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What's Inside the Black Box? – Explaining Performance Assessment to Stakeholders - 9173

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ABSTRACT

The performance assessment (PA) process is being applied to support an increasing variety of waste management decisions that involve the whole spectrum of stakeholders. As with many technical tools, the PA process can be seen as a black box, which can be difficult to understand when implemented. Recognizing the increasing use of PA and the concerns about difficulties with understanding, the Savannah River Site Citizens Advisory Board (CAB) made a recommendation that the U.S. Department of Energy (DOE) provide a Public Educational Forum on PAs.

The DOE-Headquarters Environmental Management (DOE-EM) Office of Compliance and the DOE-Savannah River (DOE-SR) responded to this recommendation by supporting the Savannah River National Laboratory (SRNL) in developing several presentation modules that can be used to describe different aspects of the PA process. For the Public Educational Forum, the PA modules were combined with presentations on DOE perspectives, historical modeling efforts at the Savannah River Site, and review perspectives from the U.S. Nuclear Regulatory Commission (NRC). The overall goals are to help the public understand how PAs are implemented and the rigor that is applied, and to provide insight into the use of PAs for waste management decision-making.

INTRODUCTION

The first step in building understanding of the PA process is to help people realize that PAs are not simply a modeling exercise to calculate a dose. PAs are actually a process used to demonstrate sufficient understanding of the disposal system in order to make informed decisions about disposal. In this respect, PAs are more like a puzzle, where the goal is to be able to identify the aspects of the problem that have the most impact on overall performance and to demonstrate an understanding of the key features of the disposal system that control performance (e.g., cover, engineered barriers, containers, etc.).

It is also important to place the role of PAs in perspective with all of the inputs that contribute to a decision. PAs are only one part of a full package of information that is typically required. The full package can include information on operating procedures, waste acceptance criteria, monitoring plans, closure plans, facility design documentation, PA maintenance activities, etc. This full package of information is sometimes referred to as a Safety Case in the international community. Providing a more comprehensive view helps to reinforce the rigor that is involved in waste management decision making.

OBJECTIVES OF THE EDUCATIONAL FORUM

As stated above, the overall goals were to help the participants gain an understanding of how the PA process is implemented and an appreciation for the rigor applied to PAs, and to learn how PAs are used to help with waste management decision making. Within these broader goals, four key objectives were identified for the detailed PA presentations in the Educational Forum:

1) Introduce the thought process used to conduct performance assessments (i.e., PA is more than just running models),
2) Encourage the participants to gain an appreciation of the role of the source term and how it drives the complexity of the PA process,
3) Develop an understanding of how the iterative, graded approach is used to focus efforts on the areas of greatest importance, and
4) Help to build an understanding of how different features of the system (e.g., covers, engineered barriers, waste forms) influence releases and migration of radionuclides.

STRUCTURE

The Savannah River Site Public Educational Forum on PAs was conducted on July 30, 2008. The forum lasted a full day and involved several presentations, discussion sessions and exercises (see Table I). Attendees for the Educational Forum included members of the general public, CAB Members, and representatives from South Carolina Department of Health and Environmental Control and the U.S. Environmental Protection Agency. The audience was encouraged to ask questions during the presentations and the discussions and exercises were successfully used to encourage participation.

The group was very interested in asking questions and participating in open discussions. Thus during lunch, plans for the afternoon were modified to shorten the formal presentations and to allow more time for discussion and questions. Each participant had been provided a binder with all of the presentation materials and the exercises, which could serve as reference material for further reading after the forum. It was clear that the audience was gaining significant benefit from asking questions and participating in open discussion.

The first presentation was provided by Martin Letourneau, Chair of the DOE-EM Low-Level Waste Disposal Facility Federal Review Group. The presentation highlighted the DOE regulatory structure, authorities, and the process for review and approval of PAs. The presentation emphasized the depth and breadth of the reviews that are conducted within the DOE system and the documentation that is necessary to receive a Disposal Authorization.

The second presentation on PA history at the Savannah River Site was provided by Elmer Wilhite of Savannah River National Laboratory. The presentation highlighted the evolution of disposal practices, reviews and the different PAs that had been conducted at the Savannah River Site and placed them in context of other significant events related to waste management in the United States.

TABLE I. Agenda for Educational Forum

Topic	Speaker
Welcome and Introduction	Howard Pope, DOE-SR
Performance Assessment Regulatory Framework and Reviews – DOE-HQ	Martin Letourneau, DOE-EM Office of Compliance
Performance Assessment History at the Savannah River Site	Elmer Wilhite, Savannah River National Laboratory
Overview of Performance Assessment & Exercise 1	Roger Seitz, Savannah River National Laboratory
Performance Assessment Process & Exercise 2	
Environmental Modeling & Exercise 3	
Nuclear Regulatory Commission Performance Assessment Perspectives	David Brown, U. S. Nuclear Regulatory Commission
Close-Out	Sherri Ross & Howard Pope, DOE-SR

The introductory presentations were followed by three detailed presentations that illustrated how PAs are conducted. These presentations were provided by Roger Seitz of Savannah River National Laboratory. Exercises were included between the presentations to highlight specific concepts. The emphasis of the detailed presentations was on illustrating the thought process used for PAs, and to portray the PA process as being similar to solving a puzzle where you are trying to identify aspects of the disposal system that control performance and demonstrate your understanding of the system's expected behavior. The detailed presentations comprised a large number of slides more extensive than could be covered in a one day forum. The intent was to develop a large number of slides that could be used as a resource from which to select a more limited set of slides for a focused presentation depending on the interests and backgrounds of the participants.

The first set of detailed presentation materials was used to introduce fundamental concepts and provide an international perspective regarding PAs, which are called "safety" assessments in the international community (e.g., [1]). The relatively strict nature of the dose standards was illustrated in the context of background radiation and other standards (see Table II). This is important to provide perspective regarding the level of protection expected. The importance of persistence, mobility, toxicity and location of the facility were introduced in the context of determining the type of disposal approaches to be used for wastes with different radionuclides. These concepts were also used to emphasize the importance of the source term (i.e., radionuclides in waste to be managed, the form of the waste and mechanisms controlling the rate of radionuclide release from the waste form) and how the source term often defines the complexity of the PA that is required.

The second detailed presentation included an illustration of the process for conducting a PA and identified important considerations throughout the process. The emphasis of the process presentation was on helping to appropriately plan for what will be involved in the implementation of a PA. It became clear from the discussions that there was less interest in the

TABLE II. Perspective on Dose Objectives Using Examples

Dose (mSv/yr)	Description
0.01	International Exemption/Clearance Standard [2]
0.04	EPA Drinking Water Standard (40 CFR Part 141)
0.05	*Estimated Dose for One Transcontinental Round Trip Flight* [3]
0.1	Air Standard (NESHAPS) (40 CFR Part 61)
0.15	EPA Radiation Standard (40 CFR Part 191)
0.25	**NRC and DOE Disposal Standard (e.g., DOE Order 435.1)**
1	All Sources Dose Standard (DOE Order 5400.5, [2])
3.6	*United States Average Public Dose All Sources* [3]
10	International Generic Reference Level for Intervention for Remediation [4]
50	Occupational Dose Standard (e.g., [2], 10 CFR Part 20)
100	International Mandatory Level for Remediation in Most Cases [4]
1,000*	*Dose Leading to 4.3-7.2% Chance of Fatal Cancer* [5]

* This is an acute dose in mSv, not mSv/yr.
Note: Doses referenced above are examples for purposes of comparison and may be expressed using different dose terminology in the references (e.g., effective dose, organ-specific dose, etc.).

details regarding the PA process in the context of the forum, so much of the material on process was not formally presented. The participants were encouraged to read through the materials if they were interested. Shortening this presentation provided additional opportunity for questions and discussions on topics of greater interest for the group.

The third detailed presentation was a description of concepts important to modeling fate and transport of radionuclides in the environment. Examples of different levels of modeling were provided from screening models to detailed process-specific models. Equations were provided for a number of different processes and parameters and the presentation materials include some examples of simplified calculations. The actual presentation was an abbreviated version of the full presentation. Several of the detailed equations and calculations were removed and not presented. The participants were encouraged to look through the printed copy of the presentation materials for more details. The discussions demonstrated some interest in the equations, including one person that did not understand all the mathematics, but enjoyed seeing some of the more straightforward equations described.

After the detailed presentations, the NRC provided a presentation to describe their role in PA reviews and their review process. Examples of review procedures were provided with some elaboration of types of information considered in a review. The NRC monitoring role relative to DOE PAs for residual high-level waste being managed as LLW was also described.

KEY MESSAGES

In the course of the presentations there were several key messages that were reinforced to help meet the goals of the Educational Forum and to foster a better understanding of the PA process. The first message was to emphasize the extensive record of successful use of PAs in the United States and globally. Examples were used from other countries to illustrate how the process has been applied. Examples of guidance from National [6] and International organizations were also discussed to demonstrate that external recommendations are being recognized.

The concept of a graded and iterative approach to PAs was introduced and reinforced throughout the detailed presentations. These ideas provide perspective regarding the thought process that is followed for conducting a PA. The concept of a graded approach highlights the intent to use appropriate levels of resources depending on the difficulty of the problem to be solved. The iterative approach highlights the desire to continually try to focus the process on elements of the problem that are most important relative to the decision to be made. Highlighting the graded and iterative approach can also be used to condition the audience to expect multiple iterations and to help them place early results in proper perspective (e.g., screening results are intended to be conservative). It is also helpful to highlight PA as a learning process, which helps to explain why an iterative approach is used.

The role of the source term as a driver for the PA process was also emphasized in the context of a graded and iterative approach. The persistence, toxicity, mobility and location in respect of the waste form was also used to illustrate how the PA process is used to justify the choice of barriers or features that can be used to demonstrate the safety of disposal. For example, from the perspective of persistence, relatively short-lived radionuclides can be effectively managed using physical barriers (e.g., concrete vaults or special containers) designed to maintain integrity while the radionuclides decay. Half-lives were also used to illustrate that long-lived radionuclides may comprise a small fraction of the initial inventory, but can be the most significant contributor to dose in the longer term. From the perspective of mobility, a table showing differences in distribution coefficients, K_d (ml/g), for a variety of soils and different cementitious environments was provided to illustrate how different materials can act as “chemical” barriers with different effects depending on the radionuclide and the material (see Fig. 1). There is more discussion of the table in the following Section.

APPROACHES FOR EXPLANATIONS

Several different approaches were used to illustrate some key concepts related to the PA decision process. Two approaches are discussed in this Section: use of equations to illustrate how different parameters affect the results and use of exercises for first-hand experience regarding the thought process.

Engineered covers are a typical type of physical barrier and grout is often used as a fill material for disposal of radioactive waste. An equation that can be used to calculate a release rate from a source term was used to illustrate how covers and chemistry impact the predicted releases. The simplified equation [7, 8] to calculate a release rate is:

	Oxidizing Cement K_d			Reducing Cement K_d			Soil K_d	
	Young	Middle	Old	Young	Middle	Old	Sandy	Clayey
H	0	0	0	0	0	0	0	0
C	20	10	0	20	10	0	0	0
Ni	1,000	1,000	500	1,000	1,000	500	7	30
Co	4,000	4,000	1,000	5,000	5,000	1,000	7	30
Tc	0.8	0.8	0.5	5,000	5,000	5,000	0.1	0.2
Cs	2	20	10	0	2	10	50	250
Np	1,600	1,600	250	3,000	3,000	300	0.6	35
Pu	5,000	5,000	500	5,000	5,000	500	270	5,900

Fig. 1. Example Slide from Exercise Illustrating "Chemical" Barrier Concepts (Units are mL/g).

$$\lambda_L = \frac{I}{R_d \cdot H \cdot n} \qquad \text{(Eq. 1)}$$

where:
λ_L = leaching constant (yr^{-1})
I = infiltration rate (m/yr)
R_d = retardation coefficient (dimensionless),
H = thickness of waste (m)
n = porosity (dimensionless), also can substitute moisture content, θ (dimensionless).

This simplified equation was used to illustrate that, as expected, decreasing the flow through the cover decreases the release rate, and increasing the distribution coefficient (and retardation coefficient) reduces the release rate. It was commented that this illustration helped to provide some meaning to the mathematics that are involved and how the parameters influence the result.

One of the exercises provided to the participants used the table in Fig. 1. The participants were asked to identify what types of materials would have the most benefit for isolating specific elements. The intent was to illustrate how PAs are used to make decisions about facility or waste form design. From Fig. 1, using the assumption that performance improves for higher values of the distribution coefficient, it can be seen that in the case of Cs, soils are more effective. For Pu, the use of clayey soil provides a significant benefit. However, for C, cementitious materials provide improved isolation. The difference between oxidizing and reducing cementitious materials is highlighted for Tc, where the use of reducing cementitious materials provides a significant benefit over other materials.

LESSON LEARNED AND CONCLUSIONS

Several lessons were learned during the Educational Forum. It became apparent early in the day that the participants were ready to ask a lot of questions and wanted to have active discussions. This resulted in trimming a number of slides from the prepared presentations. This was easily accomplished and, although some slides were not presented, the participants had all of the materials in binders that were provided. In that respect, it was worthwhile to produce a large collection of presentation materials that served as references. A subset of those materials can be selected for presentations based on the interests of the audience. It is important to maintain flexibility, even on the day of the forum, in order to best meet the needs of a specific audience.

There was less interest in the detailed PA process slides in terms of the presentations. Thus, slides from that presentation were the primary focus of the cuts. Cutting these slides was a logical choice because the PA process slides were amenable to independent study and did not require as much explanation as other slides. It was deemed more productive to allow the participants to ask questions and participate in discussions than to present more slides.

The participants found the exercises very useful. As shown in Fig. 1, the exercises used in the Educational Forum were focused on concepts and the thought process rather than calculations. This reflected the intent of the forum to illustrate PAs as a thought process and not just calculations. An exercise to conduct some simple groundwater calculations was included with the printed material, but was not used in the Forum.

There were a variety of reactions to the use of equations in the presentations. Although there were some concerns expressed about the number and level of detail of equations in the presentations, the general consensus was that there is a need to show some equations to help with understanding. The equation discussed above (Eq. 1) was cited as an example of an effective illustration of fundamental concepts that also provided an easily understood link to the mathematics.

In conclusion, the general consensus was that the participants felt they had a better appreciation of the thought process involved in conducting PAs and the level of rigor involved in the PA process. The participants also believed that they had a better understanding of how PAs contribute to decisions that are made in the context of radioactive waste management. There is interest is conducting similar Forums for Site-Specific Advisory Boards and the public at other DOE sites.

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