Issue I

Report

Risk Management Issues in Site Stewardship

A Discussion Paper

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EXECUTIVE SUMMARY

The US Department of Energy's Environmental Management (DOE EM) Program is responsible for the cleanup of the radioactive, chemical and other hazardous waste remaining after 50 years of nuclear weapons production. Current efforts are focused on bringing sites to closure as quickly and cost-effectively as possible. Given the nature of the contamination and technical, financial constraints, many sites will be left with residual contamination, requiring some form of long-term stewardship to maintain protection of public health and the environment.

To provide a focus for the DOE's Center for Risk Excellence (GRE) in the development of its program for addressing the risk management requirements of long-term stewardship, a discussion paper has been prepared to encapsulate some of the key issues and provide a basis for initiating a debate on the way forward. Such a program may incorporate a diverse range of components, covering basic research and development activities, development of guidelines, information dissemination and stakeholder consultation.

Questions raised in the paper address issues surrounding the principles, the process and the regulatory and institutional framework that will underpin effective long-term residual risk management at DOE sites. The questions and issues reflect the views of a wide range of individuals and organizations involved in the stewardship arena and are not necessarily the views of the authors. The questions are posed to initiate discussion and debate, recognizing that work that has already been undertaken within DOE's EM program and elsewhere, and reviewed as part of this current exercise, may go some way to answering many of them. The issues and questions put forward to initiate the debate are as follows:

Guiding Principles. A number of guiding principles have been identified by which risks, costs and benefits may be balanced fairly across generations. These have been derived through consideration of ethical questions surrounding intergenerational equity. Key principles identified are, *the Precautionary Principle, the Trustee Principle, the Sustainability Principle* and the *Chain of Obligation Principle.* These are supported by the two further principles of *Cost-effectiveness* and *Affordability.*

Discussion Points

- Have we identified an appropriate, self-consistent and comprehensive set of guiding principles that can form a sound basis for a future stewardship program?

- Does DOE as a whole subscribe to these principles?

- Will the wider community subscribe to them and how should DOE present them to its stakeholders and to the Indian Nations?

- By what mechanism will the identified principles be implemented in practice?

Scope of Stewardship. The scope to be addressed within DOE's stewardship program is potentially broad. Defining that scope requires consideration of: the appropriate timescale that should be considered; the integration of cleanup with stewardship in the decision-making process; and, issues beyond health, safety and environmental risk

management, in particular community related matters.

Discussion Points

- What should be the scope of stewardship?
- To what extent should DOE be seeking to integrate cleanup and long-term stewardship?
- How long may long-term stewardship be needed at DOE sites?
- How far into the future should we be planning and how far ahead is it feasible to plan?
- Does the scope of stewardship encompass broader community issues?
- Does DOE have a continuing responsibility for the welfare of the communities that were created to meet its original national defense mission?
- How should public perceptions of risk be factored into stewardship?
- Are there particular concerns shown by communities that are unique to long-term stewardship?

Relevant Risk Issues. A range of risk end-points that may be covered under stewardship can be identified, including human health and safety risk, environmental and ecological risk, cultural, historic and tribal risk, and programmatic risk. Specific hazard scenarios that may be of particular concern in longer-term residual risk management can also be identified, including the failure of planned long-term controls, non-traditional risks such as terrorism and human intrusion, future land use, cultural and lifestyle changes, incremental effects over extended timescales and rare catastrophic geological or meteorological events. The significance of uncertainty over the extended timescales that may need to be addressed under stewardship is also recognized.

Discussion Points

- What are the risk end-points that need to be catered for in long-term stewardship?
- What specific hazard scenarios need to be addressed, outside the normal remit of conventional risk assessment and management?
- How well do we understand these long-term risks?
- What are the programmatic risks associated with long-term stewardship? (Risk associated with institutional management are considered further below.)
- How should cultural risks be addressed within the decision-making process?
- What are DOE's long-term ecological risk management responsibilities?
- How should the uncertainties in predicting risks far into the future be dealt with?
- What is the public perception of long-term residual risk and how should this be addressed within a stewardship

program?

The Decision-making Process. A number of key issues surrounding the decision-making process relating to, for example, selection of cleanup end states and technology development, have been identified. These cover the existing regulatory framework, the complex, multi-attribute nature of the problem, the sort of approach they maybe needed to address it, and the supporting tools and methodologies that may support the process. Consideration of these issues raises questions concerning the appropriate level of flexibility of the process and the potential benefits of using a goal-based approach to balance between competing objectives within technical and financial constraints.

Discussion Points

- Is there an existing framework and approach that will enable long-term residual risk management to be taken forward effectively?
- Is there merit in moving to a more flexible, goal-based rather than prescriptive approach to address the issues of cost-effectiveness and overall affordability?
- To what extent does the existing framework allow for the adoption of such a goal-based approach and how effectively is it currently being implemented to provide flexible, site specific and cost-effective solutions?
- Could defined quantitative risk criteria and standards support the decision-making process and, help to provide a more rational basis for resource allocation?
- How can balanced decisions be made and can the process be effectively supported by decision tools such as cost-benefit analysis and multi-attribute techniques?
- Do we have an adequate understanding of the technical constraints upon both cleanup and stewardship, when to accept them and when to seek to overcome them?
- How do we decide which technologies to invest in, and how can long-term technology development needs be better integrated across the complex in order to maximize risk reduction?
- What are the real financial constraints on the program and how are they perceived by those that set budgets and by the affected communities?
- How should the balance be drawn between investment now in permanent solutions and expenditure on longer-term stewardship?

Institutional Management DOE has initiated research effort to provide a better understanding of the issues associated with institutional management in relation to both its weapons sites and proposed long-term radioactive waste disposal facilities. In addition to this work, DOE is gaining practical experience in stewardship through its UMTRA site management program. This goes some way towards addressing many issues within institutional management but further work is required.

Discussion Points

- What are the components required to establish effective institutional management programs that can address long-term residual risks?

- How might changing risk management needs be accommodated over time?
- What is the reliability of institutional controls and how should programmatic risks associated with their use be addressed?
- What are the risk data needs of stewardship and how will the availability of critical risk information be ensured in the longer-term?
- What are the organizational requirements for implementation and regulatory oversight of long-term stewardship and will new agencies with specific mandates need to be created?

It is hoped that the above considerations provide a catalyst for discussion, aimed at achieving concensus among stakeholders on the issues surrounding stewardship and on the actions necessary to take things forward.

Contents

1 INTRODUCTION

The US Department of Energy's Environmental Management (DOE EM) Program is responsible for the cleanup of the radioactive, chemical and other hazardous waste remaining after 50 years of nuclear weapons production. Current efforts are focused on bringing sites to closure as quickly and cost-effectively as possible. Not all sites brought to closure will be clean enough for the DOE to walk away from because of the nature of the contamination and technical, financial or other constraints. Many sites will need some form of long-term management, known as long-term stewardship, to maintain the protection of public health and the environment. Long-term stewardship has been defined as “all activities required to maintain an adequate level of protection to human health and the environment from hazards posed by nuclear and/or chemical materials, waste and residual contamination after cleanup is complete”[1,2].

Stewardship is not a new concept to DOE. Valuable work has been carried out in this area by a number of groups. The aim of this discussion paper is not to repeat work which has already been undertaken but to bring together the different elements which are in place in order to assimilate the current DOE position. In particular, this paper will concentrate on the key risk issues associated with long-term stewardship and how they may best be managed. It is intended to provide a focus for the DOE's Center for Risk Excellence (CRE) in the development of its program for addressing the risk management requirements of long-term stewardship. It also seeks to act as a focus for coordination with other organizations addressing broader issues of stewardship, beyond CRE's risk management remit.

The discussion paper is based on a review of recent publications and on other material gathered during a series discussion meetings with organizations involved in the stewardship arena[3]. It seeks to draw, not only on work specifically directed at stewardship in the context of site cleanup but on other relevant work, for example in waste disposal and risk management more broadly where related issues have been considered. A wide variety of views are reflected within the document which are not necessarily the views of the authors. The objectives of the discussion paper are first discussed. The following aspects of the current stewardship debate are then addressed in turn:

- the guiding principles and objectives that underpin stewardship;
- the scope of stewardship in the context of the current debate;
- specific risk issues in stewardship, including:
  - the types of risks that stewardship must address;
  - community transition issues associated with stewardship;
  - process for making effective risk management decisions;
  - institutional management requirements;
  - technology issues;
  - regulatory and other constraints

2 DISCUSSION PAPER OBJECTIVES

The objectives of this discussion paper are:

- to provide a basis for DOE to evaluate its current position and understanding of risk in long-term stewardship;
- to continue the development of the understanding of the risks associated with post-closure activities;
- to identify how this understanding can better inform risk management decision-making in long-term stewardship;
- to begin the process of further information dissemination and discussion on the way forward in the management of long-term risks.

Overall, its primary purpose is to initiate a debate, within DOE in the first instance and then more broadly, that will help to evaluate the current status of thinking on stewardship and build towards a consensus. This will lay the foundation for future programs to address the risk management requirements of long-term stewardship, drawing on existing expertise and identifying areas for further development.

Specifically, it seeks to provide a basis for the development of CRE's program for addressing the risk management requirements of long-term stewardship. It is apparent from earlier discussions initiated by CRE that stewardship and residual risk management are broad issues and are a concern of many organizations. Effective teaming between these organizations may help the DOE to meet its stewardship challenges and the discussion paper therefore seeks to act as a focus for coordination with other organizations addressing these broader issues of stewardship.

The paper is not intended to be a complete review of the work carried out into long-term stewardship to date, but to identify selected elements which may usefully contribute to the risk debate. It is intended to suggest ideas which may support the long term management of risk.

3 PRINCIPLES AND OBJECTIVES OF STEWARDSHIP

3.1 Objective

The overall objective of long-term stewardship at DOE sites is to protect human health and the environment from residual risks which are the legacy of many years of nuclear research and production. Long-term stewardship may be needed for thousands of years at some sites and so it is important to establish principles by which risks, costs and benefits can be balanced across many generations, if risk is to be effectively factored into the decision making process.

3.2 Guiding Principles

There has been much debate concerning the ethical considerations of balancing risks, costs and benefits across generations. The proceedings of an international workshop organized by the Nuclear Energy Agency in conjunction with the Environment Directorate[4] raise a number of important ethical questions:

- Can risk, or responsibility for essential actions, be imposed on future generations when the benefits are perceived to be incurred by the current generations?

- Should the current generation punish its children and grandchildren in order to fend off imaginary demons in the unforeseeable future?

- Could or should responsibility for developing solutions to the radioactive waste management problem be transmitted to future generations?

- Is it sensible for the current generation to try and protect its own parochial values far into the future?

A number of organizations support the concept that future generations should be exposed to no greater hazard or risk than current generations. However practical considerations mean than near-term future hazards can be managed more effectively than far-term hazards.

If these ethical considerations are to be taken into account during the long-term stewardship process a set of guiding principles is needed to assist decision-makers. A report by the National Academy of Public Administration (NAPA), prepared on behalf of DOE and entitled “Deciding the future: Balancing risks, costs and benefits fairly across generations”[5], identified several principles which could be used to guide the long-term stewardship debate. These principles are:

- ***The Trustee Principle***: Every generation has obligations as trustees to protect the interests of future generations.

- ***The Sustainability Principle***: No generation should deprive future generations of the opportunity for a quality of life comparable to its own.

- ***The Chain of Obligation Principle***: Each generation's primary obligation is to provide for the needs of the living and next succeeding generations. Near-term concrete hazards have priority over long-term hypothetical hazards.

- ***The Precautionary Principle***: Actions that pose a realistic threat of irreversible harm or catastrophic consequences should not be pursued unless there is some countervailing need to benefit either current or future generations.

Cost considerations are inherent in these broad principles but it is appropriate to state explicitly the principles that will underpin decisions on allocation of resources. In this context, two basic principles are identified:

- ***Cost-effectiveness***. This is an established practical principle in the existing regulatory process: evaluation of total short- and long-term costs is a requirement in remedial action selection under CERCLA legislation[6]. The recently issued “Framework for Environmental Health Risk Management” identifies that benefits should be reasonably related to costs[13].

- ***Affordability***. Beyond the cost-effectiveness of individual remedies, the overall affordability of the program as a whole has been identified[7] as a key principle that must be satisfied.

3.3 Discussion

These principles neatly sum up some of the considerations which need to be taken into account when looking at long-term stewardship needs. Measures must be put into place now to control and manage the risks that future generations will face, but not at the expense of exposing the current generation to excessive risk. Consideration needs to be given to the future as well as the present.

Rather than considering a present and a future the NAPA report suggests that a “rolling present” concept is considered. This assumes a smooth passage where the future becomes the present involving an iterative decision process. Succeeding generation will reevaluate the decisions of the past using their own values and knowledge. This may be facilitated by the use of an integrated approach which gives regulators and the regulated communities incentives to look holistically at environmental hazards, both existing and future, and to develop creative ways of setting risk management priorities[8].

Accurately predicting the values and behavior of future generation may be an impossible task. It may be more realistic for decisions regarding long-term stewardship to be based on the short-term future with some consideration beyond that. It is important that basic principles and a solid start to the stewardship process are established now which will aid future generations to make their own decisions, but the current generation should not presume to make those decisions now. Principles to guide intergenerational decision-making are not, in themselves, enough. The principles will need to be translated into a set of guidelines to aid decision-makers in putting the principles into practice.

4 SCOPE OF STEWARDSHIP

Long term stewardship has been defined as “all activities required to maintain an adequate level of protection to human health and the environment from hazards posed by nuclear and/or chemical materials, waste and residual contamination after cleanup is complete”[1,2] and “long term care of DOE sites after cleanup is complete”[9].

Establishing the scope of stewardship to be covered within the risk management decision-making process is a prerequisite for identifying future risk management program requirements. In addressing the scope of stewardship in the current context, we consider three basic issues in turn:

- the timescale of long-term stewardship to be considered in the decision-making process;
- the integration of cleanup and stewardship considerations in that process;
- the relevance of broader issues beyond safety health and environmental risk management.

4.1 Timescale of Long-term Stewardship

Long-term stewardship will start at the time of site closure and may need to continue as long as some residual risk remains. To address some residual risks, stewardship activities may be needed essentially in perpetuity. However, puff measures in place which can be expected to last for thousands or even millions of years is not a viable option. EPA guidelines recommend that active controls cannot be relied upon for more than 100 years and passive controls for not more than a few hundred years[10]. It may often not be possible to prescribe solutions in which we can have confidence in the longer term.

In practice it may therefore be sensible to concentrate effort on real existing and anticipated hazards in the foreseeable future which can be effectively controlled by stewardship actions taken now. The Chain of Obligation principle states that near-term concrete hazards should have priority over long-term hypothetical hazards. It is important to consider the long-term hazards and take measures that will assist future generations to take actions to protect themselves from these hazards. However it may not be prudent to spend a lot of time and money trying to take action now against unknown hazards many thousands of years in the future, especially when we do not have the technology to do so.

A key issue in planning for long-term stewardship is therefore deciding the appropriate nearer and longer term focus of the process. We will not be able to prescribe complete once and for all solutions and should not expect to do so. The principles identified earlier by NAPA can help guide the process of identifying an appropriate focus, for example using concepts such as the “rolling present”. This may be facilitated by more specific operational guidance[5].

4.2 Integration of Cleanup and Long-term Stewardship

The definitions of long-term stewardship describe the long-term activities succinctly, but tend to isolate long-term actions from shorter term actions. This may not provide for the development of the best overall solutions. It may be useful to think of long-term stewardship as a discrete subset of the overall stewardship of the site. Stewardship should begin at the establishment of the site and continue through the cleanup phase to long-term care and risk management. There is a developing consensus that better integration of cleanup and long-term stewardship activities, together with a consideration of a range of broader factors, should help to identify optimum solutions.

There are currently concerns over how well site remediation and closure and are integrated with post-closure controls[11]. Decisions made about cleanup now will affect the distribution and degree of risk that remains at DOE sites. However, cleanup decisions do not necessarily take account of all these factors.

For example, in some cases the best remedial technique available may be to allow natural attenuation to repair the damage[2]. This will mean that cleanup costs will be very low but stewardship costs, while the natural attenuation is taking place, may be substantial. In some cases the long-term care and maintenance costs may be prohibitively high, in which case the optimum course of action would be to spend more money on cleanup in order to reduce long term commitments. It is only by integrating the two phases that the overall advantages or disadvantages of specific options can be assessed. The need for integration has implications for the decision-making process, as discussed further in Section 7.

By taking an holistic approach the links between actions in one phase and another can clearly be seen, allowing integration to maintain as smooth a transition as possible. Stewardship can be thought of as the middle of a wheel with many spokes radiating from it including regulatory issues, technical matters, stakeholder views and so on. All these factors need to be taken into consideration when decisions regarding long-term stewardship are made[12].

The integration of cleanup and long-term stewardship also raises organizational and institutional issues. If an Agency other than the DOE EM program is given responsibility for managing the long-term stewardship program it may be more difficult to achieve effective integration. Similarly, integration may be impeded where responsibilities lie at different levels or in different operational units within the same organization. Under such circumstances there may be limited incentives to think holistically and organizational barriers may restrict such an approach. Even within the EM program the political pressure to show cleanup progress may have some influence on the way the long-term stewardship program can be run.

4.3 Issues other than Risks

Stewardship is a responsibility of government but effective government is about much more than health, safety and environmental risk management. The Presidential Congressional Commission on Risk Assessment and Risk Mangement recommends that risk management decisions are taken that, amongst other things, are sensitive to political, social, legal and cultural considerations[13]. Broader stewardship of the community may there for be considered to be a legitimate consideration in stewardship. The move from operation to cleanup resulted in many changes for the surrounding communities. The move from cleanup to long-term stewardship will do the same. Many communities, for example those around Savannah River, are concerned about this transition[14]. There needs to be a

structured way of managing this transition to minimize the negative impacts. This is discussed further in the Section 6.

DOE will have a long-term responsibility to ensure protection of public health and the environment at its sites but should that responsibility be wider than that? Many communities around DOE sites have only grown because of the existence of the site and are now thriving communities. To what extent does DOE have a long-term responsibility to those communities, for example by helping to create new jobs and provide a lasting future for those who served its former mission?

5 RISKS ISSUES IN STEWARDSHIP

Long-term stewardship needs to address a broad spectrum of risks. In many instances the risk issues will have much in common with those relevant to the cleanup process and to risk management more generally. However, some issues will be more specific to stewardship and the longer-term management of risks. The DOE EM program currently has relatively limited understanding of these long-term risks, but will need to develop its understanding if long-term stewardship measures are to be successful. At this stage DOE must assess what needs to be understood, what is currently understood and hence where the knowledge gaps may lie. This process has been initiated by the EM Office of Strategic Planning and Analysis. Risk factors include balancing risks to current and future generations, individual and population risks, cultural and technological risks and other types of risk. A brief summary of the some of the risk issues that may need to be addressed is given in Figure 1 and discussed below. Further consideration of these risk issues in the context of the risk assessment and management process is provided in Section 7.

Figure 1 Long-term Risk Issues

Public Health Risks - Public health risk management is a fundamental driver for the cleanup and stewardship programs. There is a need to maintain an adequate level of protection to human health which runs through operation, cleanup and long-term stewardship phases[2]. EM goals are concerned with eliminating and managing risks in their

system[15]. Where health risks cannot be eliminated they must be managed over time which is the purpose of long-term stewardship measures. There is a need to balance short term and long term public health risks; some remedial activities may increase the risk of public exposure while the activities are taking place and this risk must be balanced with the likely resultant decrease in overall risk in the longer term. There are recognized standard techniques used to assess the magnitude of public health risks which allow for some risks to be well understood although others are not. This is discussed further in Section 7.1 which considers the approach to risk assessment.

Worker Health and Safety Risks - It is important that worker risks are considered when deciding what cleanup or long-term stewardship actions are to be taken[15]. Worker health and safety is not generally considered as forceful a driver as public health and safety in the decision-making process although short-term risks, including worker health and safety, are covered by the CERCLA process. Worker safety is often only fully considered once the decision on the actions to be taken has been made and the safest way to perform the chosen tasks is assessed. This is a key issue to be addressed in the risk management decision-making process, discussed further in Section 7.

Reducing risks to workers may often be in direct conflict with reducing risks to the general public. Generally, the less remediation or active stewardship actions which are taken the lower the worker risk will be, but the resultant residual risk to the public may be higher. Therefore, worker safety has to be balanced carefully with public safety risks. Again, this is a key issue in the decision-making process.

Worker risks may be expected to be a relatively small component of the overall risk once long-term stewardship measures are in place because stewardship activities are unlikely to involve many operations that expose workers to significant risks. However, this general perception of worker risk levels during stewardship may require further consideration and verification. Worker risks may be significant during the cleanup phase and a full evaluation of these risks may indicate a preference for less cleanup at the expense of greater long-term stewardship requirements.

Environmental Risks - The natural environment is at risk from residual radioactive or chemical contamination at DOE sites. The protection of the environment is a driving force in the cleanup and long-term stewardship program. Where contamination cannot be removed it needs to be contained to minimize the impact on the natural environment. A balance needs to be struck between cleanup and long-term stewardship actions, taking account of all the relevant factors. There are a number of environmental risk issues of more particular relevance to the stewardship debate:

- Remedial actions may themselves present an environmental risk. In many cases there are isolated beds of contamination which may potentially spread and cause wider contamination if disturbed. In these cases it may be better to contain the area and monitor regularly, either in the long term or until more reliable technology is available. This is long-term stewardship.

- Radioactively or chemically contaminated material or soil removed from a site will have to be disposed of elsewhere. All the risks involved must be taken into account - the risks at the original sites, risks associated with removal and transport of waste and residual risks which will remain at the disposal site. It is important to look at all the aspects of the situation, including the overall long-term stewardship needs. It may be more effective to bring large quantities of waste together for long-term care.

- Another issue which needs to be addressed is the extent to which DOE retains responsibility for natural habitats on its land. The maintenance of buffer zones, in particular, often protects natural habitats which have been largely wiped out by development in the surrounding area. In some cases those habitats are artificially supported, for example by a supply of water in an otherwise arid environment. Once the DOE site is closed the habitats may be under pressure from developers and other potential users of the site. The DOE needs to decide to what extent it will intervene to continue to protect the natural environment it has stewarded for many years. Some sites, such as

Rocky Flats, have initiated Natural Resource Management policies in order to address this issue[16].

Cultural, Historical and Tribal Risks - Cultural risk assessment considers the risk to the lifestyle and culture of the population involved. If a community is prevented from carrying out activities which are considered part of the identity of that community then this is a cultural impact. A significant amount of work has been carried out into cultural risk, for example in a series of tribal risk assessment forums[17]. Some contaminated sites are of historical or Tribal value and it is important not to lose sight of that in the cleanup process, once monetary considerations come into play.

- The cultural risk assessment process needs to take account of all the cultures involved. When considering long-term stewardship, assumptions need to be made on how the culture may change in the future and how this may affect the risks involved.

- In response to surveys, different cultural groups have viewed cleanup and the associated risks in different ways. This needs to be taken into consideration in the decision-making process[14]. Some members of the Native American community have expressed the view that risk assessments are used as a tool to justify involuntary exposures in order to save money. Many believe that risk assessments do not take enough account of cultural factors[17]. Getting an insight into the views and fears of the local population is a fundamental first step to taking account of cultural risks in the decision-making process surrounding cleanup and long-term stewardship.

Programmatic Risks - There are a number of programmatic risks associated with the actions taken in cleanup and long-term stewardship. The benefits of undertaking a comprehensive project risk assessment and management exercise before remediation work begins, ideally at the decision-making phase, is increasingly being recognized. Some of the programmatic risks which may be encountered are summarized below:

- The cleanup and long-term stewardship phases may make extensive use of new technology. If the technology is novel and unproven it is vital to consider the risk of under performance and the effect that may have on the environment or public health.

- Long-term stewardship may involve controls or other measures which need to be in place for long periods of time. Consideration of the risk of controls failing needs to be an integral part of the decision-making process. This is considered further under institutional management in Section 8.

- Activities may also involve intersite cooperation which itself introduces a range of programmatic risks. There may be delays, outside the control of the waste producing site, which result in increased cost and/or risk of exposure to the environment or local populations.

- There is also a risk of lost opportunities in the future if the wrong decisions are taken now. Measures and controls installed for long-term stewardship should, wherever practically possible, not preclude alternative measures being taken in the future when technology may have advanced. Measures should be reviewed every five years under the CERCLA process and it is important to avoid foreclosing options for future generations[5].

Hazard Scenarios during Long-term Stewardship

The above discussion has considered the targets at risk that should be addressed in the risk management process. In considering the risk issues to be addressed in stewardship, it is beneficial to consider also those hazard scenarios that may be of particular concern in the longer term. A number of specific risk issues that may require particular attention have been identified[1] and include the following:

- Failure of planned long-term controls;
- Non-traditional risks, for example terrorism and human intrusion, including accidental intrusion;
- Future cultural and technological change, including lifestyle changes and technology breakthroughs;
- Extremely severe weather or geological events which may have been discounted over the short term due to their rarity but may be significant in the longer term;
- Incremental effects, such as weathering over many hundreds of years;
- Future land-use changes, off-site as well as on-site.

In this last respect it may be noted that impact may change at significant distances from the site that represents the source of the residual risk. For example, it has been recognized that draw-down of groundwater in the event of altered abstraction demands has the potential to create significant changes in hydro geological baselines over considerable distances.

More broadly, longer-term risks may be influenced by geo-physical changes occurring on the longer geological time frame over which some residual risks may persist. Such issues have received significant attention in the context of long term waste disposal.

Uncertainty

Given the time scales involved and the types of risk issues that long-term stewardship must address, uncertainty is inevitably a key issue that the risk management decision-making process will have to come to terms with. It may simply not be possible in many circumstances to prescribe long-term solutions that we can be confident in meeting a defined standard of protection of human health and environmental protection. International experience has identified the potential difficulties encountered in attempts to provide longer-term safety justifications for waste disposal facilities, based on the demonstration of deninimis risk. The use of concepts such as the “rolling present”, as discussed earlier[5] may provide a basis for accommodating these unavoidable uncertainties.

6 COMMUNITY ISSUES

6.1 Community Stewardship

The transition from cleanup to long-term stewardship will affect the lives of the surrounding communities. When decisions are made about future land-use and long term management local community impacts should be an important consideration. Long-term stewardship activities will need stakeholder involvement. The local people must be aware of the risks posed by the site and the measures in place to manage those risks. Many long-term stewardship actions will need to be in place for long periods of time, and without the support of the local communities this will be very difficult to achieve.

Employment is likely to be lost to the area once cleanup is complete. In some cases it may be appropriate for the DOE land to be used for some sort of new industrial development, perhaps even involving incentives to companies to

locate there, in an effort to bring new jobs to the area. In other cases, cleanup activities have successfully involved training local young people with skills which are transferable to other jobs once the cleanup operations are complete[1.8].

During the transition from operating site to cleanup it was, to some extent, possible to protect jobs artificially by giving present staff first refusal on any jobs created for the remediation work. This acted as a temporary buffer for the community. However, in the future many sites will only require minimal stewardship activities which will not provide extensive employment opportunities. The socio-economic issues will have to be considered in another way. The local community needs a self-sustaining approach to job creation and other social factors, and the DOE needs to consider to what extent it has a long-term responsibility in that area.

Employment issues are being examined by the Energy Communities Alliance (ECA) which is an organization of local governments surrounding or impacted by DOE sites. Its mission is to improve the quality of life for its community members through continuing dialogue with DOE. Among ECA' s policies is to encourage self-sufficient economic diversification and development in order to revitalize the affected communities[19].

The current “accelerated cleanup” approach adopted by DOE focuses on a vision of closure and provides for the implementation of more cost-effective cleanup. This policy may have implications for the community and some flexibility in defining timescales may help accommodate some of the transition issues.

6.2 Public Perception of Risk

Public perceptions may not always be an accurate reflection of the risks faced but actions need to be taken to address those perceived risks. Further public education activities could be undertaken to allay the fears of the public. Alternatively, actions could be taken to eliminate or reduce the source of the perceived risk. These actions may not be justifiable on risk reduction terms but if they help to build public confidence they may be worthwhile.

Public values are an integral part of balancing risk, costs and benefits and so must be factored into the underlying evaluations of the results of decisions and actions. Public administrators need to determine important societal values that affect a decision and seek adaptable solutions to suit each individual situation[5].

Some efforts have been made to capture broader public perceptions on future land use options[14]. This work has identified a variety of opinions and concerns which included financial considerations. It is important that the public are fully involved in the decisions regarding future land-use. The overall process should not be concerned solely with risk management but also with benefit management. Certain future land-uses may be of great benefit to the local communities and this should be reflected in the decision-making process.

7 THE DECISION-MAKING PROCESS

Decision-making in the context of long-term stewardship must address two distinct aspects of the overall process over two distinct timescales.

- **Before site closure** - Decisions made on cleanup levels will directly affect the level and extent of long-term stewardship required. How can long term risks and associated stewardship actions be factored into cleanup decisions to allow for an holistic approach to decision-making to be adopted?

- **After site closure** - flow can the best risk-informed long-term stewardship decisions be made once cleanup is complete?

The current focus is primarily on addressing the first of these two aspects but, increasingly as sites move to closure, the emphasis will need to change. This section reviews the overall framework in which decision-making currently takes place and some of the key considerations in the risk management decision-making process. It then considers the implications for the development of effective decision-making processes and the tools that may support them.

7.1 Framework for Decision-making

Many existing cleanup decisions have been driven by existing regulatory frameworks, such as CERCLA and RCRA. The decision-making process has been defined and is supported by specific risk assessment protocols. The CERCLA framework, for example, provides a basis for consideration of a broad range of factors. It prescribes[6] that the cost-effectiveness of proposed alternative remedial actions be taken into account addressing the total short- and long-term costs of operation and maintenance for the entire period during which such activities will be required. It further requires that certain key factors shall, at a minimum, be taken into account, including a number of risk issues identified in the earlier discussion in Section 5, for example:

- the long-term uncertainties associated with land disposal;
- the short- and long-term potential for adverse health effects from human exposure;
- long-term maintenance costs;
- the potential for future remedial action costs if the remedial action were to fail;
- the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

Such a framework should, in principle at least, provide a basis upon which effective risk management decisions can be made, incorporating a broad spectrum of long-term stewardship issues. However, some concerns have been raised as to how effectively it has been implemented in practice, as discussed further in Section 10.

DOE guidelines are also in place to aid risk assessment and risk management decisions. For example, Risk Data Sheets and Management Evaluation Matrices exist which focus on risk reduction but also recognize mortgage reduction as a key factor. The Center for Risk Excellence is supporting efforts to maintain site-wide integrated risk prioritization processes or methodologies to address actual risks and other social and cultural factors and has managed a risk profile initiative to help sites in their understanding of risks[20].

Internationally, risk management decision-making processes that use goal-based rather than prescriptive standards have been found to be effective. There are a number of examples where the use of more flexible regulations has resulted in cost-effective solutions[21]. In recent years there has been extensive debate on the use of risk-based approaches in the US but, although the techniques are well understood in the technical community, there is yet to be widespread acceptance among the wider population. A critical issue to address in developing an effective approach is striking a balance between the provision of flexibility to meet the needs of specific problems and the avoidance of ambiguity.

7.2 Considerations in the Decision-making Process

Risk reduction is the primary factor in the decision-making process but cannot be considered in isolation. Long-term stewardship requirements are also driven by technical, financial and other constraints in both the pre-closure and post-closure phases.

7.2.1 Technical Constraints

Technological constraints on cleanup activities necessitate long-term stewardship. Technology is not currently available to clean up all DOE sites to their former state, which leaves many sites needing long-term care and surveillance. New technologies are being developed all the time but in some situations there is no realistic prospect of the site being cleaned to a standard suitable for any type of reuse in the foreseeable future, for example at the Nevada test site. In these cases long-term stewardship will predominantly involve barriers to isolate the contamination and protect members of the public and the surrounding environment.

In many cases there may be no current technology to fully remediate the land but prospects that it may be developed given time and money. A balance has to be struck between accepting technical constraints, and trying to overcome them. At some sites it may be appropriate to accept a reduced cleanup level, install long-term controls and release land for restricted use. At others, it may be beneficial to delay cleanup until a new technology is fully developed to allow for a higher standard to be reached. Cleanup to one standard should not preclude further cleanup in the future but revisiting cleanup may be very expensive.

Two critical challenges for DOE's EM program in seeking to strike an effective balance between acceptance of technical constraints and pursuing further research and development to overcome them are:

- ensuring a link between DOE's strategic vision and the issues faced at the site level;

- providing for integration across the complex to maximize the benefits from future advances.

A particular focus in the current context is how best to use risk information to address these challenges.

Long-term controls are themselves subject to technical constraints. Mitigation measures for long term risk may need to be in place for long periods of time which may not be achievable. It is important to identify where technical constraints will prevent long-term controls from being effective. At this stage in the program there is inevitably limited experience of technical constraints in these areas but this should grow as more sites move to closure. This will allow for research and development activities to be undertaken to improve long-term controls or enhance cleanup levels.

7.2.2 Financial Constraints

Decisions on cleanup and long-term stewardship must be made with financial constraints in mind. Care of DOE sites will be paid for by Federal funds and ultimately the US taxpayer. The more that is spent on cleanup then the less that can be spent in other areas such as education and healthcare.

It is important for the DOE to assess how severe these financial limitations may be in comparison to the estimated cost of meeting the objectives of long-term care across the complex. It is not just absolute values that are critical but the perceptions of financial constraints both in political circles and across the complex. In order for cost-effective

solutions to be reached there must be an appreciation of all the limitations, including financial constraints. Unless staff at sites and local communities have a perception of the funding constraints negotiations to reach solutions are not likely to take full account of monetary factors.

It has been said that enhanced performance shouldn't just be a strategy reserved for situations[22] where there is a funding shortage, it should be an integral part of EM culture[22]. This is an excellent principle, but general practice has shown that, without a financial driver, improvements in cost-effectiveness tend to be slow. Financial constraints need to be considered both at a central and at a site level to allow the best use to be made of the available funds[5].

Guidelines for intergenerational decision-making must recognize limits on funds and resources[5]. Discussions on funding for long-term stewardship activities are still in their infancy and are unlikely to be brought to the fore while funding levels for cleanup are still running high. However, consideration needs to be given to the anticipated costs and funding sources for future stewardship activities[9]. Relatively few sites are currently in the stewardship phase but this is set to rise sharply over the coming years which is liable to produce a number of financial constraints. Prioritizing sites by the magnitude of the risk they present will be one method of addressing the potential financial constraints.

A balance must be reached between spending money in the present and spending money in the future. If current technology cannot be used to remediate land to an extent where it can be released for unrestricted use, money can be spent in the present on further research, or in the future on long-term stewardship activities, or some combination of the two.

A key issue for DOE as a whole to address in this context is identifying the overall financial constraints within which it needs to bring its sites to closure and manage its longer-term stewardship responsibilities. International experience suggests[21] that clear definition of the budget constraints helps focus on the identification and implementation of affordable solutions. The scale of the challenge introduces a further dimension to be addressed. DOE needs to ensure that an appropriate balance is struck between cleanup and long-term stewardship across all of its sites.

DOE has seen an evolution in its budget process, including the use of risk information to guide that process as a better understanding of the costs and risks involved has developed. An initial focus on managing urgent risks has shifted towards a vision of coming to closure in a financially responsible manner that emphasizes the importance of mortgage reduction and recognizes that resources are limited. It should be recognized that financial constraints cannot necessarily be considered in isolation from their implications as regards achievement of program objectives. In this context it may be useful to appreciate to what extent meeting certain risk management objectives are seen to be imperatives or negotiable targets.

7.2.3 Balances in the Decision-making Process

The foregoing discussion of constraints implies the need for compromise and balance in the decision-making process. In addition to the basic balance between cost and benefit in cleanup and long-term stewardship there are a number of other factors which may need to be balanced against one another in order to gain maximum overall benefit. This involves securing some benefits on the understanding that others will not be realized.

Conflicting objectives come in a number of different forms, such as:

- immediate cleanup actions versus long-term stewardship actions,
- short-term versus long-term risk,

- limited cleanup now versus investment for better cleanup in the future,
- level of cleanup versus time to site release,
- cleanup at one site versus cleanup at another,
- cleanup versus other compensatory actions.

We consider each of these issues in turn below, by way of background to evaluating the requirements for an effective process for addressing the essential compromises that must be tackled in risk management decision-making in the context of stewardship.

Immediate cleanup actions versus long-term stewardship

The more cleanup which is carried out in the short-term, the lower the long-term stewardship requirements will be. However if cleanup is currently prohibitively expensive or technically unfeasible it may be more sensible to accept that long-term controls are the best option, as least as an interim measure.

In some cases natural attenuation may be the best remediation option. This will allow the magnitude of the hazard to diminish without exposing workers or the public to an increased risk during remediation work. Funding for these sites could be channeled into establishing appropriate measures for containing the contamination while the natural remediation takes place. If sites are so badly contaminated that they cannot be released for any alternative use in the foreseeable future then the balance is already decided. Long-term stewardship is the only feasible option.

Short-term versus long-term risks

The principles of intergenerational decision-making, discussed earlier[5], describe the responsibility one generation has to the next. In particular the precautionary principle states that “each generation must provide for the needs of the living and succeeding generation and that near-term concrete hazards have priority over long-term hypothetical hazards”.

This principle has implications for much cleanup activity. In order to reduce the risk for subsequent generations, actions need to be taken now which may increase the risk to workers, the public and the environment in the short-term. If this risk is too high it may be better to use long-term stewardship measures to control the risk and accept that it will still be a risk for subsequent generations. A balance needs to be struck. In particular the potential increased risk to remediation workers should be balanced with the expected reduction in risk to the public in general.

Many people support the idea that compromises should not be made that favor the future if they fail to meet the crucial obligations of the present generations[5]. Future impacts should be weighted differently from current impacts when making risk-based decisions, but both should be taken into consideration.

Limited cleanup now versus better investment for cleanup in the future

Decisions need to be taken on whether to cleanup sites quickly so that they can be released for other uses, even though the cleanup may be to a lower standard than desired or to invest in technology which will allow better cleanup in the future. The latter will involve potentially substantial stewardship costs in the interim period, with no guarantee that cleanup methods will be improved.

There is little dispute that some investment in new technologies is needed now in order to reduce risks further in the future. The questions remains of how much to invest and in which areas. Decisions need to be made which will maximize the extent of future risk reduction for the money spent in the present on research and development. Mortgage reduction is a key factor. By removing some sites from a care and maintenance program the costs of cleanup may be recouped in a relatively short period. At other sites the monetary driver will not be as strong but other factors may encourage a timely cleanup.

Balancing short and long term risk reduction may become more complex if the present and future budget decisions are made by different agencies. If long-term stewardship decisions and cleanup decisions are made by different agencies then this may have implications for balances which are negotiated under the present regime.

Level of cleanup versus time to site release

DOE is currently working to an accelerated program for site closure and cleanup. It is estimated that reducing the timescale for cleanup decreases the costs by over $40 billion due to completed cleanup, reduced overhead and support costs, re-sequenced activities and improved cross-site integration[22].

Complete site cleanup may be an ideal solution for many sites but is often technically unfeasible. Even if it is possible, the more cleanup work that is carried out, the longer it will take before the site can be released. Even if funding is available, site release may not happen for generations, and so the local communities may wish to accept a lower standard of cleanup, consistent with future land-use plans, in return for regaining their land for limited use on a much shorter timescale.

Cleanup at one site versus cleanup at another

It is very difficult to reach negotiated solutions with local people which involve trading-off cleanup in their locality with cleanup elsewhere. However, with a limited budget it is a concept which the DOE as a whole may need to consider, as discussed to some extent earlier under Section 7.2.2.

Some sites may contain areas of very badly contaminated land along with areas which are less contaminated. There may be limited benefit in cleaning some areas to otherwise appropriate site release standards if contamination in other areas will prevent site release. It may be better to spend that money elsewhere in order to obtain the maximum benefit for the dollar spent.

If a site is cleaned up to an appropriate site release standard, a large amount of radioactive for chemical waste may be generated which will need disposal somewhere[2]. There are advantages for long-term stewardship if waste is consolidated in a few sites rather than spread across the complex, but this will still leave some sites as waste repositories with long-term needs. The amount of waste generated will vary enormously depending on the cleanup level selected[14]. The cleaner one site is left, the more waste will be produced which will have to be deposited at another site.

Cleanup versus other compensatory actions

Money spent on cleanup is not necessarily the only form of financial compromise which can be employed. International experience in Australia has demonstrated that a community may be willing to accept some other form of compensation if complete cleanup is not viable or considered beneficial. The native Aboriginal people took compensation in recognition of the temporary removal of some parts of their land and the permanent removal of other areas which were heavily contaminated. This compensation took the form of monetary investment and

community facilities such as roads and a resource center aimed at enhancing the quality of life for the local people without impacting on their culture[21]. Monetary compensation is an issue which the international radioactive waste management community have been debating for many years. It has been suggested that direct monetary compensation is not ethical but it has been successfully implemented in some countries[4].

7.3 Implications for Definition/Selection of End-states

The end-state selected for the cleanup process will, to a large extent, determine the long-term stewardship requirements. However, constraints on possible long-term stewardship requirements should influence the chosen end-state. As discussed in the preceding sections, a wide variety of factors may need to be taken into account and balanced between one another. An effective decision-making process may need to look iteratively at end-state and associated land-use options, having regard to their cleanup and long-term stewardship requirements and related constraints, together with the preferences of local communities, before an optimum solution can be reached.

Definition of end-state should be influenced, where technically feasible, by the desired future land-use. This will have a significant impact on decisions regarding the remediation of contaminated property[14]. Defining end-states is a key aspect of defining the scope of the cleanup program but can only be effectively achieved in an iterative process. However, it is important to recognize that the process is about making decisions, not just performing analysis[5] and that it is impractical to seek always to develop optimum solutions that will stand the full test of time. A desired end-state can be chosen but this will be subject to the financial and technical constraints of both cleanup and the long-term stewardship. After consideration of these other factors it may be necessary to revisit and compromise on the end-state. The ‘Paths to Closure' document[22] is based on the best available end-state assumptions for each site but many decisions still have to be made.

The selection of a particular future land-use may create a need for long-term management to ensure that the land is not used for an alternative purpose which may expose workers, the public or the environment to a greater risk, Conversely, the need for particular long-term measures, such as continued monitoring or maintenance, may prohibit some potential future uses. Again, it is only by iterating around the loop that all the relevant factors in the situation are accounted for, revisiting the definition of the end-state until a compromise solution can be reached.

It is important to involve the local people in decisions regarding future land-use. International experience[21] has shown that the end-state chosen by the local communities is not always the one dictating the most stringent cleanup requirements, representing the most expensive or technically challenging option, but it is only by involvement that this can be ascertained.

For example, in Germany a number of former uranium mining sites were being remediated. The local people requested that many of them were turned into industrial sites in order to replace some of the employment lost to the area on the closure of the mines. Land to be reused for industrial purposes does not need to be cleaned to as high a standard as for other uses which released money for further remediation at other sites.

In Australia, large areas of traditional Aboriginal land had been radioactively contaminated during nuclear tests and were in need of remediation. However, extensive remediation would have resulted in widespread destruction of vegetation and topsoil. The native population were deeply opposed to this. Instead, hotspots of contamination were removed to allow the people to walk safely across the land even though they could not actually live and camp there. There are many similar examples both in the US and across the world where solutions have been reached which are acceptable to all parties.

Many current assumptions of land-use at DOE sites do not preclude future decisions to cleanup to a higher standard[22]. This allows the land to be released as soon as is feasible, without foreclosing future cleanup options if they arise.

7.4 Supporting Tools

Having considered the current decision-making framework and some of the issues that it will need to address, we turn now to consider some tools that may support the effective integration of risk management between cleanup and long-term stewardship. Specifically, we identify three key support tools of relevance to the current discussions:

- risk assessment methodologies;
- standards and criteria;
- decision support tools.

A comprehensive decision-making process needs to take account of a number of different factors. Conventional risk assessments are a useful tool for analyzing one key factor but need to be backed up by methods of assessing other factors such as financial or community issues. Analysis of risk and other factors in itself does not provide decisions. The significance of these factors must be evaluated and weighed in the balance against one another, inevitably introducing subjectivity into the process. Standards and criteria are useful aids to decision-making that can help bring an element of objectivity into this process, although it is important to understand their limitations.

To work effectively within financial constraints, there needs to be a mechanism for balancing cost with human health and environmental risk. One way of doing this is the use of cost-benefit analysis which quantifies the money that should be spent in order to save a life. This technique has been widely used in Europe but is not universally accepted. When dealing with environmental risks the situation becomes still more complex. How can monetary values be put on the environment? In one area a habitat or particular species may be considered very rare and in need of protection. In other areas it may be considered common place and of less value. Attempting to quantify the value of a life or an ecosystem is extremely complex and relies heavily on individual values and judgment.

Many different parties need to be involved in the making decisions on long-term stewardship. These include Federal agencies, state governments, local governments and local people. Different types of decision will be made at different levels but inter-party communication is key. The decision support tools must be comprehensible to and accepted by all parties involved.

7.5 Risk Assessment

Significant effort and resources have been directed towards the development of risk assessment techniques of relevance to the evaluation of residual risk and other risk issues in cleanup and stewardship. There are a variety of tools and well-developed approaches available. For example CERCLA and internal DOE guidelines prescribe methodologies for use in some situations. In relation to long-term stewardship, two questions need to be asked:

- How well do current risk assessment techniques deal with all risks posed by cleanup and stewardship at redundant DOE facilities?
- What are the particular issues to be addressed in long-term risk management?

In the first instance, we may identify potential limitations in the basic approach to risk assessment. Conventional risk assessments in the past have often been based primarily on the principles of toxicology. Many risk assessments have focused on cancer risks and do not take full account of other problems such as respiratory problems, birth defects and learning difficulties and may not be able to deal with the combined effects of a number of different chemicals[17]. There may often not be sufficient scientific understanding to determine some of these health effects in detail. However, in identifying an appropriate risk assessment approach to meet future requirements, it should be recognized that the level of detail need be no more than that required to make sound defensible decisions. The provision of scientifically precise and detailed analysis is not an objective in itself.

Risk assessments can only be as good as the data which is available to support them. There are almost invariably uncertainties and gaps in the information. Assumptions and estimations will therefore usually be an integral part of the risk assessment process. Both the risk assessment and risk management decision-making processes must therefore be compatible with these data limitations. Alternatively, if robust decisions cannot be made on the basis of available data, programs to address these data gaps may be required. This is discussed further in Section 8.

A number of issues that maybe of particular relevance to the assessment of longer-term risk have been identified earlier in Section 5. In particular, risk assessment for long-term stewardship will need to take account of a number of factors not previously considered, due to the extended periods of time which are involved. Given the uncertainties with any risk assessment, quantifying the risks stretching over many years into the future is even more difficult. The risk analysis also needs to be site specific to include local factors. For example, in some areas the roots of particular types of plants are attacking caps which have been put in place. These plants will not be able to grow in other areas and climates[18]. There are many other factors which will need to be taken into account when risks are to be assessed over hundreds or thousands of years which are not relevant to short-term risk assessments. The DOE has begun to research and understand these risks but more work is needed.

Risk analysis needs to be based upon a proper understanding of the communities at risk, for example their cultures and lifestyles, as the assumptions made are key to the outcome of the analysis. Risk assessments need to take account of present and future risks. In order to achieve this predictions must be made about the behavior of future generations to feed into the assessment. These can never be more than an educated guess but are a vital part of the assessment of long-term residual risk.

The preceding discussion has focused around the role of risk assessment in support of long-term risk management. Another key aspect to consider is how long-term stewardship can accommodate the current status of risk assessment. The uncertainties and other limitations associated with risk assessments will influence long-term stewardship and risk management planning, for example as regards monitoring and surveillance requirements or perhaps revisiting risk assessments.

Risk assessments need to be transparent and understandable to the general population if they are to be accepted and believed. Long-term stewardship actions will need the support of the local communities if they are to be successful into the future and this will only be obtained if the communities have confidence that the measures in place are protective of their health and environment. Some people would prefer to move away from technically detailed quantitative risk assessments into a more qualitative process but there are a lot of legal, political and technical challenges to overcome before that could become a reality[17]. There could still be a place for conventional risk assessments in decision-making but perhaps as one of a range of tools rather than the principle mechanism.

7.5.1 Standards and Criteria

Defined quantitative risk standards and criteria have commonly been applied to risk management decision-making in

a number of countries and to address a wide range of risks[21] . Specifically, quantitative standards for fatality risk have been identified in the context of CERCLA and RCRA legislation. Risk management goals and objectives under CERCLA have evolved over time as real-world experience has tempered the idealist vision of eliminating risk. A climate of artificial protectiveness has given way, to some extent at least, to a more pragmatic one that accepts some risk. A framework of risk standards is therefore available, at least in respect of fatality risk.

Criteria for other health effects and for environmental factors are less well-defined. Approaches to defining quantitative criteria for environmental risks have been considered. More qualitative “descriptors” of the level of risk have often been applied to the prioritization of risks and as an aid to focus risk management[23]. Such an approach is adopted in DOE's process for collation of risk management information under the Management Evaluation Matrix Effective[24]. Effective criteria must provide a basis for balancing between a broad spectrum of risks.

If a risk-based approach is to be embraced, underpinned by defined quantitative criteria, it is important that these criteria are properly applied. The misapplication of standards is a relevant issue in residual risk management. Derived cleanup standards, in the form of residual soil contamination for example, may be appropriate for the particular situation for which they were developed, taking account of not only the level of contamination but site specific factors influencing the associated level of exposure. However, unless it is clear how they were derived there is a danger that they will be misapplied in the future. In these cases, existing standards may force actions to be taken which were not really necessary, diverting funds away from more pressing risk management issues. On the other hand, local communities may find the risk-based approach difficult to understand and may prefer a more prescriptive guarantee.

A specific issue to address in long-term stewardship is the longer term applicability of standards. There can be no guarantee that a criterion set now will still be applicable in the distant future. On the contrary, experience would clearly indicate that standards may change significantly. Standards and criteria can be reevaluated as time goes by and knowledge increases. Such issues might be better accommodated within long-term institutional management rather than in the cleanup decision-making process.

It may be appropriate to consider the failure of institutional controls when cleanup standards are set. For example, an exposure limit could be set which takes institutional controls into account but another level could be set as a maximum exposure if the institutional controls, such as deed restrictions, are ignored or fail. This approach has been used at Rocky Flats to evaluate soil action levels[25].

7.5.2 Decision Support Tools

As is clear from the above discussion, process guidelines for intergenerational decision-making must be capable of dealing with the many values and interests involved[5]. Decision support tools are available to facilitate the process.

To address the specific balance between the cost and the benefit of risk reduction, the cost-benefit analysis approach has been applied in a number of cases internationally[21] and is quite well-developed. As indicated earlier in the introduction to this section, adoption of this approach will require that a number of technical issues are addressed, for example how a value for preventing a fatality should be established and how environmental risks should be valued in comparison with human health and safety risks. However, more fundamental to the success of any attempt to follow this approach will be the acceptance by stakeholders that it represents a viable basis for decision-making. Some in the Tribal Nations, for example, have viewed the approach as a mechanism for justifying the imposition of involuntary risk[17], rather than a sensible and rational means for directing the user of limited resources.

More broadly, the multi-attribute value analysis method (MAVA) has been employed in order to factor all the

relevant issues into a decision. In principle, it is a transparent way of making decisions that clearly states the significance that has been put on different factors, but must involve all the concerned parties to be effective.

However the MAVA method can be of limited value when the negotiating parties have different value systems, as it becomes very difficult to agree on weightings of attributes. This has meant some stakeholders are hesitant in engaging in such an exercise. For example Tribal Nations, in particular, can be reluctant to use such methods[17]. There may be mechanisms for using MAVA in stewardship decisions which are more acceptable to all concerned. If there are not, alternative processes must be used to involve all the affected parties in the decision-making.

8 INSTITUTIONAL MANAGEMENT

Institutional management is the process of managing long-term stewardship, with the overall aim of controlling long-term risks. It has been described as *a term for the system of people, governments. agencies and mechanisms needed to develop, monitor, enforce and monitor the controls put in place to maximally ensure compliance with land use restrictions*[26]. Institutional controls are a very important component of institutional management but would not be able to function effectively without the human institutions put in place to manage them.

The functions of a long-term stewardship program are site monitoring and maintenance, application and enforcement of institutional and other controls, information management and environmental management[11]. Work at the Oak Ridge Operations Site has identified three fundamental attributes for a long-term stewardship program: responsibility, long-term effectiveness and adaptability. A successful institutional management process should address all three attributes[27].

DOE has begun to undertake fundamental research to provide a better understanding of the issues associated with institutional management. Work undertaken in connection with proposed long-term disposal of radioactive waste may also support the weapons site stewardship program. In addition to this work, DOE is gaining practical experience in stewardship though its LLMTRA site management program. Institutional management will inevitably raise some specific risk management and related issues. Some of the background to institutional management is considered briefly below to support identification of key risk issues.

8.1 Institutional Controls

Institutional controls are designed to protect human health and the environment from the effects of residual contamination on a site and the risks posed by such contamination. They have two principle functions:

- to control exposure pathways of residual contamination on the site;
- to protect any remedy put in place and monitor its effectiveness.

There are a number of different types of institutional control[28]. Some are purely legal controls such as easements, deed notifications, deed restrictions, zoning and other legislative requirements. Others are physical barriers such as fences, gates, guards or natural barriers. A third grouping is those that can be described as information provision. These include signs and other public awareness activities. The most effective means of institutional control may be continued Federal ownership but this may be politically unacceptable at many sites.

Attempts have been made to classify institutional controls. One classification system divided controls into active or

passive. Active controls require actions to be taken while passive require no action except for perhaps occasional maintenance activities. It is not always easy to classify controls and it may be more appropriate to think of them all as mechanisms that require an institutional structure for their implementation and maintenance, rather than trying to categorize them.

A number of critical risk issues need to be considered in the area of institutional management.
They include:

- how much control is enough to manage the residual risks?
- for how long will the controls be needed?
- how will the cost of controls be factored into the cleanup decision-making process?
- how will control needs change over time and how will this be managed?
- what is the risk of controls failing during their active life?
- how will data information needs be met?

These points are discussed in more detail below.

How much control is enough to manage the residual risks?

The institutional controls in place must be commensurate with the risk posed by the site to ensure that effective use is made of the available funding[28]. Long-term controls need to be effective in managing the long-term risks at DOE sites. However at present there is limited understanding of the nature and magnitude of these long-term risks. It is only as knowledge in this area grows that effective mitigation measures can be developed. The process is underway but more work is still needed. This topic has already been discussed in previous sections of this paper.

For how long will the controls be needed?

Controls may be needed at some sites for a relatively short period of time. However, at other sites they may be needed for hundreds or thousands of years. There is a long-term risk associated with the use of institutional controls as they have not yet proved to be effective over time. In general, active controls are not considered reliable for more than a hundred years and passive controls for more than a few hundred years[10]. This presents a difficult challenge for the management of waste which may be hazardous for tens of thousands of years.

How will the cost of controls be factored into the cleanup decision-making process?

As discussed earlier in Section 7, the definition of a preferred end-state will typically involve a balance between a range of competing objectives, one of which will be the cost of institutional management. The discounting method, as practiced in life cycle analysis would provide one approach. However, the provision of accurate data on likely long-term future costs may determine the extent to which the costs can be effectively factored into the process.

How will control needs change over time and how will this be managed?

The institutional controls themselves are only one part of the overall process. The management of these controls is

equally important. Institutional management is an iterative process which involves monitoring, review and, if appropriate, revision of controls.

The review may lead to revision of long-term controls for a variety of reason which include:

- the controls may not have performed as effectively as envisaged;
- new research may have changed the perception of risks at the site;
- new technology may have provided alternative mechanisms for long-term risk management;
- changes in lifestyle or other behavior may have changed the risk exposure pathways.

The effective implementation of long-term stewardship requires an institutional framework to facilitate the management of the entire process. DOE currently manages some long-term surveillance and maintenance activities from the Grand Junction Office. Other activities are coordinated with operations at the individual sites. Although long-term stewardship is currently only a minor component of EM's work it is set to increase over the coming years. Responsibility for EM's nuclear materials has not yet been determined beyond 2006[1]. There has been much debate over where the responsibility for long-term stewardship should lie, with DOE, EPA or a newly formed agency. This is a valid concern but perhaps one that detracts from some of the more pressing issues.

It may not be appropriate to try to establish a permanent stewardship organization now: change is inevitable and should not be viewed in a negative light. It is important that some entity staffs the process of ensuring that stewardship functions are preserved[11] but this should be done in such a way that the responsibility can be passed to another agency in a smooth transition if this becomes appropriate. Further work is needed addressing ways of assessing and managing long-term risks, taking account of the achievements so far, and so there needs to be an entity responsible for the direction and coordination of this work. However, longer term responsibility can be decided at a later date.

What is the risk of controls failing during their active?

The risk of controls failing over the long periods of time they may be required is potentially a significant one. For physical barriers, this can be managed, either by investing in robust technologies that minimize the likelihood of failure, or by implementing a monitoring and maintenance program to detect failure, as part of the institutional management process. It may be somewhat harder to monitor compliance with controls based on legal restrictions. Relatively little is currently known about the effectiveness of long-term management controls but a substantial amount of work is being undertaken. For example, the National Academy of Sciences and the Environmental Law Institute are looking at different aspects of institutional controls and extensive work is underway evaluating controls for the proposed disposal site at Yucca Mountain[1]. Institutional control needs for a major repository will be different from those of other DOE sites although lessons learnt can be applicable to all sites. These are only a few examples of the current research program. In the coming years much more may become known about the effectiveness of long-term controls which will make decisions regarding the management of long-term risk less uncertain.

How will data/information needs be met?

The production and maintenance of accurate records is an essential element of long-term risk management. Some work is being carried out in this area to assess data needs, in particular by the EM Office of Strategic Planning and

Analysis and their contractors[29] but the subject is still in its relative infancy.

8.2 Data needs

For effective long-term stewardship, there are a number of data requirements. These include information on hazards and controls, operations and activities, regulatory and legal frameworks, site characterization and setting[29]. In particular, if long-term risks are to be effectively managed the site stewards will need to know[2]:

- an estimation of the contamination remaining on site,
- an evaluation of the pathway from the site to hypothetical receptors,
- proposed site cleanup end-state configurations,
- human health effect models and protection standards

In general, effective long-term risk management requires an understanding of the source of the risks. This information could come from records of activities on the site and from site investigations. In decision-making there is no substitute for relevant, objective information but a decision-maker must be realistic and recognize the limitations and uncertainties of the data available[5]. The risk that information is incorrect or incomplete needs to be considered as part of the risk assessment process.

Existing data

Most of the required information already exists in one form or another in different sources but it is difficult to find and is being lost[29]. Approximately 3.2 million cubic feet of DOE records survive in dozens of locations across the US but the costs associated with locating and retrieving this information are significant. Information may be destroyed before it is needed for stewardship activities. Even if the data is kept, future generations may not know of its existence and spend valuable resources recreating it. Of greater concern is the information which will not be retrievable.

Future requirements

Currently there are no requirements or standardized practices relating to the provision of information to support long-term stewardship activities. Although most of the required information is available, there needs to be a mechanism for recognizing and organizing the data so that it is readily retrievable. Measures may include modifying existing record retention systems, to ensure that data is kept for long enough, and developing a system, such as a National Record Center, to improve the accessibility of stewardship data. Such an information system should probably involve both high and low technologies, e.g. be both computer and paper based.

Information management needs to be properly coordinated with property transfer to ensure that any long-term risks associated with a site are understood and managed by the new owners. Ownership of DOE sites may be transferred to other parties, or another Federal Agency may take over long-term responsibility for sites. It is vital that new owners have easy access to all the information generated in the past so they can accurately assess and manage risks.

9 TECHNOLOGY

Continued new technology development and effective deployment of both existing and developing technologies is integral to DOE's EM mission. Site specific ‘Paths to Closure' documents have identified 543 science and technology needs based on the designation of technical programmatic risk. DOE have an extensive technology development program and plan to bring into use more than a hundred new technologies in the next four years[22]. This illustrates the scale of the technology development program which, to date, has focused largely on cleanup technology.

The development of long-term stewardship programs and their effective integration with cleanup require that we begin now to consider technology needs. It has been recognized in earlier work that processes for intergenerational decision-making should be technically comprehensive, seeking out the best available knowledge and data on a continuous rolling basis[5].

Technology development impacts long term stewardship in two areas:

- improved cleanup technology will reduce long-term stewardship requirements through the better elimination or reduction of risk;

- new technology for institutional controls will allow more efficient and cost-effective long-term stewardship.

The present generation have a duty to foster the development of new techniques so that subsequent generations may be able to solve existing contamination problems[5] but a balance has to be struck. The first step needs to be the identification of long-term challenges which exist because of non-existent or currently ineffective technologies[9]. New cleanup technology research needs to be focused on areas where the most benefit can be gained, such as cross-site issues and technologies which have a good chance of working effectively.

Money spent today on long-term stewardship research must be focused on the current and anticipated technological needs. Decisions should reflect the limitations of existing technologies, risk management goals, technology development costs and potential benefits and the breadth of application[1]. Investment decisions must be made on the basis of risk or cost reduction. These consideration should address the potential for cost reduction in both cleanup and stewardship phases of the EM program.

In all areas, development effort must be focused where there is a defined need which cannot be met cost-effectively by current technologies. Many decommissioning and long-term care tasks do not need brand new technology, just innovative use of existing technologies. Creative solutions should be the overall goal: development of novel technology is just one approach.

Overall, there has to be a balance between short-term and long-term objectives. If cleanup and long-term stewardship considerations are to be effectively integrated into the current decision- making round, it is important to begin to address now some of the technological problems that long-term stewardship will present. However it may be difficult to focus effort and resources into the future when the current emphasis is on achieving as much cleanup as possible in the next few years.

10 REGULATORY CONSIDERATIONS

There are two principle regulatory considerations which need to be addressed:

- How do the risk issues of long-term stewardship, as identified in this paper and elsewhere, fit into the current

regulatory framework?

- What are the future regulatory needs of long-term stewardship?

10.1 Current regulations

Any process guidelines for intergenerational decision-making must be linked to current structures, institutions and decision processes. They must be stable, sustainable and rooted in the constitution[5]. A crucial part of the debate of the issues raised in this paper and in subsequent discussions is whether they are in line with current legislative requirements.

The cleanup and stewardship of DOE sites is governed by a number of Federal regulations. These include NEPA (National Environmental Policy Act), CERCLA (Comprehensive Environmental Response, Compensation and Liability Act, and RCRA (Resource Conservation and Recovery Act) regulations.

These regulations prescribe a process for decision-making which includes environmental risk assessments and public involvement. The process is supported by guidance on the performance of key steps in the process, including risk assessment. The output from the CERCLA process is a Record of Decision (ROD) agreed in accordance to the CERCLA Cleanup Standards. As noted earlier, these standards define a specific requirement that measures taken provide for a cost-effective response. The standards farther require that account is taken of long-term uncertainties, short and long-term potential for adverse health effects, long-term maintenance costs, potential for future remediation costs and the potential risks of remediation activities. They also stipulate the need for review of remedial measures every five years and set a minimum level for state involvement. Wider community issues are not explicitly covered in the regulations.

The decision-making process itself is prescribed in some detail by the regulations and supporting guidance. The specific remedial measures are not prescribed by regulation but are derived by following the defined process. The remedial measures that are identified are then prescribed in the ROD. In principle, such an approach should allow for the flexibility that may be required to arrive at pragmatic decisions that balance between the wide range of factors discussed in Section 7.

The current process and associated guidance acknowledges the significance of long-term risk and the role that institutional management and long-term stewardship can play in addressing residual risk. Long-term stewardship issues are not excluded from the existing regulatory framework though they are not specifically addressed in detail. The initial emphasis has been very much on finding permanent remedies though this has perhaps shifted somewhat to greater acceptance of the use of institutional controls in light of practical experience gained in implementing the current regulations. However, as noted earlier in Section 4.1, EPA guidelines recommend that active controls cannot be relied upon for more than 100 years and passive controls for not more than a few hundred years[10]. This would imply avoidance of reliance on institutional controls when dealing with many of the hazards at DOE that may persist for thousands of years.

This regulatory framework also requires that account be taken of applicable, relevant and appropriate regulations (ARARs) when reaching remedial action decisions. These may include, for example, state and federal laws that prescribe environmental quality standards in terms of maximum permissible concentrations of identified contaminants. For example, under the Safe Drinking Water Act (SDWA) EPA promulgate a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL). EPA has typically developed such standards through consideration of human health risk management objectives, which requires assumptions to be made on exposure pathways.

Compliance with such regulations and associated standards may be a relevant consideration in the current context. However, if the principles of risk-based decision-making and cost-effectiveness are to be applied in taking account of such derived environmental quality standards, care should be taken to ensure that the standards are applicable to site specific circumstances. However, there may be a tendency to seek the assurance of prescribed standards when developing environmental management objectives.

Some environmental groups have suggested the current approach to environmental protection is too “piecemeal”, encouraging compliance with a long list of requirements. These groups have campaigned for a more “holistic” approach to enable all aspects of a situation to be taken into account[8].

As indicated above, the current regulatory process leads to legally binding remedial actions being prescribed. However, beyond the initial cleanup decision, decisions on long-term stewardship should be made with the actual magnitude of the risk in mind, in light of current understanding. In cases where institutional controls that are in place to reduce or eliminate the risk have been prescribed this prescription may not be consistent the current assessment of the actual risk posed. For example, where caps are in place to contain contamination, regulations may specify dimensions and materials of the cap and remedial action is automatically required if the caps fall outside of these requirements. Such an approach does not necessarily take account of the actual risk the contaminated material is presenting, or the risk of material leaking if the cap dimensions change. Protection will be maintained by these standards but perhaps not in a cost-effective way. Experience indicates there may be a case for modifying these defined solutions in light of improving understanding. The five year review that is built into the current CERCLA legislation should allow for this, but there may be a reluctance promote change.

Overall, the current regulations would appear to provide a framework that allows a balance to be struck, tailoring solutions to address site specific problems. The extent to which this flexibility is utilized effectively will depend upon the way in which the regulations are implemented. It relies on a premium being placed on compliance with the “spirit of the law” rather than the “letter of the law”[8]. In many cases the system has been shown to be flexible and allow negotiated solutions to be reached on the basis of the real risks involved. The key factor is to ensure that all parties involved have confidence that the solution reached will comply with the regulations. Without that confidence a prescribed, strict course of action is likely to be preferred.

Although the situation is complex, in cases where a risk-based approach has not been successfully implemented it is perhaps more a matter of interpretation than inherent regulatory inflexibility which has been the limiting factor. There has been much discussion on the use of goal-based rather than prescriptive approaches to risk management within the USDOE[21]. One conclusion which was reached is that, while goal-based regulations can encourage cost-effective solutions to be reached, the implementation of the regulations is more complex and requires more discretion on the part of the regulator. If the monetary driver is not present to push for a more cost-effective solutions, prescriptive regulations may be thought of as the more straightforward option.

10.2 Future regulatory requirements

Some aspects of long-term stewardship are addressed by current regulations, and may be effectively governed, in the short-term at least, without major regulatory revision. Areas of regulation which may need to be developed in the future are those addressing long-term responsibility for both the implementation of a long-term stewardship program and its regulatory oversight.

Federal legislation may ultimately be required to create an enduring long-term stewardship mandate. Such legislation would outline the stewardship function, define the scope of the program and set out the roles and responsibilities of all involved parties[11]. Legislation would help to guarantee the survival and the funding of a stewardship function but

the question remains as to when this may be necessary. Some believe it is an urgent requirement while others would prefer to see the long-term stewardship function grow and develop within the EM program with long-term responsibility allocated at a later date once the scope of the program is better defined.

There may be a need to ensure external accountability. Assuming that the DOE retains responsibility for long-term stewardship, this could come from the EPA, the NRC or by creating a new independent agency[11]. There are advantages and disadvantages of all three options but any may provide the answer. This issue is perhaps for debate in the longer term rather than an immediate factor for resolution.

11 SUMMARY DISCUSSION POINTS

Drawing on the material that has been presented in the preceding discussion, a number of questions are identified as a starting point for development of CRE's program for addressing the risk management requirements of long-term stewardship. Such a program may incorporate a diverse range of components, covering basic research and development activities, development of guidelines, information dissemination and stakeholder consultation.

The questions address issues surrounding the principles, the process and the regulatory and institutional framework that will underpin effective long-term residual risk management at DOE sites. They are posed to initiate discussion and debate, recognizing that work that has already been undertaken within DOE's EM program and presented in the preceding discussion may go some way to answering many of them.. The issues and questions put forward to initiate the debate are as follows:

- **Guiding principles.** In Section 3, a number of guiding principles are identified by which risks, costs and benefits may be balanced fairly across generations. These have been derived through consideration of ethical questions surrounding intergenerational equity. Key principles identified are, the Precautionary Principle, the Trustee Principle, the Sustainability Principle and the Chain of Obligation Principle. These are supported by the two farther principles of Cost-effectiveness and Affordability.

  Discussion Points

  • Have we identified an appropriate, self-consistent and comprehensive set of guiding principles that can form a sound basis for a future stewardship program?

  • Does DOE as a whole subscribe to these principles?

  • Will the wider community subscribe to them and how should DOE present them to its stakeholders and to the Indian Nations?

  • By what mechanism will the identified principles be implemented in practice?

- **Scope of Stewardship**. In Section 4, consideration is given to the potential scope of DOE's stewardship program, addressing in particular the appropriate timescale that should be considered, the integration of cleanup with stewardship in the decision-making process and the possible inclusion of issues beyond health, safety and environmental risk management. Further consideration is given to community related issues in Section 6.

  Discussion Points

- What should be the scope of stewardship?

- To what extent should DOE be seeking to integrate cleanup and long-term stewardship?

- How long is long-term in the context of DOE site stewardship?

- How far into the future should we be planning and how far ahead is it feasible to plan?

- Does the scope of stewardship encompass broader community issues?

- Does DOE have a continuing responsibility for the welfare of the communities that were created to meet its original national defense mission?

- How should public perceptions of risk be factored into stewardship?

- Are there particular concerns shown by communities that are unique to long-term stewardship?

- **Relevant Risk Issues**. In Section 5, consideration is given to the range of risk end-points that may be covered under stewardship, including human health and safety risk, environmental and ecological risk, cultural, historic and tribal risk, and programmatic risk. Consideration is also given to hazard scenarios that may be of particular concern in longer-term residual risk management, including the failure of planned long-term controls, non-traditional risks such as terrorism and human intrusion, future land use, cultural and lifestyle changes, incremental effects over extended timescales and rare catastrophic geological or meteorological events. The significance of uncertainty over the extended timescales that may need to be addressed under stewardship is also recognized.

  Discussion Points

  - What are the risk end-points that need to be catered for in long-term stewardship?

  - What specific hazard scenarios need to be addressed, outside the normal remit of conventional risk assessment and management?

  - How well do we understand these long-term risks?

  - What are the programmatic risks associated with long-term stewardship? (Risk associated with institutional management are considered further below.)

  - How should cultural risks be addressed within the decision-making process?

  - What are DOE's long-term ecological risk management responsibilities?

  - How should the uncertainties in predicting risks far into the future be dealt with?

  - What is the public perception of long-term residual risk and how should this be addressed within a stewardship program?

- **The Decision-making Process**. In Section 7, consideration is given to a number of issues surrounding the decision-making process, covering the existing regulatory framework, the complex, multi-attribute nature of the

problem, the sort of approach they may be needed to address it, and the supporting tools and methodologies that may support the process. The discussion raises issues concerning the flexibility of the process and the potential benefits of using a goal-based approach to balance between competing objectives within technical and financial constraints.

Discussion Points

• Is there an existing framework and approach that will enable long-term residual risk management to be taken forward effectively?

• Is there merit in moving to a more flexible, goal-based rather than prescriptive approach to address the issues of cost-effectiveness and overall affordability?

• To what extent does the existing framework allow for the adoption of such a goal-based approach and how effectively is it currently being implemented to provide flexible, site specific and cost-effective solutions?

• Could defined quantitative risk criteria and standards support the decision-making process and, help to provide a more rational basis for resource allocation?

• How can balanced decisions be made and can the process be effectively supported by decision tools such as cost-benefit analysis and multi-attribute techniques?

• Do we have an adequate understanding of the technical constraints upon both cleanup and stewardship, when to accept them and when to seek to overcome them?

• How do we decide which technologies to invest in, and how can long-term technology development needs be better integrated across the complex in order to maximize risk reduction?

• What are the real financial constraints on the program and how are they perceived by those that set budgets and by the affected communities?

• How should the balance be drawn between investment now in permanent solutions and expenditure on longer-term stewardship?

- **Institutional Management.** In Section 8, the broad elements of the institutional management requirements for long-term stewardship are considered. This draws on work DOB has initiated to provide a better understanding of the issues associated with institutional management in relation to both its weapons sites and proposed long-term radioactive waste disposal facilities. In addition to this work, DOE is gaining practical experience in stewardship through its UMTRA site management program.

Discussion Points

- What are the components required to establish effective institutional management programs that can address long-term residual risks?

- How might changing risk management needs be accommodated over time?

- What is the reliability of institutional controls and how should programmatic risks associated with their use be

addressed?

- What are the risk data needs of stewardship and how will the availability of critical risk information be ensured in the longer-term?

- What are the organizational requirements for implementation and regulatory oversight of long-term stewardship and will new agencies with specific mandates need to be created?

It is hoped that the above considerations provide a catalyst for discussion, aimed at achieving consensus among stakeholders on the issues surrounding stewardship and on the actions necessary to take things forward.

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