June 24, 2013

MEMORANDUM TO: Christepher McKenney, Chief
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
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Office of Federal and State Materials
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FROM: George Alexander, Systems Performance Analyst ***/RA/***
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SUBJECT: SUMMARY OF THE NRC WORKSHOP ON PERFORMANCE ASSESSMENTS OF NEAR-SURFACE DISPOSAL FACILITIES: FEPS ANALYSIS, SCENARIO AND CONCEPTUAL MODEL DEVELOPMENT, AND CODE SELECTION

The U.S. Nuclear Regulatory Commission (NRC) held workshop on August 29 and 30, 2012, in Rockville, Maryland on Performance Assessments of Near-Surface Disposal Facilities. The purpose of the meeting was to facilitate communication and gather information from Federal and State agencies, industry representatives, contractors, and members of the public. Information gathered in the meeting is being used to improve guidance on performance assessments for near-surface disposal of Low-Level Waste (LLW). The workshop was organized into four sessions comprising a series of presentations followed by panel discussions of invited subject matter experts. The workshop sessions were as follows: (1) LLW Performance Assessment: Overview, Approaches, and Context; (2) Analysis of Features, Events, and Processes for Near-Surface Disposal Facilities; (3) Scenario and Conceptual Model Development; and (4) Code Selection and Implementation, Model Abstraction, and Confidence Building Activities. Many important points were discussed during the presentations and the panel discussion and several key insights are briefly summarized below. The views expressed in this summary are those of the individual workshop participants and do not necessarily reflect the views or policies of the NRC and the other participating Federal agencies.

Enclosure: Meeting Summary

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Summary of the NRC Workshop on Performance Assessments of Near-Surface Disposal Facilities: Features, Events and Process Analysis, Scenario and Conceptual Model Development, and Code Selection

In Session 1, representatives from the NRC, Savannah River National Laboratory (SRNL), and Intera provided an overview of Low-Level Waste (LLW) Performance Assessments (PA), including approaches, assessment context, and the associated types of uncertainty.

Key Insights from Session 1 LLW Performance Assessment: Overview, Approaches, and Context	
Overview	PA is a systematic analysis of what can happen, its likelihood, and the consequences.
	PA is a graded (i.e., level of detail based on impact on decision) and iterative process of collecting data, identifying potential scenarios, developing conceptual and numerical models, and analyzing results.
	PAs provide insight and information for decisions, not exact predictions.
	PAs can provide risk insights for very long periods of time; however, a quantitative comparison of projected doses against dose criteria at these timeframes might not be meaningful.
	PAs inherently have a heavy reliance on qualitative information and subject matter experts. Accordingly, the expertise and judgment of the people developing the PA is critical.
Approaches (International and Domestic)	A variety of modeling approaches (e.g., bottom-up and top-down) provides insight and confidence.
	Development of the various PA steps (e.g., Features, Events and Process (FEPs) analysis, scenario identification, conceptual and numerical model development) should not be done in isolation.
	Modelers, regulators, and stakeholders can have biases that can lead to significant differences in what is considered “realistic” or “conservative”.
	Multiple independent modelers and reviewers help to build confidence.
	International and domestic approaches to LLW PA are largely parallel, with an exception of intruder analysis.
	In the US, waste classification tables preclude the need for intruder analysis. Internationally, intrusion calculations are often required.
	Exposure scenarios vary significantly and are highly speculative.
Context	The assessment context should clearly define: What is being assessed? Why is it being assessed? What is the scope of the assessment?
Uncertainty	Accounting for uncertainty is critical, but how uncertainty is categorized (e.g., scenario, model or parameter uncertainty) can be semantics.
	Conservative assumptions can be used to help address uncertainties. Similarly, the less conservative the assumption the more justification that is required.

	Care is needed to avoid compounding conservative assumptions, which can result in unduly pessimistic assessments and lead to poor decision making.
Stakeholder Communication	Interactions with local communities provide information for the modelers as well as the stakeholders and help to build confidence.
	PA is only one part of a broader safety case that also includes R&D, monitoring, and experiments, which can also be useful in stakeholder communication.

In Session 2, representatives from Sandia National Laboratory, Neptune and Company, and the NRC provided presentations on the rationale and application of FEPs analysis, lessons learned, and proposed FEPs analyses for LLW disposal facilities. FEPs are defined as: Feature – an object, structure, or condition that has a potential to system performance; Event - a natural or human-caused phenomenon that has a potential to affect system performance and that occurs during an interval that is short compared to the period of performance; Process - a natural or human-caused phenomenon that has a potential to affect system performance and that occurs during all or a significant part of the period of performance.

Key Insights from Session 2 Analysis of FEPs for Near-Surface Disposal Facilities	
Motivation for FEPs Analyses	Models can only evaluate aspects that are included in the model; avoiding the omission of risk-significant FEPs in a model (i.e., errors of omission) is a challenge.
	Errors of omission can be reduced by implementing a FEPs analysis that utilizes a broad range of expertise and independent peer review.
	FEPs analyses can provide structure, accountability, transparency, and serve as a communication tool.
General	FEPs analysis is a systematic process consisting of identification (i.e., Have we thought of everything?) and screening steps (i.e., Are all important phenomena represented in the model?) that can be used to help develop conceptual models.
	FEPs are more easily accounted for earlier in the PA process.
	Although FEPs analyses are rooted in disposal of High Level Waste (HLW); international guidance is available on the use of FEPs in support of LLW PA.
	Regulatory guidance is needed for LLW on the use of FEPs in support of the PA process, in particular the identification and screening of FEPs.
	The approach to FEPs analysis should be consistent with HLW programs, however, the level of effort should vary according to the longevity and severity of the risk.
	Relatively low risk sites can rely on more conservative assumptions to represent a FEP (e.g., higher infiltration rate, lower Kd value), whereas, a higher risk site may need to use more realistic values requiring greater justification.
	Approaches to FEPs analysis can be described as being bottom-up (where scenarios and/or models are built-up from initial screening of individual FEPs) or top-down (where scenarios and/or models are audited against a FEP list). The

	distinction is not clear-cut and assessments can employ a combination of these approaches.
	Bottom-up approaches to FEPs analysis tend to frontload some of the costs associated with a PA.
	The use of the alternative approach during an internal review can help verify that important phenomena or barriers are accounted for.
	FEPs analysis should be iterative and amenable to internal and external review.
	The FEPs analysis should be flexible to account for site-specific characteristics.
Approach (Identification)	Identification of FEPs for a site can be informed by generic FEPs lists, previous PAs, and site-specific information.
	Generic FEPs lists can be used as a starting point for scenario/model development or as an auditing tool, but should not be considered comprehensive.
	A generic FEPs list for LLW has been developed by the International Atomic Energy Agency, building on that compiled for HLW by the Nuclear Energy Agency.
Approach (Screening)	FEPs screening can be based on probability of occurrence, magnitude of consequence, or regulation.
	FEPs that are significant to the performance of the disposal facility must be included in the PA scenarios and models. A defensible and transparent rationale must be provided for the excluded FEPs.
	Level of support for excluding FEPs should be risk informed.
	Importance analysis can be used for FEPs screening.
	Care should be taken when screening out FEPs; first order effects of some FEPs may be insignificant, however, the interaction between two FEPs may be significant.
	Our understanding of the effects of all the potential FEPs is limited; our understanding of secondary and tertiary effects is significantly more constrained.
	Inclusion of a FEP in a model can sometimes be easier than justifying exclusion.
	FEPs screening is part of an iterative PA loop (i.e., FEP significance could be determined during the early iterations); FEPs can be refined or screened out.
	Categorization of the screened-in FEPs and their relationships can provide a framework (e.g., via influence diagrams) for scenario identification and conceptual/mathematical model development, and/or associated auditing.
Stakeholder Participation	Identification and screening of FEPs could be improved by expanding stakeholder participation.
	Early stakeholder participation, particularly in the identification and screening of FEPs, tends to frontload of costs, but it can ultimately improve the overall PA process.

In Session 3, representatives from Quintessa, Facilia, and Neptune and Company presented an international and U.S. perspective on scenario and conceptual model development and the integration of these aspects into a PA through an iterative process.

Key Insights from Session 3 Scenario and Conceptual Model Development	
General	Scenario and conceptual model development should be systematic, comprehensive, logical, and transparent.
	Scenario and conceptual model development are subject to bias; accordingly, professional judgment is a key aspect.
	The purpose of the PA is not necessarily to demonstrate that every possible scenario and conceptual model meets the performance objectives (i.e., there may be scenarios and conceptual models that exceed the performance objectives).
Scenario Development	The system description coupled with the retained (i.e., screened-in) FEPs leads to scenarios.
	FEPs analysis and scenario development is dependent on the site, the longevity of species in the waste, and the period of performance.
	Scenarios address future uncertainty by evaluating a range of potential futures. Exposure scenarios describe the end process by which people may become exposed to radiation.
	Typically, external factors (e.g., seismicity, climate change) drive scenarios, whereas internal factors (e.g., engineered barriers, surface environment) represent variants to scenarios.
	The normal evolution scenario can include external FEPs likely to affect the system rather than less likely disruptive scenarios.
Exposure Scenarios	Principal basis of waste classification tables in Part 61 was protection of the inadvertent intruder, which was based on stylized scenarios.
	Stylized intruder scenarios obviate the need for speculating about future human behavior by constraining an infinite number of exposure scenarios.
	The stylized scenarios in Part 61 are based on disposal facility designs that are not typical today. These exposure scenarios may not be realistic for current disposal facilities with barriers that limit intrusion (e.g., concrete structures, cover material greater than 10 ft thick).
	Dose predictions are typically sensitive to the exposure scenario; however, exposure scenarios are seldom varied and therefore, do not show up in sensitivity analyses.
	Justification for site-specific intruder analyses should be commensurate with the level of reliance a site assumes for limiting intrusion (i.e., how much the site-specific analyses deviate from the stylized scenarios).
	It is typically easier to justify the source term and barrier assumptions than assumptions for future human behavior.

	The use of stylized intruder calculations allows for an inter-comparison of site/design performance.
	Part 61 provides an option for site-specific intruder analyses for sites that are not representative of the disposal facilities that were originally envisioned.
	Site-specific intruder analyses differentiate relative risk between sites by taking advantage of different human activities in different areas.
	Monitoring does not preclude the possibility of intrusion and credit should not be taken for institutional controls beyond a reasonable period (e.g., 100 years).
	The intruder scenario assumes that institutional control and societal knowledge are lost.
	Site-specific intruder analyses should consider other sites with similar climate and environmental conditions (i.e., analog sites) when determining the exposure scenarios.
Conceptual Model Development	Conceptual models are developed for each scenario to be assessed and include the retained FEPs, the relationships between the FEPs, and the spatial and temporal domains.
	The treatment of conceptual model uncertainty is typically much weaker than the treatment of parameter uncertainty.
	Alternative conceptual models should be used to evaluate uncertainty in the conceptual model.
	All conceptual models that are consistent with available information should be considered. Accordingly, the less information that is available, the more alternative conceptual models may need to be considered.
	Aggregating multiple conceptual models based on assumed probabilities may not be appropriate and provides results that are difficult to interpret and communicate.
	The use of multiple independent modelers and reviewers can help to identify conceptual model uncertainty; although, the modelers and reviewers may have the same limitations and biases.
	Variability in results from independent modelers can help to quantify model (and data) uncertainties and reduce them in iteration, but it may also present communication challenges.

Session 4 was split into two segments, with the first part consisting of presentations from the U.S. Department of Agriculture (USDA), the Savannah River National Laboratory, and the NRC addressing model abstraction and model support.

<table>
<tr><th colspan="2">Key Insights from Session 4
Code Selection and Implementation, Model Abstraction,
and Confidence Building Activities</th></tr>
<tr><td rowspan="2">General</td><td>Conservatism is difficult to foresee in complex systems. Accordingly, care should be taken when applying conservatism to parameters to account for uncertainty.</td></tr>
<tr><td>Model development should be systematic and comprehensive.</td></tr>
<tr><td rowspan="3">Model Abstraction</td><td>The term model abstraction is used to describe both: (i) the process of reducing the complexity of a conceptual model of the actual system so that it can be represented by a mathematical model and (ii) the process of reducing the complexity of a simulation model while maintaining the validity of the simulation results.</td></tr>
<tr><td>Observations and experiments are the best mechanisms to determine if the model is a reasonable representation of reality, although the potentially long timescales of interest in PAs can provide significant challenges. The next best line of evidence is multiple independent reviews by subject matter experts.</td></tr>
<tr><td>A comparison of simulation results after the addition and subtraction of complexity against information developed from confidence building activities can be used to demonstrate adequate model complexity.</td></tr>
<tr><td rowspan="6">Model Support</td><td>Model support is an essential element of the PA due to the reliance on assumptions in PAs and the inability to validate models.</td></tr>
<tr><td>Model support reduces uncertainty and provides confidence in modeling results.</td></tr>
<tr><td>The level of model support should be commensurate with the level of risk.</td></tr>
<tr><td>A variety of elements can be part of the model support process:
• internal review
• independent external review
• documentation of verification efforts
• multi-faceted confidence building activities (e.g., field experiments, laboratory experiments, natural and man-made analogs)</td></tr>
<tr><td>Multiple lines of evidence and direct observations are preferred.</td></tr>
<tr><td>Model results should be compared against information developed from confidence building activities.</td></tr>
</table>

The second part of Session 4 consisted of a series of short presentations from representatives of organizations involved with the development of codes for LLW disposal. Representatives from Quintessa, Los Alamos National Laboratory, Facilia, GoldSim Technology Group, and Argonne National Laboratory provided a brief discussion of: (i) recent and upcoming code developments, (ii) examples of disposal sites where the codes have been used, and (iii) key elements of a system-level code that are important for modeling of LLW disposal facilities.

Key Insights from Session 4 Codes Roundtable Discussion
The use of the terms "codes" and "models" is inconsistent within the PA community. The term code typically describes the source code which is written in programming languages such as FORTRAN, C++, Java, etc. The model platforms (e.g., AMBER, ASCEM, Ecolego, GoldSim, RESRAD) are developed using programming languages and can be used to build PA models.
The PA process is iterative and starting with a simple model, and possibly a simple code, is good practice.
The PA process is more important than code selection.
Given similar conceptual models, different codes should provide similar results (provided the conceptual models are compatible with the different codes).
PA software cannot compensate for errors of omission (e.g., missing FEPs, incorrect conceptual models).
A robust safety case requires an in-depth uncertainty analysis.
Model complexity should not exceed the level of detail of the supporting information. However, the model can be less complex than the supporting information if the abstraction does not affect the results.
Use of a code outside of the internal QA/QC program (e.g., coupling of codes) requires careful consideration by the modeler and additional QA/QC.
Communication of the model and model results to stakeholders is critical; although the model is only one tool to assist us in the decision making-process (i.e., one part of a broader safety case).
Key Code Elements • flexibility of code to handle different assessment endpoints, different sites, and multiple conceptual models • modularity • extensibility (i.e., model can be changed by adding or subtracting features) • availability of software (e.g., open-source code) • transparency to facilitate internal and external reviews • QA/QC of the code • ease of use • computational efficiency • capability to interface with other codes • capability to conduct a deterministic or probabilistic analysis • capability to conduct a sensitivity analysis, including a global sensitivity analysis

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