An Information Template for Evaluating the Relative Priority of Remediation Projects that Pose a Risk to Receptors - 18674

Joanna Burger*, **, David Kosson***, Chuck Powers** and Michael Gochfeld**,**

*Division of Life Sciences, Rutgers University, Piscataway, NJ 08854-8082
**Consortium for Risk Evaluation with Stakeholder Participation (CRESP, Vanderbilt University, Nashville, TN 37235)
***Civil and Environmental Engineering, Vanderbilt University, Nashville, TN 37235-1831,
****Environmental and Occupational Medicine, RWJ Medical School, Rutgers University, Piscataway, NJ 08854-8082.

ABSTRACT

The U.S. Department of Energy (DOE) has one of the largest remediation tasks in the world, in terms of the number of sites, the complexity of individual sites, the number of remediation projects at individual sites, and the full range of stakeholders involved. The question of how to decide what projects to initiate, at any point of time and how to prioritize the deployment of resources for these tasks, occurs both within and among sites. The Consortium for Risk Evaluation developed a Risk-informed Prioritization Framework for Oak Ridge Reservation. Our goal was to develop a risk-informed methodology for prioritizing remediation projects for the Department of Energy’s Oak Ridge Reservation that can be adapted to other remediation projects elsewhere. The heart of the framework is a template that includes information about each site necessary to make prioritization decisions. The information in the template describes the environment (hazard, pathway, consequences), the receptors (workers, public, ecological) and the risk management considerations (cost, risk reduction effectiveness, capacity, efficiency and sequencing). The questions in the template provide a wide range of information that managers and regulators need to make decisions, and that Tribes and the public need to evaluate the efficacy of remediation decisions. Completing the template will also help identify data gaps, model parameters needed, and the agencies or individuals responsible for obtaining the information. The information presented in the Template will be useful for regulators (DOE, Environmental Protection Agency, states, Tribes), managers and workers at the sites, trustees of natural resources, site neighbors, and the general public, but more importantly, provides an example of information needed to rate the priority of remediation projects. DOE, other federal and state trustees, and regulators were included in all phases of the development, including the scope, overseeing its development, and evaluation of projects.

INTRODUCTION

The U.S. and the World are faced with large remediation tasks that require considerable management, planning, funds, expertise, and personnel, and have the potential to reduce risks to people, species, ecosystems, and cultural places. Cleanups of complex contaminated sites to address environmental regulatory standards, often cost billions of dollars, leave large scarred footprints on the landscape, take decades or longer, and may leave a legacy of institutional controls limiting future land uses [1, 2]. Evaluating risk, and managing risk are sometimes separate processes that are conducted in isolation from one another, and from a range of stakeholders. However, to be effective, environmental managers need to integrate risk assessments with other considerations in determining which sites to remediate, to what extent, when and in what order, and how to choose from a range of remedial actions. It is essential to consider whether the benefits of remediation at any time outweigh the costs [3, 4]. Further, managers need to make evidence-based, data-driven decisions that also take into account the values, concerns, and legal considerations of a range of stakeholders.
Thus the task for managers, and their regulators, is to determine what needs remediation, and when. Often the knowledge needed to make decisions is incomplete, with high complexity [5]. And the information, particularly details on the “inventory” to be remediated, is often scattered or disorganized.

The Department of Energy (DOE) has the largest remediation task in the world [6-8]. Given the large land-holdings of the DOE, the large nuclear and chemical stockpile remaining from the Cold War, and the potential current and future risk to humans and the environment. All possible methods of compiling the necessary information to make sound, risk and cost-based decisions that protect humans and the environment should be considered [7, 9, 10]. The process for sequencing decisions should evolve as new information becomes available, and should be accompanied by effective communication. Narrative descriptions, information templates, conceptual models, and mathematical models are used to inform public policy-makers, regulators, decision-makers and the public, and can be used for environmental management [11-14].

An essential question facing managers and regulators is what information is necessary to make sound environmental remediation decisions [15]. Following closely is how to present the information so that it is useful, accessible, and accurate. Information sources, whether narratives or models, must balance the complexity of remediation projects, with risk considerations to receptors (human and ecological), and the need to present information so that the complexity does not lead to losing the essential messages or conclusions. Although the information needs may be different for scientists, engineers, modelers, risk-assessors and managers, regulators, and public stakeholders [4, 15], a uniform comprehensive template, extracting information from reports, narratives, communications, tables, should meet the needs of all, clarifying and facilitating decision-making.

Having developed remediation options for a given site, or for very large sites, managers (in consultation with regulators and other stakeholders), need to decide on priorities since it is not possible to conduct all remediation projects at a given site simultaneously [16]. For example, the initiation of some projects may requires the prior completion of nearby remediation projects, or may be dependent upon equipment, transportation containers, and interim or final disposition sites, among other factors. All remediation management decisions require sufficient information, including what to remediate, when to remediate, how to remediate, and who will do it.

This paper presents a template for information necessary for managers and regulators to develop priorities among remediation projects and to facilitate communication to stakeholders, maintaining transparency insofar as possible. The template was developed by the Consortium for Risk Evaluation (CRESP) for use at Oak Ridge Reservation [17]. CRESP is a DOE-funded multidisciplinary, multi-university organization to advance cost-effective risk-based cleanup of the Nation’s nuclear production facilities and legacy waste sites, and cost-effective risk-based management of potential future nuclear sites and waste. CRESP seeks to improve the scientific and technical basis for environmental management decisions with technical, engineering, scientific, and policy experts from 10 universities.

The Template is a significant part of the overall Risk-informed Prioritization Framework developed by CRESP for Oak Ridge [18]. An important first step of the framework is problem definition, and project definition (Fig. 1). These may not be the same thing, as a problem may have several different discrete projects, of different immediacies, risks, and costs, among other factors.
Fig. 1. Overview of the Risk-informed Prioritization Framework developed by CRESP. The Template (the subject of this paper) is an important phase because it provides the information, data, models and other documentation for decision-making.

At some DOE sites there has been confusion about how decisions are made, particularly about the level of cleanup required and prioritization of projects. The relevant parties include DOE, the US Environmental Protection Agency (EPA), and state agencies. DOE is both a regulator and a trustee, EPA has regulatory authority over people and media (CERCLA, RCRA, Clean Air Act, Clean Water Act), and state agencies are responsible for state laws and regulations. They all participate in the Tri-Party Agreements for the Department of Energy facilities, with annual and 5-year milestones. The CRESP project aimed to examine current prioritization methods at Oak Ridge, and provide suggestions that might aid decision-makers [17].

METHODS

The CRESP overall approach to prioritization was to assess: 1) information from the refereed and gray literature on risk evaluation, remediation management, prioritization methods, and specific information about Oak Ridge prioritization procedures, 2) discuss strengths and weaknesses of the Oak Ridge process, and 3) hold interdisciplinary meetings to discuss the information required to make prioritization decisions (including a rating scale). These resulted in agreement on the information fields that would be necessary and/or useful to support the decision process. These fields comprised the template, which went through several iterations. Our protocol included a review of all the available information on prioritization and
development of a general model for risk-informed prioritization that included both risk evaluation and risk management sections. Upon completion the template contained information essential for ratings and prioritization that supported a matrix for risk-informed priority rating that would be easily understood by a range of stakeholders. All of these phases involved meetings of the CRESP team, and meetings of the CRESP team with the engaged parties and DOE personnel.

The template discussed here was a basis for CRESP’s development of a Framework and methodology that was informed by the team’s combined risk assessment and risk management experiences and expertise (engineering, chemistry, human health, ecology) and has been applied to on a range of DOE sites nationwide. The authors each have over 25 years of experience working with DOE headquarters (Washington, DC) and the major DOE sites.

**TEMPLATE FOR EVALUATION**

Many factors must be considered within a conceptual framework that requires information on the source, pathways, risk to receptors, cost, workforce capacity, and other management considerations for a particular project. Our approach included two parts: risk evaluation and risk management. Risk evaluation includes hazards, pathways, barriers to impacts, and effects for receptors, while risk management includes capacity, effectiveness, sequencing, and risk reduction for projects. The template, the document that includes all information for making decisions includes: identification (usually by number), project description (including history, inventory, current status), risk ratings, and references and documentation. The documentation is extremely important because it provides the basis for the final ratings, and allows transparency in decision-making for a range of stakeholders.

**Project Identification and Risk Ratings**

The first part of the template identifies the project, its location, status, and provides a summary of the risk ratings. However, the risk ratings are not completed until all other section are completed. This part of the template is shown in Table 1 below.

Table 1. Information required for identification of the project and a final summary of the risk ratings for receptors. Questions 1-4 are answered initially, when the prioritization is beginning.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall- Very High, High, Medium or Low Hazard- Very High, High, Medium or Low; Pathways- Very High, High, Medium or Low; Consequences- Very High, High, Medium or Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>Risk Reduction Effectiveness</td>
<td>Capacity</td>
<td>Efficiency &amp; Sequencing</td>
<td>Overall Risk Mgmt Rating</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project Summary, Risk, and Information for Risk Rating for Receptors

Before any ratings can be completed, data needs to be gathered that describes the project, the sources of contaminants, quantity of contaminants, pathways, possible blocks, and receptors. This phase of the evaluation requires collaboration among scientists and managers in many different disciplines. Some of the information may be available from historic documents and reports, from contractors, and from scientists in the EPA or state agencies, as well as the refereed literature. Institutional memory can be important. Current and retired employees, may fill information gaps with information regarding processes, products, wastes, locations, and other information (for example, about unmarked burial places for drums). The template evolves as new information is added. Some fields may be designated as not applicable, incomplete, or lacking. This section requires substantial research, and may identify information that is requires additional field investigation.

Table 2. Project summary and risk ratings for receptors is a key component of the evaluation template. This part of the template asks questions about the contaminants, sources, pathways, barriers and risks to receptors. These parts and questions begin with 7 because these parts should be re-assembled at the end to form one document for managers, regulators and other stakeholders.

Project Summary

7. Current state and risk overview - Provide brief summary (i.e., 1-2 paragraphs).
8. Mitigation strategy – Provide brief summary (i.e., 1-2 paragraphs).
9. Mapping/GIS linkages – Provide citation or linkage to relevant map(s) and/or geospatial information.

Risk Rating Evaluation

10. Risk Prioritization: General Model – The risk prioritization model includes evaluations of hazards, pathways and consequences based on answering risk prioritization questions with the responses evaluated and integrated to result in a risk categorization of either very high, high, medium or low. Hazards, pathways and consequences are defined as follows:
   a. Hazards - hazard identification and characterization, whereby the type (e.g., special nuclear materials, wastes, contaminated facilities or soils/ground water/surface water/sediments/biota containing radionuclides or chemicals), amount, and intrinsic dangerous or detrimental characteristics (e.g., radiation, ingestion/inhalation toxicity, fire or explosion potential) of the primary risk source are evaluated.
   b. Pathways – where potential pathways or routes to human and ecosystem exposure and natural resource degradation (e.g., contamination of soil, water, sensitive ecosystems) and barriers or blocks (engineered and natural) are evaluated. Current barriers to human and ecosystem exposure and natural resource degradation are identified and described in terms of their effectiveness and likelihood to maintain partial or full integrity over specific time intervals. Identified barriers may include natural systems (e.g., slow environmental transport, sequestration or contaminant decay), engineered systems (e.g., waste forms, vaults, capture and treatment systems), and institutional controls (e.g., warnings, surveillance, entry restrictions).
   c. Consequences – where current and potential future human (workers and public) and ecosystem exposures or injuries and degradation of natural resources are considered. Exposures, natural resource degradation and ecosystem impacts are significant when they exceed regulatory requirements or guidance as used in environmental restoration decision making.
11. Risk Rating Evaluation Narrative
This should provide a brief summary of the basis/rationale for the risk ratings in the subsequent sections and address specific aspects of the Hazard(s), Pathway(s) and Consequence(s) applicable to the project.

The overall justification for the evaluation of the risk posed is summarized as follows:

Hazard(s) –
Pathway(s) –
Consequences -

12. Responses to Risk Evaluation Questions
A short answer and appropriate citations should be provided in the response for each question that follows.

Hazard
1. What are the primary constituents of concern (e.g., identify specific isotopes and/or chemicals)?
2. What is the approximate quantity present of each of the primary constituents of concern (e.g., decade quantification of curies or kg; unknown, 10, 100, 1000, etc.)?
3. What is the primary media in which the primary constituents of concern are present? (stored in durable containers, stored in leaking or vulnerable containers, in building piping and materials, debris in buildings, debris in glove boxes, debris in hot cells, soils, sediments, groundwater, landfill)?
4. What is the approximate quantity of the primary media in which the primary constituents of concern are present (cubic meters)?

Consequences
1. Who are the primary people at risk (in-facility workers, on-site workers, off-site inhabitants)?
2. What are the approximate numbers of people in each population indicated above?
3. Are any of the primary people at risk currently being exposed to the primary constituents of concern?
4. What are the primary ecological receptors at risk?
5. Which environmental resources are currently contaminated above regulatory thresholds as a direct part of the project (soil, groundwater, sediment, biota)?
6. What are the approximate quantities of the environmental resources currently contaminated (cubic meters or acres or waterway kilometers)?
7. Which environmental resources are at risk if the project is not completed or other risk mitigation measures are not taken (soil, groundwater, sediment, biota, or endangered species)?
8. What are the approximate quantities of each environmental resource at risk if the project is not completed or other risk mitigation measures are not taken (cubic meters or acres)?

Pathways and Barriers
1. What are the primary current barriers to human exposure or environmental dispersal of the primary constituents of concern (engineered containment systems (describe – containers, glove boxes, hot cells, tanks, engineered waste forms, lined landfill), building or process structures, transport through environmental media (soil, vadose zone, groundwater, atmospheric dispersal))?
2. What is the integrity of the primary barriers (failed/leaking, likely to fail within 5 years, likely to fail within 10-20 years, Likely to fail in >20 years; failure indicates loss of containment)?
3. What are the secondary barriers to human exposure or environmental dispersal? (describe the containers, glove boxes, hot cells, tanks, engineered waste forms, lined landfill), building or process structures, transport through environmental media (soil, vadose zone, groundwater, atmospheric dispersal).
4. What is the integrity of the secondary barriers (unknown, failed/leaking, likely to fail within 5 years, likely to fail within 10-20 years, Likely to fail in >20 years; failure indicates loss of containment)?

5. What is the estimated time from time of failure of the primary barriers to human exposure (immediate, <1 year, 1-5 years, 5-10 years, >10 years)?

6. What is the estimated time from time of failure of the primary barriers to further environmental degradation (immediate, <1 year, 1-5 years, 5-10 years, >10 years)?

7. What is the estimated rate of increasing amounts of contaminated environmental resources if primary barriers fail (unknown, <20% per year, 20-50% per year, 50-100% per year, >100% per year)?

---

Risk Management Information and Ratings

The final phase of the evaluation template is examining risk management, a phase often ignored by people interested only in ecological or human health and well-being. Evaluating risk management is an integral part of making decisions about either specific remediation projects or prioritization among remediation projects. While this information is extremely important, it is less often documented. This section includes remediation options, feasibility, costs, predicted consequences, both for risk reduction and possible unintended consequences. Information needs for this phase is presented below (Table 3).

Table 3. Information and models required for risk management evaluations. The questions start with number 13, so that this can be added to the final template.

13. Risk Management Evaluation:
   General Model – In addition to assessing and binning the level of risk posed by the situation for which a project has been developed, the associated risk prioritization model includes a two-step process for incorporating risk management factors into the overall prioritization analysis. Evaluation of risk management factors is only completed for the highest risk categories, and this focus allows the risk management evaluation to be carried out at the level of specific project elements (i.e., project sub-components that are discrete risk reduction implementation steps). The first risk management evaluation step evaluates the risk reduction effectiveness of the mitigation option(s) selected to reduce the human health and environmental risks posed by the problem the overall project is addressing.
   Individual project elements are evaluated and ranked very high, high, medium or low for risk reduction effectiveness. For some projects, the mitigation options are 1) interim risk mitigation measures; and/or 2) not yet finally selected; and/or 3) competing or complementary approaches to achieving long-term risk reduction. Hence, the ability to make “risk effectiveness judgments” will, for some projects, by definition be incomplete and or uncertain.

   The second risk management step involves qualifying the overall risk management judgment by assessing the factors that will shape the timeline and efficiency for implementation. Among the factors that will be taken into account at this step are capacity factors (work force availability, disposition path availability), and efficiency factors (project sequencing requirements for work completion, project cost, mortgage reduction, and the cost of delay).
   This should provide a brief summary of the basis/rationale for the risk ratings in the subsequent
   sections and address specific aspects of Risk Reduction Effectiveness, Capacity and Efficiency for
   each project element.

15. Responses to Risk Management Rating Questions
   A short answer and appropriate citations should be provided in the response for each question that
   follows.

   Risk Reduction Effectiveness
   1. What are the primary project subcomponents (e.g., characterization, debris removal, demolition,
      source removal, remedial design, remediation process construction, monitoring)?
   2. What is the anticipated impact and risk reduction effectiveness of each of the proposed project
      elements?

   Capacity and Efficiency
   3. What are the programmatic drivers for project completion (worker safety, mitigate contamination
      of environmental resources, make land or facilities available for alternate uses, reduction in
      maintenance and surveillance costs)?
   4. What is the approximate on-going maintenance and surveillance cost of the project until
      remediation/mitigation is initiated (e.g., security, maintenance, etc.)?
   5. What is the estimated complete project cost and what is the cost basis?
   6. What is the estimated time for project completion?
   7. How will project delay increase execution and completion complexity?
   8. How will project delay increase cost (percent cost increase per 5 years of delay)?
   9. What are the approximate costs for each of the primary project subcomponents?
   10. How much time will be required to complete each of the primary project subcomponents?
   11. Which project subcomponents must be carried out sequentially vs. in parallel? (provide work
       flow diagram if project elements are linked)

16. Risk Management Ratings
   The risk management rating for each of the project elements is provided below:

References and Documentation

A final part of the evaluation template includes references and supporting documentation. This section is
extremely important because it allows managers, regulators and the public to find the sources of
information, to find additional information, and to build confidence in the evaluations. An integral
objective of CRESP’s project was to produce a template that would provide the public with enough
information to make their own judgment about a project. Further, it ensures that all parties, whether
scientists, regulators or other stakeholders have access to the same presentation, information, and
documentation. It also allows for a description of the concepts or data that are missing – allowing for a
data gap analysis. It is predicated on the assumption (and also experience) that risk communication and
transparency, enhances “buy-in” by stakeholders, including regulators, and facilitates moving forward to
closure.
DISCUSSION

The template we initially developed was meant to be used as a prioritization tool. However, it could also be used as an initial decision tool to describe a proposed remediation project, compare the risks to receptors among a range of different remediation projects, compare risks among receptors (e.g., workers vs co-located workers or the public), evaluate the cost of delaying a project, or evaluate past remediation projects [19]. It is usually the case that there is competition among projects or sites for funds, personnel, equipment and disposition pathways and sites, among others. Having a method of comparing among remediation projects can be useful. Assembling information, data, conceptual models, and analytical models about specific problems or remediation projects not only informs decision-making, but is useful for the full range of Tribes and stakeholders (workers, natural resource trustees, resource managers, conservationists, public health personnel, safety personnel, and neighbors of the site, among others). Further, documentation in the template supports the data, and allows everyone to find additional information about the issue.

An additional benefit of the template is that it provides documentation and the rationale for decisions. At a later point, anyone can go back and review the information used to make a decision, as well as examining the consistency among decisions. It will allow managers and regulators to assure consistency and transparency among decisions at one site, or among different sites. Since the DOE is such a large complex, there is a unique opportunity to evaluate whether the same circumstances (and risks) exist, the same decision would be made.

Although the template was developed for Oak Ridge, it can be used at other DOE sites, as well as other cleanup sites. It could also be modified for use at these sites, as well as for any site destined for some ecological modification. There is, however, value in keeping most of the elements because it will allow comparisons among types of remediation projects, and different sites.

ACKNOWLEDGMENTS

Many people and agencies contributed to our thinking, and we thank them now: DOE personnel and contractors at Oak Ridge and other sites, the officials responsible for implementing the Federal Facilities Agreement at Oak Ridge (OR), including the Tennessee Department of Environmental Conservation (TDEC), U.S. Department of Environmental Protection (EPA), and the U.S. Department of Energy (DOE-EM). We also thank: David Adler (DOE-OR), Susan Cange (DOE), Arthur Collins, Jeff Crane and Carl Freude (EPA), Mark Gilbertson, John Eschenbergh and Jay Rhoderick (DOE-EM), and Chuck Head, Shari Meghreblian, John Owsley, Roger Petrie, and Paul Sloan (TDEC). The authors acknowledge other members of the CRESP team, especially Kevin Brown, Jim Clarke, Steve Krahn, Hank Mayer, Lisa Bliss, who contributed markedly in numerous ways, and C Jeitner for technical aid during preparation of the ms. This report was supported by the US DOE under Cooperative Agreement number DE-FC01-06EW07053. The opinions, findings, conclusions or recommendations are entirely those of the authors, and do not represent those of funding agency or respective universities involved.
REFERENCES
