OVERVIEW OF THE FACILITY ACCIDENT ANALYSIS FOR THE U.S. DEPARTMENT OF ENERGY ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT*

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ABSTRACT

An integrated risk-based approach has been developed to address the human health risks of radiological and chemical releases from potential facility accidents in support of the U.S. Department of Energy (DOE) Environmental Restoration and Waste Management (EM) Programmatic Environmental Impact Statement (PEIS). Accordingly, the facility accident analysis has been developed to allow risk-based comparisons of EM PEIS strategies for consolidating the storage and treatment of wastes at different sites throughout the country. The analysis has also been developed in accordance with the latest DOE guidance by considering the spectrum of accident scenarios that could occur in implementing the various actions evaluated in the EM PEIS.

The individual waste storage and treatment operations and inventories at each site are specified by the functional requirements defined for each waste management alternative to be evaluated. For each alternative, the accident analysis determines the risk-dominant accident sequences and derives the source terms from the associated releases. This information is then used to perform health effects and risk calculations that are used to evaluate the various alternatives.

INTRODUCTION

This paper is an overview of the facility accident analysis being developed in support of the U.S. Department of Energy (DOE) Environmental Restoration and Waste Management (EM) programmatic environmental impact statement (PEIS). The objective of the EM PEIS is to examine the potential environmental consequences of an integrated program for managing radioactive and chemically hazardous wastes. Embodied in this objective is the need to compare the relative risk impacts of waste process and waste consolidation alternatives for the radiological and chemical waste inventories across the DOE complex. A key factor in this comparison is the safety of both the general public and the site or facility work forces involved in the overall environmental restoration and waste management effort in relation to radiological and chemical releases.

To understand the potential scope of the facility accident analysis, it is necessary to understand the scope of the EM PEIS. The EM PEIS addresses strategic alternatives for the management of six different waste types: greater-than-Class-C low-level waste, hazardous waste, high-level waste, low-level mixed waste, low-level waste, and transuranic waste. For each waste type, five categorical strategies have been devised for the consolidation of wastes for treatment and storage: 1) centralization, where from one to a few DOE sites will be used to treat and store a given waste type from the entire DOE complex; 2) regionalization, where several sites distributed throughout the country will be used to treat and store that waste type for their geographical regions; 3) decentralization, where regionalization is extended to include more sites; 4) "no action," where existing sites will generally store and treat their own wastes consistent with currently approved plans; and 5) a "current program" that includes the existing no-action facilities plus additional facilities included in the DOE Five-Year Plan. Each of these consolidation strategies has associated siting options, and each option involves both existing and conceptual design facilities. Each siting option also implies unique inventories of waste to be stored and treated at each site and associated facilities. Finally, a number of treatment technologies and storage options for each waste type are to be evaluated.

Radiological and chemical releases may occur as a result of 1) normal waste management operations; 2) accidents involved in the transportation of wastes to or from waste facilities; or 3) facility accidents, including industrial accidents during treatment or storage operations and external challenges to the facility from initiating events ranging from fires in adjacent facilities to earthquakes. Waste management alternatives result in different risks from these three sources, and these risks constitute the total societal risk from releases in the DOE/EM waste management program. It is important both to minimize the total societal risk and to assure that no one segment of the population bears a disproportionate risk because of a specific waste consolidation alternative.

For example, a DOE waste management strategy emphasizing consolidation of wastes at a small number of sites nationwide would require that waste from sites all over the country be transported to a selected few central or regional sites for treatment, storage, and disposal. For this strategy, the risk to the public from transportation accidents would be expected to rise with the level of consolidation. On the other hand, consolidation requires large facilities with associated economies of scale and efficiency that would be expected to minimize the total human health risk resulting from facility

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accidents. However, this risk would be borne by populations at and immediately surrounding the consolidation sites. As illustrated in Fig. 1, tradeoffs between the impacts on risks for facility accidents and for transportation, as a function of the degree of consolidation of wastes, are seen to emerge with the different populations being affected. It is thus incumbent upon the EM PEIS to allow evaluation of the relative risk contributions of accidents from facility operation and transportation.

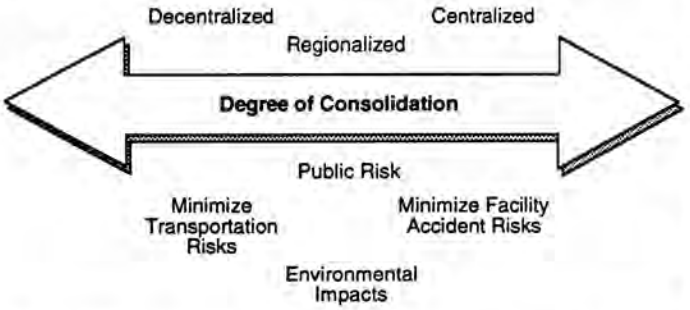

Fig. 1. Effect of consolidation alternatives on competing risks.

The purpose of the facility accident analysis then is to evaluate the risk to the public and occupational work forces from potential accidents that may occur at DOE facilities involved in waste management so that the safety of alternative strategies can be compared. The analysis supports the EM PEIS by facilitating a comparison of the impacts on risk of alternative waste storage and treatment technologies and consolidation strategies in relation to chemical and radiological releases resulting from potential facility accidents. This paper describes the scope of the analysis, outlines the overall approach and methodology, and identifies the key sensitivities and uncertainties. The effects on risks to human health from normal operational effluent releases and transportation accidents are evaluated in separate efforts supporting the EM PEIS and will not be discussed here.

GENERAL REQUIREMENTS AND SCOPE OF FACILITY ACCIDENT ANALYSIS

The requirements on and the scope of the accident analysis are driven by the scope of the EM PEIS and by guidance provided by DOE on the purpose of accident analysis in the preparation of environmental impact statements. The most recent guidance from the Office of the National Environmental Policy Act (NEPA) Oversight within DOE (1) calls for consideration of the spectrum of accident scenarios that could occur in activities encompassed by the actions evaluated in the EM PEIS. This guidance also calls for a graded approach in emphasizing the risk-dominant scenarios. Determination of risk dominance requires assessment of both the likelihood and the severity of plausible accident scenarios that could present a significant health hazard to either the occupational work forces or the general public.

The first requirement on the accident analysis stems from the very large number of combinations of possible treatment and storage processes, existing or new facilities to accommodate these processes, storage and process inventories and throughput, and related possible accident scenarios to be evaluated for assessing management alternatives for each waste type. Accordingly, one obvious objective of the accident analysis methodology was the development of a strategy that would facilitate focus on the risk-dominant sites and facilities for the waste management alternatives under consideration in the EM PEIS for each waste type.

Another requirement stems from the fact that accident analysis information is needed to allow systematic comparison of the safety aspects of treatment, storage, and site consolidation options for both new and existing sites and facilities across the DOE complex. Such information must also be generic enough to encompass plausible accidents in unbuilt facilities whose design criteria can be only scoped. Current safety analyses, environmental assessments, and impact statements provide much site-specific information. However, these documents have been developed over many years as the underlying technology base, while the related regulatory guidance has improved. Consequently, the scope and supporting levels of detail in site safety reports vary widely. Accordingly, a second key objective of the accident analysis methodology was to facilitate the integration of the information in existing site safety documentation with the most recent state-of-the-art guidance to provide a uniform and consistent treatment across the relevant technologies and sites for analyzing accidents.

A third requirement comes from the need to intercompare the risks from facility accidents for the various alternatives as well as to compare these risks with other components of risk. The waste throughput for some of the alternatives is heavily dependent on the waste inventories being generated from various environmental restoration programs that are not well characterized at this time. Public and occupational risks from facility accidents are driven by the amount of waste throughput. This is reflected in both the potential consequences and the potential likelihoods of accidents, which increase with throughput as illustrated in Fig. 2. Therefore, a third key objective of the accident analysis methodology was to facilitate comparative and sensitivity evaluations, thus allowing the risk of accidents at each facility to be characterized as a function of the throughput of a given waste type at that facility.

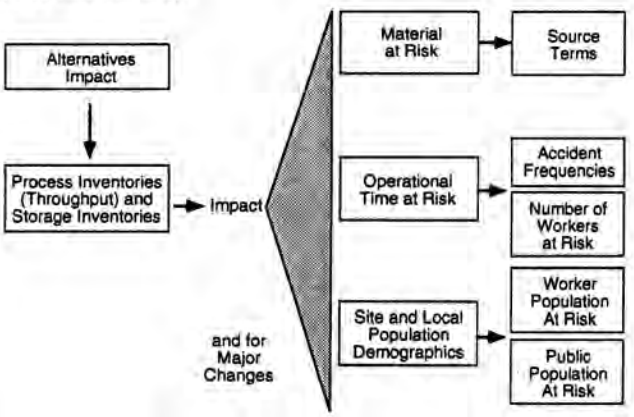

Fig. 2. Effects of waste throughput on occupational and public risk.

ANALYTICAL APPROACH AND PRELIMINARY RESULTS

To meet these objectives, a phased approach was developed. The first part of the analysis focuses on radiological and chemical source term generation and includes the following

interrelated elements: 1) screening of storage and treatment processes and related facility configurations across the DOE complex with large and potentially hazardous inventories of radioactive or chemically toxic wastes vis-a-vis the attendant vulnerabilities of the facilities, 2) development and frequency estimation of the risk-dominant sequences of accidents that could plausibly occur during storage and treatment, 3) determination of the evolution of and final compositions of radiological or chemically hazardous source terms predicted to be released as a function of the storage inventory or treatment process throughput as a result of these postulated accidents. A PC-based computational framework and database has been developed to automate these elements and provide a source term input for the second part of the analysis.

The second part of the analysis focuses on health effects. The main elements include 1) development or integration of existing site-specific demographics and meteorological data and calculation of attendant unit-risk factors and 2) assessment of the radiological or toxicological consequences of accident releases to the general public and to the occupational work forces by using the source term and unit-risk information.

Figure 3 illustrates the integration of these elements into a systematic programmatic approach for performing risk impact analysis for the EM PEIS. The waste management alternatives discussed in the EM PEIS include the identification of siting options for storing and treating each waste type prior to disposal. Storage inventories and treatment throughput for each site affected by a given alternative are then defined by the current inventories, existing and projected waste generation rates, and the disposition of the waste as identified in the alternative. The volume and radionuclide composition of each waste are tracked in a relational database as the waste is processed through to final disposal. Details of the methodology and computational framework developed to implement or link these elements for the accident analysis are described elsewhere (2).

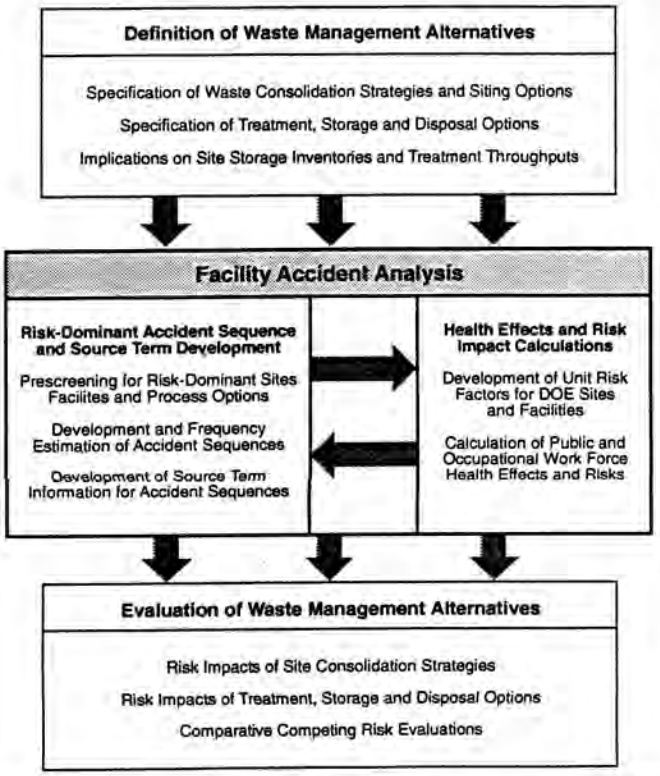

Fig. 3. Overview of facility accident analysis for the EM PEIS.

Implementation of this phased approach is being performed through the collaborative efforts of interdisciplinary teams from Argonne and Oak Ridge national laboratories. Selection and development of the risk-dominant accident sequences and development of the associated source term informational output were performed by Argonne as the first part of the analysis. The unit-risk factors outlined above were developed by Oak Ridge as the second part of the analysis. This information was then transmitted to Argonne for use in the screening phases to establish the reference accidents for more rigorous evaluation. The source terms for the dominant risk accident scenarios were then evaluated by Argonne and transmitted to Oak Ridge for the health effects calculations.

Appropriate organization, updating, and presentation of this accident information is ongoing to enable risk impact comparisons of the various waste management alternatives as illustrated in Fig. 3. Preliminary calculations with currently projected waste generation rates, storage inventories, and treatment process throughputs are being performed. It is expected that the health risk to the public from radiological releases following conceivable facility accidents will be negligible for the greater-than-Class-C, low-level, mixed low-level, and transuranic waste management alternatives. Minor public health effects may be predicted for the most severe high-level waste storage and treatment accidents. However, the likelihood of these is remote on the basis of preliminary evaluations.

SUMMARY

The work reported herein has served the short-term needs of DOE by facilitating the evaluation of the risks to the occupational work forces, site populations, and general populations surrounding sites involved in the waste management strategies being investigated in the EM PEIS. Perhaps more importantly, this work has provided a risk-based computational framework and database that can effectively be updated and implemented to support future DOE programmatic decision making.

REFERENCES

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2. C.J. MUELLER et al., "Methodology and Computational Framework Used for the U.S. Department of Energy Environmental Restoration and Waste Management Programmatic Environmental Impact Statement Accident Analysis," presented at WM'94 Conference, February 27 - March 3, Tucson, Arizona (1994).