Best Practice – Stakeholder Engaged Structured Decision Making

Facility: All (EM and NNSA)

Best Practice Title: Stakeholder Engaged Structured Decision Making to improve performance and reduce costs while protecting human health and the environment

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Brief Description of Best Practice: The overall objective of this Best Practice is to introduce a paradigm shift in approaches to decision making for nuclear waste management, disposal and remediation decisions. The stakeholder-engaged structured decision making (SDM) paradigm shift provides a transparent framework for developing optimal solutions to complex problems (Keeney, 1992, Gregory et al, 2012). An illustrative example is provided in the attachment.

SDM is a deliberative-analytical process. The deliberative part addresses understanding stakeholder values and concerns, developing objectives from those values and concerns, and identifying options that might achieve those objectives. SDM is implemented through computer tools that are aimed specifically at capturing these deliberative aspects of a decision analysis. The SDM process and tools capture this deliberative information in a structured system that formalizes and memorializes the values and concerns, objectives, weights for the objectives, and options that have been identified. This approach provides transparency, traceability, and reproducibility. The goal of SDM at this stage is to provide a formal structure for capturing the deliberative information.

The deliberative part sets the stage for the analytical part of SDM. A variety of Subject matter experts (SMEs) are engaged in how to evaluate the options through the objectives. Objectives often include minimizing human health risk and minimizing cost, but in the full scope of a sustainability-based approach to decision making, it can include objectives related to economic, environmental and social issues. Subject matter experts might provide other options for achieving the objectives, but their primary role is to evaluate/model the options to the endpoint defined by the objectives or in other words perform a consequence analysis. The structure of SDM makes it clear exactly what is needed from the SMEs, because the options are identified, and the endpoint (objectives) are defined – evaluations and/or models are needed to connect options to objectives. This consequence analysis completes the evaluation, and directly addresses which of the options is the best option. The same SDM approach to finding the best options can also be used for prioritization and resource allocation.

Because all of the information is captured in a formal system with the help of computer tools (a software framework for implementing SDM), the decision models that are developed for an application can be fully evaluated numerically and for the insights gained from using a formal process for managing the multiple factors that need to be considered for complex decisions. This includes uncertainty and sensitivity analysis that can be used to guide the need for further data/information collection if the optimal decision is not adequately supported – that is, if there is insufficient confidence in the decision. Also, this feeds directly into adaptive management therefore if more data/information are collected then the efficacy of the current decision can be evaluated, potentially leading to a change in decisions if warranted.

Why the best practice was developed: This best practice has been developed for two primary reasons. The first is a recognition that many of the remaining waste management and environmental management problems in the complex are likely to be challenging and that the current approach that has, arguably, worked well for relatively simple problems cannot, or should not, be applied to more complex problems. The second reason is cost. This has perhaps become more critical since the GAO recently announced that DOE's environmental liability is a high-risk concern, but has been a concern for DOE for some years. The SDM approach has the potential to help substantially reduce costs while maintaining protection of human health and the environment as required under various environmental regulations. The cost reductions come from three factors: The first is the engagement of stakeholders through SDM reduces the need for rework; the second is the approach is a technically correct method for solving decision problems using decision analysis, which removes the types of conservatism that plague current practice for environmental assessments of various kinds; the third is that options can be identified with stakeholders that are not always found by practitioners alone, and sometimes these are more cost-effective solutions.

There is no guarantee that applying SDM will result in reduced costs for every application, but the level of conservatism that is inherent in the current environmental assessment systems for nuclear/radioactive issues is sufficiently large that reduction in conservatism, and usually cost, is not difficult to achieve. Note that cost reductions are not always immediate. For example, if waste disposal is the decision problem, a large disposal volume can be filled for a long time before the current approach will cause the cell to be filled sooner than necessary. In effect, SDM plays directly into a long-term sustainability based analysis, or life-cycle analysis.

Although this SDM approach is an innovation, it can also be viewed as the modern, correct, implementation of EPA's Data Quality Objectives (DQO) process, although classical DQOs are aimed only at design and without focus on completion of the decision cycle. Applying the DQO process has always been challenging for complex problems because the mathematical/statistical paradigm associated with DQOs did not support decision making for complex problems. It was the wrong paradigm, which, for example, did not properly integrate costs and values with the technical data/information associated with complex problems. The underlying formalism of SDM overcomes those limitations and effectively operationalizes the DQO process. SDM also aligns with the requirements of OMB's approach to evaluating the economic impact of regulatory and policy decisions, providing further evidence that DOE should adopt SDM to support decision making.

What are the benefits of the best practice: This paradigm shift to SDM is needed to provide greater technical defensibility for solving complex problems, and for reducing costs. Benefits include effective engagement of stakeholders in the decision making process, use of the SDM structure to clarify the modeling needs and engagement of SMEs, and the ability to evaluate the decision system, or model, to determine what's important in driving the decision.

Benefits gained from the formalism of applying SDM while using software tools for implementation include technical defensibility, transparency, traceability, and reproducibility. The time frames required for solving the types of complex problems that remain for the radioactive waste industry, including the evaluation, the decision and the eventual completion, are often long. Consequently, the principal parties involved can change during a project. Using a system that achieves the benefits listed above becomes critical for ensuring project continuity. SDM coupled with a software application can provide those benefits. These benefits can also be regarded as critical QA requirements that should support any decision that is being made for a complex problem. To achieve these QA benefits, the SDM tools can be embedded in a web-based framework program that provides sharing of data, values and concerns, information and models, presentation in a user-friendly environment, visualization of data and models, and other features related to understanding and solving the decision problem.

The primary benefits for nuclear waste management, disposal and remediation decisions will be realized in the reduced costs and schedule to achieve the mission of DOE and other groups to clear their current environmental liabilities.

What problems/issues were associated with the best practice: Problems with the SDM paradigm shift are associated primarily with lack of capacity in the industry to implement this approach. This approach requires skills that have not often been used in the industry, such as stakeholder engagement experts, elicitation experts, decision analysts, and statisticians. Scientists and engineers still have a critical role to play as SMEs, but their role is supporting a decision analysis, development of which requires a further set of skills. The industry has moved towards probabilistic risk assessment (performance assessment), which is also embedded in the SDM approach, and also requires skill sets that the industry has not addressed in the past. Capacity building and training programs in these skill sets must be developed in order to maximize success of this approach, and help the industry reach more effective decisions that will reduce costs while still protecting human health and the environment.

How will success of the Best Practice be measured: Success can be measured at various levels. For a single application direct comparison is possible between the options that are included in the SDM analysis. Success can be measured cumulatively across multiple SDM applications, which could lead to as assessment of the effect on program budgets. A potential criticism is that these measures are based on SDM models and are not measures of actual effect. It is more difficult to measure actual effect because usually only one option is implemented. However, in cases for which more than one option is implemented (perhaps at different times, or at different but similar sites), or when the costs of a pre-planned option have been estimated but the option has not been implemented, an actual comparison can be performed. The possibilities for measuring effect of the Best Practice hence fall into a few categories:

1. Using SDM for direct comparison of options for a single application:
    a. The options that are processed through an SDM application can be compared directly by comparing the relative cost savings and value effectiveness among the options that are evaluated in the SDM model.
    b. Feedback can be sought from the participants (stakeholders and SMEs) on the benefits of the SDM approach and the best option that is identified, which would include cost- and value-related benefits.
2. Using SDM for direct comparison across many SDM applications:
    a. As more SDM applications are implemented within a program such as DOE's environmental management program, the long-term effect on budget and schedule can be estimated and projected, providing a direct comparison between pre- and post-implementation budgets and schedules. Other benefits can also be captured that, for example, demonstrate that human health and environmental protection have been achieved, and that other stakeholder values have been addressed.
    b. Continuous improvement approaches can be used to learn lessons from each SDM application within a program, which is potentially measurable by assessing long-term effects on program budget and schedule.
    c. Elimination of rework, negotiation of lower cost, and shorter duration remedies also provide insight into the features and benefits that are realized through the implementation of SDM.
3. Actual comparison:
    a. In some cases it is possible to compare the best option suggested by an SDM model to a pre-planned option for a specific application.

b. If a pre-planned option is available, it is also possible to question the stakeholders and SMEs about the likely benefits of the optimal solution found through SDM (retrospective comparison).

Conclusion/Summary: SDM is a powerful new tool and approach to solving complex decision problems. For the complex nuclear waste management, disposal, decommissioning and remediation decisions that remain for DOE and other agencies, a paradigm shift is needed that has the potential to dramatically decrease costs while maintaining protection of human health and the environment, and also addressing other objectives that might be important to stakeholders (e.g., quality of life, jobs, economy). The potential benefits are large in terms of:

1. Useful and effective stakeholder engagement that feeds structured decision making.
2. Technical defensibility, transparency, traceability and reproducibility, so that if the decision is revisited after some time all of the supporting information and analysis is readily available.
3. Decisions that are supported by all stakeholders who participated in the process. In effect, inputs, instead of outputs, are negotiated. This substantially reduces the chance or opportunity for redo.
4. Potentially large reduced long-term costs for nuclear waste management, disposal, decommissioning, and remediation decisions.

The current approach to addressing nuclear waste management, disposal and remediation decisions is affecting upstream decisions related to nuclear industries, including nuclear energy. Arguably, the Country needs a nuclear energy industry to provide clean energy at low cost, and to compete economically with countries such as China that are moving ahead full-steam with nuclear energy to replace fossil fuel as a source for energy. SDM is the paradigm shift that is needed to provide the technical defensibility, stakeholder agreement, and lower costs that are needed while still demonstrating protection of human health and the environment. Consequently, EFCOG recommends use of this approach to address the complex nuclear waste management, environmental remediation, and nuclear decommissioning decision problems that remain.

References

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R. Gregory, L. Failing, M. Harstone, G. Long, T. McDaniels, D. Ohlson (2012) Structured Decision Making: A Practical Guide to Environmental Management Choices. John Wiley & Sons

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Example

The following example is presented to demonstrate the SDM process. It is a fictitious example, but contains elements of many challenging problems faced by the radioactive waste management industry. The example is formed from experience at several sites that have similar characteristics, including sites in the US and in Europe.

Some further details about the SDM process are provided to help structure and explain the example that follows, and to provide some more motivation for the SDM approach. SDM can be simply defined as formalized common sense that allows complex problems to be organized or structured so that insight can be gained and evaluation of the decision-making process is possible. The SDM process can be summarized as follows:

- SDM is organized, inclusive, transparent, traceable
- SDM includes consideration of values and consequences
- SDM is prescriptive and based on formal decision theory but applied practically to support real world decision making
- SDM accommodates iteration as more information is collected to support the decision (the decision context drives the resources dedicated to the decision analysis)
- SDM supports optimization, cost-benefit, economics, as low as reasonably achievable (ALARA), etc.

The SDM process is often described in a sequence of 5 steps (Gregory et al, 2012) that are depicted in Figure 1. The 5 steps can be described as:

1. understand the underlying context of the decision;
2. define desired outcomes and measurable objectives;
3. identify options (actions) for achieving desired outcomes;
4. evaluate options using applicable data and models; and
5. take appropriate action when significant uncertainty exists.

These steps are applied to a fictional example below. The intent is simply to demonstrate how the SDM process works. The problem is fictional and there is no intent to portray a preference in the decision making process for this example or any related cases. The example is presented following this 5-step process listed above and presented in Figure 1.

Example Step 1 – Understand Context and Decision Landscape

The example site portrays a uranium mill tailings disposal facility, which has been engineered to contain the uranium mill tailings. The facility is in a humid environment, on a natural slope downhill from which is a stream that runs towards a river. The facility is sited in previous farmland. A town is nearby, downstream on the river. More population centers are further down river, and the river ultimately enters a sea. Consequently, there are possible consequences to human health and the environment near the facility, and at locations downstream all the way to the sea.

Stakeholders include owners and managers of the facility, regulators, local government, local communities, and financiers. Regulations of interest include country-specific regulations that describe performance or safety objectives. Relevant guidance is country-specific, and also includes IAEA guidance. Note that the regulatory setting could be described in terms of NRC uranium mill tailings regulations [10 CFR Part 40] and associated guidance if the site is in the US. For this example, the specific regulations and guidance are not well defined, but they should be properly defined depending on the site-specific situation.

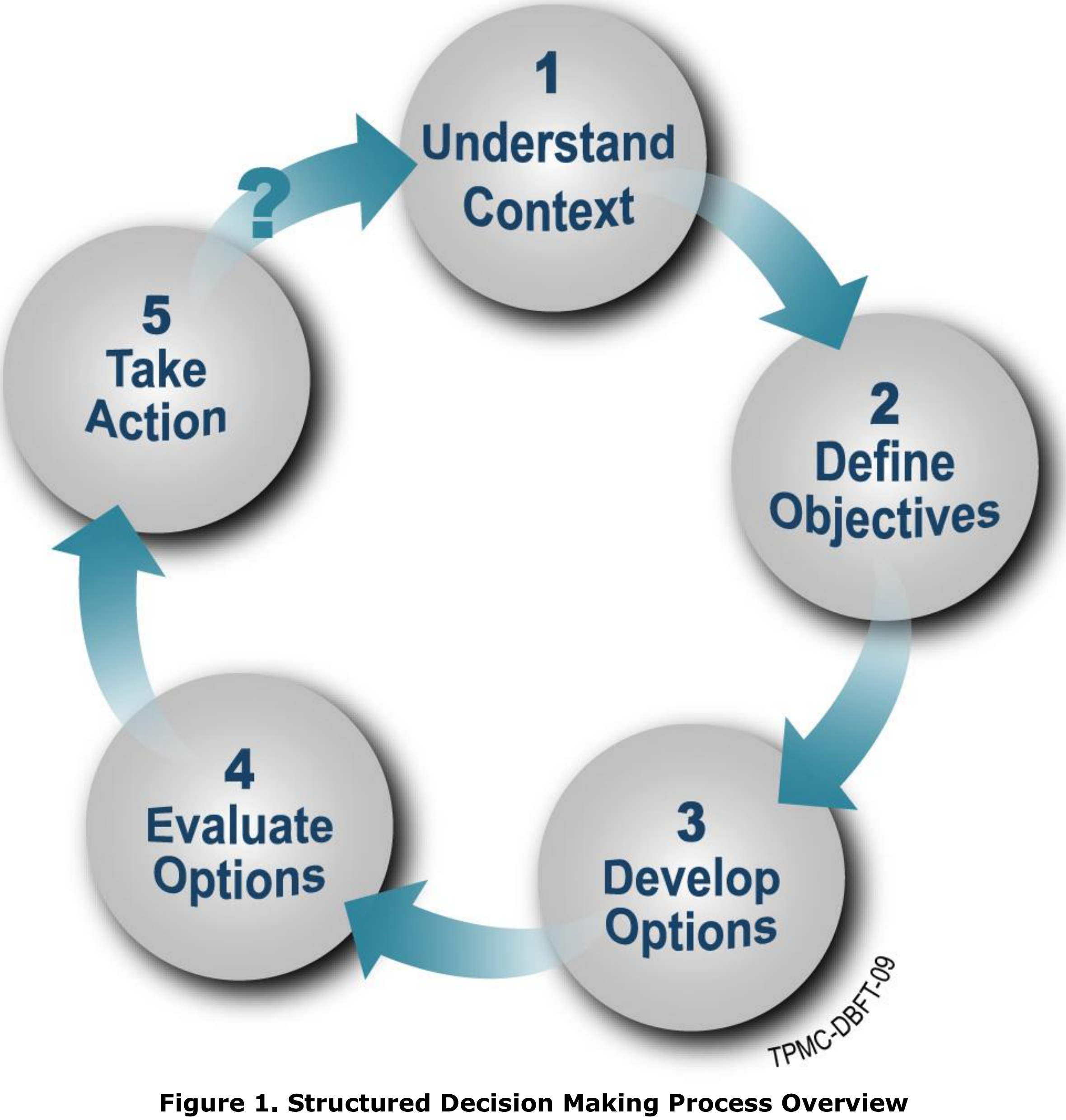


Figure 1. Structured Decision Making Process Overview

Water is diverted around the facility through engineering controls. Large storm events have the potential to change the course of the storm water run-off, cause landslides or otherwise erode the site. Consequently, water could run under the facility, infiltration could occur to near-surface groundwater, water could run through the facility and enter the stream system, and flow downstream to the sea that is about 50 km away. Primary processes of concern include groundwater flow, surface water flow, erosion, storm system effects, climate change impacts. Air dispersion of radon is a further concern, however, biotic impacts are expected to be minimal.

Potentially exposed populations or individuals include downstream communities, recreationalists, and workers including cleanup workers if the site fails. The area could also be used for farming or hunting if institutional controls were to fail. Intrusion through well drilling or excavation is possible, although unlikely.

Example Step 2 – Define Objectives

Elicitation or identification of objectives begins by questioning the stakeholders to discover their concerns, preferences and values. In general, some stakeholders are likely to want to minimize costs, and others are likely to want to focus more on minimizing impacts on human health and the environment, maintaining jobs, maintaining property values, maintaining or improving the local economy, addressing environmental justice, etc. The important point is to ensure that all concerns and values are captured from the different stakeholder groups.

For this particular example, preferences among the stakeholders are expressed in terms of protecting human health, minimizing cost, and maximizing efficiency, where the latter is a concern about obtaining financing that could be used to support actions that might be taken.

These concerns, preferences and desires must be translated into measureable objectives. That is, each concern must be measurable. The following objectives hierarchy is obtained for this example:

- **Maximize Uranium Mill Tailings Management Sustainability**
  - **Protect human health**
    - **Minimize health impacts on workers**
    - **Minimize health impacts on residents**
    - **Minimize health impacts on intruders**
  - **Minimize cost**
    - **Minimize cleanup costs**
    - **Minimize containment / migration costs**
    - **Minimize access control costs (fencing, signs, etc.)**
    - **Minimize fines**
  - **Maximize efficiency**
    - **Ensure financing**

Note that this is expressed at the top level in terms of sustainability. This is not a requirement, but it is often a convenient way to organize the objectives. The lowest level objectives need to be measured to support evaluation in the decision model. The following measures are applied:

Objective	***Objective Measure***
Minimize health impacts on workers	**Dose to humans (mSv/yr)**
Minimize health impacts on residents	**Dose to humans (mSv/yr)**
Minimize health impacts on intruders	**Dose to humans (mSv/yr)**
Minimize cleanup costs	**Cost of cleanup (M dollars)**
Minimize containment / migration costs	**Cost of containment (M dollars)**
Minimize access control costs (fencing, signs)	**Cost of access control (M dollars)**
Minimize fines	**Cost of regulatory fines (M dollars)**
Ensure financing	**Bank loan (M dollars)**

Each objective measure needs a value function. The value function expresses the relative value or preference of an objective over the range of the objective measure. Value functions are normalized to a range of 0, or minimum, value, to unit, or maximum, value. This allows value functions for all objectives to be compared directly.

An example is provided in Figure 2. A range of possible cleanup values sets the stage for specifying the value function. For this example, the range is specified from a cost of zero to a cost of $100M. Note that this range is provided in order to specify a value function. It does not represent actual predicted costs, although it should represent a reasonable range over which costs are considered reasonable.

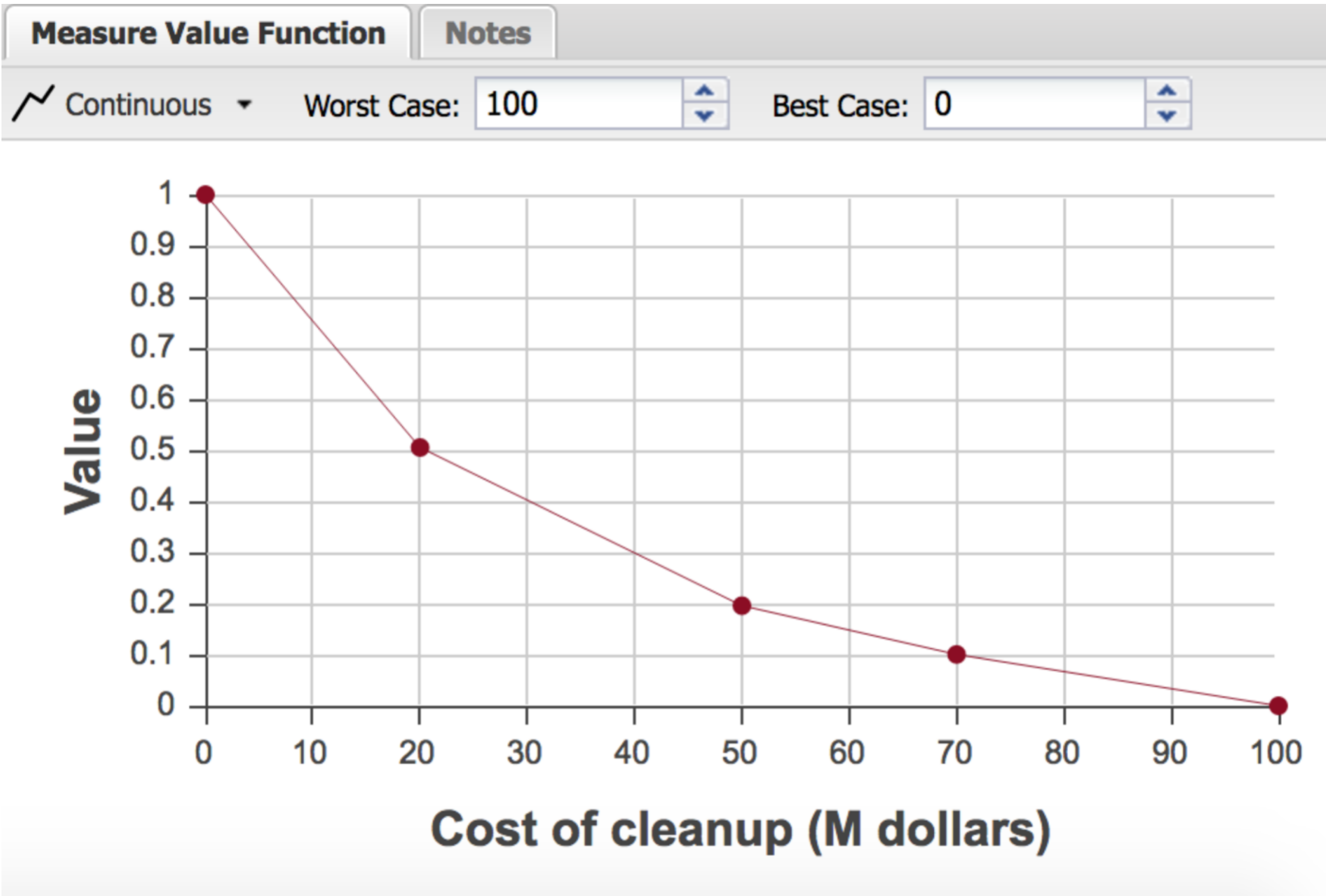


Figure 2. Value function for Cost of Cleanup

In Figure 2 a value function is presented that is essentially continuous over the specified range of costs. The value function suggests that there is greater value is spending less money. The value function also suggests, for example, that the difference in value between a cost of $0 and $20M is the same as the difference in value between spending between $20M and $100M. The underlying notion is that once the cost becomes large there is not as much difference in value. Another ay to look at this value function is that anything more than $50M is considered a large expense. This might be similar to a concept of diminishing returns, but is also associated with the notion of risk aversion. Note again, this is simply an example. This particular software interface allows the three interior points to be dragged to create relatively simple monotonic non-linear functions.

The desire to minimize costs is often countered by the desire to minimize exposure or risks to various human receptors. An example value function for human heath risk is presented in Figure 3.

This is presented as a discrete value function to demonstrate its use. Value functions can be specified either continuously or discretely, depending on the nature of the objective measure and the views of the stakeholders.

Figure 3 is discretized for example purposes only. More than three categories can be specified. This value function indicates that the maximum value corresponds to a resident dose of less than 0.01 mSv/yr (1 mrem/yr). This level is sometimes considered a *de minimus* dose level. A dose greater than the presumed regulatory limit of 0.25 mSv/yr is associated with the lowest value because this is not a desirable outcome. In this example, doses in between are associated with a middle value.

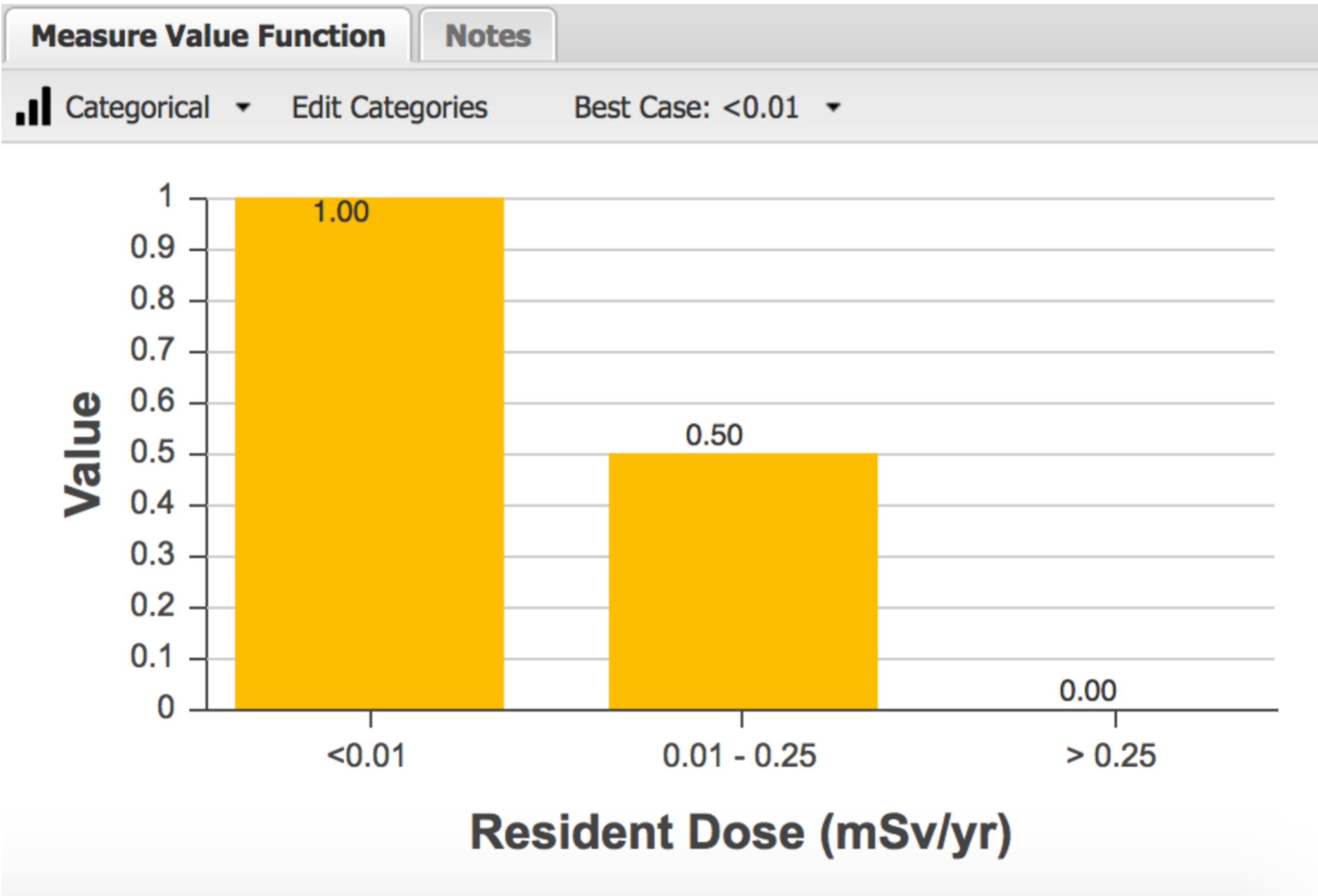


Figure 3. Value function for Resident Dose

Value functions are specified for all eight objectives listed above. Once the value judgments are specified, the final part of Step 2 is to specify relative preferences for the objectives. This is depicted for this fictitious example in Figure 4. In this example, minimizing impacts on residents and workers is considered more important than minimizing costs of actions that are taken, however, the greater concern is the desire to ensure financing so that any action that might be necessary can be implemented.

These preferences were specified using the approach of "swing weighting", which requires sequential pairwise comparison of objectives starting with the least preferred pair. This is a simpler approach to preference weighting than other approaches that require full pairwise comparisons, or full multiattribute value function specification. Nevertheless, specification of preference weights, and the prior objective measures and value functions is not a simple undertaking. For the types of complex problems that remaining it should not be expected that finding the best solution is necessarily simple. In general, the ideas behind SDM follow the notion that "all models should be as simple as possible and no simpler". The latter part of that notion is particularly important in that simplistic solutions to complex problems should be avoided. With the amount of money that is at stake to resolve DOE's environmental liability, it is worth the effort to find the best solution in a manner that is technically defensible, transparent, traceable and reproducible.

Objectives

Expand All | Collapse All | Reset Tables

Objectives	Weight
Ensure financing	0.32
Minimize health impacts on residents	0.21
Minimize health impacts on workers	0.14
Minimize cleanup costs	0.07
Minimize containment / transport control costs	0.07
Minimize access control costs	0.07
Minimize health impacts on intruders	0.06
Minimize fines	0.05

Figure 4. Preference Weighting for the Objectives

Example Step 3 – Identify Options

Once the objectives, value functions and preference weighting are complete, the next step is to identify options that might achieve the objectives. Options are tied directly to the objectives in an SDM application. Figure 5 shows the association between the objective "minimize health impacts on intruders" and options to build a retention basin (to control migration), fence the site, and remove the tailings (or cleanup). Putting up signposts could also be checked and included in this list, since signposts might deter intruders. Other objectives might be associated with a subset of these options, or different options. For example the objective of "ensure financing" is associated with the option of "obtain financing".

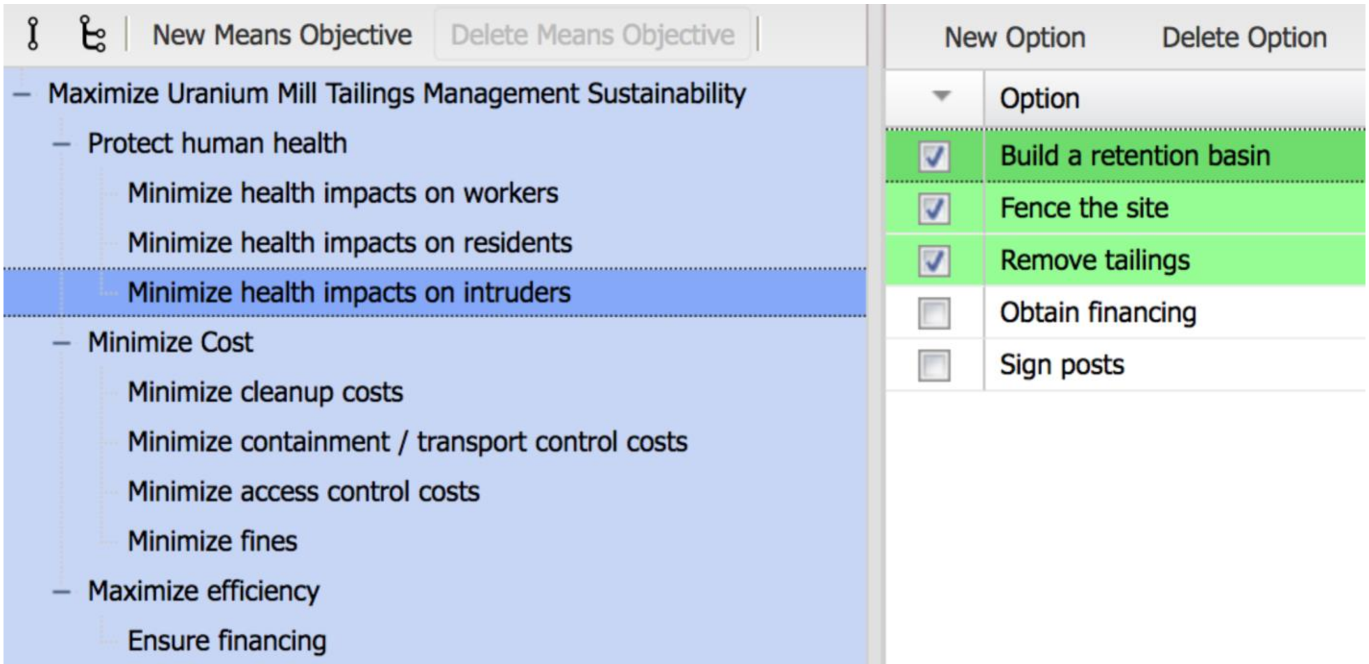


Figure 5. Identification of Options

Options need to be evaluated (Step 4), however, taking action on combinations of options is not only permissible but is probably a more likely scenario. Figure 6 shows some possible combinations of options, which are called management scenarios, or simply scenarios. Scenarios considered in this case are the no further action scenario ("Do nothing"), only performing cleanup ("Remove tailings"), and cleanup and minimize access (Cleanup and minimize access"), for which the intent is that the need to minimize access is to reduce the opportunity for exposure to post-cleanup residual contamination. These three scenarios are evaluated in Step 4.

Note that for this specific example, the scenarios are specified in terms of true/false or on/off. However, more general scenarios can be specified for which options can express quantity. For example, if fencing is part of an option, fencing can be expressed in terms of amount of fencing (e.g., 1 km, or 10 km, etc.). This allows more specific options and scenarios to be evaluated in the decision analysis.

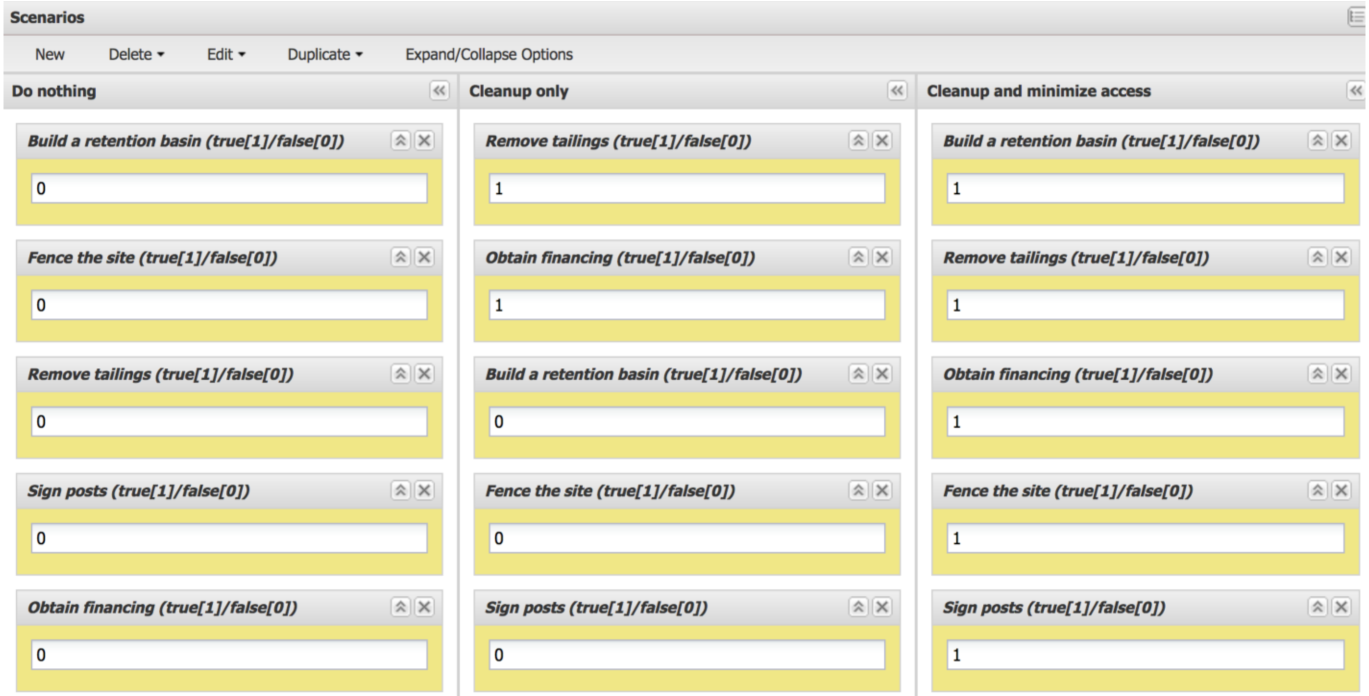


Figure 6. Scenarios

Example Step 4 – Evaluate Options

Figure 6 shows the full SDM decision model for this example, with options in yellow, objectives in green, and the connections between that provides the structure to the decision model and which are directly related to specification of objectives and options in the previous steps. The additional pink nodes are specific probabilistic models that allow each option to be evaluated through the objectives. The simplified example in Figure 7 simply shows how a full SDM decision model is structured, and should not be considered complete necessarily for any real applications.

For example, to calculate worker dose or resident dose requires some understanding of how these receptors might come into contact with the radioactive contamination. This might require a water ingestion model, or a soil inhalation model, both of which are also informed by fate and transport models. It is assumed that these models are embedded inside these “pink nodes”. Sometimes these probabilistic models might provide direct input to the model – for example, worker exposure time is specified as a direct input to worker dose.

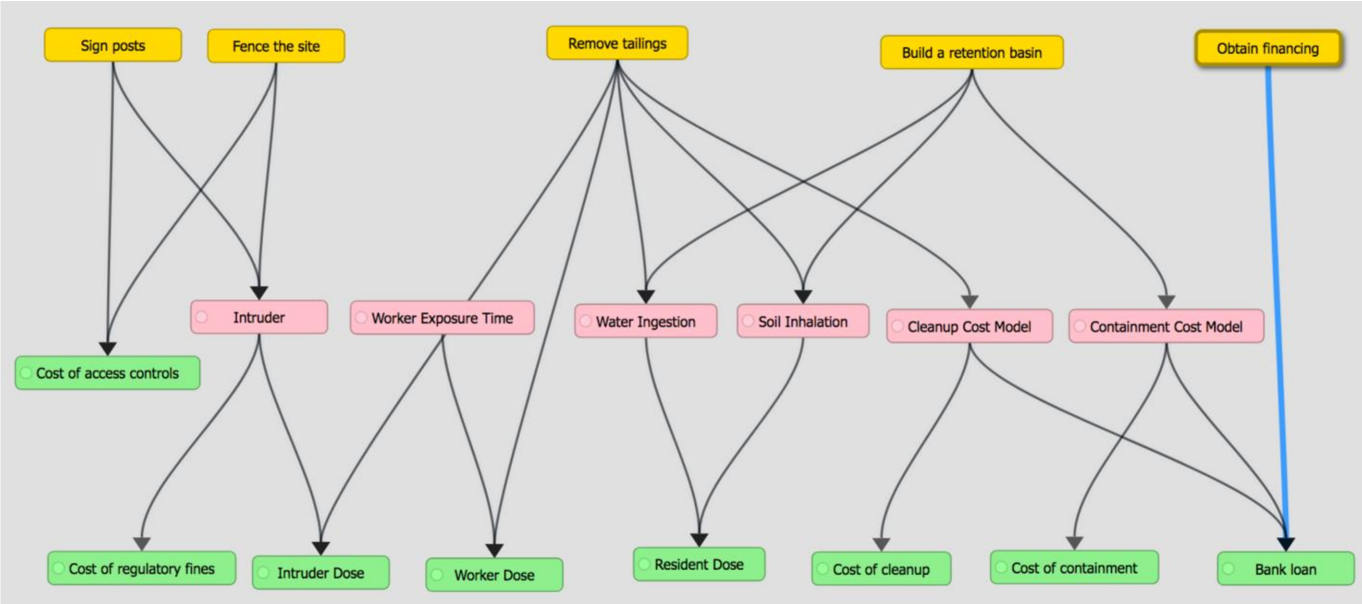


Figure 6. Influence Diagram for Evaluating Options

These probabilistic models can be structured and specified at any level of complexity, could include groundwater models, diffusion, advection, precipitation and infiltration, erosion, surface water transport, etc. These models might be written in a specific fate and transport code, the results of which can be "abstracted" into the SDM framework. These connections can also include models of potential intrusion, or cost estimation models, or job creation models, etc., depending on the needs of the problem.

In general, this application links options to risk-related objectives, cost-related objectives, and the need to obtain financing. The action-oriented terms (e.g., "minimize") are removed from the objective descriptions in the "green" nodes for simplicity of presentation, but should be assumed from the specification of the original objectives.

Note that the need to ensure financing ("Bank loan") is tied only to "Cleanup costs" and "Containment Costs", it is not tied to "Access Control costs". This is because the "Access Control costs" are very small relative to the other costs, in which case including further connections complicates the model with no real gain in insight, understanding, or choice of the best option. These types of modeling decisions are important, and again hark back to the notion that "all models should be as simple as possible and no simpler".

Example Step 5 – Take Action

The final step involves a few components that include running the model and determining the best option, and testing or evaluating the model using sensitivity analysis. Figure 7 shows the results of running this particular example model. This depiction suggests that the "Cleanup only" option is preferred. The differences between this option and the option to also implement "Containment" and "Access controls" can be seen in the cost benefit from not implementing these two options (dark red and yellow bars). This is despite the decreased likelihood of fines if "Access Controls" are implemented. The risk reduction is not as large as the cost reduction, so the trade-off leans towards only "Cleanup". The risk-related components for residents and workers carry greater weighted values, but they are not very difference for these two scenarios.

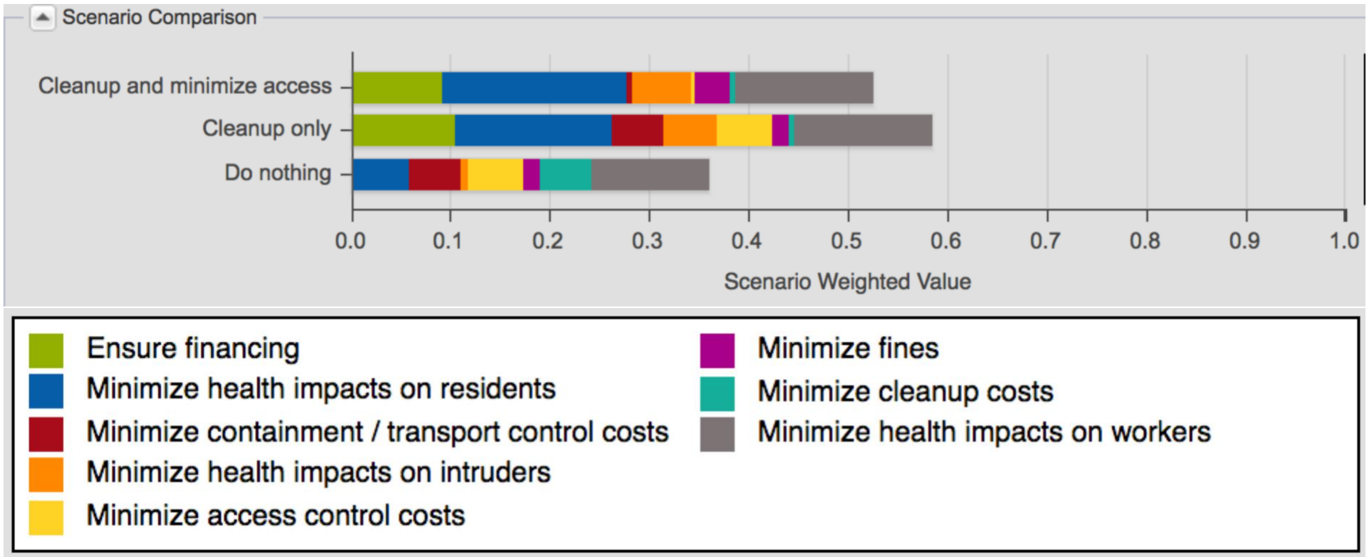


Figure 7. Comparison of Results

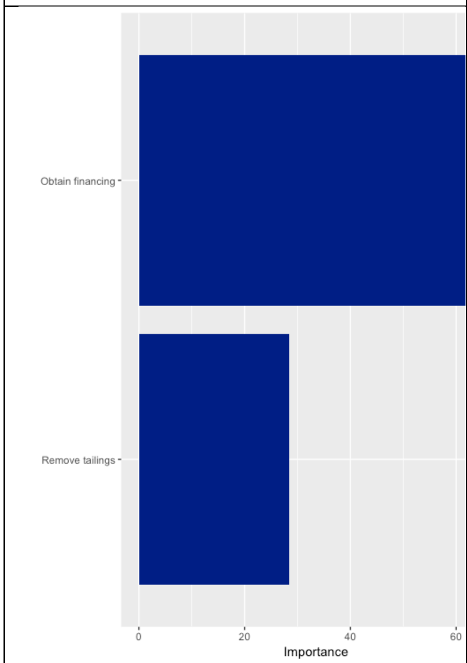
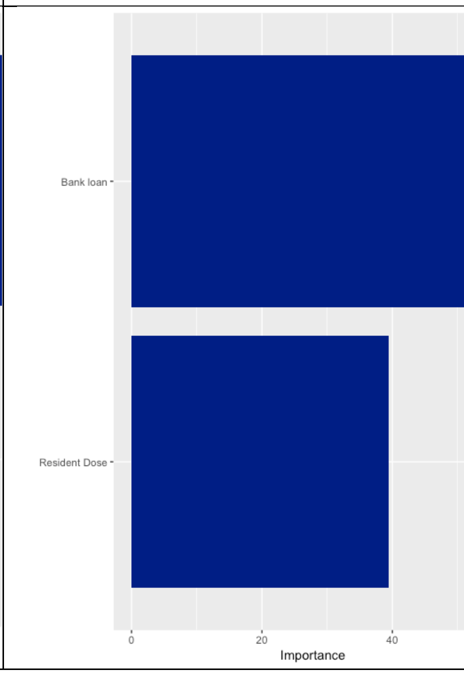
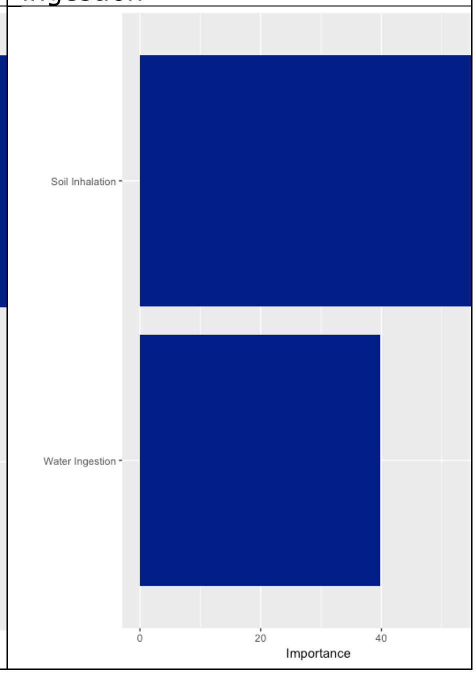
The No Further Action scenario ("Do nothing") scenario is not favored in part because the human-health risks are greater (lower weighted values). However, this scenario also has no weighted value related to obtaining financing, because financing is not considered to be necessary. By contrast, for the other two scenarios the ability to obtain financing is seen as a positive. The costs for this scenario are embedded in the other cost components, which show greater value because the costs are lower for taking No Further Action.

Although the breakdown of the overall weighted values are shown in this results figure, this does not address the sensitivity of the results to specific inputs. Sensitivity analysis can be applied across the entire decision space, including value functions, preference weighting, and probabilistic inputs. These sensitivities are shown and described in the following table. The most sensitive parts of this model are related to financing and resident dose, the latter of which can be broken down further to see that the results are marginally more sensitive to soil inhalation than to water ingestion. With that understanding, some consideration should be given to reducing uncertainty about financing options before a decision is made.

Once an SDM application is constructed it can accommodate iteration and adaptive management as new information is collected. Iteration can be performed in response to collection of new data/information intended to reduce uncertainty. The sensitivity analysis serves the role of evaluating the model and identifying features that might benefit from further data/information collection.

Adaptive management is possible after a decision is made and the model and solution are revisited in the future. For example, this is a requirement of the Performance Assessment maintenance program for radioactive waste disposal. Of course, the decision space might change (for example, a disposal decision would be followed by a decision to leave waste in place or exhume the waste), but the structure established for the initial decision can be used to determine if a different decision needs to be made in response to collection of monitoring data, for example.

SDM establishes a framework for solving complex problems, and is used properly, leads to more cost- and value-effective solutions that are technically defensible, transparent, traceable, and reproducible.

1. Sensitivity to the Options	2. Sensitivity to the Objectives	3. Sensitivity to the Probabilities for the Minimize Resident Dose Objective
The results are most sensitive to the Option to Ensure Financing. This can also be seen in the results diagram (Figure 7), where the biggest difference in results for the three options depends on the need or ability to ensure financing. Note that sensitivity indices for all options must sum to one, implying that the results are not very sensitive to the remaining options of building a retention basin (containment), or putting up a fence or signposts (access control).	The results are most sensitive to the objective to obtain a Bank Loan, although the objective to minimize Resident Risk is also sensitive. Again, the sensitivities must sum to one, in which case the other six objectives have sensitivity indices that sum to about 3-4%.	The results that relate to the objective to minimize resident dose impacts are more sensitive to soil inhalation than to water ingestion. Note that the probabilistic models for this example are very simple, and do not contain variables that explain how soil inhalation or water ingestion might arise. If the underlying probabilistic models are more complex, then this component of the sensitivity analysis would address all of the probabilistic inputs. For now, this sensitivity analysis suggests that if more data or information were to be collected to reduce uncertainty the focus should be soil inhalation rather than water ingestion
		

SDM Example Summary

This is a simple and contrived example used simply to demonstrate how the SDM process works. The SDM approach is process oriented, and relatively devoid of prescription. Process oriented solutions require thinking through the problems, which, usually lead to better solutions. In effect, "models should be as simple as possible but no simpler" could be translated a little into "models should be as simple as possible and not simplistic" – simplistic models tend to lead to poor decisions that are difficult to defend. Thoughtful solutions usually lead to better decisions and less redo. SDM allows thoughtful decision problems to be captured in a structured system that provides technical defensibility, transparency, traceability and reproducibility, all of which are useful attributes for effective decision making.

This approach is also aimed at optimization (given the inputs) rather than simple compliance. Compliance can be accommodated directly, but it is not the goal. The goal of optimization is aimed, for example, at better use of existing radioactive disposal systems, cost- and value- effective remediation and decommissioning. Given the GAO report on, and DOE's understanding of, DOE's environmental liability, a paradigm shift is needed, and SDM can provide the technical basis for that shift.