Improving DOE/EM

Risk Information: Content and Format

Conclusions and Recommendations from

Two Working Meetings

Organized by the Consortium for Risk Evaluation

with Stakeholder Participation (CRESP)

Revised Version

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1. Executive Summary

Risk assessment is a useful analytic process that provides valuable contributions to risk management, public health, and environmental policy decisions. Risk assessment was developed because Congress, regulators, and the public require scientists to go beyond scientific observations of the relationships between exposures to chemicals and pollutants to answer social questions about what is unsafe.[1] The Consortium for Risk Evaluation with Stakeholder Participation (CRESP)[2] conducted two independent reviews of the use of risk information in the FY 1998 budget formulation process. While favorably noting the development and use of these management processes, these CRESP peer reviews urged further refinements to the descriptive risk elements so they could better convey the breadth of risks considered, be more consistently applied, and enhance understanding of risk change that may occur during the stabilization and remediation of hazardous radioactive materials and chemicals. With the endorsement of Assistant Secretary Alm, two working meetings were convened by CRESP in October, 1996 to refine the risk elements. The findings and recommendations from those meetings form the body of this report.

Protection of human health and the environment is the primary mission of the Department of Energy's Environmental Management Program. Environmental Management projects are to be sequenced in a way that allows EM to address urgent risks, and reduce or eliminate all risks to the extent possible. The current EM management plan places a priority on completing many tasks over the next ten years. Many external advisory groups, including the National Research Council and the DOE Environmental Management Advisory Board, have pointed to risk as an essential and feasible decision factor for DOE managers and decision-makers. The potential benefits of a risk-influenced process include:

> <u>Better Stakeholder Communication:</u> A growing number of stakeholders understand how risk information can be used in a decision process to ensure risks are minimized as plans and alternatives are developed and implemented. Risk information should be considered along with such factors as stakeholder values, cost, land use, available technology and compliance agreements.
>
> <u>Improved Information for Decisions:</u> Risk information can have wide application within the DOE-EM context, particularly for setting priorities (sequencing) and for comparing potential adverse impact of stabilization and remediation options.
>
> <u>Greater Equity:</u> A consistently applied risk assessment tool can enhance a national dialogue to ensure equity is maintained, and risk issues are properly communicated in inter-site decisions.
>
> <u>Enhanced Performance Measurement:</u> Risk measures can be used to track performance by illustrating the degree to which risk is being mitigated while projects are underway in the EM program.

For efficiency of effort and effective communication, it is important to build upon the current level of familiarity and experience with the existing risk information approach. Operations Offices, stakeholders and regulators generally understand the Risk Data Sheet process used by EM earlier in 1996 to capture data for use in the FY 1998 budget development process. The basic content and format of that system is sound. DOE/EM should focus

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[1]President's Commission on Risk Assessment and Risk Management, 1996. Draft Report

[2]CRESP is a university-based entity created to provide credible strategies for providing information needed for risk influenced clean-up of complex contaminated environments. CRESP is funded through a cooperative agreement with the Office of Environmental Management, Department of Energy.

on incorporating refinements to the system and on enhancing implementation. The CRESP recommendations are built upon such a premise.

Recommendations

1. Continue to separately consider risks to the public, site personnel and the ecology.

2. Revise the existing risk matrix and format that constitutes the current EM risk data base[3].

3. Accord greater attention to ascertaining potential risks to site personnel safety and health, and ecological health that may arise from remediation and restoration projects. The potential for gaining positive impacts in one risk area at the expense of a negative impacts in another should be explicitly clear to all interested parties.

4. Pilot test the revised risk matrix to evaluate projects in the Ten Year Plan prior to final field submittals. CRESP is prepared to work with a site willing to perform the pilot. It is also prepared to assist other sites.

5. Realize efficiencies in collecting and using risk information by screening the revised data base to identify circumstances where further assessment is not needed.

6. Enhance the quality and completeness of the data base by using a simple "Essential Information Template" to guide collection of information.

7. Do not discount professional judgment as a valid technique and source of information. Here, as in all circumstances, the basis for the judgment should be transparent to the reader. At the same time, it is unrealistic to assume that a credible data base of risk information can be developed without the participation and guidance of personnel with appropriate training and experience. Such people exist at most DOE sites, their talent and work product needs to be more effectively utilized.

2. Summary

The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) believes that three distinct forms of potential health risk -- ecological,[4] occupational, and public health -- are important to understanding and discussing key issues at Department of Energy Environmental Management (DOE/EM) sites. Stakeholders and Tribal Nations with a range of interests seek to participate in risk-influenced decision processes that identify, prioritize, select, and monitor actions that remediate DOE/EM lands for future societal use. Their meaningful participation often depends on DOE's ability to characterize and effectively communicate the scope and magnitude of each of these three types of risk. A broadening base of support for DOE/EM management of these sites in recent years has been partly attributable to the inclusion of risk as an information element in its management, planning and decision processes. Appendix C describes the evolution of risk-influenced decision making in the Environmental Management Program since 1995.

[3]The Working Group meetings focused on the traditional elements of risk contained within the EM RDS matrix, i.e., worker, public, environment. Other legitimate elements of the decision making process such as social, cultural or economic concerns were beyond the purview of this activity.

[4]The term ecological is preferred over the term environmental in the belief that many consider environmental risk to incorporate consideration of risk to humans and other organisms from interaction with their environment.

Several CRESP peer reviews[5] favorably noted the development and use of these risk-influenced management processes, but urged further refinements to the descriptive risk elements so they could better convey the breadth of risks considered, be more consistently applied, and enhance understanding of risks that may arise during the stabilization and remediation of hazardous radioactive materials and chemicals. (See Appendix B for an Inventory of these recommendations.) Responding to some major recommendations, CRESP undertook the task of addressing specific issues that would redefine and improve matrix elements and provide more cogent guidance.

CRESP convened two meetings in early October to address ecological risk issues and issues associated with occupational and public health risk. Participants in those meetings included scientists that are experts on the specific topics plus individuals with programmatic knowledge and experience with EM management processes. Individuals from a broader spectrum of interests were invited but were unable to attend. The list of participants is found in Appendix A.

The meetings focused primarily on recommendations put forth in the CRESP Peer Reviews. In addition, we elected to be guided by two broad principles:

1. **The process of reducing existing risks may also generate risks of adverse consequences, especially for workers and ecosystems.** In developing project plans progress is often gauged by the amount that human health risk is reduced. The benefit of reducing an adverse burden to the public should be compared to ecological and site personnel risks, if any, incurred while achieving the desired end state. Further, in estimating the risk of a remediation or stabilization project, adverse outcomes associated with transportation, construction, demolition, etc., must be considered along with risks associated with exposure to chemical and radiological materials.

2. **The characterization of risk needs to bring better balance to the risk scenarios, i.e., the *Before, During* and *After* phases of a project.** To date, DOE has tended to focus upon the *Before* risk category by using such risks as the basis for prioritization of projects within and across sites. As EM activities encompass a broader range of remediation, stabilization and restoration efforts, greater attention must be accorded to the risk related aspects of these activities, i.e., the *During* category. Ecosystems and site personnel are particularly vulnerable to increased risk caused by remediation or stabilization activities. In a number of instances a stabilization, remediation or restoration project may be the major source of ecological damage. Similarly, both the nature of the risk and the specific type of worker affected by risk *During* projects are likely to be quite different from those risks that exist *Before* projects begin. Thus, *During* can have two aspects of risk: favorable and adverse. Examining the potential risks in the *During* phase may identify a need to seek alternative technologies or plans of activities.

Revise the Risk Format

The CRESP 1996 Peer Reviews and the two October meetings focus on revising the Management Evaluation Matrix of the FY 1998 Risk Data Sheet. The Risk Data Sheet, used by EM in its budget development process, provides a description of the issue to be addressed and what work is envisioned. Further, an evaluation scenario is presented that the site considers appropriate for the *Before*, *During*, and *After* conditions with detailed narrative field descriptors for each of the three risk categories.[6] The basic content and format of the matrix has several desired features. These include:

- Describes ecological health, site personnel safety and health, and public safety and health risks, including severity and likelihood.
- Allows characterization of risk at three important times, *Before* (current), *During*, and *After* a project.

[5] CRESP 1996a & b, plus discussion at the DOE "Lessons Learned" meeting in July 1996.
[6] The FY 1998 Risk Data sheet format can be found in Appendix C.

- Allows for evaluation of adverse impacts to three health risk categories separately, as well as part of a holistic perspective, i.e., during remediation and during delay.
- Builds upon basic familiarity and experience with the matrix, which has been used at the EM operations offices and sites.

Make technical changes to impact levels

We offer recommendations on each of the three risk categories, i.e., ecological, site personnel, and public health. The proposed changes incorporate the following:

- Each risk element contains four descriptions (levels) of the nature, breadth, and severity of adverse effects, instead of two or three.

- "Near Background"[7] is added to the High, Medium and Low valuations. In the past Low was used to designate background levels, diminishing the ability to discriminate between types of risk directly relevant to the site or project being described.

- Key terms are defined and several new terms with definitions are added. These changes should clarify the nature of the information needed and improve consistency.

- The words *catastrophic*, *significant*, *marginal*, and *negligible* are eliminated as shorthand terms for the risk matrix categories. These terms are viewed by some members of the Working Group as value laden and often pejorative. As a result, their use in the matrix sparks debate as to whether a particular term is appropriate in a particular situation based on different perceptions of individuals as to the meaning of the term, i.e., is a certain situation really *catastrophic*? A primary goal of the risk matrix -- to convey information in a clear and neutral manner -- is fatally compromised if the debate focuses on the meanings of particular words, and not on systematic differentiation of potential events into 4 broad categories. Thus, the use of a simple 1 to 4 numerical scale, with 1 being the most severe level of effect and 4 the least severe, is recommended. This alternate terminology is used in this document.

Provide greater clarity for the Likelihood of Occurrence element

An essential component of risk is probability, defined as the relative frequency with which an event occurs or is expected to occur. The FY 1998 RDS format allows likelihood to be expressed as "numerical probability of occurrence" or "expected time to impact." CRESP peer reviews indicate that this option resulted in responses that were not consistent across the complex. Simplifying likelihood of occurrence may enhance consistency across the DOE complex. Further, we recommend that "Likelihood of Occurrence" be defined as ***the time at which the event leading to adverse impact is expected to occur.*** These recommendations have several advantages:

- The definition permits EM to place primary focus on <u>preventing</u> a juxtaposition of agent and receptor by containment or other form of sequestration.
- The proposed language is easily understood when the adverse effect is due to trauma or other type of immediate effects. It is believed that this is the dominant type of risk that will be seen in the occupational setting in the *during* phase of a project. It is also the dominant effect in settings where transportation-type accidents may occur.

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[7]The initial version of this report used the term "Not Applicable" which prompted several critical comments. It was pointed out that the word applicable was being improperly used. Substituting the term "near background" more closely conveys the intent.

- For "delayed" effects -- such as expression of cancer (years later), or endocrine disrupters (years later), or birth defects (months later) -- it focuses attention on the point in time when the agent and receptor interact to set off the processes that lead to the adverse effect (risk), i.e., the event one is seeking to prevent.
- It still permits the use of numerical probability estimates where such data exist; actuarial tables may be appropriate in some circumstances. Likewise, professional judgment and experience have a clear role.

Add clarifying examples to the guidance

We supply a new series of examples that helps the reader to differentiate between the four levels of severity for the three types of health risks (ecological, site personnel, and public). In addition we hope they convey a better sense of how to gather and use information and communicate a judgment in a more robust and transparent manner.

Specific Modifications

Ecological

CRESP's principal concern is revising the risk matrix[8] so that it can more effectively capture ecological information; it makes the following recommendations:

- Rename the category "ecological risk" to clearly convey a primary need to consider organisms and their environment. The existing term 'environmental protection' implies the protection of media (air, water, soil) alone, whereas the term 'ecological' refers to organisms and their environment.
- In each of the impact levels, use four descriptive terms: duration of effect, unique and sensitive environment, biological condition and geographic scale.
- Provide clear examples to illustrate how the different impact levels discriminate between severity of effects.
- Fully consider two distinct forms of ecological risks: 1) those associated with existing chemical and radiological contamination; and 2) those resulting from physical disruption of the environment during remediation.

Site Personnel

As the projects at DOE/EM sites shift to an accelerated pace of remediation and restoration of chemical and radioactive waste, the *during* phase of the risk matrix merits close attention. Personnel involved in these types of projects could be at highest risk at DOE/EM sites. It is possible that estimating *during* risks in the planning process may indicate, in some instances, a need to seek alternative technologies or plans of activities. The recommendations focus on providing:

- a more specific level of definition for categories such as type of workers affected, health endpoint and nature of the hazard(s); and
- examples to demonstrate the use of the revised definitions.

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[8] Throughout this document, the words "risk matrix" will refer generically to a matrix that presents severity of impacts along the vertical axis and likelihood of occurrence along the horizontal axis. We chose not to use the term used by EM for the FY 1998 Risk Data Sheets, i.e., "Management Evaluation Matrix," because it includes other non health risk information such as compliance and mortgage reduction. For a detailed description and history of Risk Data Sheets, please refer to Appendix C.

Public Health

The focus of recommendations is to provide greater definition of the types of information considered in this Section. Specifically:

- each public health impact should be defined by a consideration of four components; injury and illness, duration of adverse effect, extent of exposure and number of individuals impacted. The latter is a new topic.
- examples are provided to demonstrate the use of the revised material.

Implementation

Several general improvements should be considered for implementation. In addition, specific suggestions are made for each of the three risk categories: ecological health, site personnel safety and health and public safety and health.

General

In general, three implementation activities should be considered: a Screening Evaluation, use of an Essential Information Template, and a pilot test of the proposed changes.

Screening: Determining the need and appropriate level of detail for assessing risk

The CRESP Peer Reviews advised that risk expertise be focused on a sub-set of projects where expertise will add greatest value, i.e., where expertise can provide information of direct value to the decision process. We endorse this change in approach and provide various techniques to screen proper data bases to determine the need or priority for risk characterization. Such an approach is suggested for the site personnel and ecological risk categories. These recommendations rely mainly on a common sense approach.

Essential Information Template

The gathering and expression of essential risk information must be improved without overburdening DOE field offices. The proposed approach for collecting essential information provides

- an efficient mechanism for the consistent evaluation of risks; and
- a record showing the logic and supporting documentation used to derive the risk evaluation.

This essential information can be readily organized under several broad categories and serve as the underpinning for the shorthand summary of risk expressed in the matrix. The information could be collected using a standard template that is not overly-burdensome. If a template is used in conjunction with a screening tool, information will only be collected for certain activities. Rough drafts of templates can be found below in the sections on risks to ecology (page 24) and site personnel (page 35).

Pilot the proposed changes

A pilot based on this revised risk matrix should occur at one or more DOE sites/facilities. This will allow further development and clarification of many recommendations in this report. It could also provide a mechanism for interaction with stakeholders and Tribal Nations.

Ecological Health

- Clearly differentiate between time to recovery and time to impact.
- Give close attention to ecological risks due to remediation activities.
- Consider five principles (below) when defining measures of progress.

Site Personnel Safety and Health

- Better utilize on-site resources. An efficient means for assembling the EM site personnel data base is to capitalize on the Office of Environment Safety and Health (EH) expertise and infrastructure that is resident within the operations offices. In addition, management, particularly on-site personnel with working familiarity with operations, should be a component of a team that develops such a data base. Budget personnel should not be expected to possess the depth and range of skills needed to properly characterize issues of this sort.

Issues requiring further work

The majority of major recommendations emerging from the CRESP peer reviews can be resolved if the recommendations in this report are adopted. However, a few issues remain unresolved, and are summarized below.

Improve meaningful dialogue with stakeholders and Tribal Governments

We regret that, in our attempt to have influence on DOE's FY 1999 Budget Development process, we were unable to solicit a desired degree of stakeholder interaction and involvement. With the submission of this document CRESP will commence that activity by distributing this document widely, requesting comments and fostering interactions with a wide range of interested parties. Based on those interactions we will provide the Assistant Secretary with a summary of any changes to the recommendations in this document.

Find effective means to incorporate probability of adverse events and effects

Quantitative risk assessments can provide useful information for evaluating potential human and ecological hazards. Quantitative risk information comes from estimates of chemical as well as radiation hazards and represents potential for risk for both cancer and non-cancer impacts. However, each of these hazard or risk categories has different methods of presenting information and calculating levels of certainty. This state of affairs is a barrier to those who would like to use such data in a meaningful and consistent manner. The issues surrounding this conundrum are presented in the section on public health.

Essential Information Templates

We suggest that EM use Essential Information Templates to collect information from the key site personnel and serve as the underpinning for the summary information presented in the matrix. Templates are presented in draft form in sections 3 and 4; they require further development and testing.

Geographic specificity

CRESP peer reviews noted that improving direct links from descriptions of DOE operations and projects to specific geographic locations is critical to a better understanding of risks. The FY 1998 Risk Data Sheets called for a geographic locator in the form of the State in which the project was occurring. This may be appropriate for some of the smaller sites; however, many of the larger sites should be broken down into smaller units for a more precise frame of reference. Geographic locations can serve as the anchor for the many different types of information that are collected on-site by EM and other offices, i.e., Environmental Impact Statements, BEMR data, Safety Analysis Reports, and Environment, Safety and Health data. Such a logical linking of data would reduce duplication of effort and assist management in identifying research needs and data gaps. This issue needs further consideration and development. CRESP's work with GIS is directly applicable.

3. Ecological Risk

General

The issue of risk to Ecological Health was the main topic of the CRESP Working Group meeting held October 3-4, 1996 at the Environmental and Occupational Health Sciences Institute in New Jersey. The meeting primarily focused on issues identified through previous review activities.

According to the CRESP peer reviews, the three most glaring problems with the "Environmental Protection" category in the former matrix were:

- Only in rare instances was information provided that was relevant to ecological risk. Instead, the information almost exclusively focused on ground water contamination and the associated exposure to <u>human</u> populations. (CRESP 1996a, p 3)
- The environmental category was "lacking in some of the basic details which would allow either a lay-person or a DOE manager to determine the key aspects of the ecological or environmental risk." (CRESP 1996a, p 35)
- An enormous amount of ecological information was un-tapped by the process. (Multiple sources)

A principal concern is to revise the risk matrix so that it can more effectively capture ecological information. Moreover, we urge DOE/EM to fully consider two distinct forms of ecological risks. The first is associated with existing chemical and radiological contamination - typically found in the "*Before*" scenario. The second is the potential for significant ecological risk due to physical disruption of the environment as part of remediation. The impact of proposed action (the "*During*" scenario) needs to be clearly presented and be part of the management decision process.

The practice of including only groundwater contamination within the ecological risk category can skew the risk evaluation and obscure other real risks to ecosystems.[9] For example, during remediation, groundwater contamination may not present the most immediate risk to biota in the environment, and many other ecological risks may be more consequential and potentially more irreversible. In the FY 1998 RDS process, the apparent practice of focusing almost exclusively on groundwater masks the need to consider these concerns. Finally, if the actual concern is human risk from water consumption, such an effect should be scored in the public health and safety category.

Measures of progress

Measures of progress toward reducing and minimizing risks and averting adverse impacts are critical to the viability of the Environmental Management Program. Although we discussed measures of progress only briefly, there is a critical need to examine whether the risks predicted actually occur and how risks change over time. We suggest the following principles for developing measures of progress for ecological risk.

1. Develop tangible measures of achieving desired end state (good or excellent biological condition,[10] low long-term maintenance or management costs, etc.). Clear measures of progress are dependent on a specific description of the end state that is envisioned for a particular geographic location.
2. Determine what measures (risk-based or otherwise) will be used to evaluate the success of the activity *before* remediation or other activities are initiated.

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[9] CRESP, 1996a.
[10] The terms used here are fully defined later in this section (pages 13 - 16).

3. Relate ecological measures of progress to geographic scale of impact, change in biological condition, loss of unique habitat, and recovery time for sensitive habitats.
4. Minimize use of labor intensive measures (fiscal constraints require that inexpensive measures be used to the greatest extent possible). However, no single measure (or surrogate) for ecological risk is sufficient to evaluate progress or success. See below for specific examples.
5. Monitor and track measures regularly. Although yearly fluctuations may not be perfectly accurate, monitoring is essential to identify and follow trends. Not all measures warrant or are conducive to annual measurement -- common sense should prevail regarding frequency of monitoring.

Specific examples of measures

Examples would include but are not limited to the following:

1. The ability to keep ecological impacts due to remediation projects to a minimum. In other words, remediation impacts should
    - *usually* be kept to the lowest level of severity (Impact Level 4)
    - *occasionally* be allowed to reach the second lowest level of severity (Impact Level 3); and
    - *never* be allowed to reach higher levels of severity (Impact Level 1 or Level 2).

2. Biological measures which require monitoring, such as
    - Changes in biological condition
    - Changes in reproductive success
    - Reduction in recovery time
    - Recolonization and establishment of native or desired species

Modifications

The recommended changes to the risk matrix and definitions for its components, are described below. The proposed matrix for ecological health that incorporates the recommendations is found in Table 2 on page 18. [11]

Differentiate ecological risks due to existing contamination from those due to remediation activity

We believe that ecological risks at EM sites can result from quite different causes and that such possibility should be explicitly clear to DOE and other interested parties. The “*Before*” scenario at a particular location typically characterizes risk associated with existing chemical and radiological contamination. In contrast, the potential for ecological impacts due to physical disruption of the environment as part of remediation activities (the “*During*” scenario) needs to be clearly presented. In order to highlight the potential for these different ecological impacts, we recommend they be evaluated separately in the risk matrix (see Table 2). In addition, examples for both contamination and remediation impacts are presented below, starting on page 18.

Expand the impact levels from three to four

The proposed matrix incorporates four levels of ecological impact, with each level receiving a designation of either 1, 2, 3, or 4. The addition of a fourth level permits a greater opportunity to discriminate between levels and types

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[11] For comparison, see Appendix C for a description of the matrix used in the FY 1998 Budget Development process.

of adverse effects. The use of four levels is consistent with that used for characterizing public or site personnel risks.

Use descriptive terms to describe interrelated impact factors

Four descriptive terms are used to characterize the nature and severity of ecological impact at a particular site of interest. Many of the terms are qualitative in the hope that use of descriptive language would enhance the ability to clearly differentiate between the different levels of impact. The four descriptive terms are duration of effect, unique and sensitive environment, biological condition, and geographic scale.

Table 1, below (page 16), was developed as an aid to demonstrate how one might integrate the four descriptive terms defined above to determine the appropriate impact level, given a particular scenario. It is not our intention that such a table provide a "cookbook approach," it is meant to be a guide. Expert judgment is required for determining ecological risk.

1. Duration of impact (time needed for recovery)

The time periods selected for duration of effect reflect a practical decision to use time frames that relate to periods most useful to DOE/EM.

<u>Long term</u>: Duration greater than 20 years.

<u>Intermediate term</u>: Duration that spans 5-20 years.

<u>Short term</u>: Duration that spans 2-5 years.

<u>Immediate</u>: Duration less than 2 years.

2. Impact on unique and sensitive environment

A <u>Unique</u> environment could be defined as the **ONLY** existing habitat of its type in the region.

A <u>Sensitive</u> environment is:

- An environment that is so fragile that any disruption would result in permanent damage. Ecosystems on certain shallow or fragile soils or on steep slopes are examples.
- A habitat defined as a sensitive habitat by inclusion in the EPA Sensitive Environments list.
- A locally rare habitat, i.e., where a significant percentage of habitat is located within the local site.

3. Impact on biological condition

<u>Biological Condition</u> is defined by the richness and composition of species (structure), processes within the ecosystem, and health of individuals. The examples below are meant to illustrate how the status of ecosystem structure, processes and individual health can be measured. Some of the examples may be more or less appropriate for given circumstances. Since it is impossible to provide a "cookbook" that would allow standard judgments to be made about biological condition, consultation with ecological expertise in the evaluation process is critical. Metrics to consider include (but are not limited to) the following.

Structure: (e.g.) Types of species (native vs. exotic; long-lived species present or absent)
Numbers of individuals
Native species (%)
Species composition
Species richness

Process: (e.g.) Predator / prey relationships
Age and sex structure
Primary productivity[12]
Nutrient flow / energy flow
Food web organization
Generalists vs. specialists[13]
Tolerants vs. intolerants[14]

Health of individuals: (e.g.) Presence of disease or other signs of stress.

Decrements in Biological Condition are very difficult to characterize because of the diversity of potential scenarios and severity of effects. Biological condition is a clinical evaluation of the status of biological systems with at least four distinct levels which can be commonly and easily differentiated.[15] We suggest that the following definitions of biological condition be used in the ecological risk matrix:

Level 1, Very Poor: major decline in species present; highly skewed food web organization; dominance by introduced or tolerant species; health of individuals degraded.

Level 2, Poor: significant decline in species present; shift in food web organization; increase in introduced or tolerant species; individuals show some signs of stress or disease.

Level 3, Fair: species present are somewhat below expectation; food web organization shows some alteration.

Level 4, Good to Excellent: comparable to the best situations without human disturbance; all regionally expected species are present; balanced food web organization.

4. Geographic scale of impact

Defining an environment according to the boundaries of DOE/EM sites is arbitrary from an ecological perspective, yet of practical utility from an operational perspective. While direct impact on a DOE project site is likely to always be assessed, consideration of ecological effects within a regional perspective should not be neglected. The regional environment is defined by the scenario under consideration and should include the larger area beyond the boundaries of the DOE site that may be impacted. If the stressor is airborne or waterborne, the regional environment may be, respectively, the area downwind, or the watershed. If certain species of concern are being considered, then the regional environment might be defined as the geographic area that encompasses the relevant migratory pathways of that species. Some have suggested that ecological designations such as EPA Ecological Regions may have utility, in some instances.[16]

For use within the ecological risk matrix, geographic scale of impact has been separated into four degrees of severity: wide, intermediate, small and negligible. Estimating the degree of severity (or percent affected) must be considered on a case by case basis, preferably with input from local ecologists familiar with the site, its

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[12]The amount of plant biomass created in a given area, often expressed on an annual basis.
[13]Generalists can eat just about anything while specialists have specialized diets (or breeding habitat, or some other ecological context). With disturbance and degradation from human actions, the generalists increase and the specialists often disappear.
[14]The ability of species to survive in places where human actions have altered the environment -- their tolerance of human disturbance. Bald eagles are intolerant while house sparrows are tolerant.
[15]Karr, JR 1991. *Ecological Applications* 1: 66-84. (Table 3 page 74.)
[16]JM Omernik, 1995. Ecoregions: A Spatial Framework for Environmental Management. Pp 49-62 in W.S. Davis and T.P. Simon, editors. *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making.* Lewis Publishers, Boca Raton, FL.

ecosystems, its role in the local and regional environment, and available literature. The following discussion may act as a guide to determine the severity of geographic impact.

> Wide: Significant proportion of habitat in the region affected so that it threatens that habitat's existence. (Again, the percentage will vary on a case by case basis -- for example 20-50%[17] of available habitat.)
>
> Intermediate: Significant proportion of the habitat within the site boundary affected.
>
> Small: Significant proportion of habitat within one mile of the evaluated site affected (i.e., where the project contamination is located).
>
> Negligible: Non-significant proportion of the habitat affected.

Table 1. Using the Defined Terms to Select Ecological Risk Impact Level

Impact	Recovery Time (Sensitive Habitats)	Loss of Unique Habitat	Biological Condition	Geographic Scale of Impact
Level 1	Irreversible or 20+ years	Lost	Very poor	Wide
Level 2	5-20 years	NA	Poor	Intermediate
Level 3	2-5 years	NA	Fair	Small
Level 4	less than 2 years	NA	Good	Negligible

For the sake of clarity, the elements of Table 1 are presented below in narrative format. These definitions also appear in the revised matrix format below (see Table 2 on page 18).

> **Level 1 Impact** to local or regional environment
> Long time for recovery [20+ years], OR irreversible loss of unique or sensitive environment, OR very poor biological condition, OR a wide geographic impact.
>
> **Level 2 Impact** to local or regional environment
> Intermediate time for recovery [5-20 years], OR poor biological condition, OR intermediate geographic impact.
>
> **Level 3 Impact** to the local or regional environment
> Short time of recovery [2-5 years], OR fair biological condition, OR small geographic impact.
>
> **Level 4 Impact** to the local or regional environment
> Immediate recovery [less than 2 years], AND good biological condition, AND negligible geographic impact.

[17] Given the diversity of ecological systems present at the DOE sites, it is difficult to provide a range that can be generalized across sites. Each will be unique in different situations. For example, 200 acres of sagebrush steppe destroyed at the INEL, where there are 230,000 acres of such land available, has different implications than the same amount of steppe land destroyed at Hanford, where there are many fewer acres of undisturbed steppe land. See the examples beginning on page 18 for further explanation.

Likelihood of Occurrence

Since the goal of EM projects is to prevent or minimize risk, the matrix should highlight the event that puts the agent of concern in contact with the receptor. In other words, the evaluation should focus on when the event that initiates the adverse effect occurs (so it may be prevented), not on when the adverse effect actually occurs. Thus, it is recommended that "likelihood of occurrence" be defined as the ***time at which event leading to adverse impact is expected to occur.***

We do not propose changes in the time scale for likelihood of occurrence (<1 year, 1-10 years, 11-100 years, 100+ years). At the same time, several of us are of the opinion that the time spans in the current matrix have proved to be of limited value to management. Simply put, one seeks a reasoned estimate of the time span in which an adverse occurrence may occur. From a management perspective, such information may have value if expressed in terms of immediate effect (weeks to one year), near term (one to five or possibly ten years), mid term (10 to 50 years), and long term (greater than 50 or 100 years). A greater degree of sophistication would seem to render little management value.

The FY 1998 RDS format allowed "likelihood of occurrence" to be expressed either as "numerical probability of occurrence" or "expected time to impact." CRESP peer reviews found that the data provided were very uneven. We believe a simplified approach may lead to more consistent data. For ecological risk "time to impact" is most relevant, particularly for the remediation phase of activities. It is expected that, in most instances, adverse effects as a consequence of remediation would occur contemporaneously with the activity, i.e., immediately and for some time thereafter.

Revised risk matrix

The revised matrix, which incorporates our recommendations is presented below. The H, M, L, or NB (High, Medium, Low, or Near Background designations represent a typical display of how such designations may be used in a revised framework. It is more illustrative than reflecting deeply held views. However, there a few points that do reflect a strong Working Group view.

- Level 1 designations should occur infrequently, especially for characterizing existing radiological or chemical contamination.
- The lowest damage category should not be scored in a High/Medium/Low scheme. Use of a "Near Background" designation allows one to distinguish more severe risks from those of relatively low impact and low probability. The matrix is a tool that allows discrimination; thus, we were constantly looking at ways to improve this characteristic. If Low is used to describe background levels (as was done in FY 1998), this leaves only two other choices (High or Medium), thereby reducing the user's ability to discriminate.

Table 2. Revised Risk Matrix: Ecological Risk Category

IMPACTS	**Likelihood of Occurrence** *Time at which event leading to adverse impact is expected to occur*			
	A *< 1 year*	***B*** *³ 1 year; < 10 years*	***C*** *³ 10 years < 100 years*	***D*** *³ 100 years*
Contaminant Effects on Ecological Systems				
1 Long time for recovery [20+ years], OR irreversible loss of unique or sensitive environment, OR very poor biological condition, OR a wide geographic impact	***H***	***H***	***H***	***H***
2 Intermediate time for recovery [5-20 years], OR poor biological condition, OR intermediate geographic impact.	***H***	***H***	***M***	***M***
3 Short time of recovery [2-5 years], OR fair biological condition, OR small geographic impact.	***M***	***M***	***L***	***L***
4 Immediate recovery [< 2 years], AND good biological condition, AND negligible geographic impact.	***NB***	***NB***	***NB***	***NB***
Remediation[18] Effects on Ecological Systems				
1 Long time for recovery [20+ years], OR irreversible loss of unique or sensitive environment, OR very poor biological condition, OR a wide geographic impact.	***H***	***H***	***H***	***H***
2 Intermediate time for recovery [5-20 years], OR poor biological condition, OR intermediate geographic impact.	***H***	***H***	***M***	***M***
3 Short time of recovery [2-5 years], OR fair biological condition, OR small geographic impact.	***M***	***M***	***L***	***L***
4 Immediate recovery [less than 2 years], AND good biological condition, AND negligible geographic impact.	***NB***	***NB***	***NB***	***NB***

H = High; M = Medium; L = Low, NB = Near Background

Examples

The following examples outline scenarios from which an impact level can be determined. There are two sets of examples. The first set is intended to help the reader discriminate between the different impact levels due to

[18]Remediation is defined in the broadest possible sense to include all projects undertaken by DOE/EM to address problems and “clean up” sites.

chemical or radiological contamination. The second set is intended to help the reader discriminate between the different impact levels due to *remediation effects*.

Chemical or radiological contamination effects on ecological systems

Contamination Impact Level 1

A reasonable and credible radionuclide contamination scenario that would result in Level 1 damage to the local environment would be a very uncommon event. Two non-radionuclide examples are provided.

Wetland destruction

This example illustrates several points: a) the complexity and interconnectedness of the impacts, b) local and regional effects, c) short-term and long-term effects, and d) the importance of biological effects that are not focused just on individuals or habitats.

A large unique wetland adjacent to a river is destroyed, due to direct contamination (spill of solvent or oil). This might result in direct mortality and indirect effects, i.e., loss of suitable habitat for breeding or feeding causing altered behavior, reduced growth or reproduction on resident species. Beyond the impact on the wetland itself, the contaminant is introduced to the adjacent river where it causes similar effects downstream. Increases in organic material dramatically change the nutrient levels in the river. The wetland is no longer capable of buffering the impact of flooding on the river, leading to further erosion and siltation. Downstream flooding may cause damage to natural and populated areas in the floodplain and may also affect the estuarine areas along the coast where the river enters the sea. The effects are, therefore, a **level 1 contamination impact** due to the uniqueness of the habitat and the regional scale affected.

Fire

Historical data suggest one major fire occurs at a particular site every 20 years. A fire originates from a chemical storage tank and is not contained quickly enough to prevent it from consuming unique and sensitive shrub-steppe habitat. The widespread fire burns both on and off-site. The grasses are only burned back to ground level (the root system survives), but the shrubs are killed. Weedy annual species invade, altering the species composition of the plant community which in turn affects the birds, insects and mammals that use the area. It is expected that the pre-fire assemblages of species would only be established after more than 20 years. The effects warrant a **level 1 contamination impact** due to the uniqueness of the habitat, the regional scale affected, and the long recovery time (even though the fire did not result in widespread contamination from chemical or radiological materials).

Contamination Impact Level 2

Fuel tank spill

An aging diesel fuel tank contains a sufficient volume of fuel that could result in the contamination of a local watershed if the tank were breached. While the tank itself is not located in an area containing a sensitive habitat or species, the local watershed constitutes critical habitat for birds, fish and other aquatic biota. The effect of the spill is a degradation of biological condition, i.e., the reduction of the abundance, distribution, or composition of species. Beyond the mortality of organisms caused immediately after the spill, there are indirect effects (i.e., as seen in a decrease in health of individuals, local reduction in species abundance, loss of species, or other biological effects.) Recovery is expected to take 5 to 10 years. Such contamination effects result in a **level 2 impact**.

Contamination Impact Level 3

Floodplain destruction

A persistent, bioaccumulative chemical released to a small stream is deposited locally in sediments and floodplain soils. The chemical is bioaccumulated in stream invertebrates, fish, terrestrial insects, birds, and small mammals. The chemical is expected to cause reductions in reproductive success to populations of fish-eating birds and mammals, and to animals utilizing the stream, and small reductions in numbers of fish-eating animals inhabiting the stream. Impacts to populations of other plants and animals inhabiting the stream and its floodplain are expected to be negligible. The geographic impact would be small and offsite effects to all species would be negligible. These effects are considered moderate on the local scale and minor on the eco-region scale. If the contamination were eliminated, recovery would occur within 5 years. This scenario is designated a **Level 3 contamination impact**.

Contamination Impact Level 4

Wetland Disturbance

A pond on a facility is contaminated with a mixture of various radionuclides at very low concentrations, for example, less than or equal to 20% above background levels. A high percentage of waterfowl in the flyway use this pond as a stopover during migration. No ecological effects have been identified on the populations of plants or animals using the ponds, primary production is unaffected, and individual animals and plants are healthy. However, recent drawdowns of this pond for dam repair have resulted in minor windblown contamination, reduced health of fish populations, reduced waterfowl visitation, and other localized, temporary ecological impacts. Once the repairs are completed and the pond restored to normal depth the ecosystem restoration would be rapid. The contamination of the pond currently has a **level 4 contamination impact** due to the small geographic scale and short recovery time.

Remediation effects on ecological systems

Remediation Impact Level 1

Wetland Disturbance

A pond on a facility is contaminated with a mixture of various radionuclides at very low concentrations, however it is a unique regional habitat. A high percentage of the waterfowl in the flyway use this pond as a stopover on migration. The pond is unique, since it is the only one of its kind in the area and is classified as a sensitive wetland. No direct ecological effects from the contamination have been identified on the populations of plants or animals using the pond (i.e., primary production is high, and individual animals and plants are healthy). However, regulatory concerns have necessitated draining the pond and trucking the soil to a secured landfill. The effects of this remediation will be **impact level 1** due to irreversible loss of unique and sensitive waterfowl habitat and severe effects on biological condition of the reservoir’s community, including the loss of fish, amphibian and plant populations, the cessation of waterfowl visitation, and other ecological impacts.

Wetland destruction

A wetland adjacent to a river is destroyed, due to the remediation associated with cleaning up a significant spill of solvent or oil. This might result in direct mortality and indirect effects, i.e., loss of suitable habitat for breeding or feeding causing altered behavior, reduced growth or reproduction on resident species. Remediation projects destroy some habitat and create heavy siltation of the river that reduces oxygen levels, increases temperature, and destroys habitat for benthic invertebrates, fish and aquatic plants. Increases in organic material dramatically change the nutrient levels in the river. The wetland is no longer capable of buffering the impact of flooding on the river, leading to further erosion and siltation. The scale of the effects is large and widespread, because flooding downstream may cause damage to natural and populated areas in the floodplain and may also affect the estuarine areas along the coast where the river enters the sea. The time for this aquatic system to recover would be >20 years. Thus, this scenario is rated as an **impact level 1.**

Remediation Impact Level 2

Floodplain destruction

A persistent, bioaccumulative chemical was released to a small stream, where it became deposited in sediments and floodplain soils. Remediation to reduce concentrations of the chemical in soils and sediments would require removal of topsoil from 25% of the floodplain and sediment from 10% of the stream bed. This destroys 25% of mature floodplain forest and disturbs 10% of the stream habitat and causes a degrading biological condition. During the past few decades floodplain development has occurred for agriculture, housing and industry; thus, remaining mature floodplain forest is a relatively unique habitat type on the site and within the region. This habitat will become rarer in the future due to additional development. The loss of this amount of mature floodplain forest due to proposed remediation would be considered a level 2 effect at the local and eco-region scale. Recovery will take up to 20 years. Remediation damage will be a **level 2 impact** due to the rare habitat, regional level of geographic effect and length of time for recovery.

Remediation Impact Level 3

Sagebrush steppe destruction

A small area on a facility is to be remediated due to an immobile soil contaminant that is a human health concern. Remediation projects will involve removing topsoil from the surrounding sagebrush steppe. The remediated area, along with the necessary roads and lay down areas comprises less than 1% of the available sagebrush steppe. The area will be revegetated with a native seed mixture and is expected to return to a near natural state within 3 years. The remediation effects in this case are **impact level 3**, due to the small[19] geographic scale and relatively short recovery time.

If the geographic scale described in this example were expanded to a greater percentage of the available ecosystem the remediation effects could warrant designation as *level 2* damage to the local or regional environment. For example, if the affected area was 20% of the total available sagebrush steppe the effects would warrant a level 2 impact.

Oil/fuel run off

A road is constructed to act as a route for equipment being used in a remediation activity. Part of the road runs along a stream. Due to the impervious surfaces, runoff containing oil and fuel seeps into the surrounding soil and washes into the stream. Compaction of soil along the shoulders of the road also leads to a significant increase in runoff, washing away topsoil and eroding the stream bank. Animals and birds are killed by traffic. Dust and exhaust fumes from the traffic affect the productivity and reproduction of nearby vegetation, further impacting the birds and animals that use them for food and shelter. The composition of plant species along the roadway changes and many weedy annuals become dominant. Mowing next to the road leads to increased disturbance from dust, noise, and soil compaction. Application of herbicides along the roadway for weed control leads to some contamination of the stream, affecting plants, birds, fish, animals, and invertebrates immediately downstream. Recovery time for all of these effects is ≤ 5 years. The remediation effect in this case is a **level 3 impact** due to the small geographic scale and short recovery time.

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[19] The term small always needs a context. Remediation of 200 acres would seem large by most standards but would be "small" if it was within a sagebrush steppe community measured in hundreds of thousands of acres. Such scales exist at certain DOE sites.

Remediation Impact Level 4

Cesium Plots

During the 1960's radio-ecological research activities involved the experimental contamination of 5 outdoor field plots each of 100 m^2 in an area with radioactive Cesium (Cs-137) to study the migration and effects of weapons fallout. These experimental plots contained high levels of radioactivity and trace levels had the potential for migrating off the DOE reservation. The area has potential for ecological exposures and low levels of human health risks to individuals immediately off the DOE reservation. The potential for human health risk is high if these plots are opened for public access and no institutional controls are invoked. Planned remediation involves low cost soil removal and disposal activities utilizing small equipment and existing roads and on-site waste disposal systems. The area affected by remediation will be small and is not a unique or sensitive portion of important ecological habitat, thus the remediation effect in this case is a **level 4 impact**.

Implementation

A revised ecological risk database will significantly alter current classifications.

Peer review identified that the current ecological risk data base is deficient and will need to be redone (or augmented). A revised data base, developed according to the recommendations in this document, will identify a considerable number of areas that have been misclassified as being of high ecological concern when they are of medium or even low concern at present. It is believed that using a revised data base, and a screening evaluation (see below) will conserve and focus the use of expert ecological resources.

Use a screening evaluation for ecological risk

The level of effort invested in a risk assessment should be determined by the nature and characteristics of a particular project or site (as well as off-site impacts). Adopting an approach that determines whether a project raises ecological concerns and thus warrants systematic evaluation is feasible. The following approach is suggested:

a. Perform a *Screening Evaluation* of a revised data base. Categorize as follows:

- Identify physical areas or projects that are unlikely to be of ecological concern and, therefore, require little or no further assessment. Examples of such areas include:

    1. Designated industrial zones that do not attract species of special concern, or do not provide habitat for species of interest, or do not have significant off-site effects.
    2. Designated disposal sites that do not provide habitat for species of interest, do not contain significant ecological habitats, or do not have significant off-site effects.
    3. Physical areas where ecological exposures have not occurred and will not occur, i.e., the hazard is physically contained.
    4. Physical areas where ecological exposure has occurred but contaminant concentrations are below limits of concern for ecological health effects.[20]

[20] IAEA Technical Report 332 and similar documents.

5. Physical areas where ecological exposure has occurred, the contaminant remains on-site, but the ecological impact of the site contamination is negligible ("de minimis").

- Identify physical areas where the ecological impacts are obviously high and require immediate containment and remediation of chemical or radiological material. Further characterization of ecological risk is not needed to support management prioritization.

- While a current situation may warrant no additional characterization, the ecological risk potential of actions being planned always needs to be evaluated.

b. The *Screening Evaluation* will also identify areas where additional ecological information or risk analyses could enhance decision-making. These include:

- Remediation projects whose implementation may significantly degrade ecological resources, or where remediation might have little positive effect. In some cases, remediation poses the only risk to ecosystems.
- Sites with ecological features that may be unique and/or valuable and are inadequately characterized (i.e., the overall impacts including those from other planned projects cannot be assessed for some reason).

Use an Essential Information Template

FY 1998 peer reviews identified critical deficiencies in the gathering and expression of essential risk information. Providing this level of detail for key projects is critical to the understanding of risks posed to human and ecological health, which rise from circumstances or projects at DOE sites. Recognizing the need to conserve the level of effort expended in the field to gather this information we have attempted to develop a "bare minimum" approach. The value of this approach is that it provides an efficient mechanism for the consistent evaluation of risks, and a record showing the logic and supporting documentation used to derive the risk evaluation.

What is Essential Information?

We developed strong consensus around what essential information is required for understanding ecological risks. This essential information can be readily organized under several broad categories. These categories are loosely arranged around the traditional risk assessment paradigm but are presented in a simplified format.

How can Essential Information be collected more efficiently?

An Essential Information Template can be developed to collect this information. A very rough first cut of such a template can be found below. A series of questions would be asked in a logical format to foster data collection in a systematic but not overly-burdensome manner. If the template is used in conjunction with a screening tool, information will only be collected for desired activities.

How would Essential Information be used in relation to the matrix?

Ultimately, the essential information is envisioned to be contained within a description of the "scenario" provided for each separate projects. (For example, the FY 1998 Risk Data Sheet required a "Scenario Development" field to describe the events and effects expected to occur.) This essential information would serve as the underpinning for the shorthand summary of risk expressed in the matrix -- once the information is gathered writing a "scenario" and completing a revised "data sheet" would be a far simpler exercise.

DRAFT Essential Information Template for Ecological Risk

This is an early draft version of a template that outlines the type of information required to complete the ecological risk matrix. Further work on this template is needed

Description of Stressor

- biological
- physical
- radiological
- chemical

Characterization of Ecological Effects

What are the receptors of concern?

What is (are) the response(s) of the receptor to the stressor?

- Direct effects (i.e., mortality)
- Indirect effects (i.e., sub-lethal effects such as altered growth, reproduction etc.)

Characterization of Exposure

If chemical, radiological, or biological, how much of the stressor is present?
If chemical, radiological, or biological, what are the sources of the stressor?
If chemical, radiological, or biological, what are the distributions of the stressors in the environment?
If chemical, radiological, or biological, how do the stressors reach the receptors (i.e. what are the exposure pathways)?
If physical, what are the stressors and how do they contact or co-occur with the receptors?

Geographic Scale of Ecological Effects

- Wide (significant proportion of available habitat regionally)
- Intermediate (significant proportion of available habitat on-site)
- Small (significant proportion of available habitat within 1 mile of site)
- Negligible (non-significant proportion of the available habitat)

Temporal Scale of Ecological Effects

What is the length of time that the ecological effects are expected to persist?

- Long-term (>20 years)
- Intermediate term (5-20 years)
- Short-term (2-5 years)
- Immediate (<2 years)

Loss of Habitat

Is there loss of unique habitat? (i.e., the only existing habitat in the region)
Is there loss of sensitive habitat? Sensitive habitats are defined as:

- locally rare
- so fragile that any physical disruption would result in irreversible damage
- a significant percentage of total habitat regionally
- on the EPA Sensitive Environments list

Rare, Threatened, or Endangered Species

Are there any listed species present (rare, sensitive, candidate, threatened, or endangered)?

Biological Condition

- Good to excellent: comparable to the best situations without human disturbance; all regionally expected species are present; balanced food web organization.
- Fair: species present are somewhat below expectation; food web organization shows some alteration.
- Poor: significant decline in species present; shift in food web organization; increase in introduced or tolerant species; individuals show some signs of stress or disease.
- Very poor: major decline in species present; highly skewed food web organization; dominance by introduced or tolerant species; health of individuals degraded.

Probability of Realizing Ecological Risk

- High
- Medium high
- Medium
- Medium low
- Low

Certainty level concerning risk

- very high certainty
- high certainty
- medium certainty
- low certainty
- completely unknown

Source of data

What are the sources of your information?
In general, what is the basis for information provided in this template?

- peer reviewed scientific evidence
- some scientific evidence
- consultation with expert having extensive on-site knowledge
- professional judgment[21]
- a wild guess

[21] It is important not to discount professional judgment as a valid technique and source of information. Many individuals often have substantial personal research experience in these topics that provides as much or more background of relevance than can be found in the peer reviewed literature.

4. Site Personnel Safety and Health Risks

General

Site personnel safety issues were discussed at a working meeting held October 9-11, 1996 at the School of Public Health and Community Medicine, University of Washington, Seattle. Specific attention is given to interaction with chemicals, particularly metals and organic solvents, as well as a range of radioactive materials. A number of deficiencies identified by Peer Review of the FY 1998 budget process are also addressed. These include:

- Not enough transparency -- additional details about hazard source, quantity of release, exposure type and pathway, receptors required to understand basis for evaluations.
- The range of severity of impact was found to be non-discriminatory -- too much fell into the "medium" category.
- Unclear how impact levels were influenced by the number of individuals affected (1 vs. 1000).
- Lack of distinction between radiological and chemical hazards.
- Lack of distinction between carcinogenic and non-carcinogenic health effects.
- Temporal considerations were deficient.
- Documentation of source data was deficient.

The nature of the risk and the specific type of worker affected in the *During* phase of EM projects are likely to be quite different from those at risk *Before* projects are initiated. Because of the changes in work activities, historic accident statistics of DOE workers may be of limited predictive value. The historic data should be examined to determine if different coding or sorting could broaden its predictive utility. In addition, it would be of value to assemble and distribute actuarial information relevant to typical worker practices.

As DOE/EM accelerates the actual stabilization and remediation of wastes at these sites, the surveillance and maintenance worker who has training, experience and familiarity with the hazards and physical locations in which they are contained, will be joined, or even supplanted, by workers involved in construction trades or transportation tasks. In contrast with the traditional DOE worker, the latter workers may have less sensitivity and training for the hazards and operational procedures typical of a DOE/EM site. Such problems can and should be addressed by developing worker involvement training, during which personnel are taught how to inventory their own risks.

Below, we provide broader technical definition and guidance to enhance the Environmental Management Program's ability to capture information that encompasses a wide array of worker activities. Modifications to the risk matrix, and several implementation issues are also presented.

Measures of progress

Measures of progress for public and site personnel safety and health were not specifically addressed during the Working Group Meeting. However, several of the principles put forth in the ecological section (see page 12) are applicable to site personnel safety and health.

Modifications

Retain the four impact levels in the risk matrix.

Continued use of four impact levels provides sufficient opportunity to discriminate between differing types of adverse effect. It is also consistent with the number of impact levels used to describe public health and ecological risks. The terms *catastrophic, critical, marginal, negligible* have been discarded in favor of *Impact Levels 1-4*, per the discussion found on page 7.

Define specific worker groups

The kind of worker (indicating what activities he/she performs) involved in a particular project can be useful information when attempting to understand the nature of an increased worker risk during completion of that project. Several general categories and definitions are suggested below. In addition, specifying worker types, within the general categories, could provide an additional useful level of detail.

General Categories

Incidentally exposed workers. Workers whose risk is unrelated to the work they are doing - i.e., their exposure is a function of their location. For example, if the risk to an operations worker is directly related to the operation they are performing, that would not be incidental. However if the operations workers are exposed to a hazard while commuting to work, that would be incidental.

Operations personnel. Traditional site worker whose surveillance or maintenance duties result in exposure to adverse agents or traumatic injury.

Remediation workers. Generally considered newcomers to the site, perhaps with no institutional knowledge of processes and facilities. Such workers may have greater probabilities of incidents due to unfamiliarity with the site and its processes.

Specific Worker Types

Office workers -- completing administrative duties normally seen in office settings.

Construction workers -- including all conventional construction crafts such as: labor, masonry, electrical, carpentry, sheet-rocking, roofing, plumbing , steel-working, welding, operation of heavy equipment (cranes, bulldozers, scrapers), etc.

Transportation workers-- packaging, hoisting and rigging, driving, etc.

Inspection workers -- health and safety inspectors (concern is higher when they are operating by themselves).

Surveillance & maintenance workers -- monitoring, measuring, repair work, slips, trips and falls, confined space work, high work, etc.

Security workers-- working in remote locations, susceptible to fire arms injury, traffic injuries, training injuries, heart attacks, etc.

Technicians -- including chemical, radiological, biological, laboratory. Susceptible to industrial hygiene concerns due to exposure to chemicals or radionuclides. For example, electronics technicians exposed to fumes, electrical shocks, etc.

Other categories of job types are envisioned, such as those being developed for the Environmental Jobs Task Analysis at Hanford.

Broaden the content of information within the data base

Peer review comments on the FY 1998 RDS process clearly state that the quality and the type of information needs to be enhanced. We developed a strong consensus around the type of information that should be captured and how such information could be readily organized. The information is envisioned to be contained within the *Scenario* description of the risk element.[22] This information is essential as it serves to underpin the shorthand summary of risk that is expressed in the matrix.

Most of the information terms proposed for use are readily understood by individuals within the DOE complex and the stakeholder community. These terms are:

Type of worker
Population at risk (size of the worker population directly involved and duration of activity)
Hazard type
Hazard descriptor (quantity)
Exposure pathways of primary concern
Probability of exposure
Health endpoint and severity of effect
Impact probability
Sources of information used
Other unique considerations

A summary of the information sought and what purpose it is expected to serve is presented in Table 3. The elements are loosely arranged around the traditional risk assessment paradigm but are presented in a simplified format. A process for collection of such information is discussed under the heading of Essential Information Template (page 35).

[22] Refer to Appendix C for details about the Scenario Description called for by the FY 1998 Risk Data Sheets.

Table 3. Elements and Information utility for Site Personnel Safety and Health.

Element	What are we asking?	Why are we asking it?
Type of worker	Who is involved?	Describes the receptor. There are several worker types, e.g., construction, maintenance, transportation, technician, etc.
Population at risk	How many people are involved? For how long will they be involved?	Describes the magnitude of the population involved.
Hazard type(s)	What type of agent is involved?	Describes the hazard generally, in terms such as chemical, physical, radiological, etc.
Hazard Descriptor	What specific hazard is involved? If chemical or radiological -- How much of the hazard is present?	Provides a specific descriptor of particular chemicals, radio-isotopes, traumatic injuries, etc.
Exposure Pathway	By what media will the receptor be exposed?	Identifies the pathway of exposure, such as water, air, soil/dust, etc.
Health Impact	What is the nature of the effect expected in the receptor?	Provides a general description such as injury, disability, cancer, non-cancer effect, etc.
Health Impact Severity	What is the extent of the effect expected?	Provides a measure of the severity of effect, i.e. death, total disability, partial disability, etc.
Health Impact Probability	What is the probability that the health impact will present itself in the receptor?	Identifies the expected frequency of the adverse effect.
Source of Data	What is the evaluation based on?	Conveys a degree of reliability of the estimates.
Other unique considerations	What else is important to bring to the risk discussion?	Provides a catch-all location for essential data, such as located near a school or a site of cultural or religious significance.

Likelihood of Occurrence

Since the goal of EM projects is to prevent or minimize risk, the matrix should highlight the event that puts the agent of concern in contact with the receptor. In other words, the evaluation should focus on when the event that initiates the adverse effect occurs - *so it may be prevented*, - not on when the adverse effect actually occurs. Thus, it is recommended that “likelihood of occurrence” be defined as the time at which event leading to adverse impact is expected to occur.

We do not propose changes in the time scale for likelihood of occurrence (<1 year, 1-10 years, 11-100 years, 100+ years), as there is value in having consistency with ecological and public health risk. However, there is a sentiment that four time spans, as in the FY 1998 matrix, have proven to be of limited value to management . Management only needs a reasoned estimate of the time span in which an adverse occurrence may occur. Such estimates may be adequately expressed in terms of immediate effect (weeks to one year), near term (one to five or possibly ten years), and long term (greater than ten years).

Revised Risk Matrix

The revised matrix, which incorporates the recommendations (discussed above) is presented below. The H, M, L, NB (High, Medium, Low, or Near Background) designations represent a typical display of how such designations may be used in a revised framework. It is more illustrative than reflecting deeply held views. However, there are a few points that do reflect a strong Working Group view.

- The matrix should permit the greatest degree of discrimination consistent with the quality and value of the data that underpin it. This provides value to stakeholders and management. DOE may wish to consider the use of a *Very High* designation for category 1A risks. This would permit a distinction between Category 1A and 2A *High* designations that receive equal ranks under the current RDS scheme.
- Use of a *Near Background* (NB) designation allows one to distinguish more severe risks from those of relatively low impact and low probability. No activity in the modern work place is risk free, particularly given the hazards and types of projects or activities performed in the DOE complex.

Table 4. Revised Risk Matrix: Site Personnel Safety and Health Category

	Likelihood of Occurrence *Time at which event leading to adverse impact is expected to occur*			
IMPACTS	***A*** ***< 1 year***	***B*** ***³ 1 year; < 10 years***	***C*** ***³ 10 years < 100 years***	***D*** ***³ 100 years***
Site Personnel Safety and Health				
1 Death or injuries or illnesses resulting in permanent total disability, chronic or irreversible illnesses, or extreme over-exposure	***VH***	***H***	***M***	***M***
2 Injuries or illnesses resulting in permanent partial disability or temporary total disability > 3 months, or serious overexposure	***H***	***H***	***M***	***L***
3 Injuries or illnesses resulting in hospitalization, temporary, reversible illnesses with a variable but limited period of disability of < 3 months overexposure	***M***	***M***	***L***	***L***
4 Injuries or illnesses not resulting in hospitalization, temporary reversible illnesses requiring minor supportive treatment or exposures at or below regulatory levels, or cumulative exposures above limits that have no lasting effect	***NB***	***NB***	***NB***	***NB***

VH = Very High; H = High; M = Medium; L = Low, NB = Near background.

Examples

The following examples outline scenarios from which an impact level can be determined. The first four examples seek to help the reader discriminate between the different impact levels in the site personnel safety and health category. The final example briefly shows how a scenario could be evaluated *before*, *during* and *after* projects occur. In all the examples, the barest minimum of detail has been provided so that a few key points would be expressed. Consequently, these examples DO NOT provide the complete level of detail that might be expected for a full evaluation. There is merit in developing a full-blown example (to be included in training manuals) and recommends that an example using a real situation be developed as part of guidance/training efforts. Such an example should include all relevant risk information (in order to determine impact levels and likelihood of occurrence), specific document references, full scenario description and evaluation of risks *Before*, *During* and *After* projects for all relevant risk categories.

Site Personnel Impact Level 1 - Transuranic Waste Storage

Currently high concentrations of Transuranic Waste (i.e., Pu) are being stored in 55 gal drums in Land/Sea containers awaiting shipment to WIPP (Waste Isolation Pilot Plant, a national waste repository located in New Mexico) for disposal. The heating and cooling of these drums make them susceptible to breaching from buildup of pressure. Because these drums have been classified as mixed waste, the State regulatory agency has required the DOE to move the drums from the present storage containers onto a large asphalt pad which must be constructed to individually separate them and allow weekly visible inspections. This requires that five technicians spend 8 hours a day walking around the drums to visibly inspect the labels and look for any signs of drum deterioration. Experience has documented infrequent venting of Pu aerosols which have caused high levels of contaminant to be found on the insides of the former storage containers. During the move and inspection activities, workers will be at high risk from drums accidentally being breached from handling and/or venting caused by direct exposure to solar heating and subsequent cooling. These incidents may expose the facility workers and other personnel nearby (10-100) to potentially lethal doses from inhalation of Pu. It is possible that Pu inhalation will cause death and/or permanent disability from lung cancer within 1-10 years, thus **Impact Level 1** applies.

Type of Worker	Technician
Population at risk	10-100 technicians and facility workers in general vicinity
Hazard Type/Amount	Radiation (Pu, Np, U and Cs)
Exposure Pathway	Inhalation
Hazard Descriptor	High concentrations of alpha and gamma radiation
Impact Category	Death, Severe Disabling Injury
Impact Descriptor	Pulmonary edema, exposure to high alpha doses to the lung
Impact Probability	Within 1 -10 Years
Source of data	Occurrence Reports, operating logs

Site Personnel Impact Level 2 - Construction Activity

A storage facility containing large quantities of low level waste products is in an advanced state of deterioration. A sizable chunk of concrete recently broke away from the upper wall and last week it was noted that there was a minor crack in the ceiling of this 20-foot high building. Sixteen construction workers from a local company have been contracted to assess the extent of deterioration, to repair the crack in the ceiling, and to do the necessary work to assure the soundness of the building. Site data show 31% of occupational fatalities among construction workers is due to falls. There is a concern that the unstable conditions of the worksite coupled with the workers' lack of familiarity of the site may lead to a serious injury or even death. **Impact level 2** is chosen **-** the relatively low ceiling height keeps it from being a more severe assessment.

Type of worker	Construction
Population at risk	16
Hazard Type/Amount	N/A
Exposure Pathway	N/A
Hazard Descriptor	Falls
Impact Category	Disabling injury
Impact Descriptor	Head injury, general body injury
Impact probability	Very Low (OSHA regulations to be followed)

Source of data	Previous site records, OSHA data, studies

Site Personnel Impact Level 3 - TRU Wastes

This task ensures compliance with the Defense Waste-EIS as it applies to TRU and alpha wastes. The preferred alternative in the EIS calls for collecting TRU waste retrievably stored since 1970 and processing that waste along with newly generated TRU waste. The project involves about 10,000 containers of waste that contain approximately 450 kg of Plutonium. Specifically this task will remove containers currently stored underneath dirt, repackage them, if needed, to contain any radioactive or hazardous leaks, and transport them to nearby compliant storage. The waste will then be processed and held for scheduled transport to WIPP for final disposal.

The transportation safety function is designed to mitigate transportation risks through traffic engineering and through compliance with DOT regulations. Probability for local accidents, given a short transport distance and the exclusion of general traffic in the area, is low (none expected, with a certainty of 99%). Presently in the United States, approximately 50,000 traffic fatalities and 300,000 traffic injuries occur per year. The treated waste will meet WIPP (Waste Isolation Pilot Plant) requirements, and applicable Department of Transportation regulations will also be adhered to. However, 300 shipments increases the probability of an accident. Container design and emergency response procedures will minimize these impacts.

Type of worker	Truck Driver
Population at risk	Varies with transportation Route (100-1000)
Hazard type/amount	Alpha radionuclides, three canisters per truck, 2 kg TRU/canister
Exposure Pathway	Airborne
Hazard descriptor	Transuranic waste
Impact category	Trauma (accident); exposure above limits
Impact descriptor	Injuries involving hospitalization
Source of data	Transportation Safety Statistics
Impact Probability	Within 1-10 years

Site Personnel Impact Level 4 - Min-Safe Surveillance and Maintenance

A project is defined to provide surveillance, maintenance and operations for spent nuclear fuel and contaminated equipment stored in an approved (current safety basis authorized) facility. The surveillance and maintenance function is requirements-based and provides for minimum safe operations. Specific activities include maintaining a decontamination facility in a condition ready to perform its decontamination and storage missions, (HVAC systems maintained, basic training provided, utilities assessments completed, basic management structure intact), and maintaining compliance with safety, quality, and environmental regulations required for stand-by conditions. Areas of the facility deck are used for storage and handling of radioactive waste awaiting decontamination or resulting from decontamination efforts. These are routine efforts, performed by an experienced maintenance crew. There are 20 surveillance and maintenance workers, and the facility houses approximately 100 other employees on a daily basis. There is little occupational risk in performing base safe operations of this facility. This is supported in the safety analysis published in the facility Safety Analysis Report and Interim Safety Basis. In all accident scenarios, risks to the properly protected on-site worker are low.

Type of Worker	Technician, maintenance personnel
Population at risk	5 maintenance workers; 100 workers in general vicinity
Hazard Type/Amount	Chemicals and Radiation (Spent Fuel in pools), 4MT
Exposure Pathway	Dermal, inhalation
Hazard Descriptor	Spent Nuclear Fuel
Impact Category	Death, Severe Disabling Injury
Impact Descriptor	Occupational exposures; minor injuries anticipated in a relatively static facility

Impact probability	Within a year
Source of data	SARs, Interim Safety Basis documentation

Example of *Before, During* and *After* risks associated with a specific project

This example briefly shows how a scenario could be evaluated *Before*, *During* and *After* projects occur. While not a formal part of the example, ecological or public health risks associated with this scenario would be in the level 4 or near background category.

Scenario

A former plutonium processing facility has a large number of plutonium nitrate solutions in storage in 4 liter polyethylene bottles. There are currently 200 of these 4 liter bottles stored, within glove boxes, in one building. The typical plutonium concentration in these bottles exceeds 1.5 grams/liter in a 10 M acid solution. The material condition of some of the gloveboxes is poor, and although compensatory measures and temporary repairs have been made, there is a high probability of exposure pathways from the gloveboxes into the open work areas. The gloveboxes are all located in rooms separated from other work areas of the building. This reduces the potential for exposing incidental workers in the event of an accident. The overall worker population in the building is 300 employees of which 20 workers normally occupy the glovebox storage rooms and would constitute the impacted worker population in the event of an incident.

The polyethylene bottles have a history of failure due to the radiolytic decomposition of the bottles by the plutonium. Historic event data indicates a polyethylene bottle failure can be expected to occur every 2 years in the absence of proper monitoring. Because of this trend, a surveillance program has been implemented to examine the condition of the bottles on a weekly basis. This operation normally involves one worker per glove box conducting the surveillance. The potential for bottle failure and chemical/radiological exposure of the glovebox worker, and radiological exposure of other workers in the room is considered the most credible potential hazard.

Although not directly related to the bottle storage of $PuNO_3$ solutions, other hazards in the building include: 1) storage of pyrophoric plutonium metals and scraps (in sealed cans in inverted storage areas in the building to mitigate this hazard), 2) storage of plutonium residues and salt precipitates in containers which may fail due to hydrogen generation in the corridor areas of the building, 3) storage of plutonium solutions in tanks and piping in adjacent rooms which may leak at gaskets and flanges creating a potential chemical burn and radiological concern , 4) presence of oxyacetylene cylinders in the glovebox storage rooms creating a potential flammability hazard or ignition source for fire or explosion, and 5) the building itself is not seismically qualified. A seismic event could result in breach of the building structure allowing radiological release of the stored plutonium, particularly in the event of a conflagration. Such an event would spread plutonium contamination downwind towards the adjacent population center 2 miles outside the site boundary.

Before

The occupational hazard is considered to be potential acid burns and potential radiological dose exceeding 50 rem committed effective dose equivalent (CEDE) from alpha contamination and gamma dose (due to americium-241 in growth). Probability of a bottle failure is high (every 2 years if surveillance is not maintained) with potential exposure to the chemical process worker conducting the bottle surveillance and adjacent workers in the room due to poor material condition of the gloveboxes. Thus impact level 2 applies in the *before* case.

During

A program to stabilize these plutonium nitrate solutions to a more stable solid form has been instituted. This process involves transporting the 4 liter containers in 55 gallon carbon steel drums to an adjacent building where the plutonium is precipitated as a solid, then packaged and stored in qualified containers in one consolidated storage facility. The potential occupational exposure remains for acid burns and radiological dose exceeding 50 rem CEDE. The number of workers potentially affected will increase to include the entire 300 worker population of the building, due to transportation of the liquids through the hallways of the building, and 50 process workers involved in the hydroxide precipitation work in the adjacent building. Impact level 2 applies in the *during* condition.

After

Upon completion of the liquid stabilization work the liquid and chemical acid burn hazards will have been eliminated. The radiological hazard of the material will still exist though the material will be stored in a less accessible location. Thus impact level 4 applies after the project is complete.

Type of Worker	Chemical process worker
Population at Risk	1 impact level 2, and 19 impact level 3
Hazard type/Quantity	Chemical and radiological/800L
Hazard Descriptor	Chemical acid burns, radiological dose exceeding 50 rem CEDE
Exposure Pathway	Surface contamination and exposure, inhalation
Impact category	Exposure above occupational limits, disabling injury (chemical burns)
Impact descriptor	Failed glovebox and breached 4 liter bottle of plutonium nitrate solutions causing radiological alpha and gamma dose, acid burns
Impact Probability	High (bottle failures every 2 years and glovebox failure likely)
Source of Data	Occurrence Reporting history, Plutonium Vulnerability Study, Los Alamos Technology Office Study, 1993

Implementation

Screening

The FY 1998 RDS data base could be screened to identify a limited number of projects that require no additional risk evaluation. Such screening allows the Department to focus risk expertise where it is most needed -- a clear recommendation from the CRESP peer reviews. Under selected circumstances, site personnel safety and health concerns could be assumed negligible in the *before* and *after* phases without further analysis.

Such circumstances include instances where no workers are expected to be in:

a) locations potentially impacted by hazards associated with a particular site. To avoid overlooking less obvious groups of workers, the following categories of workers should be explicitly considered before assuming a negligible risk scenario:
   - maintenance workers (including landscape maintenance)
   - security personnel
   - workers commuting to, from, or within the site

b) locations where no hazards are present other than those found in a usual office environment, i.e., the only workers involved in a scenario are carrying out routine administrative, clerical, or housekeeping functions.

Essential Information Template

CRESP peer reviews identified critical deficiencies in the gathering and expression of essential risk information. Providing this level of detail for key projects is critical to the understanding of human health risks arising from circumstances or activity at DOE sites. Recognizing the need to conserve the level of effort expended in the field to gather this information we have developed a "bare minimum" approach. We believe this approach is valuable because it provides an efficient mechanism for the consistent evaluation of risks, and a record showing the logic and supporting documentation used to derive the risk evaluation.

What is Essential Information?

Strong consensus developed around what essential information is required for understanding risks to workers. This essential information can be readily organized under several broad categories (see Table 3 on page 29).

How can Essential Information be collected more efficiently?

A template should be developed to collect this information. A series of questions would be asked in a logical format to foster data collection in a systematic but not overly-burdensome manner. If the template is used in conjunction with a screening tool, information will only be collected for desired activities. A rough draft of the template can be found below.

How would Essential Information be used in relation to the matrix?

Ultimately, the essential information is envisioned to be contained within the "Scenario" description of the risk element. This essential information would serve as the underpinning for the shorthand summary of risk expressed in the matrix -- once the information is gathered, writing a "scenario" and completing a revised risk matrix is a far simpler exercise.

DRAFT Essential Information Template for Site Personnel Risk

The following Draft Essential Information Template is intended to provide risk evaluators with the means to consistently evaluate risks associated with the hazards at DOE sites. This template is a rough draft intended to demonstrate a method by which uniformity, consistency and ease of data collection on worker safety could occur. It is a guide to prompt the collection of pertinent information on: 1) the types of hazards associated with particular work activities, 2) determining who is at risk from the hazards, 3) how an individual may be affected by the hazards and, 4) what the potential risks are.

The template could be developed in both an interactive software[23] and a written format. It would have to be written in such a way that a manager could look at it and check or circle items, or fill in blanks. A blank template would not be expected to be greater than 3 pages in length. The example shown on the following pages provides a strawperson format of what information would be asked.

Type of Worker

What general category do affected workers fall into?

- Incidentally exposed workers or general on-site workers (bystanders)
- Operations personnel
- Remediation workers

[23] Interactive software would prompt a response in each field. Tables and menus would automatically "pop up" based on the answers to specific questions. The program should be developed for a user who has a working knowledge of Windows software, and a basic understanding of risk concepts.

What specific type of work is being done (answer if Operations or Remediation worker)

- Office
- Construction
- Transportation workers
- Inspection workers
- Surveillance & maintenance workers
- Security workers
- Technicians

Population at Risk

How many people are potentially affected?

- 1-10 workers
- 11-50
- 51-100
- 101-1000
- 1000+

Hazard Type

What is(are) the hazard(s)? (Pick all that apply.)

- <u>Chemical</u>: If this is selected, a pop-up menu would offer a list of chemicals (e.g. from CAS number list) or standard groups of chemicals (such as chlorinated solvents) as well as leave an “other” category for manual input. It is suggested that a simple CAS chemical list be inserted to promote uniform references throughout the database.
- <u>Radiological</u>: If this is selected, a pop-up menu would offer a list of radiological hazards (e.g. from CAS number list) or standard groups of hazards as well as leave an “other” category for manual input.
- <u>Physical</u>: If this is selected, a pop-up menu would offer a list of physical hazard types hazards as well as leave an “other” category for manual input.

If chemical or radiological, how much (quantity and concentration) of the hazard is present?

Hazard Descriptor

Based on hazard type, menus from chemical, radiological, and/or physical hazards would come up with a selected list of potential hazards.

What is your source of information?

Exposure Pathway

By what pathway(s) could the hazard reach potential receptors?

- Airborne
- Surface water contamination
- Ground water contamination
- Soil contamination
- Other: (provide a description of the pathway)

What is the extent of exposure?

- Extreme Overexposure
- Serious Overexposure
- Slight Overexposure (20-100% of exposure limits)
- Below 20% of Limits

Exposure Probability What is the probability of the exposure scenarios described?

- ≥99%
- 95% - 98.9%

*Notes: It is also important to keep track of the cumulative exposures. In addition, many in the Working Group believe a field which allows a quantitative description of the exposure levels in the scenario would be more useful than a list of arbitrary categories. Exposure limits mean different things for different chemicals (e.g., a one month exposure to 5 times the permissible exposure for a carcinogen might be less serious than a 1 day exposure to twice the permissible limit of something acutely toxic like carbon monoxide). Thus, it might be better to simply report the expected distribution of exposures (e.g., average and per cent above some level of concern). The "seriousness" should be captured in the description of the health impact and its likelihood.

Health Impact

Note that injury resulting from trauma is separated from illness. In addition, illness should be further described; especially separating cancer from non cancer endpoints. What type of effect (illness) is expected?

- Injury
- Cancer (If yes, what kind will be expressed in next question)
- Non Cancer (If yes, what kind will be expressed in next question)

Health Impact Severity

What is the expected extent of illness or injury?

- total permanent disability or death
- permanent partial disability
- temporary total disability
- limited temporary disability

What is the duration of effect

- greater than one generation
- through 1 generation
- 2-50 years
- less than 2 years.

Health Impact Probability

Probability of Realizing Health Outcome:

- High
- Medium high
- Medium
- Medium low
- Low

Source of data

In general what is the basis for information provided in this worksheet?

- peer reviewed scientific evidence
- non-peer reviewed scientific publications
- professional judgment
- site specific exposure, injury or illness data
- DOE-specific exposure, injury or illness data

What is the source for your information? Provide full citation of all relevant materials.

5. Public Health Risk

General

The Working Group met October 9-11 at the School of Public Health & Community Medicine, University of Washington, Seattle, to consider the public safety and health category. In its FY 1998 form, this is the most complete of the three health risk categories (ecological, site personnel, public) and therefore, receives less attention given the practical limitations of time. We believe that if the recommendations, contained elsewhere in this report, for an emphasis on risk to ecology and site personnel in the *During* phase of activities is realized, then risk to the public in this period generally will not elevate. In addition, many of the technical changes in the impact levels recommended for the Site Personnel Category are also applicable to this category due to similarity of issues. Several recommendations are put forth addressing technical issues related to the matrix.

Key problems identified by the Peer Review of the FY 1998 processes

- Not enough transparency -- additional details about hazard source, quantity of release, exposure type and pathway, receptors required to understand basis for evaluations.
- The range of severity of impact was found to be non-discriminatory.
- Unclear how impact levels were influenced by the number of individuals affected (1 vs. 1000).
- Lack of distinction between radiological and chemical hazards.
- Lack of distinction between carcinogenic and non-carcinogenic health effects.
- Cumulative effects of exposure were ignored.
- Temporal considerations were deficient.
- Documentation of source data was deficient.

Modifications

Expand impact levels in risk matrix to four

The proposed matrix incorporates four levels of public health and safety impacts. Four impact levels provide sufficient opportunity to discriminate between differing types of adverse effect. It would also be consistent with the number of impact levels used to describe site personnel safety and health and ecological risks. The terms *immediate, excessive and moderate to low* have been discarded in favor of *Impact Levels 1-4,* per discussion on page 5.

Each impact level should reflect consideration of four components

The Working Group recommends that each of the public safety and health impact levels be defined in terms of four elements. Three of these terms are similar to those used in the site personnel category. One term, *number of individuals impacted*, is proposed for formal inclusion in public health risk definition. Comments on each of the four components follow and also summarized in tabular fashion (Table 5).

Injury and illness

The recommended levels of injury and illnesses include:

- Permanent, irreversible effects such as permanent total disability or chronic diseases. Death is included in this category.

- Permanent partial disability or temporary total disability with a duration greater than 1 year.
- Temporary, reversible impacts. All disabilities greater than 3 months but less than 1 year.
- Partial or temporary reversible impacts.

Number of individuals impacted

We recommend the matrix include a broad structure by which numbers of individuals impacted can be described. However, there was great debate among us as to what the distribution of individuals should be across the four impact categories. The numbers proposed span orders of magnitude. While it can be debated that exposing one individual to a hazard should be treated the same as exposing 100 (i.e., both are unacceptable), this approach is not practical for the purposes of managing risks and ensuring limited resources are directed at mitigating the greatest and most relevant risks. Therefore, the following guidelines are suggested when considering the population at risk:

Level 1 impact category could affect a population size of over 1000 people.
Level 2 impact category could affect a population size of 100-1000 people.
Level 3 impact category could affect a population size of 10-100 people.
Level 4 impact category could affect a population size of 1-10 people.

Although there is general agreement that the larger the potentially impacted population, the more catastrophic the potential impact, we feel that even one potential human life lost is a very serious and significant health impact. Thus, we use size of potential human populations impacted to *support* evaluation of the impact level (i.e., not as part of the official matrix definition), and we recommend that clear language be issued in DOE guidance so as not to exclude significance of effects on small populations.

Duration of adverse effect

An example of an approach to capture duration of effect for the four impact levels is to define them in the following way:

Level 1 would include health impacts that extend to more than 1 generation.
Level 2 impacts that extend through 1 generation.
Level 3 impacts that extend from two years up to 50 years.
Level 4 impacts that would be less than 2 years.

Extent of exposure

This concept should be defined using four levels of severity: extreme overexposure, overexposure, exposures exceeding acceptable environmental limits by only a small margin, and exposures at or below regulatory limits.

- *Extreme overexposure* would result in cancer risk greater than two orders of magnitude greater than those typically defined for drinking water or ambient air. Acceptable environmental exposure levels for non cancer health effects (such as birth defects, reproductive effects) would be greatly exceeded as evidenced by margin of exposure (MOE) values less than 1.[24]
- *Overexposure* would result in cancer risks an order of magnitude higher than those typically defined for drinking water or air. Acceptable environmental exposure levels for non carcinogenic impacts would be exceeded as evidenced by a margin of exposure value of about 1-10.

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[24]Hazard Quotient values could also be cited. However, an uncertainty analysis of the calculated hazard quotient should be performed before automatically assuming a hazard quotient much greater than 1.0 warrants consideration as a level 1 public health impact.

- *Exposure limit exceedences* are exposures that occasionally exceed drinking water or ambient air standards or whose margin of exposure values are between 10 and 100 or which result in lifetime cancer risks that are greater than 1 excess cancer per 10,000 exposed individuals but less then 1 excess cancer per 1,000 individuals exposed. Affected populations would be relatively small (10-100 potentially impacted individuals).
- *Exposures at or below regulatory limits.* Here incremental exposures for radiation are at or below regulatory levels.

These recommendations promote consistency and allow for all factors to be included in the matrix. Ultimately, reducing information to shorthand, as is characteristic of risk matrices, forces analysts to place complex population factors into boxes that fail to capture all the risk elements. In evaluating a scenario, a trade-off between a more severe impact affecting a small population and a less severe impact affecting a large population may have to be considered. Reasoned judgment and stakeholder values play a key role in making such determinations. Table 5 was developed as an aid to help determine the appropriate impact level given a particular scenario. It is not our intention to provide a “cookbook approach” with this table, thus many of the terms in the table are qualitative.

Table 5. Terms used in Public Safety and Health Category

Impact Level	Injury and Illness	Number of affected individuals	Duration of potential health impacts	Exposure
1	Permanent, irreversible effects such as permanent total disability or chronic diseases.	Very large (1000+)	> 1 generation.	Extreme exposure. MOEs around 1.0 for non-carcinogens or, 100 fold higher than water or air standards for carcinogens.
2	Permanent partial disability or temporary total disability of greater than 1 year.	Large (100+)	through 1 generation	Overexposure. MOEs around 10 for non-carcinogens or, 10 fold higher than water or air standards for carcinogens
3	Temporary, reversible impacts. Disability may be total but of <3 months duration.	Between 10-100	2-50 years	Modest exposure limit exceedences. MOEs less than 100 for non carcinogens or small exposure limit exceedences of water or air standards for carcinogens.
4	Partial or temperate reversible impacts.	Between 1-10	less than 2 years.	Exposures at or below regulatory levels.

Likelihood of Occurrence

The comments provided in the Section on site personnel are also relevant to this Section (see page 29.)

Revised Risk Matrix

The revised matrix, which incorporates our recommendations, is presented below. The H, M, L, NB (High, Medium, Low, and Near Background) designations represent a typical display of how such designations may be used in a revised framework. It is more illustrative than reflecting deeply held views. However, there are a few points that do reflect a strong Working Group view.

- Level 1 designations should occur infrequently, especially for characterizing existing radiological or chemical contamination.
- The lowest damage category should not be scored in a High/Medium/Low scheme. Use of a "Near Background" designation allows one to distinguish more severe risks from those of relatively low impact and low probability. The more focused H/M/L/NB designation permits greater discrimination as to the nature and severity of public health impacts that should be of management and stakeholder interest.
- The impact categories also contain a time element. For public safety considerations, factors such as recovery time from an exposure determine the level of risk. Therefore, personnel recovery time is needed as an impact element to assist the decision maker in determining these impacts.
- Public health impacts, even those deemed minor (e.g., exposures below limits, affecting very few people, etc.) are of major concern to the DOE.

Table 6. Revised Risk Matrix: Public Safety and Health Category

	Likelihood of Occurrence *Time at which event leading to adverse impact is expected to occur*			
IMPACTS	***A*** ***< 1 year***	***B*** ***³ 1 year; < 10 years***	***C*** ***³ 10 years < 100 years***	***D*** ***³ 100 years***
Public Safety and Health				
1 Death or injuries/illnesses involving permanent, irreversible effects such as permanent total disability or chronic diseases. Extreme overexposures.	***H***	***H***	***M***	***M***
2 Injuries/illnesses involving permanent partial disability or temporary total disability of greater than 3 months. Over exposures.	***H***	***M***	***M***	***L***
3 Injuries/illness that result in temporary, reversible impacts. Disability may be total but of <3 months duration. Small overexposures.	***M***	***L***	***L***	***L***
4 Injuries/illness that result in partial or temporary reversible impacts. Exposure at or below regulatory limits.	***L***	***NB***	***NB***	***NB***

H = High; M = Medium; L = Low; NB= Near Background

Examples

The following examples outline scenarios from which an impact level can be determined. These examples seek to help the reader discriminate between the different impact levels in the public safety and health category. Only the barest minimum of detail has been provided so that a few key points would be expressed. Consequently, these examples DO NOT provide the complete level of detail that might be expected for a full evaluation. There is merit in developing a full-blown example (to be included in training manuals) and we recommend that an example using a real situation be developed as part of guidance/training efforts. Such an example should include all relevant risk information (in order to determine impact levels and likelihood of occurrence), specific document references, full scenario description and evaluation of risks *Before*, *During* and *After* projects for all relevant risk categories.

Public Health Impact Level 1

Spent Nuclear Fuel is being moved from its current storage basin location to dry cask storage. During movement and placement into the multi-canister-overpack (MCO) cask, hydrogen gas can be produced. Additionally, hydrides of uranium have formed on some of the fuel. At normal pressure and ambient temperatures, these hydrides can spontaneously combust or burn if ignited. The casks are engineered to avoid these problems. It can be postulated (though there is a very low probability), hydrogen gas could leak and be ignited. The resulting fire would breach the canister storage building with a radioactive plume drifting off-site to the south (prevailing winds). This is a **level 1 impact**. Acute lethal radiation effects and subsequent leukemias can be postulated from the off-site radiation release.

Type of worker Operational technician

Population at risk	>100 general rural and suburban public
Hazard type/amount	Radiation and respirable particulates
Hazard descriptor	Mixed nuclides
Exposure Pathway	Respiratory, gastrointestinal and dermal
Impact Category	Acute lethal radiation effects, subsequent leukemias
Impact Descriptor	Off-site radiation release violating Dept. Health air regulations
Impact probability	Very Low
Source of Data	Spent Nuclear Fuel EIS, additional engineering specifications. on MCOs, NRC BIER V Report.

Public Health Impact Level 2

Based on fire history for the past 50-100 years, a major fire can be expected approximately every 20 years in the desert steppe which surrounds the Hanford facility. In addition to the natural ignitions from lightening, human activities on the site are a source for fires. Under ideal fire conditions, a dry grass and sage fire could spread quickly through more vegetated parts of the site. Range fires such as this could easily move beyond the site boundary and endanger public health and property, particularly where Richland encroaches on the site to the south. The public health impact is the immediate threat through burns, though there is a potential for a long-term impact of radionuclide uptake through smoke inhalation. This is a **level 2 impact** due to the low level of known contamination, and the postulated dispersal patterns of the smoke plumes.

Type of Worker	General Site population
Population at risk	General rural and suburban public (>100)
Hazard type/amount	Burns and asphyxiation
Hazard descriptor	Same
Exposure Pathway	Radiation of heat (dermal), particulates and gases (respiratory)
Impact Category	Partial temporary disability
Impact Descriptor	Range fire spreading off site
Impact probability	1 in 20 years
Source of Data	Hanford Site Environmental Report 1995, CRESP Ecological Hazard ID

Public Health Impact Level 3

High levels of radionuclides and nitrates have been observed in groundwater samples at a facility. If used in drinking water, these concentrations of radionuclides would produce an annual effective dose equivalent of 100 mrem/year. Nitrate concentrations are present at levels 10,000 times applicable groundwater standards. Pump and treat remediation has been implemented, and consistently levels of contaminant have been observed in the process effluent for several years. This is a **Public Health Impact Level 3 -** the radionuclides and nitrate concentrations are significantly diminished in ground water at the site boundary. In general, they are at or below applicable standards at the point of human contact.

Type of Worker	General Site population
Population at risk	General rural and suburban public (100-1000)
Hazard type/amount	Radionuclides and nitrates/various concentrations exceeding standards
Hazard descriptor	Same
Exposure Pathway	Groundwater, though pathway not established
Impact Category	Partial disability of short duration
Impact Descriptor	Short term, reversible illness due to nitrates
Impact probability	Very low (>100 years)
Source of Data	Site Environmental Report, 1995

Implementation

Screening criteria and an Essential Information Template should be used to improve the implementation of the technical recommendations made in regards to the revised matrix. Since the Site Personnel Safety and Health Category is a subset of the Public Safety and Health category, essentially the same screening criteria and core information template can be used. Please refer to section 4 (page 34) for details.

Probability

Quantitative risk assessments can provide useful information for evaluating potential human and ecological hazards. Quantitative estimates can be developed for cancer and non-cancer risks resulting from exposure to either chemical or radiation hazards. However, each of these hazard or risk categories have different methods for calculating and presenting information; each method also provides results that have different levels of certainty. This situation is a barrier to those who seek to evaluate health effects from chemical and radiological agents in a meaningful and consistent manner. Further, either by tradition or policy, the "tolerated" numerical estimates of risk commonly are different for occupational as compared to public populations; "tolerated" estimates are also different depending on whether the agent is radioactive on non-radioactive.

Cancer as an endpoint

Quantitative evaluations of potential cancer risks from chemical exposures are usually presented as upper bound estimates of the probability of getting cancer after lifetime exposure at a given level. Estimates of cancer risks from radiation exposures are usually based on target organ dose and frequently incorporate dosimetry information. This contrasts to the chemical based risk evaluations where minimal kinetic and no dynamic information is used.

Using these estimation procedures, acceptable ("tolerated") levels of chemical exposure that may cause cancer have been defined by federal agencies. For example, USEPA dietary risk levels for the public, from a pesticide residue in food, are typically in the range of 10^{-6}. This same agency often defines acceptable occupational exposure levels to pesticides as being allowable in the range of 10^{-3}-10^{-4}. Acceptable occupational exposure risk for radiation exposure can range up to 10^{-2} or even 10^{-1} lifetime cancer risk (Upton, 1996). Risk levels of 10^{-4} or greater can be present at current acceptable public radiation exposure limits. These examples demonstrate that the margin between regulatory limits for public versus occupational risk for chemicals is a difference of approximately 100 whereas for radiation standards, the margins are lower and range from 20-50 fold (Upton, 1996). Such radiation limits represent total radiation exposure while chemical risk levels represent individual chemical risks.

We sought ways to incorporate such information into the matrix. One approach discussed was to define extreme overexposure (Public Health level 1) as upper bound estimates of 10^{-2} or greater for cancer risks. Overexposure (Public Health level 2) defined at 10^{-2} to 10^{-4}, etc. We were unable to reach consensus on this point. Several other groups such as the International Atomic Energy Association have been working on similar broad bands of risk categories.

Noncarcinogenic endpoints

Quantitative risk information for chemicals is usually given as reference doses (RfDs). These doses are used by federal agencies, for example USEPA, to represent acceptable exposure levels for humans. RfDs are calculated in two ways. One method uses a No Observable Adverse Effect Level (NOAEL) based on animal or human studies and combines this with an uncertainty factor to account for extrapolation of results from animal to human species, average to sensitive human populations, inadequacies in experimental design, or pharmacokinetic or dynamic information. RfDs can also be set using defined risk levels such as ED_{10} (where the exposure that results in a 10 percent response rate in the adverse endpoint is taken and divided by uncertainty factors to obtain an RfD).

RfD values also pose a challenge to incorporate into a risk matrix. Frequently, RfD values are compared with actual environmental exposure levels and a margin of exposure can be calculated. Because the potency of chemicals varies with dose, simple paradigms that bin to different categories based on exceeding the margin of exposure values by 10 or 100 fold are problematic for defining level 1 versus level 2, etc. For example, for chemicals that have a shallow dose response relationship, exceeding the margin of exposure by 10 fold might have health impacts but may only increase the frequency of effects by 5%. In contrast, for many agents with very steep dose response relationships, exceeding the margin of exposure by just 2 or 3 fold could result in 100% of the population being affected.

In some evaluation approaches, the size of the potentially impacted population is multiplied by the estimated potential risk (probability estimate) to identify total numbers of potentially impacted people. We also discussed this information as it related to various levels of health impact. Although there is general agreement that the larger the potentially impacted population, the more catastrophic the potential impact, we feel that even one potential human life lost is a serious health impact. Thus, we recommend the development of clearer language so as not to exclude considering the social significance of effects on small populations.

We continue to wrestle with these issues and feel that an additional work is needed to better clarify these issues in future iterations of the data gathering process. In particular, additional input from stakeholders and Tribal Nations on these impact levels and how probability information will be used effectively is needed.

6. References

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Appendix A Working Group Meeting Participants

Working Meeting to Improve the Qualitative Evaluation of Ecological Impacts at DOE Environmental Management Sites

October 3-4 1996
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Appendix B Inventory of Recommendations

Inventory of Recommendations for Improving the MEP and MEM Requiring Technical Development

Recommendation	Aspect of MEM Affected[25]	Source[26]	Rank[27]
1. Establish a stable and consistent baseline against which risk reductions are scored and that properly values permanent risk reduction.	A	2, p. 30 3, p. 1	
2. Provide sufficient detail to follow the logic in the evaluation (completeness of information; transparency of the process; what is the task? what is the nature of the risks? what is the basis for assigning the risk designation?)	A	1, p. 2	
3. Specify: hazard source, quantity of release, exposure type, exposure pathways, receptors	PS, SP, EN	1, p. 35	
4. Develop more discriminating range of severity of impacts, e.g., Expand the matrix scoring to include a negligible risk category for situations when the risks are equal to or indistinguishable from background (see good examples on PP 51-52 of Tier 2 report)	PS, SP, EN	1, p. 5, 51, 82; 3, p. 1	
5. Develop H/M/L binning (not just severity of impacts) so they are more discriminating	A	3, p. 1	
6. Define lowest severity of impact	A	1, p. 83 3, p. 1	
7. Use same number of severity of impact levels for each category	A	1, p. 83	
8. Provide the means to assess and specify the extent of impacts, e.g., to individual vs. large population	G, A	1, p. 5, 23, 34	
9. Incorporate non-cancer endpoints into impacts	G, A	1, p. 23 2. p. 11	
10. Improve consistency and lucidity of likelihood estimates	G, A	1, p. 34	

[25] Indicates when there are implications for Guidance (marked G); Software (marked S) and the specific categories of Risk Data Sheets (A-all categories; SD-summary description; PS-Public Safety; SP-Site Personnel; EN-Environmental Health; SO-Social; CU-Cultural; EC-Economic).
[26] Refers to source of the recommendation: see references below.
[27] Provided to allow sorting for ranking the recommendations in an order to be addressed.

Recommendation	Aspect of MEM Affected[25]	Source[26]	Rank[27]
11. Develop the evaluation of impacts to site personnel to be comprehensive, i.e., to include the ability to assess risks from cumulative exposures as well as acute risks from accidents	SP	1, p. 5, 52	
12. Provide temporal aspects of activities: length of time for the activity, time (season) of its occurrence, time for expected impacts, and life cycle information on the receptors of interest	PS, SP, EN	1, p. 36	
13. Scale back time lines to a more near term scale (100 years too far to be meaningful)	A	3, p. 1	
14. Increase the clarity and consistency with which "minimum-safe" and essential, site-wide programs are defined across the complex	G	2, p. 11	
15. Develop 2 tiered ranking system with an overall rating for the larger project/activity and a specific rating for the component	G, A	1, p. 51 2, p. 17	
16. Replace the existing activity-oriented scoring system on cross-site comparisons of projects with an objective-oriented scoring system	A	2, p. 11	
17. "Show your work." Develop worksheets to prompt evaluators to display the steps in the evaluation	A	1, p. 2, 23	
18. Address technology alternatives	A	1, p. 82 2, p. 12	
19. Consider how the MEM and MEP will be utilized in the 10-year plan	A	2, p. 12, 36	
20. Assess uncertainties (provide the means for effectively expressing the confidence level in the "occurrence" of in impact)	A	1, p. 5, 36, 82	
21. Focus the scoring system on cross-site comparisons of projects that are at the budget margin within any given site	A	2, p. 11	
22. Rework the evaluation of environmental impacts to address ecological issues. Examine the use of a screening or phasing approach	EN	1, p. 4, 42	
23. Develop the means and guidance to consider how best to treat the risks related to contaminated ground water and the vadose zone and the need for remediation	EN	1, p. 6, 52	
24. Include information on sensitive species	EN	1, p. 35	
25. Improve the quality, consistency, and documentation of the information and criteria used in the evaluation and prioritization process	A	2, p. 11	
26. Provide more precise geographic locations (more info than "state" in many cases)	A	1, p. 48, 82	

Recommendation	Aspect of MEM Affected[25]	Source[26]	Rank[27]
27. Involve stakeholders	A	2, p. 11 4, p. 11 5, p.	

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Appendix C

Summary of the RDS process and Risk Matrix

This appendix provides a description of Risk Data Sheets and the Risk Matrix, how these tools evolved within the budget development process, and what peer review activities have been performed. The final section reiterates the purpose of the working meetings.

What was a Risk Data Sheet?[28]

EM managers need information tools to help them ensure that an appropriate set of activities is funded in a given year and to help them explain the budget to Congress and the public. EM has been developing these tools since the program began in 1989. One of the key tools used in the Fiscal Year (FY) 1998 Budget Development Process was the Risk Data Sheet (RDS). The RDS was first introduced in 1995 as means to respond to a Congressional mandate to describe risks across the DOE complex. The data collected were partially used in developing the FY 1997 budget. Based on this experience the RDS format was modified and incorporated into the process to prepare the FY 1998 budget request.[29] See further details on the historical development of RDSs below.

The FY 1998 RDSs were standardized forms completed by project managers in the field that described a unique set of related activities. The RDSs were designed to be used as tools for evaluating activities and providing input to the prioritization and sequencing of projects. One RDS, for example, may discuss activities associated with surveillance and maintenance of a waste storage facility, while another RDS may address remediation of a contaminated site or stabilization of nuclear materials in a given building. In the FY 98 process, 1,408 RDSs were submitted on April 15 by DOE's various field offices to explain the basis for the FY 1998 budget request for EM activities. All FY 1998 RDSs were combined into a single Fox-Pro database called the FY 1998 EMMP (Environmental Management Management Plan) Software. This is a public database that will be available in local reading rooms in support of the FY 1998 Presidential Budget.

Each RDS includes a summary description of the activities, evaluation scenarios, budget needs, and a risk evaluation using seven factors. The seven evaluation factors used to assess risk in this process were public safety and health, site personnel safety and health, environmental impact, compliance, mission impact, mortgage reduction, and social, cultural, and economic impacts. The activities characterized by an RDS are evaluated for each of these factors where appropriate, giving decision makers an indication of whether the RDS covers activities having High, Medium, or Low risk for each factor. This evaluation is presented in the Management Evaluation Matrix (MEM), a table within each RDS. Thus, the RDSs are designed to provide a linkage between budget and the risk of the activity.

What was DOE/EM’s “risk matrix”?

The Management Evaluation Matrix (MEM) is a component of each Risk Data Sheet (RDS). The MEM is used to assess the relative risk of current conditions (*before* the activities are performed or initiated), the risk of performing that activity (*during* activity), and the relative risk expected to remain after the activities are completed (*after* activity). An example of the FY 1998 MEM appears at the end of this appendix.

The MEM was intended to provide the structure for examining both severity of effect and likelihood of occurrence for seven different categories:

- Public Safety and Health
- Site Personnel Safety and Health
- Environmental Protection
- Compliance
- Mission Impact
- Cost-Effectiveness/Mortgage Reduction

[28]The text in this and the following section has been adapted from EM’s FY 1998 Budget Guidance, Attachment 3, Management Evaluation Matrix Instructions.

[29]The nature of the Congressional Budget Process requires that budgets be prepared well in advance. DOE traditionally submits budgets to OMB on September 1 for the following fiscal year. In preparation an Internal Review of Budget (IRB) is held yearly in May to review requests from the field. In other words, the FY 1998 Budget was reviewed at the May, 1996 IRB.

- Mission Impact
- Social/Cultural/Economic Impacts

The term Management Evaluation Matrix was used in the FY 1998 process. As described above, several factors, including health risks, were included in the matrix. The Working Group Meetings focused only on the health risk elements, and therefore used the term risk matrix to describe a matrix incorporating severity of impact with likelihood of occurrence.

To complete the matrix during the FY 1998 process, Field offices were instructed to evaluate severity and likelihood of a reasonable and credible scenario for each activity. Likelihood levels were uniform throughout the matrix: very high, high, medium or low. These qualitative terms were defined by the following table.

Likelihood	Very High	High	Medium	Low
Numerical Probability of Occurrence	1 per year	≥ 0.1 per year < 1 per year	≥ 0.01 per year < 0.1 per year	<0.01 per year
Expected Time to Impact	≤ 1 year	> 1 year ≤ 10 years	> 10 years ≤ 100 years	> 100 years

In addition, each category contained between two and four levels of severity. Definitions of each level and examples were provided in the instructions but will not be reviewed in detail here. An example of the FY 1998 Management Evaluation Matrix is located at the end of this Appendix.

Once the levels of severity and likelihood were determined, each activity was given a value of High Medium or Low in each of the seven categories where, appropriate. The more likely a condition to manifest itself (cause harm), and the more severe the impact of that event, the higher the risk.

For each of the seven Management Evaluation Matrix impact category, the evaluators were instructed to do the following:

1. Characterize and evaluate the risks that exist *before* a planned activity occurs, or that would exist if a current activity were to cease.
2. Characterize and evaluate the "inherent" risks that occur *during* the performance of the activity.
3. Characterize and evaluate the risks that would remain *after* successful completion of the activity. The difference between the *before* and *after* evaluations represents a qualitative estimate of the risk reduction associated with the activity.
4. Perform an internal and external review to ensure consistent and correct application of the Management Evaluation Matrix

How did the risk matrix evolve?

The concept of using a matrix to capture risk information relevant to the Environmental Management Program was developed by DOE/EM for the mandated report to Congress, *Risks and the Risk Debate: Searching for Common Ground. "The First Step"* (Draft), presented in June 1995. The RDS process and the matrix evolved from the Environmental Safety and Health Management Plan developed for the Office of Environment Safety and Health to capture risks to site personnel. The Risk Report's matrix not only captured occupational risk, but also risks to the public and the environment and considered compliance, mission impact, and cost effectiveness. Risk information collected from the field in the early months of 1995 was used to inform managers making budget decisions during the Program's Internal Review of Budget in May of that year.

Peer review of Risk Data Sheets and the budget process

In 1995 the Environmental Management Advisory Board (EMAB) recognized technical flaws in the FY 1997 RDS process and matrix, but endorsed its general purpose and objectives. Further, EMAB recommended that EM officially link risk information to the budget development process. Throughout Winter 1995-96, the Risk Data Sheet (RDS) process and the matrix were used to collect information for all activities funded through the EM program. Data were collected from the EM Site Operations offices electronically throughout the Spring of 1996, again with the intention of using risk to inform decision making during the May Internal Review of Budget.

CRESP led two independent peer reviews of EM's FY 1998 Budget Development Process recommended by the EMAB. The first was an independent review of the quality, completeness and utility of data submitted by the DOE/EM field offices. A National

Review Panel of experts was convened to review Risk Data Sheets and provide a report within two-weeks of the field submittal.[30] The second CRESP peer review was a much broader evaluation of the entire risk-informed decision and priority setting process. Both reviews noted the Department's efforts favorably, but found deficiencies and made recommendations for improvements.

In addition, an Inter-site Review Meeting of the Field Management Evaluation Process and Risk Data Sheets was held on June 18, 1996 in Denver. The purpose of this meeting was to gather field representatives to evaluate the strengths and weaknesses of the process used to generate the information used to support the FY 1998 Budget development process.

Purpose of the October working meetings

Recommendations emerging from the CRESP peer review activities and the June Denver meeting prompted CRESP to initiate a mechanism to improve the characterization and scoring of the matrix elements. With endorsement from Al Alm, DOE Assistant Secretary for Environmental Management, two working meetings were conducted by CRESP in early October, 1996 to address these issues. The purpose of these meetings was to address and resolve as many issues as possible in a time frame that would allow Assistant Secretary Alm to use the RDS and MEM during the FY 1999 Budget Development Process. For this effort, only three factors of the MEM were considered: Public Safety and Health Risk, Site Personnel Safety and Health Risk, and Ecological Risk (Environmental Protection). Scientists expert in each of the three areas of risk and individuals experienced in DOE management processes or site activities, met and responded to the earlier peer review recommendations, using their own knowledge of RDSs and of risk. A list of participants is located in Appendix A. Recommendations located in the main body of this report were developed during the two October working meetings.

[30]CRESP, 1996a.

Management Evaluation Matrix (MEM)
Sheet 1 of 2

LIKELIHOOD OF OCCURRENCE

IMPACTS		***A*** VERY HIGH	***B*** HIGH	***C*** MED-IUM	***D*** LOW
CATEGORY: PUBLIC SAFETY & HEALTH					
PS1.	***Immediate or eventual loss of life/permanent disability***	**H**	**H**	**M**	**M**
PS2.	***Excessive exposure and/or injury***	**H**	**M**	**M**	**L**
PS3.	***Moderate to low-level exposure***	**M**	**M**	**L**	**L**
CATEGORY: SITE PERSONNEL SAFETY & HEALTH					
SP1.	***Catastrophic - Injuries/illnesses involving permanent total disability, chronic or irreversible illnesses, extreme overexposure, or death***	**H**	**H**	**M**	**M**
SP2.	***Critical - Injuries/illnesses resulting in permanent partial disability or temporary total disability > 3 months, or serious overexposure***	**H**	**M**	**M**	**L**
SP3.	***Marginal - Injuries/illnesses resulting in hospitalization, temporary, reversible illnesses with a variable but limited period of disability of < 3 months, slight overexposure, or exposure near limits (20-100%)***	**M**	**M**	**L**	**L**
SP4.	***Negligible - Injuries/illnesses not resulting in hospitalization, temporary reversible illnesses requiring minor supportive treatment, or exposures below 20% of limits***	**M**	**L**	**L**	**L**
CATEGORY: ENVIRONMENTAL PROTECTION					
EN1.	***Catastrophic damage to the environment (widespread and long-term or irreversible effects)***	**H**	**H**	**M**	**M**
EN2.	***Significant damage to the environment (widespread and short-term effects, or localized and long-term or irreversible effects)***	**H**	**M**	**M**	**L**
EN3.	***Minor to moderate damage to the environment (localized and short-term effects)***	**M**	**M**	**L**	**L**

IMPACTS		***A***	***B***	***C***	***D***
		VERY HIGH	***HIGH***	***MED-IUM***	***LOW***
CATEGORY: COMPLIANCE					
CO1.	***Major noncompliance with Federal, state, or local laws; Enforcement Actions; or Compliance Agreements significant to ES&H and involving significant potential fines or penalties***	***H***	***H***	***M***	***M***
CO2.	***Major noncompliance with Executive Orders; DOE Orders; or Secretary of Energy Directives (Notices or Guidance Memoranda) significant to ES&H and not involving significant potential fines and penalties***	***H***	***M***	***M***	***L***
CO3.	***Marginal noncompliance with Federal, State, Local Laws; Enforcement Actions; Compliance Agreements; Executive Orders; DOE Orders; or Secretary of Energy Directives significant to ES&H***	***M***	***M***	***L***	***L***
CO4.	***Significant deviation from good management practices***	***M***	***L***	***L***	***L***
CATEGORY: MISSION IMPACT					
MI1.	***Serious negative impact on ability to accomplish major program mission***	***H***	***H***	***M***	***M***
MI2.	***Moderate negative impact on ability to accomplish major program mission***	***H***	***M***	***M***	***L***
CATEGORY: MORTGAGE REDUCTION					
MR1.	***Significant avoidable cost (today's dollars) due to degraded infrastructure, inefficient management systems or program implementation, accident-related capital loss, or operational expense (annual cost > 1% of annual site EM budget or > $5M)***	***H***	***H***	***M***	***M***
MR2.	***Moderate avoidable cost (today's dollars) due to degraded infrastructure, inefficient management systems or program implementation, accident-related capital loss, or operational expense (annual cost .1-1% of annual site EM budget or $1-5M)***	***H***	***M***	***M***	***L***
CATEGORY: SOCIAL/CULTURAL/ECONOMIC					
SO1.	***Significant adverse: Damage so severe to a social, economic, or cultural value, e.g., a Tribal burial ground, that no mitigation is possible, i.e., the value would be irrevocably lost.***	***H***	***H***	***M***	***M***
SO2.	***Moderate adverse: Damage the social/cultural/economic value. Mitigation may be possible, but would involve a considerable investment of time and money.***	***H***	***M***	***M***	***L***

Appendix D Letters of Intent

September 9, 1996	John A. Moore, CRESP to Alvin L. Alm, Assistant Secretary for Environmental Management.
September 19, 1996	Alvin L. Alm, Assistant Secretary for Environmental Management to John A. Moore, CRESP.
November 22, 1996	John A. Moore, CRESP to Alvin L. Alm, Assistant Secretary for Environmental Management