{-3}	10^{-3}	**0**
NEGLIGIBLE	**IV**	10^{-4}	10^{-3}	10^{-3}	**0**	**0**

LACK OF RISK STANDARDS FOR OE REMEDIATION

The lack of official DOD standards of risk for OE remediation continues to be a significant obstacle to effective program management and technical execution of the OE program. Both the risk and the consequences of exposure to hazardous OE are poorly understood by policy makers and stakeholders involved in remediation of FUDS projects. The USAESCH Ordnance Center of Expertise is working continuously to develop improved risk methodologies which utilize comparative risk of OE exposures and consequences to common activity risk data to better communicate the basis for site improvement actions.

CONCLUSIONS

The OE comparative risk analysis methodology as currently being used for the FUDS Program can be extended as described in this paper, and has the potential to provide an understandable interpretation of public risk as an element of the NCP evaluation criteria. It can address both probability of exposure and severity of consequences, and relate these to commonly understood risk, providing the basis for a badly needed ***risk standard***.