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Repository Performance Confirmation

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ABSTRACT

Repository performance confirmation links the technical bases of repository science and societal acceptance. This paper explores the myriad aspects of what has been labeled *performance confirmation* in U.S. programs, which involves monitoring as a collection of distinct activities combining technical and social significance in radioactive waste management. This paper is divided into four parts:

1. A distinction is drawn between *performance confirmation* monitoring and *other* testing and monitoring objectives,
2. A case study illustrates confirmation activities integrated within a long-term testing and monitoring strategy for Yucca Mountain,
3. A case study reviews compliance monitoring developed and implemented for the Waste Isolation Pilot Plant, and
4. An approach for developing, evaluating and implementing the next generation of performance confirmation monitoring is presented.

International interest in repository monitoring is exhibited by the European Commission Seventh Framework Programme "Monitoring Developments for Safe Repository Operation and Staged Closure" (MoDeRn) Project. The MoDeRn partners are considering the role of monitoring in a phased approach to the geological disposal of radioactive waste. As repository plans advance in different countries, the need to consider monitoring strategies within a controlled framework has become more apparent. The MoDeRn project pulls together technical and societal experts to assimilate a common understanding of a process that could be followed to develop a monitoring program. A fundamental consideration is the differentiation of confirmation monitoring from the many other testing and monitoring activities.

Recently, the license application for Yucca Mountain provided a case study including a technical process for meeting regulatory requirements to confirm repository performance as well as

considerations related to the preservation of retrievability. The performance confirmation plan developed as part of the Yucca Mountain license application identified a broad suite of monitoring activities. A revision of the plan was expected to winnow the number of activities down to a manageable size. As a result, an objective process for the next stage of performance confirmation planning was developed as an integral part of an overarching long-term testing and monitoring strategy.

The Waste Isolation Pilot Plant compliance monitoring program at once reflects its importance to stakeholders while demonstrating adequate understanding of relevant monitoring parameters. The compliance criteria were stated by regulation and are currently monitored as part of the regulatory rule for disposal. At the outset, the screening practice and parameter selection were not predicated on a direct or indirect correlation to system performance metrics, as was the case for Yucca Mountain. Later on, correlation to performance was established, and the Waste Isolation Pilot Plant continues to monitor ten parameters originally identified in the compliance certification documentation. The monitoring program has proven to be effective for the technical intentions and societal or public assurance.

The experience with performance confirmation in the license application process for Yucca Mountain helped identify an objective, quantitative methodology for this purpose. Revision of the existing plan would be based on findings of the total system performance assessment. Identification and prioritization of confirmation activities would then derive from performance metrics associated with performance assessment. Given the understanding of repository performance confirmation, as reviewed in this paper, it is evident that the performance confirmation program for the Yucca Mountain project could be readily re-engaged if licensing activities resumed.

ACKNOWLEDGEMENTS

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NOMENCLATURE

COMP	Compliance Monitoring Parameter
CCA	Compliance Certification Application
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EPA	U. S. Environmental Protection Agency
EPRI	Electric Power Research Institute
FEPs	features, events, and processes
MoDeRn	Monitoring Developments for Safe Repository Operation and Staged Closure
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
PA	performance assessment
PC Plan	performance confirmation plan
PNSDB	postclosure nuclear safety design bases
SAR	Safety Analysis Report
SNL	Sandia National Laboratories
SRRC	standard rank regression coefficient
TBD	to be determined
TRU	transuranic
TSPA	total system performance assessment
YM	Yucca Mountain
YMRP	Yucca Mountain Review Plan
WIPP	Waste Isolation Pilot Plant

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1. PERFORMANCE CONFIRMATION VERSUS OTHER TESTING AND MONITORING

1.1 Introduction

Performance confirmation testing and monitoring are conducted to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Two key aspects of a successful performance confirmation program are: (1) the selection of the parameters to be measured or monitored, and (2) the determination of the conditions for which the regulatory authority would be notified regarding measured and monitored information that differs from the technical baseline. Performance confirmation is a binding commitment to the regulator that is consummated in the licensing process.

This section clarifies the distinction between performance confirmation testing and monitoring versus *other* testing and monitoring of additional kinds and purposes. A performance confirmation program is specifically required by regulation and a description of such a plan is an important part of the license application. Because an undertaking as complicated and significant as a nuclear waste repository involves many testing and monitoring requirements, it is often confusing to differentiate clearly between performance confirmation monitoring and other testing and monitoring pursuits. Performance confirmation constitutes a specific part of an overarching long-term testing and monitoring program and is distinct from *general* monitoring for permits and other administrative requirements. Discussion in this section touches upon many aspects of testing and monitoring, but will concentrate on the details that comprise three main elements of an overarching long-term testing and monitoring strategy for repository science:

1. Elective testing,
2. Regulatory requirements, and
3. Performance confirmation.

Performance confirmation monitoring evolves as the repository design concept and regulations mature. Site understanding—improving as science programs collect additional information—places an inherent need for flexibility within the confirmation planning strategy. The stepwise process for repository development includes site characterization, licensing, construction, operations and closure. The interpretation and technical bases for the features, events, and processes (FEPs) progress as data, results, and observations accumulate. The evolutionary process of confirmation requires synchronization with the phased repository development. Facets of activities undertaken for site characterization might logically become a performance confirmation testing or monitoring function during construction or operations. Thus, an assemblage of performance confirmation testing and monitoring program *begins* during site characterization and continues until permanent closure and perhaps after closure, depending on the national regulatory setting. Only a select set of testing and monitoring activities undertaken for characterization is likely to be influential enough to be identified in the performance confirmation program.

Conducting science and developing a highly regulated facility necessitate an awareness of design, licensing, construction, and operations, as well as external influences. The long-term strategy must continue to effectively defend the licensing bases, incorporate societal input, provide for a responsive performance confirmation program, and continue appropriately scoped elective scientific investigations to advance general technical understanding. A long-term testing and monitoring strategy for repository science will continue for the life of the repository project as an integral part of the licensing processes consistent with statutory and regulatory constraints. Elements of the science program that are directly incorporated into a license application and demonstrative of the safety case, such as performance confirmation, are a critical part of the broader science program.

Performance confirmation technical objectives are natural components of the science program. Performance confirmation parameter measurements become program requirements when the confirmation plans accepted as part of the licensing bases are issued as specific performance confirmation test plans (PC test plans). From the technical perspective, monitoring parameters would be predicated on those elements of the safety assessment that most strongly influence risk, dose, uncertainty or other metrics of the performance assessment deemed important within the regulatory framework. Thus, performance confirmation measurements are distinct from elective testing activities, which are discretionary (not dictated by regulatory requirements). The third part of the overarching testing and monitoring strategy includes specific items identified by the regulatory authority, which may or may not have a strong performance impact. These three components (performance confirmation, elective testing, and regulatory requirements) comprise the long-term testing and monitoring strategy.

1.2 General Repository Monitoring

Repository monitoring is conducted for a variety of purposes. This section describes linkages between strategic national decisions regarding nuclear waste disposal, the concomitant FEPs, the models used to represent the FEPs in the safety assessment, and the implications that a staged repository development process imposes on the many monitoring requirements. In particular, the context for performance confirmation monitoring is distinguished from elective science testing programs and other monitoring activities undertaken for permits and operational considerations.

A specific hierarchy can be recognized for implementing a monitoring strategy, beginning with national law and policy decisions regarding waste disposal options. Once the high-level decisions are made, the relationships between the geologic medium and the waste form are established by virtue of the disposal concept. Depending upon national statutory and regulatory conditions, a repository program is expected to progress through a series of decision points, which could involve feasibility or viability assessments or license applications at sequential milestones of repository development. Decision points in the step-wise process provide the opportunity for all stakeholders to assess accumulated technical findings for comparison with the regulatory expectation. At these junctures, the affected community of stakeholders, regulators, applicants, and the general public is afforded the opportunity to participate in the evaluation of the information before them.

To expand on the place and role of monitoring in the staged repository development process, it is necessary to sequentially filter from statutory or regulatory conditions all the way down to specific performance confirmation parameters. To achieve that objective, the sequence of developing technical arguments of the safety case and the parallel evolution of a repository program will be used to guide the discussion. For example, initial site characterization programs explore the scientific basis for the repository and initiate compilation of the technical information, which is subsequently considered for repository decision-making. The accumulated technical information therefore establish the foundation for periodic decisions regarding the repository program progress. The basis of a testing and monitoring program to confirm, enhance, evaluate, or challenge the license application is established during the investigation process. This reality means that an investigative science program begins well before sufficient information is available to develop a performance confirmation program in a regulatory context.

Ongoing step-wise repository program activities facilitate staged decision making. Technical arguments and findings are accumulated as repository programs advance, as safety assessments are made, as licenses are solicited and considered and as decisions are rendered. A framework for continuous monitoring is a fundamental component of repository sciences, and regulatory authorities dictate a program structure inclusive of the manner and scope of testing and monitoring activities. As decisions are made to proceed with the repository, clearer definition of the performance confirmation is possible because this important undertaking is presumed to confirm the basis for expected or predicted repository system behavior. Measurements and observations made as part of the performance confirmation activities are compared to the data and assumptions used to develop the long-term safety case. In some national contexts, performance confirmation activities also support preclosure design and operational issues.

A responsive, transparent, scientifically sound, and flexible long-term testing and monitoring strategy addresses the needs of the overall repository program and the concerns of stakeholders. As noted previously such a strategy can be subdivided into three parts, namely, elective testing, regulatory requirements, and performance confirmation, all of which are influenced by public or stakeholder input. While a large portion of performance confirmation activities is linked to repository performance, other elective scientific investigations will undoubtedly be pursued with the intent of advancing the technical understanding in areas that are not linked directly to the safety case. Such a testing and monitoring philosophy allows degrees of freedom for research, which may inform the performance confirmation activities, allay societal concerns, or result in implementation of elective programs.

Table 1. Repository monitoring requirements

OPERATIONS	1. Engineering Systems Testing & Evaluation
	2. Design, Construction & Operations Testing
	3. Health, Safety & Effluents
	4. Security and Emergency Testing
	5. Licensing Specifications
LONG-TERM SCIENCE	6. Regulatory Directed Testing
	7. Elective Testing
	8. Performance Confirmation

Performance confirmation monitoring ensures that the technical basis of the long-term performance of a nuclear waste repository remains sound. This specific type of monitoring should not be confused with other repository science programs, site investigations, and operations, which involve many disparate monitoring requirements as shown in Table 1. As a repository program advances, the mission will include scores of monitoring activities such as those itemized elsewhere in this report to support overall programmatic needs and implementation.

The first five general monitoring categories in Table 1 involve operational safety and health, environmental impact and security issues, such as nuclear safeguards. Whereas these are recognized obligations for a viable repository program, they are not usually considered within the overarching long-term science strategy for the geologic repository itself.

1.3 Performance Confirmation

The performance confirmation program develops along with the maturing of the other components of the science program. Upon licensing, performance confirmation objectives become *de facto* monitoring requirements because parameters will be predicated on the most influential elements of the safety assessment. Elective science by contrast include research elements deemed appropriate to enhance the repository baseline information, to evaluate barrier performance, to address remaining uncertainties, or perhaps to reduce conservatism in some models.

A hierarchy for developing a performance confirmation program is sketched in Figure 1, which describes similar strategies developed in Belgium and the USA (NOCA 2009). First, the national statutory and regulatory framework governs strategic choices. The high-level policies are often called "boundary conditions," as reflected in Figure 1 (NOCA 2009). Strategic choices for each country context would include the geologic formation, the waste inventory and the concept of disposal. As illustrated in Figure 1, inputs at higher levels dictate many of the specific requirements, which after evaluation are implemented into performance confirmation activities. After the requirements are established, the methods of implementation, evaluation and feedback are defined at increasing levels of detail. The figure illustrates how requirements were evaluated and implemented for performance confirmation of Yucca Mountain in the United States. In Figure 1, the *assessment basis* that might be used in other repository programs may involve similar processes as applied in the Yucca Mountain assessments shown in the lower right as feeding back to the requirements. Assessment bases are discussed for two case studies and in additional detail throughout this document.

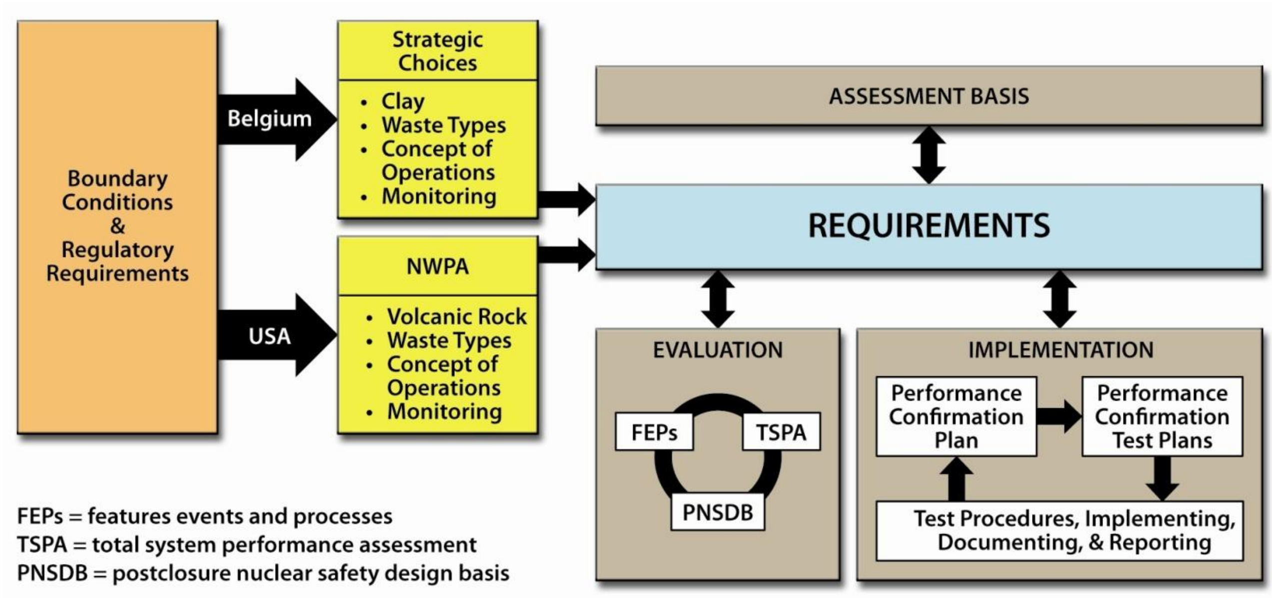

Figure 1. Hierarchy for developing and assessing performance confirmation

A long-term testing and monitoring strategy for repository sciences must be sensitive to many external and internal influences, in addition to the relatively straightforward assessment processes described in the following section. Research reported in the technical literature, international repository collaborations, findings of external agencies and other sources may need to be considered over the life of the repository program. This type of information is considered in the review process, which usually occurs on a yearly basis.

1.4 Parameter Identification

A description of the performance confirmation program including candidate parameters was required within the construction license application for Yucca Mountain. Confirmation parameters for any repository program will involve appreciable technical input, which must be objectively justified. Test parameters to be monitored or measured for performance confirmation derive from sources such as illustrated in Figure 2. Note these parameter sources are the same as used for the technical assessment and evaluation illustrated in Figure 1. In Figure 2, the performance assessment sequence shown on the left-hand side identifies many of the most important parameters influencing risk and dose. Similarly, the design basis for postclosure safety as shown on the right-hand side identifies parameters and characteristics of features and components important to barrier capability. If it is possible to test or monitor these quantitites, they could become candidates for inclusion in the confirmation program. Candidate confirmation parameters are selected from the results of the performance assessment and the FEPs analysis of the barriers as shown in Figure 2.

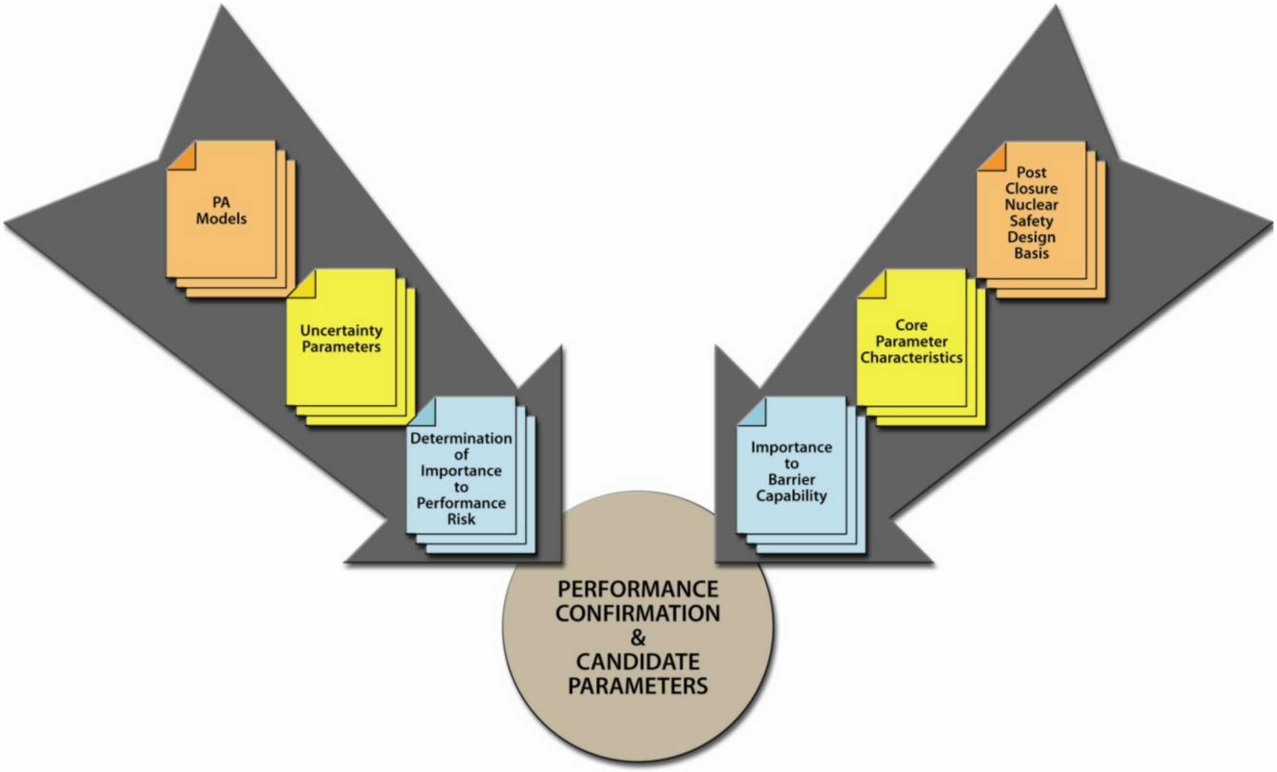

Figure 2. Sources used to identify performance confirmation parameters

The Electric Power Research Institute (EPRI 2001) outlined an eight-stage approach for performance confirmation:

1. Select performance confirmation parameters and test methods
2. Predict performance and establish a baseline
3. Establish bounds and tolerances for key parameters
4. Establish test completion criteria and variance guidelines
5. Plan activities and construct and install the performance confirmation program
6. Monitor, test, and collect data
7. Analyze and evaluate data
8. Recommend corrective action in the case of variance.

The eight stages of the EPRI performance confirmation approach rely on the selection of parameters subject to testing based on the sensitivity to performance. It is imperative to recognize the enormous amount of work that is completed *before* parameters are selected for performance confirmation activities. Along with parameter selection are data quality objectives, trigger values, and objective justification, which are considered in the following section as part of implementation and evaluation.

1.5 Implementation and Evaluation

Implementation of performance confirmation activities is an iterative process of test plan development, deployment, acquisition of data, evaluation of the data relative to the licensing bases, and then using results to guide further activities. The overall testing and monitoring program is expected to develop jointly with stages of repository advancement and refinement of the understanding of the repository system.

Performance confirmation testing and monitoring are implemented using a specific test plan, which is usually initiated and justified by a principal investigator. Based on the safety case, the principal investigator(s) will establish parameters, data quality objectives, and ranges for confirmation testing and monitoring. The diagram shown in Figure 3 incorporates the eight steps identified by EPRI (2001) in the implementation process. Figure 3 further illustrates the iterative assessment process associated with performance confirmation implementation. Individual PC test plans are developed, reviewed, authorized, and implemented. These requirements are then translated into a structured set of testing and monitoring needs that address long-term repository performance and support the decision-making process. Detailed requirements for individual monitoring or testing activities describe the parameter's importance to barrier capability, specify an acceptable (expected) parameter range, and describe the procedure and actions required for handling results outside of the expected range.

Performance confirmation programs are developed and implemented under the provisions of strict quality assurance requirements. Specific requirements for testing and data management are developed in PC test plans and implementing procedures. These test plans contain sufficient detail to conduct the test, as well as describe applicable functional and test-specific requirements. Approved plans provide the primary means to reach a documented consensus on all aspects of a test or experiment, including design, cost, schedule, interface controls, and data management. These plans are used for review and documentation of the test effort and serve as an agreement between the principal investigator, the test implementing organization, and the authorizing management.

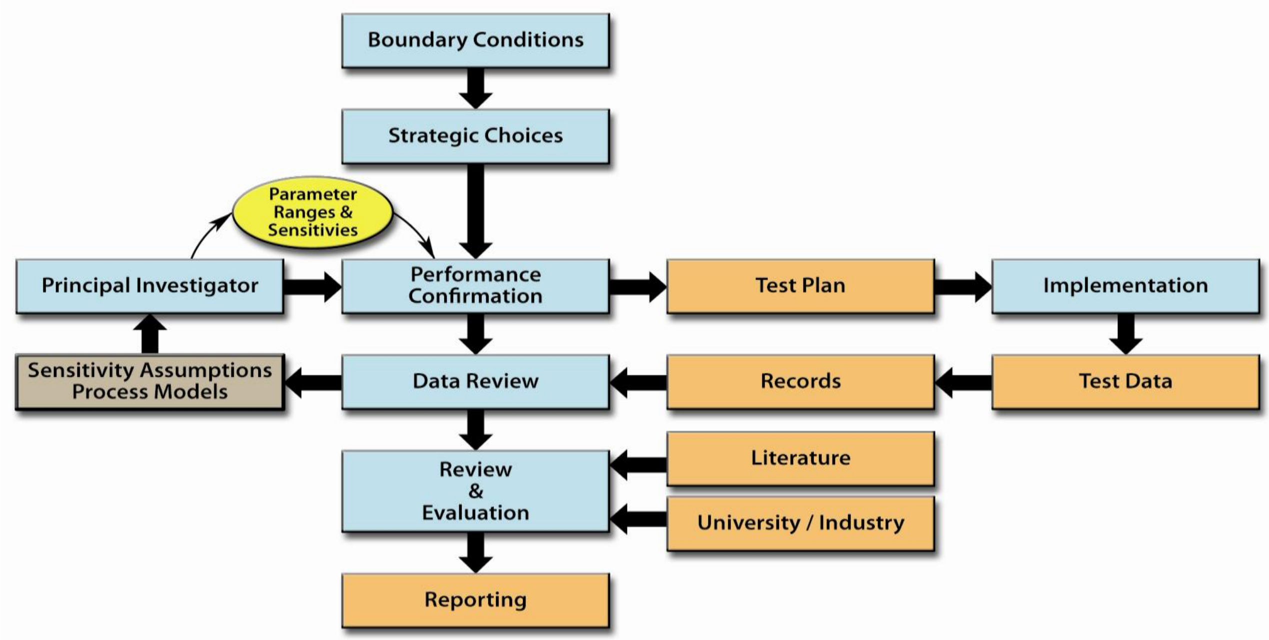

Figure 3. Implementation of a performance confirmation program

Enhancing the technical baseline by testing and monitoring can confirm or challenge assumptions made in performance predictions supporting the licensing submittal. Results that call into question the adequacy of assumptions, data, or analyses in the baseline information will initiate additional examination and evaluation. The repository program will adapt to inevitable changes, which are anticipated from technical advances, possible design alternatives, or similar circumstances. An evaluation of changes with respect to the postclosure technical basis and performance assessment is a recognized part of change control management. The testing and monitoring program includes a process to reevaluate, reexamine, and modify activities in a flexible and responsive manner.

1.6 Background for U.S. Regulations for WIPP and Yucca Mountain

WIPP and Yucca Mountain represent vastly different repository concepts; however, each has specific requirements for performance confirmation monitoring. WIPP has been in operation since 1999 and has met regulatory requirements for recertification every five years. Yucca Mountain followed a well defined, staged decision process for site recommendation and licensing. The nuclear waste repository programs in the United States involve waste inventories and geologic settings that are exceedingly diverse; however, both programs are governed by the Code of Federal Regulations (CFR). The most important regulations are:

- 10 CFR Part 60: Disposal of High-Level Radioactive Wastes in Geologic Repositories
- 10 CFR Part 61: Licensing Requirements for Land Disposal of Radioactive Waste
- 10 CFR Part 63: Disposal of High-Level Radioactive Waste in a Geologic Repository at Yucca Mountain, Nevada
- 40 CFR Part 191: Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes

- 40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations
- 40 CFR Part 197: Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada.

The regulations of 10 CFR Parts 60, 61, and 63 are authored by the Nuclear Regulatory Commission (NRC). In general, monitoring requirements contained within these regulations focus on the operational period. They require a confirmatory monitoring program to be initiated before operations begin and continuing until site closure. Confirmatory monitoring includes tests, experiments, and analyses that are conducted to evaluate the adequacy of the information used to demonstrate compliance with the site specific preclosure and postclosure performance objectives.

The regulations of 40 CFR Parts 191, 194, and 197 are authored by the Environmental Protection Agency (EPA). While the NRC regulates commercial nuclear power activities, the EPA has historically regulated or authored the requirements for disposal of waste generated or owned by the U.S. government. In general, these regulations require operational and postclosure monitoring of the disposal system. Operational monitoring ensures that dose limits to the public and the environment are not exceeded. These regulations also impose confirmatory monitoring requirements to identify parameters important to performance assessment that are capable of being monitored.

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2. PERFORMANCE CONFIRMATION FOR YUCCA MOUNTAIN

2.1 Bases

The extensive process involved with development of the safety case for Yucca Mountain provided opportunity to approach performance confirmation in assorted ways. The fundamental premise was always understood: confirmation evaluates information used as input to models, or evaluates whether observed behavior is consistent with expected or modeled performance. Before the move to rescind the Yucca Mountain license application, the enduring confirmation program was reviewed, evaluated, and updated as needed to reflect new technical, programmatic, and regulatory information and maintain consistency with the licensing bases. Development of the performance confirmation process and its accomplishments over the life of the Yucca Mountain project provide an informative case study.

The version of the performance confirmation plan (PC Plan) that supports the license application is the product of several revisions (SNL 2008a, Revision 5, Addendum 1). The fact that the confirmation program had undergone substantial review and revision over more than a decade leading up to the license application submission for construction authorization is consistent with our anticipated continuing evolution of the program if the Yucca Mountain Project moves forward. The perspicuous intention to update the PC Plan supporting the license application could prioritize confirmation activities and improve consistency with the physics of the process models integrated into the total system performance assessment. Such a process for sharpening the focus of performance confirmation is described in Section 4 of this report.

The initial version of the Yucca Mountain performance confirmation plan was issued in 1997 as part of the basis for the Viability Assessment. Extensive revisions were incorporated for the Site Recommendation in 2000. It was completely rewritten in 2003 and revised and rewritten in 2004 to reflect level of detail sufficient for license application. The performance confirmation plan continued to be updated and revised up to License Application submittal in 2008. Another revision is planned if the Yucca Mountain program is continued.

In this section, we summarize the basis and content of the performance confirmation program as it exists in the license application submitted to the Nuclear Regulatory Commission (NRC). The main activities identified in the PC plan were developed and published in late 2004. Obviously, this version of the plan predates the total system performance assessment for the license application submitted in 2008. The PC Plan, as with all supporting components of the license application at the time of submittal, was as complete as possible in light of information that is reasonably available. Toward this end, a completeness evaluation of performance confirmation was undertaken (SNL 2008a Appendix A[a]) to demonstrate that the PC Plan remained relevant to the license application bases.

The performance confirmation program described in the license application incorporated results of comparisons between the total system performance assessment (TSPA) (SNL 2008b), the *Postclosure Nuclear Safety Design Bases* (PNSDB) (SNL 2008c), and the content of Revision 5 of the PC Plan (SNL 2008a), as illustrated in Figure 1 and Figure 2. These three documents are referenced frequently in this section by their respective abbreviated titles (e.g., TSPA, PNSDB, and PC Plan). The TSPA consists of performance assessment models, in which many of the most important parameters are identified. The TSPA provides information on influential parameters, processes and barriers related to risk and dose. Similarly, the PNSDB identifies parameter characteristics of features and components important to barrier capability, which could be candidates for evaluation and monitoring in the performance confirmation program. The activities described in the PC Plan (SNL 2008a) were developed and informed by the knowledge of performance assessment analysts.

The license application submitted in 2008 contains an updated TSPA, which includes the latest assumptions and technical information available to the project. The basis for the safety case as supported in the TSPA identifies the influential parameters for potential monitoring. To ensure consistency between the confirmation program developed by the decision analysis techniques and the TSPA supporting the license application, an evaluation was performed at the time of the license application submittal. The adequacy of the confirmation activities described in the PC Plan is summarized in Chapter 4 of the Yucca Mountain Safety Analysis Report (SAR) (DOE 2009), which can be found on the web (http://www.nrc.gov/waste/hlw-disposal/yucca-lic-app/yucca-lic-app-safety-report.html). This evaluation confirmed that the existing performance confirmation activities provide a breadth of investigations sufficient to evaluate the performance basis of the license application and provide for continued evaluations into the future. Section 4 of this report describes how the performance confirmation planning would update the activities to capture the most important parameters with respect to appropriate performance metrics.

2.2 Activities and Schedule

The performance confirmation plan described in the submitted license application included a suite of twenty activities developed through a decision analysis process. Technical and subject matter experts used their knowledge of total system and subsystem (barrier) performance sensitivity to specific input, confidence in the current representation of the input, and accuracy of the proposed activity in quantifying the input. Of the twenty identified performance confirmation activities, eleven similarly named activities were undertaken during site characterization as listed in Table 2. These activities undertaken during site characterization are expected to be continued as part of the performance confirmation program and are listed in the first column of the schedule shown in Figure 4. The figure reflects an assumption of an approved license application following the submittal of the license application on June 3, 2008.

Table 2. Performance confirmation activities, license application 2008

Activity Title	Activity Description	PC Test Plan Current Revision Date
Testing and Monitoring during the Licensing Period		
Construction Effects Monitoring	Monitoring of subsurface opening convergence to confirm mechanical properties continues, but is dependent on tunnel access.	Completed 2006 Planned to be updated FY 2010
Seismicity Monitoring	Monitoring of regional seismic activity continues, with an expected revision to the PC test plan in FY 2009.	Completed 2007 Planned to be updated FY 2010
Precipitation Monitoring	Monitoring precipitation rate and volume continues for the six stations used for the licensing database.	Completed 2007 Planned to be updated FY 2010
Corrosion Testing	Corrosion testing is being conducted in an elective laboratory science program. Currently, no field test activities are being performed.	TBD
Waste-Form Testing	Waste form testing (including waste package coupled effects) in the laboratory under internal waste package conditions is not currently underway.	TBD
Saturated Zone Monitoring	Monitoring of water level and hydrochemical sampling of the saturated zone will be discontinued. The Office of the Chief Scientist and Lead Laboratory agreed with an assessment that the activities, while valuable, are not critical at this time to the Performance Confirmation Program or other aspects of the current mission.	TBD
Saturated Zone Alluvium Testing	Tracer testing at the Alluvial Test Complex using multiple boreholes is being conducted by Nye County, and is independent of the Performance Confirmation Program.	TBD
Testing and Monitoring Re-initiated during the Repository Construction Phase		
Mapping	Mapping of fractures, faults, stratigraphic contacts, and lithophysal characteristics	TBD
Subsurface Water and Rock Testing	Laboratory analysis of chloride mass balance and isotope chemistry based on samples taken at selected locations of the underground facility	TBD
Seepage Monitoring	Seepage monitoring and laboratory analysis of water samples	TBD
Unsaturated Zone Testing	Testing of transport properties and field sorptive properties of the crystal-poor member of the Topopah Spring Tuff, in an ambient seepage alcove or a drift	TBD
NOTE: FY = fiscal year; TBD = to be determined, PC = performance confirmation.		

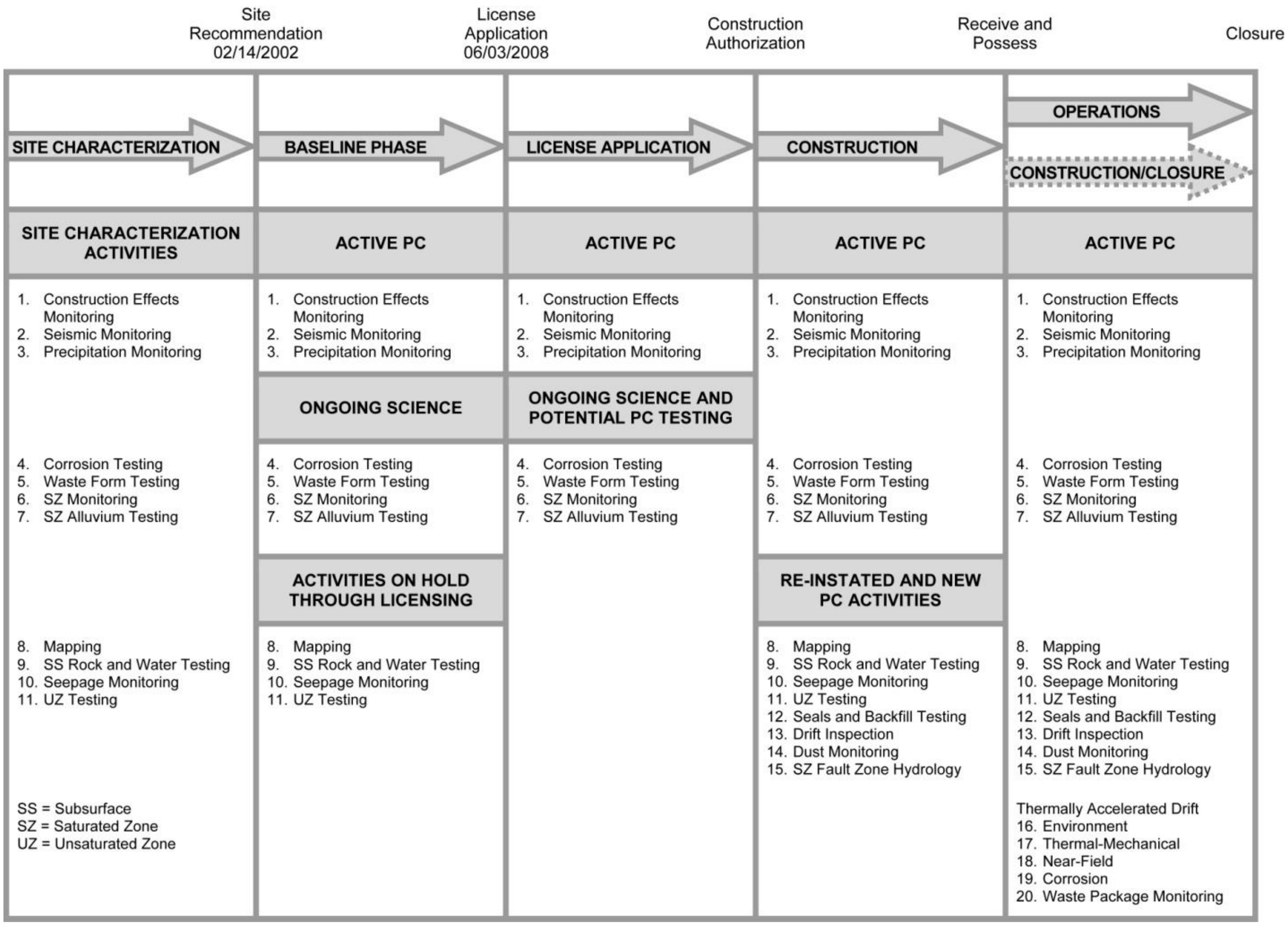

Figure 4. Generalized performance confirmation schedule

The PC test plans that were ongoing at the time of license application submission are also shown in the second column in Figure 4, "Baseline Phase," and are labeled "Active PC." These PC test plans and dates of formal initiation are:

- **Construction Effects Monitoring**—Monitoring of subsurface opening convergence. Completed 2006.
- **Seismicity Monitoring—**Monitoring of regional seismic activity. Completed 2007.
- **Precipitation Monitoring**—Monitoring precipitation rate and volume. Completed 2007.

As noted in Table 2, these three ongoing performance confirmation activities were expected to be updated after the license application was made. Construction effects monitoring requires access to the exploratory studies facility. As with any monitoring or testing program, seismicity and precipitation require financial and technical support to continue. In addition, a limited science program including investigations such as corrosion testing was expected to continue during the license review period. These activities were discontinued coincident with DOE's move to withdraw the license application. Given the time that has elapsed, it is unclear whether these activities would resume upon re-initiation of the licensing proceedings, or if their resumption would be deferred until the granting of a construction authorization. Further development of PC test plans would depend upon program guidance and prioritization at the appropriate time. The last four of the site characterization activities (mapping, subsurface rock and water testing, seepage monitoring, and unsaturated zone testing) were suspended before the license application submittal and were scheduled for start-up during construction activities. Other subsurface activities would be supportable when underground space is made available during the construction period. The performance confirmation activities that require radioactive waste in the drifts can only be realized during the operational period after a license to receive waste is granted. These circumstances typify the opportunistic nature and sequential necessity of long-term testing and monitoring.

Many of the twenty activities included in Revision 5 of the PC Plan (SNL 2008a) represent generalized processes and methodologies, recognizing that many of the activities can be implemented in a number of ways. Some activities are described in detail in the PC Plan, while others are conceptual and require additional consideration as the specific PC test plans are developed. The descriptions of the activities in the PC Plan provide the expected starting point and anticipated methodologies. There is no implied requirement regarding performance confirmation parameters and/or methodologies set by the language in the PC Plan. The candidate parameters, test concepts, and implementation technologies described in the PC Plan are intentionally preliminary until they are formalized in activity specific, detailed PC test plans. Justification for differences from the PC Plan is documented in the PC test plans, when appropriate. This distinction between the PC Plan and the PC test plans is necessary to ensure flexibility for implementation of requisite details in the activity-specific PC test plans.

Most of the performance confirmation activities have remained unchanged for several years. A planned revision and update was forestalled by the withdrawal of the license application, presaging ultimate termination of the Yucca Mountain project.

2.3 Evaluation Methodology

Each of the twenty activities selected includes multiple parameters and monitoring options. The decision analysis process considered "performance" in terms of influencing releases at the boundary and "risk" expressed in regulatory terms as probability-weighted annual dose associated with uncertainty. Because of its regulatory significance, the PC Plan must ensure the information therein is consistent with the license application information and reflects the understanding of the postclosure safety analysis under regulatory review. Confirmation activities may be revised in the future to reflect changes in the technical basis of the safety case. Any changes to the proposed confirmation scope will be carefully examined consistent with regulatory requirements.

The approach that ultimately identified the twenty activities described above used risk information to focus attention on issues important to public health and safety. The evaluation methodology is described elsewhere, such as the PC Plan (SNL 2008a) or SAR Chapter 4 (DOE 2009). The process will be summarized here to set the stage for a more appropriate methodology described in Section 4 of this document. The so-called risk triplet (*What can go wrong? How likely is it? What are the consequences?*) was applied to a set of parameters identified by subject matter experts[1]. The decision analysis process thereby initiated with subject matter experts identifying key individual natural system and engineering parameters of interest to the definition of performance confirmation, together with methods of data acquisition.

In the course of this practice, the subject matter experts identified over 300 activities, parameters, and data acquisition methods. Each combination of parameter and data acquisition method, termed an "activity," was assigned a unique numeric identifier. Management value judgments were used to determine the relative importance of each technical criterion, and the resulting overall utility was assigned to each activity. The approach explicitly recognized that both technical judgments and value judgments are a necessary part of decision-making, and that different people may be responsible for the different sets of judgments. The decision analysis approach to activity selection was conducted in three phases. In the first phase, candidate performance confirmation activities were identified and evaluated for inclusion in the performance confirmation program. In the second phase, the activity evaluations were used in combination with some general guidelines to develop candidate sets, which were evaluated and compared based on a number of criteria. In the third phase, project management and senior advisors reviewed the candidate sets, selected a base set, and directed modifications to increase the robustness.

Following the third phase, an additional series of refinement and evaluations through management and key technical representative reviews was conducted to bring activities listed in previous revisions of the plan into closer alignment with plans for the license application. These evaluations later culminated in a series of meetings where project management and key technical representatives reviewed the refinements, drawing a distinction among activities that were more commonly recognized as technical or design specifications, activities that were necessary for licensing defense and activities that were required to confirm predictions of long-term performance. The management and key technical representative evaluation resulted in related activities being consolidated where appropriate. Activities that did not strongly support regulatory compliance or the assessment of repository performance were deleted from the program. The result of these evaluations is the current list of twenty test activities.

2.4 Summary

This section described the performance confirmation basis that was included in the license application submitted to NRC for the repository construction authorization. SAR Chapter 4 (DOE 2009) relates the elements of the performance confirmation program to the regulatory requirements. We have briefly reviewed the multiattribute decision analysis process for selection of the twenty performance confirmation activities. In retrospect, although it is described in detail and documented in reports, the selection process was subjective in many respects, and perhaps not as objectively transparent as desired from a technical or stakeholder perspective. Nonetheless, the performance confirmation activities were subsequently evaluated on the eve of the license application to ensure consistency between the activities described in the

[1] Note the process begins in this instance with selection of parameters by subject matter experts. As will be discussed in Section 4, a more formal and transparent process for selection of confirmation parameters based on the results of performance assessment may serve to establish the relevance of the parameter to performance metrics and reduce the number of parameters.

PC Plan and the content requirements of the SAR. The existing performance confirmation activities support the technical basis for postclosure performance assessment of the natural and engineered barriers and provide adequate coverage to confirm the licensing basis (SNL 2008a).

The NRC recently (September 2011) released its findings on the performance confirmation section of the SAR. The NRC Technical Evaluation Report on the Content of the U.S. Department of Energy's Yucca Mountain Repository License Application Administrative and Programmatic Volume is publicly available on the NRC website (pbadupws.nrc.gov/docs/ML1125/ML11255A152.pdf). The NRC finds that the performance confirmation program described here is consistent with the NRC's Yucca Mountain Review Plan (YMRP).

> The SAR includes a description of the Performance Confirmation Program, which evaluates the adequacy of the supporting assumptions, data, and analyses in the SAR. DOE stated that key geotechnical and design parameters, including any interactions between natural and engineered systems and components, will be monitored and changes will be analyzed throughout site characterization, construction, emplacement, and operation to identify any significant changes in the conditions assumed in the SAR that may affect postclosure performance. DOE described its performance confirmation activities and stated it would provide to NRC, prior to test implementation, future performance confirmation test plans outlined in the SAR. On the basis of the NRC staff's review of the SAR and other information submitted in support of the SAR, the NRC staff notes that DOE has provided a reasonable description of its Performance Confirmation Program that is consistent with the guidance in the YMRP.

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3. PERFORMANCE CONFIRMATION FOR WIPP

3.1 Introduction

The Waste Isolation Pilot Plant, or WIPP, safely disposes of defense-related transuranic radioactive waste. The repository layout is illustrated in Figure 5. Recognized as an exceptionally successful nuclear waste repository, the WIPP was licensed in a regulatory environment, which included performance assessment methodology and a performance confirmation monitoring program. Development and implementation of confirmation monitoring for the WIPP provide a second significant case study.

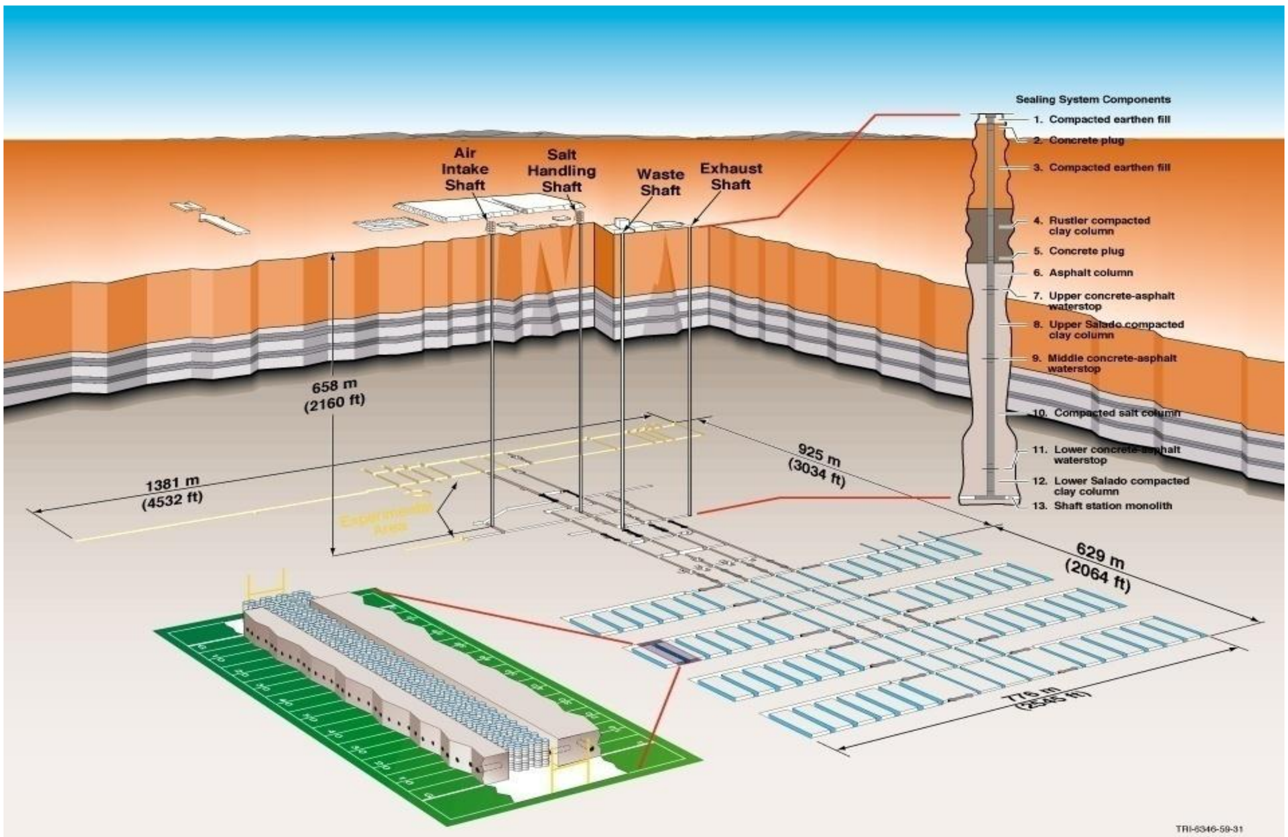

Figure 5. Schematic of the WIPP facility

3.2 WIPP Monitoring

As discussed for the Yucca Mountain program, an overall monitoring program is based on assumptions and regulations for the disposal concepts and waste types. Monitoring requirements logically derive from the functional, operational, and postclosure goals. Monitoring a radioactive waste disposal facility ensures protection of the public and environment from current and potential future hazards. This is accomplished by undertaking activities that confirm compliance with applicable protective regulations and through activities that confirm critical aspects of the expected performance of the repository.

Because monitoring is a confirmatory activity, information gathering occurs before and during operations, and could continue after the facility is closed. Similar to Yucca Mountain, the WIPP monitoring spectrum includes different categories that apply to a disposal system, which in the relevant documentation are termed environmental monitoring, operations monitoring, and performance confirmation defined as follows:

- *Environmental monitoring* includes sampling and evaluation of air, surface water, groundwater, sediments, soils, and biota for radioactive contaminants. This type of monitoring determines public and environmental impact of the site. Comparisons are then possible between baseline data gathered before site operations and data generated during disposal operations.
- *Operations monitoring* is defined here as monitoring activities used to comply with regulatory requirements for general siting, facility operations, and decommissioning. These requirements are identified in existing regulations, state agreements or organizational agreements.
- *Performance Confirmation* constitutes a program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to demonstrate compliance with the site specific preclosure and postclosure performance objectives. In the WIPP case, some performance confirmation monitoring started during initial site characterization.

Thus performance confirmation is distinct from the many other monitoring practices involved with environmental permits and repository operation. The WIPP documents refer to performance confirmation as “compliance” monitoring. Periodic review of these monitoring parameters is necessary to meet the intent of the EPA’s assurance requirements applicable to WIPP, 40 CFR 191.14(b):

> Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring.

The DOE oversees and directs the monitoring program to ensure compliance with the EPA monitoring and reporting requirements. Observations beyond the acceptable range of trigger values represent a condition that requires further evaluation. This approach ensures that conditions that challenge expected repository performance are recognized as early as possible. These conditions may include data inconsistent with the conceptual models implemented in performance assessment or invalidation of assumptions and arguments used in screening FEPs.

3.3 Parameter Selection

Technical decisions for selection of parameters to be monitored and analyzed should be made accounting for regulatory requirements, modeling assumptions, features, events, and risk information derived from performance assessment results. Uncertainty and sensitivity analyses often quantify the importance of the parameters that are candidates for monitoring in the performance confirmation plan. Such statistical analyses are likely to provide a sufficient set of diagnostics to justify parameters selected as well as the parameters not selected for performance confirmation monitoring.

Preclosure and postclosure monitoring at WIPP was described in detail in Appendix MON of the Compliance Certification Application (CCA) (DOE 1996). Significant and measurable parameters were screened by summarizing the regulatory requirements (40 CFR 191.14(b) and the criteria in 40 CFR 194.42). The five screening criteria applied to the parameters individually were:

- Addresses significant disposal system parameters,
- Addresses an important disposal system concern,
- Obtains meaningful data in a short time period,
- Does not violate disposal system integrity, and
- Complements Resource Conservation and Recovery Act programs.

The WIPP CCA also suggests postclosure monitoring of subsidence and application of other possible geophysical techniques. Monitoring and measurement activities include the determination of values that are directly and indirectly related to parameters that have survived a screening process which includes the criteria described above. These ongoing monitoring programs include geomechanics/geotechnical, groundwater, environmental, volatile organic compounds, and subsidence surface surveys. The connection—or lack of one—between these parameters and FEPs embodied in performance assessment is addressed in the next section.

3.4 Parameter Tie to Performance

In general, the screening practices noted above were *not* predicated on a direct or indirect correlation to system performance metrics, as was the case for Yucca Mountain performance confirmation parameters. The WIPP project continues to monitor these ten parameters diligently and report annually in what are called compliance monitoring parameters reports, or COMPs. Although the screening criteria for WIPP parameters appear to be rather subjective, the monitoring program has proven to be effective both for the technical purposes and the societal or public assurance purposes. Relevance of each activity and associated monitoring parameter is given below:

- **Creep Closure and Stresses**—The closure rate increase signals potential de-coupling of rock.
- **Extent of Deformation**—Coalescence of fractures at depth in rock surrounding drifts will control panel closure functionality and design, as well as discretization of performance assessment models.
- **Initiation of Brittle Deformation**—This is a qualitative parameter and not related to performance.
- **Displacement of Deformation Features**—Lateral displacement of boreholes allows global interpretation of rock mass behavior.

- **Culebra Ground Water Compositions**—Provide validation of the various conceptual models, potentially significant with respect to flow, transport, and solubility and redox assumptions.
- **Change in Culebra Ground Water Flow**—Provides validation of transmissivity models and the groundwater basin model.
- **Drilling Rate**—Direct-release calculations are influenced by drilling rate changes.
- **Probability of Encountering a Castile Brine Reservoir**—The EPA conducted analyses that indicate a lack of significant effects on performance from changes in this parameter.
- **Subsidence Measurements**—Predictions are of low consequence to the calculated performance of the disposal system.
- **Waste Activity**—May affect human intrusion scenarios, so a substantial change in average activity of intersected waste is potentially significant.

As pointed out by Hansen and Stein (2005), there are several important characteristics of the WIPP underground that can be modeled more accurately and that perhaps could be monitored. However, the original parameters remain unchanged.

Monitoring requirements and possible improvements have been revisited since disposal operations commenced, and have concentrated on major uncertainties in the existing performance assessment, and on known differences between the performance assessment models and the actual conditions existing or expected within the waste room. Of specific note with respect to monitoring is a report by the National Academy of Sciences National Research Council Panel, entitled *Improving Operations and Long-Term Safety of the Waste Isolation Pilot Plant* (NAS 2001). The Panel report in 2001 was the first such review following the certification of the facility by the EPA in 1998. The Panel was tasked: (1) to identify technical issues that can be addressed to enhance confidence in the safe and long-term performance of the repository and (2) to identify opportunities for improving the National Transuranic (TRU) Program for waste management, especially with regard to the safety of workers and the public. The NAS panel report (NAS 2001) makes specific recommendations tying monitoring to performance indicators:

> The CCA relies on a model, called a "performance assessment," that calculates the probability and consequence of several scenarios by which radionuclides could be released into the environment. The performance assessment also identifies the major uncertainties and their impact on the overall performance of the system. To reduce some of the uncertainties in the performance assessment and to add confidence in the containment performance of the repository, *the committee recommends taking advantage of the long (35 to possibly 100 years) preclosure operating period to monitor selected performance indicators.*

Notwithstanding these worthy comments from an outside advisory Panel, none of these recommendations led to addition or deletion of the compliance monitoring parameters for WIPP. Today, the original ten parameters are monitored.

4. RECOMMENDATIONS FOR PERFORMANCE CONFIRMATION

Section 1 of this document provided an overview of an integrated long-term testing and monitoring strategy that includes confirmation activities. Section 2 presented the performance confirmation information provided with the Yucca Mountain license application for construction authorization. Section 3 described the compliance monitoring instituted for the WIPP, which has been satisfactorily conducted under EPA regulations since 1999. By virtue of these experiences, the U.S. repository program has a substantial understanding of the workings and requirements of performance confirmation. This section builds on material presented in Sections 1, 2, and 3 and illustrates development of a performance-based process that relies principally on TSPA results. Using these tools and experience, the U.S. is appropriately positioned to reinstate the performance confirmation program for Yucca Mountain if the adjudicatory process is resumed and the submitted application is found acceptable. The approach articulated here may provide valuable guidance to repository programs internationally as they contemplate the concept of performance confirmation.

4.1 Confirmation of the Performance Assessment

Prioritization of parameters for the monitoring program is traceable back to the safety and feasibility statements (and hence, the FEPs of the disposal system) in terms of their importance to barrier capability and waste isolation. These relationships can be derived by statistical postprocessing of the computations comprising the safety performance assessment.

> ***A performance confirmation program will be conducted to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes.***
> ***— 10 CFR 63.102***

Section 1.4 stressed the concept that performance confirmation parameter identification is a result of several prerequisite analyses. In one case study, Yucca Mountain decision analysis methodology described in Section 2.3 generated over 300 parameters, activities, and data acquisition methods. Here we review the technical essence of performance confirmation in the context of performance assessment. This process illustrates how rigor and attendant transparency can improve the process for set-up of repository performance confirmation in days ahead.

A performance confirmation program evaluates information used as input to models, or evaluates whether observed behavior is consistent with expected or modeled performance. The scope of the performance confirmation plan for Yucca Mountain was judged to capture adequately performance confirmation needs for the license application, which was indeed substantiated by the recent finding of the NRC (see section 2.4). It is understood that a performance confirmation program should remain as consistent as possible with the license application baseline information. To achieve that goal, the performance confirmation plan would continue to be reviewed, evaluated, and updated as needed to reflect new technical, programmatic, and regulatory information. If the licensing process for Yucca Mountain is resumed, the following blueprint describes possible steps for confirmation parameter selection.

4.2 TSPA Models/Parameters

An evaluation of the Yucca Mountain performance confirmation activities was performed just before the license submittal (SNL 2008a, Appendix A[a]). The breadth of the plan covered the technical basis for postclosure performance assessment of the natural and engineered barriers. Therefore, no new performance confirmation activities were added to the existing plan. However, considerable insight was gained toward parameter selection in the framework of the process models incorporated in the TSPA. As comparisons were made between the models and parameters used for the TSPA and the performance confirmation activities, each model was evaluated for importance to dose and contribution to uncertainty. In certain cases, higher priority based on significance to dose or uncertainty can be inferred and would be considered as performance confirmation activities are written in refined detail in individual PC test plans.

All repository postclosure analyses will have a number of models developed on the basis of FEPs. Importance of models, parameters, and processes used for the Yucca Mountain license application was evaluated in advance of the license application. Parameters were identified whose uncertainties have significant effect on dose to the reasonably maximally exposed individual over the regulatory periods. The parameters in TSPA models that are most significant were identified and then weighed against planned performance confirmation activities (SNL 2008a). TSPA model results derive from particular parameter distributions and other assumptions. Therefore, the testing and monitoring details, including justification, parameter ranges and condition limits, can be gleaned from the TSPA baseline. Front-end analyses for these purposes are available, including uncertainty and sensitivity analyses for expected dose and other statistics (SNL 2008b, Helton et al. 2008). These and other analyses would be used when and if the Yucca Mountain PC Plan is reissued.

4.3 Selection of Confirmation Parameters

It should be noted that values for standard rank regression coefficient (SRRC) were used to guide qualitative evaluations. The SRRC values were available from Appendix K of the TSPA analysis model report (SNL 2008b). The evaluation and ranking of each TSPA model was summarized model-by-model to identify the performance confirmation activity or activities that apply to each of the TSPA models. In this manner, it was determined that influential TSPA models had identifiable performance confirmation activities in the license application documentation. A complete listing of the process models used in TSPA was compiled, including the input parameters and the output parameters. Uncertain parameters for each model were ranked by level of importance based on sensitivity analysis of total calculated dose. Qualitative evaluations of model parameters and processes were based on TSPA results and knowledge of the processes contributing to dose. The models and parameters used in TSPA were compared to the activities and candidate parameters included in the PC Plan. A comparison of sensitivity analysis results can be based on correlation coefficients, which provide an estimate of the monotonic relationship between input variables and the output variable under consideration (SNL 2008a).

Evaluation of parameters involves getting into the details of the models. Insight regarding the most significant parameters is consistent with technical documentation used for the license application safety case. In Appendix K of the TSPA analysis/model report (SNL 2008b), stepwise rank regression is used to identify those parameters that make the largest contribution to dose uncertainty. In a stepwise rank regression, the single independent variable that makes the largest contribution to the uncertainty in the dependent variable is selected in the first step. Then, at the second step, the single independent variable that, in conjunction with the first variable, makes the largest contribution to the uncertainty in the dependent variable is selected. This process then continues until no additional variables are found that make identifiable (i.e., significant) contributions to the uncertainty in the dependent variable; at this point, the stepwise selection process terminates. In the context of stepwise regression analysis, variable importance is indicated by the sign and magnitude. A positive SRRC indicates that the independent variable and dependent variable tend to increase and decrease together, whereas a negative SRRC indicates that the independent and dependent variable tend to move in opposite directions. Values of SRRC were compared to the sensitivity analysis results in Appendix K of the TSPA analysis/model report (SNL 2008b).

As an example, these analyses for Yucca Mountain showed the importance of stress corrosion cracking decreases at approximately 500,000 years, when general corrosion dominates the modes of waste package damage. The significance to uncertainty of models is based on the uncertainty of parameters used in those models. In this seismic-scenario, ground-motion modeling case a key parameter is the threshold for stress corrosion crack initiation, which is used to estimate waste packages failure. At the time of the license application, elective research on stress corrosion was ongoing, but had not yet been reviewed, approved and issued as a performance confirmation activity. However, the importance of stress corrosion studies was established and long-term corrosion tests of waste package materials would be given a relatively high priority for inclusion in the confirmation program based on analysis of performance assessment results.

Once parameters are selected, expected ranges, condition limits, and other related information are developed using the risk-informed knowledge base and documented in the PC test plans. The principal investigator develops expected ranges to capture the input set provided to the TSPA, as documented in analysis/model reports and technical data input packages. The expected ranges allow for natural or measurement-related variability and include values used for the performance assessment analyses. These considerations assure that the performance assessment results remain acceptable if the performance confirmation values remain within these ranges. A substantial margin is likely to exist between condition limits outside the expected range and values influencing barrier functionality or compliance with performance objectives. The condition limits are based on the performance assessment model, validity conditions, importance to barrier capability, the results of uncertainty and sensitivity analyses, and evaluation of available data.

4.4 Conclusions

There are many categories of testing and monitoring programs required to design, construct, operate, and close a nuclear waste repository. These include: performance confirmation testing and monitoring; design construction and operations testing; licensing specification testing; security, safeguards, and emergency testing; regulatory directed testing; natural and engineered systems testing and evaluation; health and safety effluents monitoring; and elective science and technology testing. Documented results of many of these testing and monitoring programs will be required to satisfy the regulatory requirements for the repository. The criteria by which activities will be evaluated for inclusion into a given category of the testing and monitoring programs, the functions each category addresses, and the current list of activities in each category will be developed at the appropriate time and for the intended purpose. Performance confirmation is a specific element among these many other programs.

The performance confirmation plan for Yucca Mountain is used as the primary example of how the next generation of such plans can be accomplished. In a general sense, the performance confirmation plan addresses uncertainties within the performance assessments used for estimating long-term safety and is intended to increase confidence that the performance objectives designed to protect public health and safety are satisfied. Specific performance confirmation activities are expected to evolve and the plans will be updated accordingly. This progression could be based on statistical studies of the TSPA data that identify parameters most significant to performance metrics.

As the licensee for both WIPP and Yucca Mountain, DOE supplied the technical basis for the models used in the performance assessment. In turn, the performance assessment constitutes much of the safety case for compliance certification or license approval for WIPP and Yucca Mountain, respectively. Performance confirmation provides data to verify the adequacy of the information presented in the certification or license application. Despite the differences in mission, geologic setting and regulatory authority, the basic workings between the safety case performance assessment and performance confirmation are analogous. In the case of the WIPP repository, the compliance monitoring program has been successfully implemented and is evaluated and reported annually. If the license review of the Yucca Mountain proceeds successfully, a transparent and technically objective course has been identified for its performance confirmation program.

Experience with the WIPP and Yucca Mountain nuclear waste repository programs involved dissimilar media, EPA versus NRC regulators, unlike waste inventories and differing disposal concepts. However, both programs embrace a performance confirmation strategy and from these experiences guidance can be rendered for future performance confirmation considerations:

- Performance confirmation parameters should be demonstrably linked to the safety assessment.

- In some manner, performance confirmation begins during site characterization but formally becomes a commitment when it is included in a license submittal.

- Because PC test plans require detail including acceptable ranges and relevance to performance assessment, care should be exercised in development of and commitment to each PC test plan.

The phased nature of repository development allows progressive development of performance confirmation approaches. The overall Yucca Mountain testing and monitoring program envisioned at the point of license application was flexible relative to the stage of repository development such as construction or operations, regulatory requirements, and the continuing refinement of the understanding of the repository system. Elements of the performance confirmation program start during site characterization and are expected to be continued over the life of the project. The regulatory nature of specific PC test plans necessitates that sound technical bases be consulted for their definition, particularly with regard to selected parameters, ranges, and reportable conditions. A parallel and complementary elective testing program will be instrumental in quantifying the appropriate parameters for some confirmation activities.

Performance confirmation adds to public confidence because it demonstrates that the repository is responding as expected and as represented in the licensing basis, or, in the event that performance confirmation reveals problems, it demonstrates transparent and responsible program management, assuming corrective actions are prompt and effective. A successful science program includes transparent public outreach and includes a process to reevaluate, reexamine, and modify activities as the state of understanding changes.

The U.S. repository programs have been conducted openly and transparently for many years. This report recounts the successful compliance monitoring history for WIPP and development of a performance confirmation plan for the Yucca Mountain license application, the latter being found reasonable and consistent with regulatory expectations. In the process of analyzing and compiling the license application for the Yucca Mountain repository, a clear path for performance confirmation within a long-term testing and monitoring strategy emerged. The experience and appropriate tools exist to readily reengage performance confirmation if the Yucca Mountain licensing process is resumed[2]. Experience developing performance confirmation in a licensing framework for two mature geologic repositories in the United States has the potential to guide other such work if the lessons are indeed learned and applied.

[2] The proposed FY 2012 budget provided no funding for contracts and federal staff hours for the High-Level Waste Repository licensing activity. The Licensing Support Network was taken off-line. Subsequently, the equipment was removed from the webhosting facility and the system's data were written to archival tape. Repository licensing for Yucca Mountain program activities came to a halt on September 30, 2011.

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