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Concepts and Strategies for Transparency Monitoring of Nuclear Materials at the Back End of the Fuel/Weapons Cycle

Summary of the CMC/WIPP Monitoring Workshop

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Abstract

Representatives of the Department of Energy, the national laboratories, the Waste Isolation Pilot Plant (WIPP), and others gathered to initiate the development of broad-based concepts and strategies for transparency monitoring of nuclear materials at the back end of the fuel/weapons cycle, including both geologic disposal and monitored retrievable storage. The workshop focused on two key questions: "Why should we monitor?" and "What should we monitor?" These questions were addressed by identifying the range of potential stakeholders, concerns that stakeholders may have, and the information needed to address those concerns. The group constructed a strategic framework for repository transparency implementation, organized around the issues of safety (both operational and environmental), diversion (assuring legitimate use and security), and viability (both political and economic). Potential concerns of the international community were recognized as the possibility of material diversion, the multinational impacts of potential radionuclide releases, and public and political perceptions of unsafe repositories. The workshop participants also identified potential roles that the WIPP may play as a monitoring technology development and demonstration test-bed facility. Concepts for WIPP's potential test-bed role include serving as 1) an international monitoring technology and development testing facility, 2) an international demonstration facility, and 3) an education and technology exchange center on repository transparency technologies.

Acknowledgements

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Acronyms

CAO	Carlsbad Area Office
CMC	Cooperative Monitoring Center
DOE	Department of Energy

EM	Environmental Management
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MOX	Mixed oxide
NN	Nonproliferation and National Security
Pu	Plutonium
RW/YMP	Radioactive Waste/Yucca Mountain Project
SNL	Sandia National Laboratories
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant

Executive Summary

A key element in the successful implementation of present arms control and nonproliferation agreements is cradle-to-grave management of fissile materials, thereby providing assurance that these materials are permanently removed from potential weapons utilization. Infrastructure for integrated, transparent management of the back end of nuclear materials cycles is lacking around the globe. Given the significant national security implications for the United States, there is a compelling need for technical, financial, and political investment to provide permanent disposition for nuclear materials streams that flow out of the back end of nuclear weapons and fuel cycles. Disposition of these materials must be safe, secure, and transparent. To this end Sandia National Laboratories (SNL) has embarked on a series of activities aimed at the development and demonstration of a process for implementation of complete repository systems that will provide safe, secure, and transparent disposition of fissile nuclear materials.

The objective of the Cooperative Monitoring Center (CMC)/Waste Isolation Pilot Plant (WIPP) Monitoring Workshop was to initiate the development of broad-based concepts and strategies for transparency monitoring of nuclear materials at the back end of the fuel/weapons cycle, including both geologic disposal and monitored retrievable storage. Two primary areas of focus were 1) determining why and what to monitor, and 2) identifying potential roles that the WIPP facility may play as a monitoring technology development and demonstration test-bed facility. The work on "why and what to monitor" focused primarily on drivers for transparency monitoring by identifying stakeholder concerns and the information needed to address those concerns. Work on potential WIPP roles focused on concepts for a long-term vision utilizing the WIPP facility as a monitoring technology test bed and on generating ideas for near-term activities and next steps.

One of the most important products of the workshop was the development of a process for mapping stakeholder concerns and the information needed to address these concerns into a framework that is applicable to a broad range of national and international settings. Within this framework, the following three categories of stakeholders are recognized:

- Local,
- National, and
- Regional/international.

The range of concerns of these three stakeholders generally fall into the following three main groups:

- Safety (operational and environmental),
- Diversion (legitimate use and security from external threats), and
- Viability (political and economic).

This framework also recognizes that transparency information generally falls into two major categories:

- Data that can be measured and monitored, and
- Access to processes that provide insight to development and implementation decisions.

This transparency framework provides a means of organizing thinking about specific facility scenarios and for comparing the similarities and differences across multiple scenarios.

The WIPP repository system and the experience base associated with it provide a unique opportunity to develop, test, and demonstrate transparency monitoring technologies that may be used in the storage and disposal of nuclear materials at national and international facilities around the globe. Through workshop discussions, concepts were developed for the long-term vision of what this WIPP test-bed role would encompass. The vision includes three key elements: 1) WIPP serves as an international monitoring technology development and testing facility; 2) WIPP serves as an international demonstration facility, establishing international norms for transparency monitoring and information dissemination; and 3) WIPP serves as a center for local, national, and international education and technology exchange on repository transparency technologies.

A synthesis of the workshop sessions revealed common concerns (of the United States and many other nations) that transparency measures could address:

- The possible diversion of fissile nuclear materials resulting in nuclear weapons proliferation;
- Radionuclide releases from operational accidents or poor repository performance resulting in multinational impacts on health, safety, and the environment; and
- Public and political perceptions that an unsafe repository in any country may have adverse effects on all repository programs.

Given the extent of political resistance to repositories in different parts of the world, solving the "back end issue" has now become the "front end" of the next generation of nuclear energy.

1.0 Introduction and Background

A key element in the successful implementation of present arms control agreements and potential future arms control treaties is cradle-to-grave management of fissile materials, thereby providing assurance that these materials are permanently removed from potential weapons utilization. Implementation of present nuclear nonproliferation treaties also requires effective cradle-to-grave management of nuclear materials from civilian power generation facilities. Infrastructure for integrated, transparent management of the back end of nuclear materials cycles is lacking around the globe. In Russia, the absence of effective solutions for disposal of treaty-driven waste materials is starting to hamper effective implementation of upstream processes, for example, the decommissioning of nuclear submarine reactor cores. In Asia, large projected increases in nuclear power generation and the need for secure energy sources are driving increasing interest in spent fuel reprocessing. In many other countries, the absence of fully implemented disposition options for nuclear materials results in large quantities of spent fuel with high uncertainty relative to its near- and long-term disposition.

Given the significant national security implications for the United States, there is a compelling need for technical, financial, and political investment to provide permanent disposition for nuclear materials streams that flow out of the back end of nuclear weapons and fuel cycles. Disposition of these materials must be safe, secure, and transparent. To this end, Sandia National Laboratories (SNL) has embarked on a series of activities aimed at the development and demonstration of a process for implementation of complete repository systems that will provide safe, secure, and transparent disposition of fissile nuclear materials. These activities will 1) enhance the security of the United States by providing the mechanism to permanently remove nuclear materials from circulation and allow other countries to meet agreement and treaty obligations regarding the management and disposal of fissile materials; and 2) reduce the environmental risk posed by the production and use of nuclear materials by providing a means of safe disposal.

As part of the initial effort to develop means for safe, secure, and transparent disposition of fissile nuclear materials, SNL conducted a workshop under the sponsorship of the Department of Energy’s Office of Nonproliferation and National Security (DOE/NN) and the Carlsbad Area Office (DOE/CAO) to examine and better define the needs and technologies for implementing transparency measures at the back end of the fuel/weapons cycles. The workshop focused on producing three key products: 1) concepts for transparency monitoring strategies; 2)

concepts for the long-term vision of WIPP's role as a facility to develop, test, and demonstrate transparency monitoring technologies; and 3) concepts for a preliminary transparency monitoring technology demonstration at WIPP. This paper summarizes the workshop process and the products produced.

2.0 Workshop Objectives and Process

The objective of the workshop was to develop a broad-based set of concepts and strategies for transparency monitoring of nuclear materials at the back end of the fuel/weapons cycles, including both geologic disposal and monitored retrievable storage. Monitoring concepts addressed spanned the full range of potential monitoring objectives, including operational safety, environmental compliance, nuclear materials control, and information transparency. Concepts explored also included identification of potential downside risks associated with transparency monitoring.

The workshop included a wide range of participants with differing perspectives that spanned repository engineering and operations, nuclear materials storage technology, monitoring technology, international nuclear waste management, international transparency policy, and environmental compliance. Workshop participants came from a broad range of organizations including: 1) DOE NN, DOE EM/CAO, and DOE RW/YMP; 2) Sandia National Laboratories (SNL) and Los Alamos National Laboratories (LANL), and 3) WIPP/Westinghouse, Carlsbad Environmental Monitoring and Research Center, and JK Research Associates. Invitations were also extended to potential participants at Lawrence Livermore National Laboratory (LLNL); however, they were not able to attend. This breadth of perspective was deemed by the workshop planners to be key to developing a full range of concepts and strategies for transparency monitoring at the back end of the nuclear materials cycle.

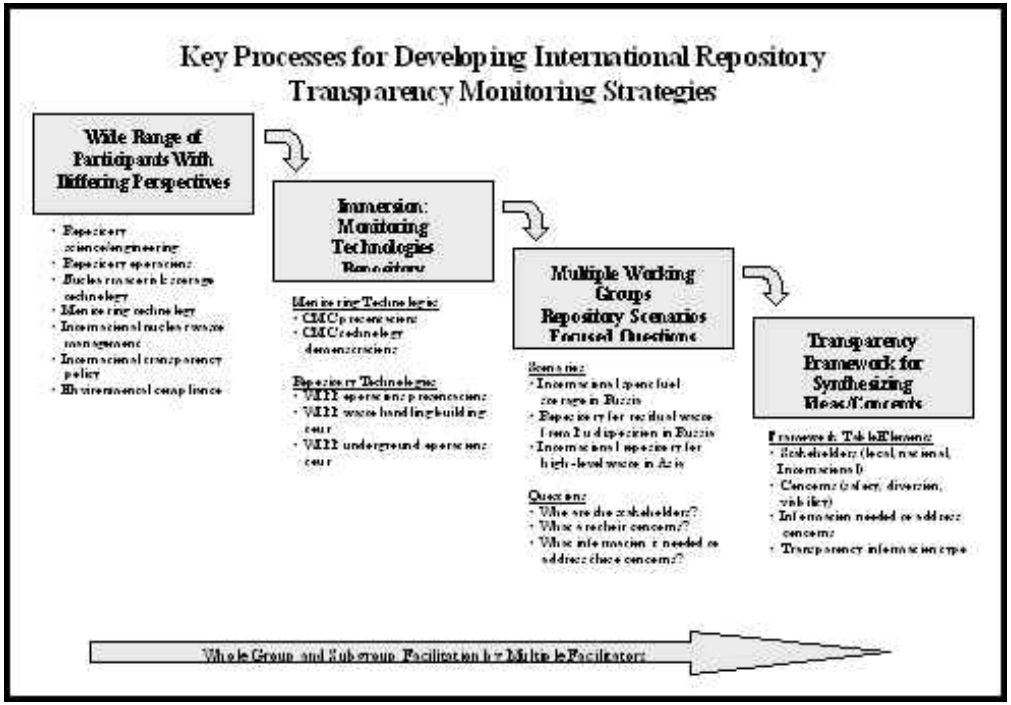
A portion of the workshop was focused on developing long-range concepts for use of the WIPP as a test bed for monitoring concepts and technology development. Because WIPP is the world's first complete geologic repository system for nuclear materials at the back end of the cycle, the WIPP system can be used as a realistic example of a system framework from which to generate ideas about what transparency may entail at the back end of the nuclear materials cycle. Yucca Mountain is the U.S. repository program for spent fuel and high-level defense waste. While it is much further away from active work on monitoring, this project also provided additional perspectives from which to consider transparency technologies and strategy.

2.1 Workshop Structure

The workshop focused on producing three key products: 1) concepts for transparency monitoring strategies; 2) concepts for the long-term vision of WIPP's role as a facility to develop, test, and demonstrate transparency monitoring technologies; and 3) concepts for a preliminary transparency monitoring technology demonstration at WIPP.

Figure 1 shows the general structure and process followed over the three days of the workshop to develop the first of the three products. Transparency monitoring rationale and strategies were developed during the workshop through a series of brainstorming sessions that were interspersed with presentations, demonstrations, and facility tours. The need to present a variety of background information was motivated by the diversity in the backgrounds of the workshop participants. A common understanding of monitoring technologies and applications as well as

Figure 1. Workshop Structure and Process



some background in repository engineering and environmental compliance were deemed necessary to ensure that all participants could fully engage in the strategy development brainstorming sessions. To complete the process depicted in Figure 1, as well as develop the other two workshop products, four brainstorming sessions were planned. These included:

- *Session I* – Why Monitor?
- *Session II* – What Should Be Monitored?
- *Session III* – Refine Strategy of Why and What to Monitor and Examine Potential Negative Implications
- *Session IV* – Long- and Short-Term Potential WIPP Roles as Monitoring Technology Development/Demonstration Facility

The question of "how" to monitor was thought to focus more on technical means and was left for future working groups to address once the rationale for monitoring was well established. The workshop also included tours of monitoring technologies at the SNL Cooperative Monitoring Center (CMC) and of the waste handling and underground repository facilities at WIPP. SNL's CMC joined with WIPP to host this workshop. The CMC contributed perspectives on the use of monitoring technologies to reduce regional tensions and risks of proliferation. WIPP contributed perspectives on how geologic disposal facilities are designed and operated, as well as a system-wide perspective of nuclear waste management.

2.2 Workshop Process

The workshop was conducted over three days. Each day was divided between information sharing on relevant topics and brainstorming sessions. For the first three brainstorming sessions that were directed toward the more general questions of "why" and "what" to monitor, the workshop group was divided into three subgroups, each subgroup considering a different facility scenario.

Scenario I

An international spent fuel interim storage facility in Russia

- Materials stored – spent fuel from nuclear power plants in Japan, Taiwan, and/or South Korea

- Other characteristics – spent fuel is to be stored for a finite period of time (50 years) and then returned to the originating country; facility to be subject to some form of International Atomic Energy Agency (IAEA) controls/inspection

Scenario II

A repository for residual waste from the back end of Pu disposition process in Russia

- Facility type – deep geologic repository; permanent disposal
- Materials disposed – transuranic (TRU) waste, residual fissile materials considered too low grade to be fabricated into mixed oxide (MOX) fuel or reprocessed
- Other characteristics – materials come from the Pu disposition program; international drivers are bilateral agreements or a treaty between the U.S. and Russia

Scenario III

International repositories for high-level waste disposal in Asia (single or multiple geologic repositories in Asia with some form of international oversight)

- Facility type – deep geologic repository; permanent disposal
- Materials disposed – processed (e.g., vitrified) high-level waste; possibly spent fuel from nuclear power reactors
- Other characteristics – A variety of international repository concepts have been discussed for Asia. Alternatives for international oversight include: international standards and mutual monitoring; single corporation runs several national repositories with mutually defined standards, procedures, and monitoring; and international body runs one or more repositories.

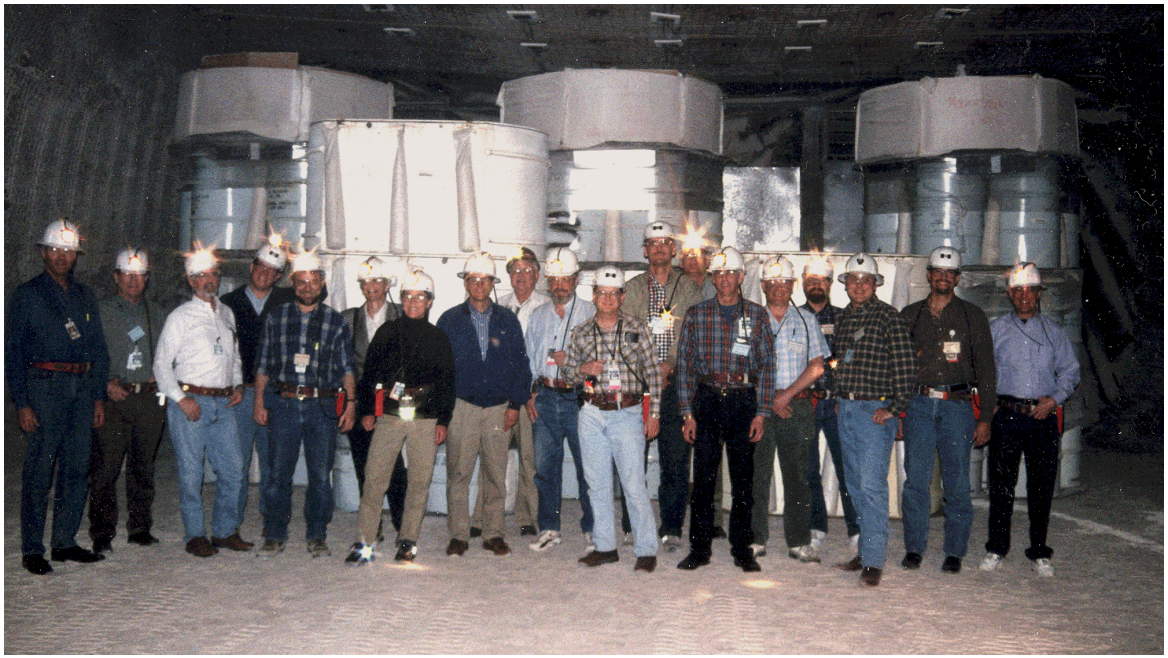
The first day of the workshop focused on background presentations on transparency monitoring policy in current applications, selected ongoing monitoring projects, and monitoring technologies. The day concluded with the first brainstorming session that addressed the question of why do various populations desire some degree of monitoring. The session tried to focus on concerns that might be raised at local, national, and international levels on the operation of a particular facility (three scenarios). For this exercise, the workshop group was divided into three subgroups, each subgroup considering a different facility scenario. The participants were asked to identify key stakeholder groups and to address the following for each scenario:

- *What are the major concerns of each stakeholder group?*
  - What are the major concerns of each broad stakeholder group?
  - What are the groups trying to accomplish; what are their objectives?
  - What are the downstream actions that might be precipitated by the groups as a result of analyzing the information?

The second day focused on WIPP as a geological repository system. Presentations were given on the development of WIPP and its current state and the workshop participants toured both the surface waste-handling facilities and the underground disposal areas. (See Figure 2.) Again, the day was concluded by dividing the workshop participants into their respective scenario subgroups for the second brainstorming session. The second brainstorming session was focused on revisiting the question of "Why monitor?" to ensure closure on that question and then addressed the additional question of:

- *What information do the user groups (local, national, and international) need to accomplish their objectives and address their concerns?*
  - What part of the system is each user interested in?
  - What specific information will this user need or want to address concerns?
  - How will the group use the information (passively to allay fears, or actively in a constructive or destructive mode)?
  - Are there reasons why the user should not have the information (national security concerns, international terrorism, etc.)?

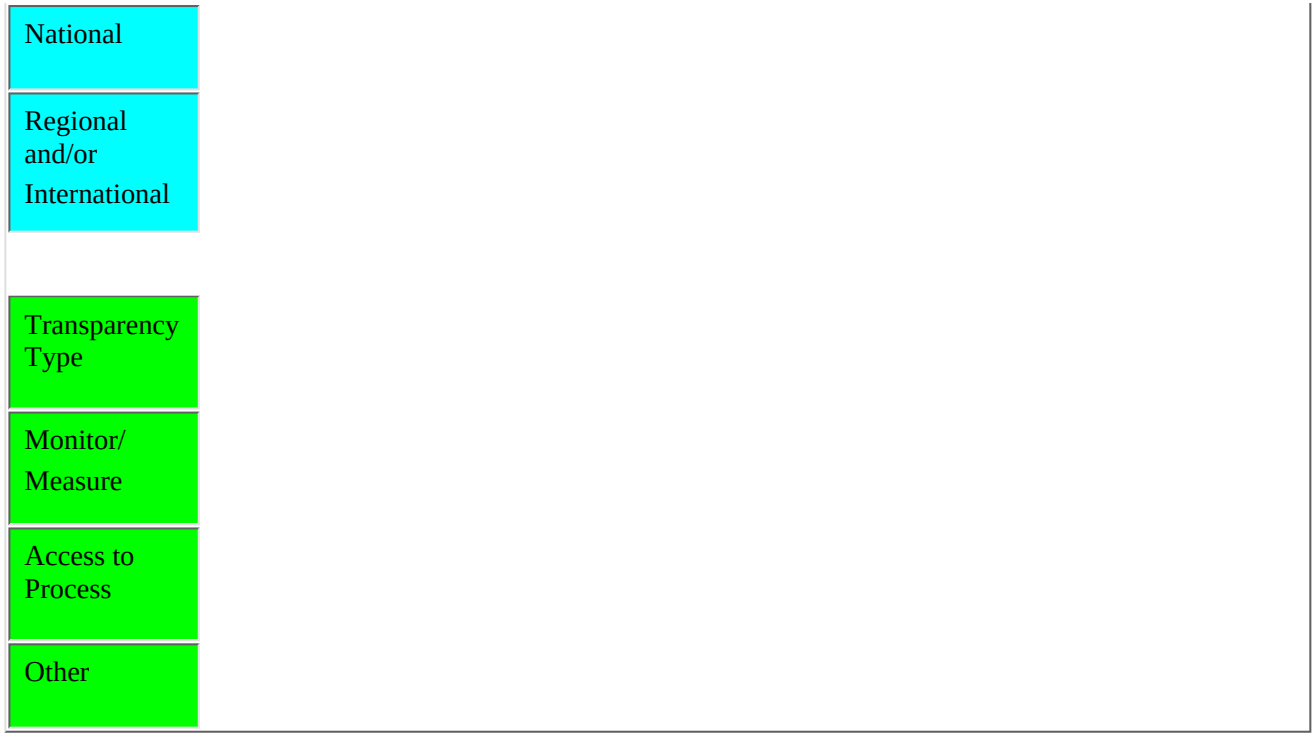
Figure 2. Workshop Participants Tour WIPP Facilities



After the end of the second day, the workshop planners and facilitators met to review the progress toward the final workshop products. They attempted to integrate information from the three scenario groups into summary form to assist the participants in identifying and assessing the major issues. As a result of this meeting, it was evident that there were clear similarities in stakeholder concerns and identified transparency measures proposed to alleviate the concerns. It was found that the lists of concerns could be summarized under one of three categories: safety, diversion of materials, or viability of the facility. Safety concerns were generally associated with environmental or operational issues. Diversion concerns were generally categorized as associated with ensuring legitimate use of materials (insider threat) and security of the facility and materials (outsider threat). The third category dealt with political or economic concerns related to the location or operation of a disposition facility. From this information, the workshop planners developed a format for summarizing the working groups' products in a table format. The summary format is given in Table 1. This table provides a framework for correlating concerns with stakeholders (why monitor?) and with proposed transparency measures to address those concerns.

Table 1. Framework used for summarizing results from brainstorming sessions

Concerns	Safety		Diversion		Viability	
	Operational	Environmental	Legitimate Use	Security	Political	Economic
Stakeholders						
Local						



In developing a summary of the proposed transparency measures that might provide the necessary information to alleviate specific concerns, it became clear that there were at least two different approaches. The first approach involves application of monitoring technology to gather key data that are shared with stakeholders. The second approach is to address other types of concerns by providing access to a process rather than providing direct data. Examples of this second type of transparency measure were allowing access to the decision-making process for locating a site, or directly participating in the performance assessment process to assess long-term safety of a site.

The final day of the workshop was devoted to producing the workshop products. It was originally planned to have presentations on the state of waste management in Russia and in Asia to provide additional background information for developing the workshop products. Because of the insight gained during the first two days, it was decided to forgo these presentations and concentrate on first developing the tables that would provide an integrated summary of the first two days of work. Then the focus of the workshop turned to the development of concepts for long-term transparent monitoring technology, development, testing, and demonstration using WIPP as a test-bed facility, and to developing concepts for a preliminary transparent monitoring technology demonstration at WIPP. The results of the latter two discussions formed the basis of the final two products of the workshop. For the WIPP discussions, the workshop group worked as a whole to brainstorm ideas and establish priorities.

3.0 Workshop Results

This section summarizes the major products of the workshop and provides some discussion on the interpretation and refinement of the results.

3.1 Why and What to Monitor

The results from the workshop discussions on why and what to monitor are summarized in Tables A.1, A.2, and A.3 for each of the three scenarios respectively. (Tables are located in the Appendix.) Not surprisingly, there are many similarities in the results from the three scenarios and some aspects of each that are unique to the circumstances of the scenario. Table A.4 presents an integrated summary of the

important aspects of why transparency monitoring would be useful and what means of transparency should be applied. This summary table provides a strategic framework for further development of specific concepts for transparency monitoring technology development and implementation.

3.2 Possible Downsides of Monitoring

While implementation of transparency measures clearly will have benefits at many levels, the potential for negative impacts must be explicitly addressed. On the third day of the workshop, one of the discussion sessions focused on identifying and discussing potential downsides of various potential transparency measures. As part of this discussion, as well as discussions within the subgroups, it was recognized that different transparency measures have different customers or stakeholders. Who receives what kind of information will likely vary with the specific measure. For example, while dissemination of environmental monitoring data may entail completely open public access on the web, open dissemination of video monitoring of certain kinds of materials handling or tracking data would likely need to be limited to selected government or international agencies in order to prevent public access to information that could be used by terrorists or other groups that may desire to divert materials. The following is a brief summary of the workshop discussions of potential downsides.

1. Risk of uninformed consumers of data and information:
   - Providing access to raw data without additional information on the context and technical significance of the data may result in high potential for misunderstanding and/or misinterpretation. Data consumers should be provided with some level of technical context, baseline data (understanding of what is normal), and some level of understanding of the potential for data glitches in the monitoring process.
   - The question of timeliness and degree of review or processing of monitoring data is also a component of the risk of uninformed consumers of data. There may be a trade-off between providing real-time, raw data versus data that have been reviewed and assessed for glitches. There was strong feeling by some participants that providing real-time, raw data is the only way to establish credibility with some stakeholder communities. There was strong feeling by others that there could be significant public perception, political, and legal risks if operational glitches are misunderstood and data are used inappropriately.
   - Access to monitoring data and other information may produce a false sense of security if the transparency measures are not carefully designed and if the consumers of data and information do not understand the full context of a particular component of data or information.
2. Risk of providing operational information to groups that represent real security threats:
   - As noted above, the working group identified a potential risk of providing information that may compromise operational security. For example, providing information that could be used for targeting by terrorist operations or for materials diversion.
   - There will likely be a need to complete some form of a vulnerability analysis, particularly for operationally oriented transparency measures.
3. Political risks:
   - One political risk that was identified was that of data or information being misinterpreted and/or misused for purely negative political purposes. The workshop participants felt that the most important way to reduce this risk would be to disseminate the data/information in a manner that fully informs and educates the customers/stakeholders for the information. The participants also recognized that to some degree, the risk of misuse will never be eliminated completely and, therefore, transparency measures must be implemented in a fashion through which the benefits clearly outweigh this type of risk.
   - Another category of political risk that was identified was the risk of setting precedents and of not following through. Once certain types of transparency measures are put in place, it may be very difficult to back off in providing the information. Clearly, implementation of transparency measures will require care in planning and care in implementation. Providing various forms of data and information will carry with it a need to maintain consistent access and follow-up in addressing issues and concerns that this

information raises.

4. Economic risks:

- Developing and implementing transparency measures will clearly entail both direct costs for implementation and maintenance and potential indirect costs associated with impacts on operations. Transparency measures will need to be designed and implemented in a fashion that minimizes impacts on operations. Implementation of transparency measures must recognize the long-term cost implications of the importance of following through and providing information over an extended period of time. Finally, the overall benefits of implementing transparency measures must clearly outweigh the costs.
- Another potential economic risk is the potential for loss of proprietary information.
- Finally, the potential for graft in implementing cross-border initiatives was also identified as a potential economic risk that must be addressed.

3.3 Summary of WIPP Test-bed Ideas

The WIPP repository system and the experience base associated with it provides a unique opportunity to develop, test, and demonstrate monitoring technologies that may be utilized in storage and disposal of nuclear materials at national and international facilities around the globe. The first component of developing the WIPP "test bed" concept is to develop a long-term vision for the role that WIPP could play as a monitoring technology test-bed facility. The second WIPP "test bed" component is to develop a group of concepts for a preliminary transparency monitoring technology demonstration to be implemented at WIPP over the next several months. The purpose of this demonstration is to create a hands-on, jump-start activity in the monitoring arena that can be used to provide experience and focus from which to develop a well-founded, broad-based program, including parallel activities in other countries.

Through brainstorming and follow-up discussion, the following concepts were developed for the long-term vision of the WIPP test-bed role:

1. WIPP serves as an international monitoring technology development and testing facility
   - Research and development for operational safety, environmental surveillance, and materials security monitoring technologies
   - Operational testing and evaluation of developed technologies

2. WIPP serves as a monitoring demonstration facility, establishing international norms for transparency processed for various types of information
   - Develop and demonstrate processes for information dissemination at various levels ranging from public confidence to state/national regulatory authorities to international engagement
   - Highlight the already existing transparency processes that were key elements in the successful development of WIPP Environmental Protection Agency (EPA) compliance certification
   - Continue to work to make the performance assessment process transparent and understandable to people of widely varying backgrounds

3. WIPP serves as a center for local, national, and international education and technical exchange on repositories for disposition of nuclear materials
   - Use WIPP to develop educational materials and outreach such as K-6 teacher education and university extension courses
   - Send WIPP experienced people to work on international sites
   - Host international scientists, engineers, and operations personnel for learning visits at WIPP

Through brainstorming and follow-up discussion, concepts were developed for a preliminary transparency monitoring technology demonstration to be implemented at WIPP over the next several months. These concepts included:

1. Use existing operational and/or environmental monitoring information in some form of transparent information access

   - Follow through on existing project plans to put water level and water quality data on the web; note that this requires that appropriate background information also be developed and provided to provide technical context for this information
   - Choose some component of current radiation monitoring information, providing public access to this data through the web and/or kiosk-based public monitors; consider using LANL NEWNET system as a framework
   - Use a combination of video and motion sensors to demonstrate feasibility of underground materials handling monitoring

2. Use the existing WIPP transportation system/materials tracking system as a framework for demonstrating materials tracking/accountability technologies

   - Consider supplementing existing tracking with a demonstration of the ability to electronically track an individual container from generator site through final emplacement at WIPP

3. Map the already existing transparency processes that were key elements in the successful development of WIPP EPA compliance certification into the transparency framework table developed at the workshop (Table 1)

4. Develop a summary paper describing the range of current WIPP international technical collaboration activities

5. Initiate the development of a transparency-focused web site for WIPP-specific transparency activities

   - Use this activity to initiate development and demonstration of web-based information dissemination for both open and restricted access information
   - Populate this web site with information resulting from the previously described activities
   - Work out processes for providing variable access to different types of information (perhaps at different web sites)

4.0 Discussion and Conclusions

Transparency is a term that is readily grasped as a high-level concept, but that is more difficult to define within the specific context of the back end of the nuclear materials cycle. Based on a broad range of discussions at the workshop, the definition adopted for this summary is as follows: transparency is the process of providing information to outside parties so that these parties can independently assess the safety, security, and legitimate utilization of repositories for nuclear materials disposition.

One of the most important products of the workshop was the development of a process for mapping stakeholder concerns and associated information to address these concerns into a framework that has application to a broad range of national and international settings (Figure 1). Within this framework, three categories of stakeholders are recognized: 1) local, 2) national, and 3) regional/international. The range of concerns of these three stakeholders generally fall into three main groups: 1) safety (operational and environmental), 2) diversion (legitimate use and security from external threats), and 3) viability (political and economic). This framework also recognizes that transparency information generally falls into two major categories: 1) data that can be measured and monitored and 2) access to processes that provide insight to development and implementation decisions. This transparency framework provides a means of organizing thinking about specific facility scenarios and for comparing the similarities and differences across multiple scenarios.

Implementing transparency measures can entail downside risks. The following categories of downside risks were identified: 1) risk of misuse of information by stakeholders (e.g., due to lack of understanding of the technical context for the information), 2) risk of providing operational information to groups that represent real security threats, 3) political risk (e.g., intentional misuse of information for purely negative political

purposes), and 4) economic risk (e.g., underestimating the long-term costs of maintaining the commitment to transparency monitoring operations). Recognition of these potential risks is very important to developing transparency strategies that minimize the potential impacts. For example, different information may be disseminated with varying levels of access depending on the nature of the information and the nature of specific stakeholder concerns and needs.

Discussion of the process of development of the WIPP repository revealed that WIPP has already implemented a large number of activities that are examples of transparency processes. For example, the EPA certification process included open publication of the Compliance Certification Application on the World Wide Web, coupled with a large number of public hearings. A second example is the extensive independent technical reviews carried out by state, national, and international review bodies. A third example is that satellite tracking information for the WIPP transportation network system is provided on a real-time basis to local authorities in many communities along the WIPP transportation routes. A final example is WIPP publication of hydrologic testing and monitoring data from water-bearing units that overlie the WIPP repository.

The WIPP repository system and the experience base associated with it provides a unique opportunity to develop, test, and demonstrate transparency monitoring technologies that may be utilized in the storage and disposal of nuclear materials at national and international facilities around the globe. Through workshop brainstorming and follow-up discussions, concepts were developed for the long-term vision of what this WIPP test-bed role would encompass. The vision includes three key elements: 1) WIPP serves as an international monitoring technology development and testing facility; 2) WIPP serves as an international demonstration facility, establishing international norms for transparency monitoring and information dissemination; and 3) WIPP serves as a center for local, national, and international education and technology exchange on repository technologies.

A synthesis of the workshop sessions revealed common concerns (of the United States and other nuclear nations) that transparency measures could address:

- The possible diversion of fissile nuclear materials resulting in nuclear weapons proliferation
- Radionuclide releases from operational accidents or poor repository performance resulting in transnational impacts on health, safety, and the environment
- Public and political perceptions that an unsafe repository in any country may have adverse effects on all repository programs

Given the extent of political resistance to repositories in different parts of the world, solving the "back end issue" has now become the "front end" of the next generation of nuclear energy.

APPENDIX—Scenario Summary Tables

Table A.1 Scenario I – International Spent Fuel Storage Facility in Russia

Concerns	Safety		Diversion		Viability	
	Operational	Environmental	Legitimate Use	Security	Political	Economic
Stakeholders						

Local **Activists** **Accident Responders** **Site Personnel** **Community/ Regional Government**	**Is site operated safely (are there published standards)?**	**Will we have timely access to information?** **Air/water contamination?**	**Are materials stored safely with accountability?**	**Are we vulnerable to terrorism?**	**Will worker privacy be protected?**	**Can all parties demonstrate economic viability or will the project go bankrupt and leave us with another mess?** **Impact on local economic and job situation?**
National **Government Agencies** **Neighbor Communities** **National Leaders** **Regulatory Bodies**	**Can we provide sufficient emergency response?** **Will the facility comply with regulations and can we verify?** **Can we convince other countries that the facility will be safe?**	**Will the government agencies comply with regulations and can we verify?** **Can we convince other countries that the facility will be safe?**	**Can we trust the facility to account for all materials?** **Can inventory control be maintained to convince others that what is actually going into the facility stays there?**	**Can we guarantee secure transport to a remote facility?** **Can we protect a remote facility?** **Can we maintain institutional control for 50+ years?**	**Is this in the national interest of the Russian image?** **Can we allay national political concerns from many factions?** **Will international monitoring or surveillance intrude on national security interests?**	**Will this be a money maker (hard currency)?**
Regional and/or International **Country of Origin for Spent Fuel** **Opponents of Countries of Origin** **Neutral Countries** **Western Europe (NATO)** **International Regulatory Bodies (IAEA, others)** **United States**	**Will we be notified of accidents?** **Will chain of custody be verifiable?**	**Will facility safety meet international acceptance?** **Will safety be monitored by independent groups?**	**Can Russia provide accountability of materials?** **Who will have institutional control?** **Will we get our materials back?**	**Will neighboring states help or hinder transportation security?**	**Will materials be controlled in a turbulent political environment?** **Will the project put weapons scientists to work on peaceful programs?** **Will neighboring states accept the facility in Russia?** **Will we get our fuel back?** **Will Russia exist in 50 years?**	**Will it be economically viable to send fuel?** **Will countries of origin have liability exposure during transportation and storage?**

Transparency Type						
Monitor/Measure	**Worker exposures and safety records**	**Real-time environmental (radiation levels, etc.) monitoring**	**IAEA-type safeguards measures** **On-site international inspections**	**Origin to storage tracking of shipments** **Site security monitoring**		
Access to Process		**Local/national participation in siting decisions**		**International participation in transportation security network**	**International agreements on transportation**	**Treaties or agreements on costs and liability**

Table A.2 Scenario II – Russian Repository for Residual Waste from Back End of Plutonium Disposition Process

Concerns	Safety		Diversion		Viability	
	Operational	**Environmental**	**Legitimate Use**	**Security**	**Political**	**Economic**
Stakeholders						

Local **Facility Operator** **Surrounding Public** **Local Governments** **Non-Government Organizations**	**Is worker training adequate to prevent accidents?** **Will we have access to site and current operational status?** **Will the workers be protected?** **Will we get immediate warnings of off-normal conditions?** **Will there be independent oversight?** **Can materials be transported safely to a remote site?**	**Will there be off-site releases of materials?** **Will the facility comply with regulations?** **Will we have access to real data?** **Will there be evacuation training and planning?**	**Will there be verifiable certification of the package contents?** **Are you doing what you said you would do (e.g. dispose of materials)?**	**Are transportation routes safe?** **Have you provided physical security?**	**Do the governments at all levels have credibility and stability?** **Will policies remain in effect over the long term?** **Will decision process be open and understandable?** **Will we have a say in key decisions?**	**Will the local economy benefit from the facility?** **Will the facility produce a negative impact on the region (e.g., on property values or trade)?** **Will taxes be affected?**
National **Federal Government** **Regulatory Authority**	**Concerns similar to Local above** **How will we document compliance?**	**Concerns similar to Local above** **How will we document compliance?**	**Will we meet arms control treaty obligations?** **How will this be verified?**	**Can we maintain control of national security information and still allow monitoring or verification?**	**Can we maintain national security?** **What impact will repository have on international relations?** **Will there be an impact on national domestic security or energy policy?** **Will regional equity be an issue?**	**How will repository impact national economy?** **What is the socioeconomic impact?**
Regional and/or International **Adjacent Countries** **Other Nations** **International Organizations (IAEA, others)**	**Will transportation on land, air, or sea be conducted safely?** **Will accident consequences outside the country be controlled to acceptable levels?**	**Will there be any trans-border releases from the site or resulting from transportation accidents?**	**Can the materials inventory be verified?** **Could there be covert re-entry into repository?**	**Will security be sufficient to prevent material theft?** **Can security forces be trusted to be loyal?**	**Will disposition in Russia provide them with a strategic advantage?**	**Would international funding be required?** **If Russian economy completely collapses, would they sell materials for hard currency?**

Transparency Type						
Monitor/Measure	Physical site monitoring	Air, water, and biological monitoring with multiple, independent sources	Monitor package and contents from source to disposition	Monitor physical security measures	Monitor political process and elections for signs of critical instability Use environmental monitoring to mitigate concerns of neighboring states	
Access to Process	Access to safety analysis process and results for independent validation of results Observer access	Access to performance assessment process and results Observer access				
Other	Maintain open records for long term	Maintain open records for long term	Maintain open records for long term		Long-term treaty compliance Maintain institutional control of repository site	

Table A.3 Scenario III – International Repository for High-Level Waste Disposal in Asia

Concerns	Safety		Diversion		Viability	
	Operational	Environmental	Legitimate Use	Security	Political	Economic
Stakeholders						

Local **Citizens** **Operators** **Government** **Law Enforcement/ First Responders**	**Is transportation safe?** **Accurate characterization and inventory of materials shipped to site?** **What materials are involved?** **What happens if there is an accident?**	**Will site affect local health?** **Is site meeting expected performance standards?**	**Have shipments been tampered with?**	**Are we at increased risk for sabotage or terrorist attack?** **Can we prevent material theft?**	**Will releasing information to local community be detrimental?** **Can we trust the operators?**	**Will economy benefit (new jobs) or suffer (property values)?** **How will site affect livelihood?**
National (nation where site is located) **National Government** **Regulators** **Non-Govt. Orgs.**	**How will you prove compliance?** **Will enough information be provided for independent verification?** **What is the national impact of an accident?**	**Do we understand site performance?** **Are our models accurate?** **How will you prove compliance?** **Will enough information be provided for independent verification?**	**How will we demonstrate compliance?** **Can we provide enough information for independent verification?**	**How will we demonstrate compliance with international safeguards?** **Will it require intrusive measures?**	**Will other nations whose spent fuel or waste I take stay the course?** **Will they pay for disposition?** **Will they take it back if necessary?**	**How much will a repository cost?** **How will it be financed?** **How much money can I make?** **What is the cost impact of dealing with external agencies?**
Regional and/or International **IAEA** **Neighboring Countries** **Non-Proliferation Community**	**Can we trust our neighbor to operate safely?** **Can we agree on safety standards?**	**How do we make measurements at a closed facility?** **Will we have access to collect data for independent verification? Now, in 50 years, forever?**	**Can we assure that host country does not change nonproliferation intent?** **How will you prove compliance?** **Can a material balance be demonstrated?** **Will enough information be provided for independent verification?** **Will material be safe from proliferation?**	**How will you prove compliance?** **Can material balance be demonstrated?** **Will enough information be provided for independent verification?** **Will material be safe from proliferation?**	**How will we support developing countries' work on back end of cycle?** **Can we trust process for site selection? Will site be near our border?** **Is host country politically stable?**	**How will we support developing countries' work on back end of cycle?** **Is host country economically stable? Will they try to sell materials if economy goes down?**

Transparency Type						
Monitor/Measure	**Gather site data at multiple levels** **Routine dissemination of data** **Process control and monitoring** **Direct tactical communication link for law enforcement and first responders**	**Display key information (air, water quality) in local communities** **Collect and process long-term performance data (available at all levels: local, national, international)**	**Material balance accounting and oversight by independent assessors** **Security monitoring** **Allow for independent measurement to supplement safeguards**	**Security monitoring**		**Cost data on site construction and operations**
Access to Process	**Open process in setting regulations and assessing compliance** **Physical access to interested parties (regular tours)**	**Open participation in site selection evaluation and decision process** **Access to site characterization data and performance models** **Round-robin modeling exercises to build confidence**	**Share safeguards process with neighboring countries**	**Share safeguards process with neighboring countries**		**Cost-benefit for governments to participate**
Other	**Training and equipment to first responders**		**Vulnerability analysis**		**Up front assessment of viability of out-of-country disposition of spent fuel/waste** **Provide technical information and guidance on how to do it in developing country**	

Table A.4 Workshop Summary—A Strategic Framework for Repository Transparency Implementation

Concerns	Safety		Diversion		Viability	
	Operational	Environmental	Legitimate Use	Security	Political	Economic
Stakeholders						
Local	Safe operations and transportation Communities informed of operational status Rapid notification of off-normal conditions and consequences Confidence in oversight of operations	Site meets defined performance standards Timely access to data on migration paths (air, water, etc.)	Complete and proper materials accounting Ensure shipments are not tampered with or packages damaged	Security along transportation routes Reduce risk of terrorist attack	Protect worker privacy Credible, stable government institutions and policy Role in key decisions affecting local populations Trust of facility operators	Benefit or harm to local economy (new jobs, property values, local stigma) Effect on local taxes Economic viability of facility – will local community be left with polluted, abandoned facility?
National	Demonstrate safety and compliance National impact of an accident Independent oversight	Independent oversight Access to information and models Document compliance with national or international standards	Meet treaty obligations Verifiable materials control Build trust with other nations Compliance with international safeguards standards	Maintain security in remote areas and along transport routes Protect national security information Maintain institutional control for very long periods of time	Will other nations stay the course? Ownership and liability for materials stored here Maintain national security Issues of regional equity Funding of disposition Implications of an accident and transnational release	Facility impact on national economy Socioeconomic impacts Positive cash flow commensurate with risk Financing of facilities design and construction

Regional and/or International	**Safety of transnational transport of materials** **Notification of off-normal conditions** **International consequences of an accident** **Trust of host country oversight**	**Participation in performance and risk assessments** **Access to data, now, many years from now** **Long-term monitoring of a closed facility** **Independent monitoring**	**Verifiable materials inventory process** **Return of stored materials** **Materials made resistant to proliferation** **Changes in host country non-proliferation intent** **Institutional control of materials**	**Providing transnational security for shipments** **Loyalty of security forces** **Prevent covert re-entry of closed repository facility**	**Support of developing countries' work on back end of cycle** **Political stability of host country over long time periods** **Return of stored materials** **Ownership and liability for materials** **Will disposition of materials in another country give them a strategic advantage?**	**Economic support to developing countries** **Liability exposure for materials sent out of country** **Cost/benefit/risks of out-of-country disposition** **Host nation holding materials hostage for additional funds**
Transparency Type						
Monitor/Measure	**Physical site monitoring** **Safety records** **Tactical communications links for local security and responders** **Routine data dissemination** **Off-normal conditions alarms to communities**	**Health of surrounding populations** **Real-time environmental monitoring** **Long-term (100+ yr.) performance confirmation monitoring** **Open display of key information (air, water quality, etc.)** **Independent monitoring** **Data security and integrity validation**	**Material balance oversight by independent assessors** **Monitor package and contents from source to disposition** **On-site audits/inspections**	**Monitor physical security**	**Monitor political process and elections for signs of instability** **Use environmental monitoring to mitigate concerns of neighboring states**	**Cost data on site construction and operations**

Access to Process	**Open process in setting regulations** **Physical access to interested parties (tours)** **Access to safety analysis process for independent validation** **Independent observer access**	**Local/national/ international access to site selection process** **Confidence building, round-robin modeling exercises**	**Share safeguards process and implementation**	**International participation in transportation security**	**International agreements on transportation**	**Treaties or agreements on costs and liabilities**
Other	**Maintain open records for long periods** **Training and equipment for responders**	**Maintenance of records in accessible form for long periods**	**Maintenance of records in accessible form for long periods**		**Long-term treaty compliance** **Maintaining institutional control of site for long period**	

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