

APPENDICES

INTRODUCTION

Appendices A through I were developed to document future DOE and NRC activities for use in DHLWM planning and scheduling of future work. Following descriptions of the DOE and NRC activities and programs, in each area, appropriate schedules are presented at the end of each appendix. These schedules provide important information for integrating the NRC and DOE HLW program activities. The scheduling information is represented by time-lines to indicate duration of activities (where such information is known), and triangles to represent milestones.

Information for the DOE program descriptions and schedules was obtained from the DOE Mission 2001 Plan (TRW, 1992), and the DOE Yucca Mountain Site Characterization Project Interim Work Breakdown Structure Index and Dictionary (DOE, 1992) except where other documents are referenced. In addition, DHLWM staff were encouraged, where possible, to provide more current information regarding DOE activities and schedules based on working knowledge in their area of expertise. Since the planning process is iterative in nature and dependent on a number of changing variables, the DHLWM acknowledges the information contained in these appendices is tentative and will need to be updated and revised periodically as new information is made available.

REFERENCES:

1. TRW, 1992. Mission 2001 Final Report (September 18, 1992). TRW Environmental Safety Systems, Inc, Las Vegas, NV.
2. DOE, 1992. Interim Work Breakdown Structure Index and Dictionary. YMP/CC-0020, Rev. 1. Yucca Mountain Site Characterization Project Office, U.S. Department of Energy, Las Vegas, NV.

APPENDIX A
THE NATURAL SYSTEMS OF THE GEOLOGIC SETTING
GEOLOGIC SYSTEM

DOE GEOLOGICAL SITE INVESTIGATIONS PROGRAM

The objective of the Department of Energy (DOE) geology program is to conduct geologic investigations to evaluate the suitability of the surface and subsurface environment for the purpose of siting a nuclear waste repository. This includes efforts to plan and conduct laboratory, surface-based, and underground investigations necessary to evaluate the geological characteristics of the site under anticipated and unanticipated processes, events, and conditions. This program includes investigations pertaining to Erosion, Rock Characteristics, Preclosure Tectonics, Postclosure Tectonics, and Resource Potential at the site. The results of investigations conducted in these areas will provide information for development of conceptual models that describe the current characteristics of the site, their future evolution in time, and potential disruptive scenarios. These models will support efforts to assess overall performance of the proposed repository.

In an effort to satisfy the requirements in 10 CFR 60.122 regarding erosion at the site, the DOE has conducted investigations to identify the erosional processes operating in the Yucca Mountain (YM) area during the Quaternary and has quantified the rates of the processes and assessed their relative importance. Estimates of the locations and rates of present and past erosion have been determined. Locations of past erosional activity have been identified and data have been collected to assess anticipated effects of erosion on the hydrologic, geochemical, and rock characteristics of the controlled area. The present locations and rates of erosion have been combined with the nature and rates of climate change to estimate significant changes in the character, distribution, and rates of surface erosion in the YM region during the next 1,000 to 100,000 years. The DOE also has estimated the effects of tectonic activity on erosion over the repository postclosure period on the basis of probable future tectonic scenarios for the YM region. A report on evidence of extreme erosion was completed in FY93 and is currently under review by the Nuclear Regulatory Commission (NRC).

Rock Characteristics tasks are divided among studies to characterize the geologic framework of YM and to acquire site specific subsurface information systematically. This effort is planned to start beginning in FY93 and close in FY95. The characterization of the geologic framework includes field studies to determine the variability and emplacement history of stratigraphic units and lithostratigraphic subunits; the frequency, distribution, characteristics, and relative chronology of structural features; and development of a three-dimensional (3D) model of YM geology. The systematic data acquisition of subsurface information will include collection of rock samples and information to characterize the 3D distribution of rock characteristics. This information will be used for the development of a computer-based 3D model that integrates data on rock characteristics and information developed by the aforementioned studies of surface and subsurface geology.

Postclosure Tectonics activities supply data on the probability and effects of tectonic initiating events that may alter existing conditions at YM and adversely affect repository performance. Considerations include direct releases from volcanic events, waste package effects, and changes in hydrologic and geochemical conditions (which can affect the rate of radionuclide movement). Part of the consideration of direct releases from volcanic events includes a determination of the probability of magmatic disruption. The DOE began work on the probability of magmatic disruption in early FY92, with completion expected in late FY97. Such an effort will require the synthesis of data on dating, location, and volume of late Cenozoic volcanic events in the region surrounding the site. Maps will be produced showing the age, location of vents, distribution, and volume of lava and pyroclastic deposits. The DOE will also investigate time-space patterns of past volcanic activity in the YM Region, including possible structural controls and potential future locations of volcanic centers. Geophysical data will be reviewed to determine if any

midcrustal magma bodies are present that might be a source for future volcanic events. Such information will be used to revise estimates of the probability of volcanic eruption at YM. Information required in the tectonics program includes characterization of volcanic features, igneous intrusive features, and faults and folds in Miocene and younger rocks of the region.

Information regarding surface characteristics will be collected by the DOE to determine location and design of repository surface facilities. These efforts must evaluate the surface elevation and relief at the potential surface facility sites and characterize soil and rock at and near the surface. These efforts will provide geotechnical information to assist in the design of foundations and in the evaluation of suitable locations for constructing the surface facilities. Such surface facility design data are planned to be available in late FY97. Additionally, design data for the Exploratory Studies Facility (ESF) surface facilities are planned to be available by early FY95.

Preclosure Tectonics activities will characterize the tectonic events and processes that could affect proposed repository structures, systems, or components important to safety (during operations), as well as the design and operation of structures, systems, and components required for exercising the retrieval option. Potential sources of impacts to be investigated include the potential for volcanism, faulting, and vibratory ground motion. Collection and analysis of tectonic data are also important tasks in the Preclosure Tectonics Program. Preclosure Tectonics efforts culminate in the synthesis of fault data relevant to tectonics to support the development of a model (or range of models) that establishes the causal relation between tectonic stresses and the formation of structures observed at YM and in the surrounding vicinity. Such a model will be developed to forecast changes in tectonic setting and to assess the impact of such changes on the regional crustal strain rate and tectonic stability. Ultimately, the model will estimate the future rate of tectonic processes at YM. Activities to conduct a probabilistic assessment of faulting at YM are planned to begin in early FY94, and a final report is scheduled to be issued by late FY98.

In response to a magnitude 5.6 earthquake in the vicinity of YM in late FY92, the DOE stated its intentions to accelerate its program to study seismic hazards at YM by implementing an accelerated action plan to assess the hazards. The planned seismic program contains four elements, including (i) a technical program, (ii) an evaluation of the seismic hazard aspects of site suitability, (iii) a study of seismic vulnerabilities of YM, and (iv) preparation of a series of topical reports to support resolution of seismic topics with the NRC. Completion of two or three of these reports each year is planned between FY93 and FY96. Sources of future seismic activity will be determined by studying Quaternary faults, evaluating contemporary and historical seismicity, and developing tectonic models for the region. Earthquake magnitudes will be estimated based on paleoseismic studies and documented historical events within the YM basin and range. Both regional and site-specific data will be used to assess ground motion from future earthquakes. Probabilistic and deterministic methods will then be used to evaluate the seismic hazard at YM and develop a seismic design basis for the potential repository.

The potential for the existence of extractable natural resources at the site will be characterized with the intent to determine the likelihood of inadvertent human intrusion into the repository block. The DOE also plans to use this information to determine the possible consequences of such interference. Studies conducted to support this effort include laboratory, surface-based, and ESF tests, studies, and investigations to evaluate the existence of energy, mineral, land, and groundwater resources at and near the site. Resource data will also be analyzed to evaluate the present and future value of these resources. This work began in FY92, and a report on Natural Resources is planned to be completed by early FY95.

The DOE is producing a number of study plans in the area of geoengineering which provide inputs for Geologic Repository Operations Area (GROA) design construction and operations. At the current time, most of the study plans are focusing on the rock-mechanics-related topics. Study plans recently submitted for NRC review are related to activities that would take place early in the ESF schedule. For example, *in situ* excavations, *in situ* rock mechanics properties, and laboratory and field rock properties (such as thermal expansion and strength) are some of the topics being studied by the DOE. The DOE continues to release study plans related to geoengineering as the ESF activities and surface-based testing continue at the YM site.

NRC GEOLOGIC SYSTEM

I. OVERVIEW

The NRC mission in the Geologic System portion of the Geologic Setting Program is to evaluate and assess the DOE geologic data-acquisition and technical analysis activities to determine if the DOE can acceptably demonstrate compliance with the requirements of 10 CFR Part 60. To accomplish this mission, the staff is conducting preclicensing consultation, developing 18 individual review plans for the License Application Review Plan (LARP) that cover geologic and geophysical factors, and developing technical guidance in areas where technical and regulatory uncertainties are of particular significance. This strategy is designed to allow the staff to use insight gained from its preclicensing consultations, LARP development, and development of guidance documents to assure topics critical to licensing are addressed in a timely fashion and to support and facilitate its review of the license application.

During preclicensing consultation, the staff is conducting focused technical reviews on geology-related regulatory topics. These reviews include those required by statute (e.g., Site Characterization Plan review) and supplemental reviews in technical areas where uncertainty is great and significance to repository performance is high. Supplemental reviews include reviews of DOE Topical Reports resulting in the development of corresponding staff Safety Evaluations (SE) in accordance with the Department of High-Level Waste Management (DHLWM) draft Topical Report Review Plan. Technical reviews are directed towards issue resolution and providing timely response to DOE in order to avoid unnecessary delays in the DOE program.

Systematic analysis of 10 CFR Part 60 and the resulting development of the LARP have resulted in the identification of geologically-related key technical uncertainties (KTUs). To address these KTUs in the context of an eventual review of a license application, the staff is developing supportive technical assessment methods (e.g., independent modeling activities) and/or technical guidance. For example, the staff is evaluating the Lawrence Livermore National Laboratory code, SEISM1, for application to a geologic repository. The SEISM1 code is a probabilistic/expert judgement-based code to assess the design bases for Nuclear Power Plants (NPP) in the eastern U.S. A follow-on version of the code, SEISM3, is under development for NPP siting in the western U.S. The evaluation of this code is directed towards identifying the modifications necessary to meet the needs of the High-Level Waste Program (HLW). In addition, the staff is currently developing a series of technical guidance documents to address topics contained in a KTU related to fault displacement and seismicity. Production of these guidance documents will enhance staff technical knowledge necessary for the development of Compliance Determination Methods (CDM) which will be used to assess compliance with 10 CFR Part 60 requirements regarding investigation and analysis of fault displacement hazards and seismic hazards at a geologic repository.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

The Energy Policy Act of 1992 (EnPA) requires the National Academy of Sciences to make findings and recommendations regarding the Environmental Protection Agency (EPA) standard including whether or not postclosure oversight of a repository, based on active institutional controls, can prevent an unreasonable risk of breaching of the repository's barriers or of causing unacceptable radiation doses to the public. The results of the NAS deliberations, should EPA adopt them, could require a significant modification to how 10 CFR Part 60 considers naturally occurring materials both in the context of human

intrusion scenarios and the characterization of the adverse conditions relating to naturally occurring materials. Considerable staff effort may be required to conform 10 CFR Part 60 to the EPA standard. The EnPA requires that the staff conform 10 CFR Part 60 to the EPA standard by December 31, 1995.

Systematic analysis of 10 CFR Part 60 identified the term "Geologic Setting" as a Category 1 regulatory uncertainty, an uncertainty in need of clarification. As now defined, the regulatory uncertainty concerning the term Geologic Setting could lead to a substantial technical uncertainty regarding the sufficiency of site characterization investigations. For example, geologists working on the recent Little Skull Mountain earthquake have proposed that the Little Skull Mountain earthquake was a response to other earthquakes located in southern California, hundreds of kilometers from YM. It is unclear using the current definition of the term, "geologic setting," whether 10 CFR Part 60 would require these events that occur hundreds of kilometers from the site and initiate seismic activity at YM to be included in the Geologic Setting, and as a result, be considered for investigation during site characterization. Without clarification, the DOE may not be able to confidently demonstrate in the License Application (LA) that those requirements containing the term "Geologic Setting" have been met. During the modifications to 10 CFR Part 60 resulting from the EnPA, the staff would clarify the term, "Geologic Setting." To avoid potentially costly delays, clarification is needed prior to the development of the DOE Seismic Hazard and Seismic Design report, now scheduled for FY96.

A rulemaking, "Clarification of Assessment Requirements for the Siting Criteria and Performance Objectives" (60.112/60.122) will resolve several uncertainties concerning the investigation and analysis of siting criteria and their relationship to the post-closure performance objectives. This rulemaking was published as a draft for public comment in FY93 and should be finalized in late FY94.

Prelicensing consultations, including reviews of statutory and other technical documents, have demonstrated that there is a substantial difference between what the staff considers necessary and sufficient to meet 10 CFR Part 60 requirements and the approach that the DOE is taking with respect to the investigation and analysis of fault displacement hazards and seismic hazards. Generally, the staff considers that the DOE planned activities to investigate fault displacement hazards and seismic hazards defined in the Site Characterization Plan appear to be insufficient to meet 10 CFR Part 60 requirements regarding the investigation of potentially adverse conditions. In addition, the staff considers that the DOE approach to the derivation of the design bases for facilities important to safety and facilities important to waste isolation will not provide sufficiently conservative inputs, to provide reasonable assurance that the performance objectives could be met.

In subsequent internal discussions, and with input from the Advisory Committee on Nuclear Waste (ACNW), the staff initiated the development of technical guidance with respect to fault displacement hazard and seismic hazard that resulted in the generation of three technical guidance documents on the following topics:

1. Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository;
2. Consideration of Fault Displacement Hazards in Geologic Repository Design; and
3. Analyses of Fault Displacement Hazards and Seismic Hazards as they Relate to the Design of a Geologic Repository.

Guidance document 1 was completed in late FY92 and published as NUREG 1451. A notice of the availability of guidance document number 2 for public comment was transmitted for publication in the Federal Register on March 10, 1993. An annotated outline (AO) of guidance document number 3 was completed in February 1993. It was envisioned that these three guidance documents would form the policy and technical foundation on which CDMs would be based. Guidance documents 2 and 3 were designed to address the remaining geological policy and technical concerns that were not specifically addressed by 10 CFR Part 60. Unlike 10 CFR Part 100, Appendix A applicable to Nuclear Power Plants, 10 CFR Part 60 has no prescriptive requirements or associated regulatory guides to describe what is necessary and sufficient in the consideration of fault displacement and seismic hazards. Guidance documents 2 and 3 address these uncertainties resulting from the nonprescriptive character of 10 CFR Part 60. These policy and technical topics span the entire repository program in that guidance is necessary to provide sufficient input to characterization activities, design activities, and assessments of performance. They therefore, represent a key ingredient in the development of review plans. As part of the effort to develop guidance document 3, a group of recognized experts was assembled and met on May 17 and 18, 1993, to review and comment on the AO. Individual comments of the experts will be considered in the final guidance preparation.

DOE is currently proceeding using the approach to the investigation and analyses of the hazards outlined in the Site Characterization Plan (SCP). In the Action Plan to Assess Seismic Hazard at YM (memo from Gertz to Bartlett, dated August 14, 1992) the DOE outlined a series of activities and reports related to seismic hazard that will be generated before late FY96. Key to the activities planned by the DOE is the development of a report on "Seismic Hazard and Seismic Design Basis for Yucca Mountain" scheduled for completion in late FY96. In the event that the development of guidance document number 3 is delayed beyond FY96, substantial differences may remain between what the staff considers as necessary and sufficient and what will result from the DOE approach. As a result a significant resource expenditure may have to be made by the DOE to address staff concerns in this area. The DOE may need to revisit design activities if those activities proceed with assumptions that are, in the final analysis, unacceptable to the staff. Substantial resources can be saved and delays in scheduled activities avoided if technical guidance is provided prior to the issuance of the DOE report.

Additional technical guidance may be required as a result of activities related to the development of review plans. Review plan development to date has identified areas where KTUs exist related to geologic or geophysical factors and where independent modeling activities are planned. Specific areas where guidance may be necessary include the "Development and Use of Conceptual Tectonic Models" as they relate to igneous activity, structural deformation, and seismicity. How conceptual tectonic models will be developed and used in the construction of scenarios for performance assessment is uncertain at this time. Guidance that describes the staff's position on the development and use of conceptual tectonic models will most likely be necessary. It is anticipated that this guidance development should occur in the FY96-98 time period. This guidance should be in place to permit the DOE to incorporate key aspects of the guidance into its development of a final tectonic model which is currently scheduled for release in FY99.

In FY93-94, the staff is scheduled to revise the Geology and Geophysical information in the draft Format and Content Regulatory Guide (FCRG) to prepare it for publication as a final guide in FY94. The staff may need to update the FCRG in the future based on its rulemaking activities, LARP development, and additional information identified through the staff's development and implementation of analysis methods. It is important that any revision be conducted in a timely manner which does not hinder continued DOE program development. The DOE AO for the Repository License Application (AO) will be enhanced by

the availability of such information.

B. Develop License Application Review Plan and Supporting Technical Assessment Capability

1. Develop Geologic System License Application Review Plans

During FY93, the staff will continue preparing the Geologic System individual review plans for the LARP by completing compliance determination strategies (CDS) for all of the 16 Geologic System requirements. These requirements include several CDS being jointly developed with hydrology and geoengineering. Also during FY93, the staff will prepare the CDM for Section 3.2.1.9 of the LARP, the potentially adverse condition of "Evidence of Igneous Activity." In FY94, the staff will continue development of CDMs for Sections 3.2.1.10, "Evidence of Extreme Erosion," 3.1.1, "Geologic System Description, and 3.2.1.1, "Nature and Rates of Physical Processes."

The remaining planned review plans for other Geologic System requirements will be completed during FY94-00. Two CDMs will be developed in each year of the FY94-00 time period.

2. Geologic System Code and Model Development

In support of uncertainty reduction related to KTUs identified in the Systematic Regulatory Analysis (SRA) process, the staff will continue and expand development of its independent assessment capability. The staff is currently involved in an assessment of codes that use probabilistic methods in the consideration of fault displacement hazards and seismic hazards. Principal among the codes being examined is the SEISM1 code, a Lawrence Livermore National Laboratory code that was funded by NRC/NRR for evaluation of the seismic design basis for NPP in the eastern U.S. Activities to date have demonstrated that with modification, SEISM1 code may be applicable to the assessment of seismic and fault displacement design bases for a geologic repository. The trend in the derivation of seismic design basis is towards the use of probabilistic methods. It is critical that the staff develop the capability to independently assess the seismic design basis that the DOE will submit in the LA, which precicensing reviews indicate will be probabilistically based. This development of analysis capability for probabilistic design basis will continue through FY96 to assist in the staff review of the DOE topical reports on "Seismic Hazard Methodology" in late FY93 and "Seismic Hazard and Seismic Design Basis for Yucca Mountain" in late FY96.

Independent assessment activities related to geometric analysis and cross-section balancing of faulting at YM also will continue in response to the generation of additional data by the DOE. This effort, using the laws of conservation of mass and volume, will continue in order to further develop the capability to assess the validity of geologic cross sections through the repository block and across the geologic setting. This effort will be used to provide timely guidance to the DOE regarding site characterization activities and the development of conceptual tectonic models for the site. For example, activities to date have attempted to quantitatively test the DOE geologic cross sections of a HLW repository site. When applied to the DOE cross sections of the YM site, the staff analysis determined that the DOE model would only be supported if a fault or series of faults were present in the vicinity of Fortymile Wash. Based on this analysis, the staff believes that the DOE must either determine if faults are present in (or to the east of) Fortymile Wash and conduct additional site characterization work, or if the fault is not present, the DOE must revise its tectonic model for the site. An outgrowth of the early cross-section balancing efforts is the recognition that 2-dimensional (2D) geometric models of faulting at YM are too simplistic to accurately portray the faulting process. As a result, in the FY94-96 time frame an analysis of the current

state-of-the-art in 3-dimensional geometric cross-section balancing methods and codes will be performed. All of these activities will support staff reviews of DOE documents related to "Probabilistic Assessment of Faulting" due to be completed in FY98 and the development of "Final Tectonic Model" due to be completed in FY99. In addition, because fault displacement is a significant concern at YM, near-field seismic ground motion may also be of concern. Therefore, the staff will undertake efforts to acquire computer codes for modeling near-field ground motions that may be input to dynamic finite-element analyses of underground structures. Part of this effort will involve the acquisition of software and data from the Institutions for Research in Seismology (IRIS).

As a follow-on to the geometric modeling efforts and in response to the identification of a KTU related to structural deformation, the staff is exploring the use of finite element codes to develop the capability to assess dynamic models of fault displacement at repository scale. These activities are being pursued in order to develop CDMs for assessing compliance with containment and total system performance requirements considering fault displacement as a disruptive process. Codes currently under consideration include ABACUS, SANGRIA, and GEOSYM. It is anticipated that the implementation of finite-element codes will provide the link between conceptual models of repository-scale deformation and the quantitative inputs necessary to assess repository performance. This capability will also assist the staff in the review of the DOE report on the effect of faulting on waste packages now scheduled to be available in FY96.

The identification of a KTU related to the effects of igneous activity on repository performance has resulted in the recognition of a need to develop independent modeling activities that have a firm scientific basis. This was demonstrated in the staff's preliminary efforts (i.e., Phase 2) on iterative assessments of performance (IPA) that incorporated the risk attributed to volcanism. Staff analysis of the results of Phase 2 of the IPA have demonstrated that, for YM the distribution of volcanic centers is not adequately described by the homogenous Poisson model used in this phase and, as a result, probability derivations for volcanism may not be robust. In addition, the consequences resulting from volcanism can be significantly affected by the percentage of volatiles in the parent magma. In the FY94-96 period, the staff intends to explore the use of other probability and consequence models for volcanic risk in attempts to provide technically defensible models for incorporation into staff efforts to develop the capability to make assessments of overall system performance. In addition, these activities are planned in the FY94-96 time period so as to have in place the review capabilities necessary to adequately evaluate DOE's planned report on "Probabilistic Future Volcanic Activity" currently planned for FY97. Without the development of this independent assessment capability, attempts at issue resolution for volcanism at YM could be severely delayed and could adversely affect DOE's schedules.

The staff will have an estimated 18-month span of time to review the DOE LA. In order to review geologic factors of the site in a timely fashion and develop the required SE, the staff will need modeling capabilities that will permit visualization and manipulation of geologic features. In FY93 the staff initiated the development of an independent modelling capability to incorporate geologic features into a true 3D framework model of the site using the EarthVision software system (Dynamic Graphics, Inc.). The DOE is currently using the software package developed by LYNX, Inc. to input data such as stratigraphy (geologic, thermal, and hydrologic) and fracture characteristics into a 3D model of YM. During the FY94-97 time period, the staff will continue to develop its capability to visualize geologic facets of the site using 3D framework modeling. This modeling capability will be used to assess repository characteristics and demonstrate the potential effects of changes in the geologic characteristics of the site on repository performance. The 3D framework modelling capability will assist the staff in the review of the DOE reports that rely on the compilation and synthesis of tectonic data scheduled to be available in the FY93-97 time period. In addition, this capability will provide decision-makers with the opportunity

to visualize repository characteristics and changes to those characteristics by such processes as faulting and intrusion by igneous dikes. The limited amount of time available for review of the LA requires the use of time-saving tools to speed the review.

C. Conduct Pre-license Application Reviews and Quality Assurance Audits

The staff will continue to conduct Quality Assurance (QA) audits in response to statutory requirements or agreements between the NRC and the DOE. Generally, this will take the form of observation of DOE audits of its internal and contractor activities in the geology and geophysics areas.

The staff will continue its review of the DOE Semi-Annual Progress Reports. Not only is this a statutory responsibility, but it is also the mechanism through which DOE reports results from its ongoing geological and geophysical programs as well as changes to those programs. Reviews of this information will allow the staff to: (i) provide guidance to the DOE on the acceptability of any proposed changes; (ii) identify if results from the DOE work are acceptable; and (iii) determine what additional work may be needed in the development of independent modeling activities, the FCRG, and the LARP.

In addition, the staff has agreed with the DOE to carry out semi-annual reviews of the DOE AO. The semi-annual review of the AO is carried out to provide the DOE with pre-LA guidance on whether or not the staff believes that the DOE is appropriately interpreting the Geologic-System-related requirements of 10 CFR Part 60 and on what geologic information is needed to complete a high-quality LA. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions with the DOE described above to ensure that the regulations are properly implemented.

The staff will also review other DOE documents including study plans and topical reports. Study plan reviews include plans related to studies not previously submitted to the NRC for review, as well as revisions to existing study plans. There are approximately 51 study plans in the geology/geophysics area. Approximately 15 of these study plans have been received by the staff, leaving approximately 36 study plans for review in the FY94-96 time period. In addition, the staff will also conduct reviews of the DOE responses to staff study plan reviews and other DOE documents to assess the possible resolution of staff open-items.

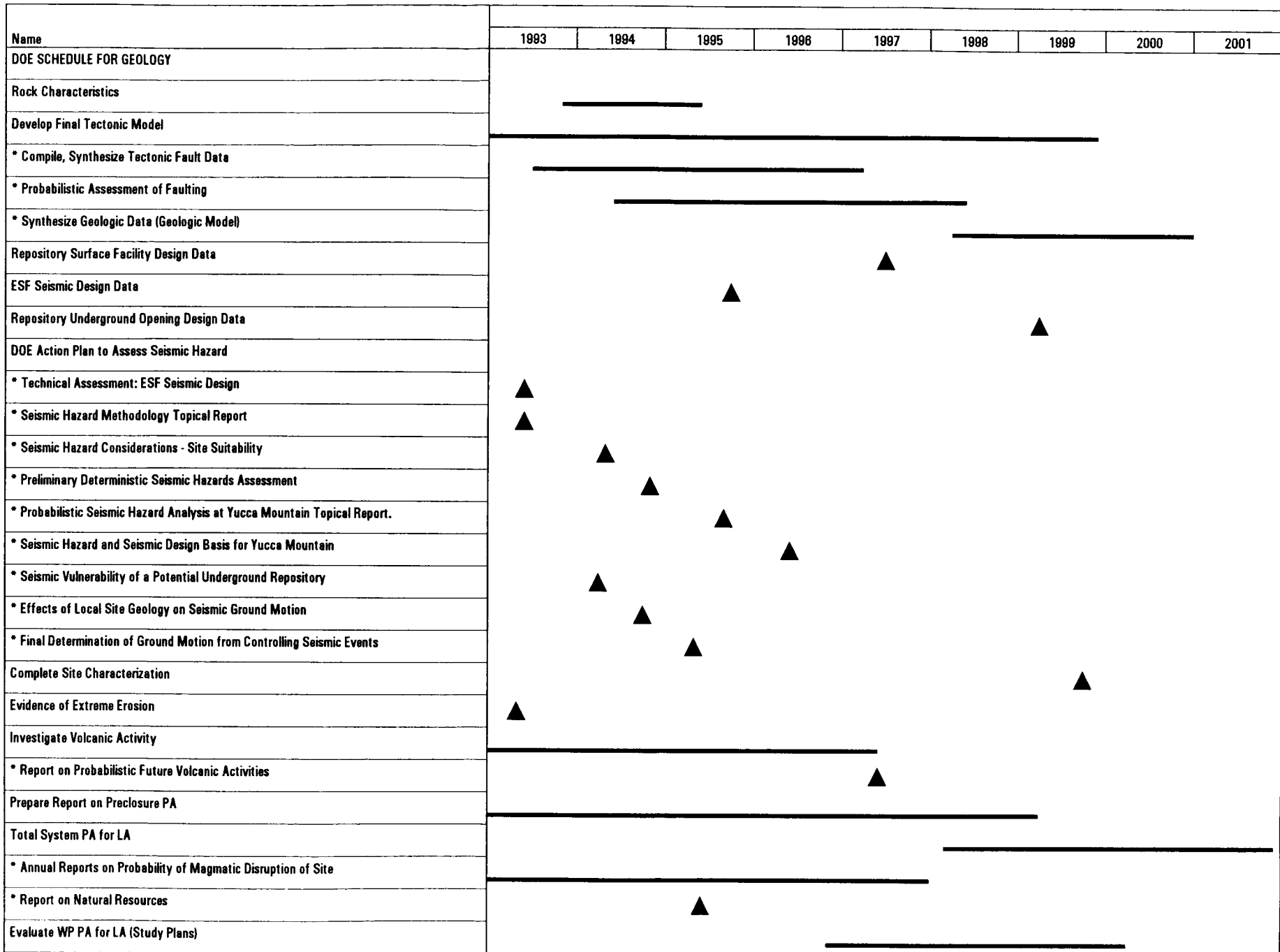
The staff conducts Phase-I review of all study plans submitted by the DOE for NRC review. A selected few of these study plans also receive detailed technical reviews. Occasionally, the DOE requests accelerated reviews of some of the study plans. The staff reacts to such requests based on the priority of on-going work and the importance of the topic to the NRC. A number of study plans in the area of geoengineering provide inputs for GROA design construction and operations. Presently, most of the study plans are focusing on the rock-mechanics-related topics. Study plans recently submitted for NRC review are related to activities that would take place early in the ESF schedule. For example, *in situ* excavations, *in situ* rock mechanics properties, laboratory and field rock properties (such as thermal expansion, strength) are some of the topics being studied by the DOE. The NRC will continue to review the study plans related to geoengineering as the ESF activities and surface-based testing continue at the YM site. This activity will continue until the LA design is completed by the DOE.

Topical reports are the DOE approach to issue resolution (see Bartlett to Bernero, dated January 8, 1993). The NRC will conduct formal reviews in accordance with the DHWLM Topical Report Review Plan, resulting in the development of staff SE for specific topics of concern to the repository program. The DOE intends that these SEs will provide documentation for resolutions reached at the staff level and will

be referenced in the LA, should the YM site be found suitable. The DOE has identified two topical reports to be produced during FY93 — "Evidence of Extreme Erosion" and "Seismic Hazard Methodology." Additional topical reports, perhaps related to 10 CFR Part 60 siting criteria and the requirements for investigation and analysis of favorable and potentially adverse conditions will be developed in increasing frequency by the DOE in the future. The staff will review these reports to resolve issues at the staff level and to provide guidance to the DOE on what, if any, changes are needed in its ongoing program and to provide guidance related to sufficiency of its site characterization program.

In addition to study plans and topical reports, the DOE has identified a series of reports related to seismic, fault displacement and volcanic hazards that will be produced during FY93-97. In the Action Plan to Assess Seismic Hazard at Yucca Mountain (memo from Gertz to Bartlett, dated August 14, 1992), the DOE identified eight reports that it intends to generate with respect to seismic hazard and design of the repository between FY93 and FY96. These reports will form a significant part of the basis for demonstrating compliance with 10 CFR Part 60 requirements related to the design of the repository elements. Staff review will be required to identify and to document concerns with the DOE approaches to the development of design bases and to provide timely guidance on acceptable approaches.

DOE study plans have described additional technical reports that will address potential effects on repository performance from igneous activity, vibratory ground motion, and fault displacement. These reports are to be issued between FY93 and FY98. In the SRA process, KTUs have been identified that are related to these hazards. The review of the DOE reports will aid in the development and possible revision of CDMs related to these hazards and will provide direction to the staff in the development of its independent assessment capability.



Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Report on Effects of Igneous Intrusion on WP			▲						
* Report on Effects of Faulting on WP				▲					
* Report on Effects of Ground Motion on WP				▲					
* Report on Probabilistic Future Volcanic Activities					▲				

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
NRC SCHEDULE FOR GEOLOGY									
A. Develop Regulatory Requirements and Technical Guidance									
* Conforming Rulemaking for New EPA standard	_____▲								
* Definition of Geologic Setting	_____▲								
* Naturally Occurring Materials/Human Intrusion	_____▲								
* 60.112 / 60.122 Rulemaking	_____▲								
* Fault Avoidance	_____▲								
* Seismic & Fault Hazard Design Bases	_____▲								
* Development and Use of Tectonic Models	_____▲								
* Revise FCRG	_____▲								
B. Develop LARP and Supporting Technical Assessment Capability									
Develop Geology LA Review Plans									
* All Geology CDS's Complete	▲								
* Evidence of Igneous Activity - CDM 3.2.1.9	▲								
* Evidence of Extreme Erosion - CDM 3.2.1.10	▲								
* Geologic System - CDM 3.1.1	▲								
* Historic Earthquakes - CDM 3.2.1.6	▲								
* Nature & Rates of Physical Processes - CDM 3.2.1.1	▲								
* Evidence of Dissolution - CDM 3.2.1.4	▲								
* Structural Deformation - CDM 3.2.1.5	▲								
* Correlation of Earthquakes with Tectonic Processes - CDM 3.2.1.7	▲								
* Minimum Waste Emplacement Depth - CDM 3.2.1.2	▲								
* Low Population Density - CDM 3.2.1.3	▲								
* Increasing Earthquake Frequency/Magnitude CDM 3.2.1.8	▲								
* Presence of Naturally Occurring Materials - CDM 3.2.1.11	▲								
* Evidence of Drilling - CDM 3.2.1.13	▲								
* Natural Phenomena & Groundwater - CDM 3.2.2.7	▲								
* Structural Deformation & Groundwater - CDM 3.2.2.8	▲								

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Evidence of Subsurface Mining - CDM 3.2.1.12							▲		
* Complex Engineering Measures - CDM 3.2.2.10							▲		
* Geochemical Properties - CDM 3.2.1.14								▲	
* Effectiveness of Natural Barriers Against the Release of Radioactive Material to the Environment - CDM 3.4								▲	
* Geologic System Performance Confirmation - CDM 8.1.1								▲	
Geology Code and Model Development									
* SEISM (Earthquake Hazard)	_____								
* 2D Geometric Analysis (GEOSEC)	_____								
* 3D Geometric Analysis	_____								
* Finite Element Modelling of Fault Displacement (GEOSYM, SANGRIA, ABACUS)	_____								
* Effects of Igneous Activity on Repository Performance	_____								
* 3D Geologic Framework Modelling (Dynamic Graphics)	_____								
C. Conduct Pre-LA Reviews and QA Audits									
* QA Audit Observations	▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____								
* Semi-Annual Progress Reports	▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____								
* Annotated Outline	▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____▲_____								
* Study Plan Reviews	_____								
* Revised Study Plan Reviews	_____								
* Open-Item Reviews	_____								
* SCP Open-Item Reviews	_____								
* Topical Rpt. Reviews	_____								
* Evidence of Extreme Erosion	_____▲_____								
* Seismic Hazard Methodology	_____▲_____								
* Others 1/yr.	▲_____▲_____▲_____▲_____▲_____▲_____								
* Technical Report Reviews	_____								
* Volcanism Technical Reports	▲_____								
* Technical Assessment.: ESF Seismic Design	▲_____								

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Seismic Hazard Consideration - Site Suitability			▲						
* Seismic Vulnerability of a Potential Underground Repository		▲							
* Effects of Local Site Geology on Seismic Ground Motion			▲						
* Preliminary Deterministic Seismic Hazard Assessment				▲					
* Final Determination of Ground Motion from Seismic Events					▲				
* Probabilistic Seismic Hazard Analysis of Yucca Mountain						▲			
* Seismic Hazard and Seismic Design Basis							▲		
* Quaternary Faulting			▲						

APPENDIX B
THE NATURAL SYSTEMS OF THE GEOLOGIC SETTING
HYDROLOGIC SYSTEM

DOE HYDROLOGIC SITE INVESTIGATIONS PROGRAM

The Department of Energy (DOE) is conducting hydrologic investigations to evaluate the suitability of the surface and subsurface hydrologic environment for siting a nuclear waste repository at YM. Specifically, the DOE is conducting laboratory, surface-based, and Exploratory Studies Facility tests, studies, and investigations to evaluate the hydrologic characteristics of the site under both expected and unexpected conditions, including water level, water flowpath and travel times, hydraulics, recharge rates, and water age and origin. Furthermore, the DOE will analyze hydrologic data and develop conceptual models to describe the hydrologic characteristics of the site.

The general approach is to develop a credible geohydrologic model. The geohydrologic model will have three components: (i) a model for the unsaturated zone, (ii) a model for the saturated zone, and (iii) a model for the surface-water system. Development of these models is planned to occur from FY93 to FY99. The model for the unsaturated zone will be developed only for the site, whereas the models for the saturated zone and surface-water system will be developed for both the site and the region. The geohydrologic model will then be combined with the geochemical model and thermal-mechanical model to produce the site model. Each of these three models will consist of both conceptual and numerical models. The conceptual models include a description of the geologic and hydrologic framework, initial and boundary conditions, processes at work within the geologic and hydrologic framework, and hypotheses describing their interrelationships. Based on the conceptual model the numerical model will be used to predict hydrologic characteristics such as travel time.

To collect the necessary data during site characterization, the geohydrology program consists of investigations which call for approximately 25 studies involving approximately 100 activities. These activities serve to describe the present and expected hydrology of the unsaturated and saturated zones at the site, the saturated zone of the region, and the surface-water systems of both the site and region. The results will be used to predict the paths and rates of groundwater travel through the saturated and unsaturated zones; this information is important in assessing the performance of the natural barrier of the repository system in limiting the release of radionuclides to the accessible environment. Information from these investigations will also be used to help evaluate scenarios in which the performance of the repository is disturbed by various postulated processes or events.

The objective of the site-scale investigation of the unsaturated zone is to define groundwater flow paths and calculate groundwater fluxes and velocities. The results are being used to develop conceptual and numerical models that can be used to assess the combined effects of heat, water, and gas flow under present conditions and to estimate the conditions expected for the next 10,000 years. Specific studies cover water infiltration and percolation; the movement of gases in the unsaturated zone; hydrochemical characteristics; and hydrologic mechanisms, including the flow mechanism in the rock mass (flow through fractures versus flow through the rock matrix) and flow associated with faults and bedding planes in the rocks. In FY93, work included the drilling of UZ-14 in Drill Hole Wash, close to borehole UZ-1. The placement of UZ-14 extends the current network of neutron holes that is being used to monitor infiltration. Also, in FY94 and FY95 it will be used to better define the steep hydraulic gradient in the saturated zone, located north of the site where it appears that UZ-1 encountered a water table much higher than expected. Other ongoing work includes: (i) field work to help prepare a map of the infiltration/runoff properties of surficial units at YM; (ii) continued monitoring of neutron boreholes to determine net infiltration; (iii) water balance studies; (iv) prototype ponding and rainfall-simulation experiments; (v) the drilling, logging, sampling, and instrumentation of UZ-16 and gas sampling and planning of low interference tests. Of particular importance are studies to be conducted in the exploratory-

shaft facility, especially studies to characterize the flow of groundwater in and around fracture zones at the contacts between stratigraphic units and the hydrologic characteristics of faults. Supporting studies in the laboratory will investigate the hydraulic conductivity of the tuff matrix, the permeability of fractured tuff at the pressures and temperatures expected in the repository, and the waste isolation potential of a partially saturated tuff matrix at the expected temperatures. Part of this work includes the development of a report on infiltration rates at YM. This report will contribute to the completion of a topical report on the potential for perched water bodies. Work on both reports is scheduled to begin in FY96 and be completed by FY99.

Similarly, the investigation for the site scale saturated zone will produce models that can be used to calculate the paths, rates, and velocities of groundwater between the unsaturated zone and the accessible environment. Specific studies focus on collecting data to characterize the groundwater flow system, including tests to determine the elevation of the water table, the hydraulic gradient, porosity, hydraulic conductivity, and the hydrochemistry of the saturated zone. For example, hydraulic testing began during FY93 at the C-hole complex following several years of test design. Previously developed methods will be used to analyze the new cross-hole and tracer tests (FY95-FY96). Also, routine monitoring of water levels around the site will continue, along with the implementation of a new capability to monitor the effects of earthquakes on groundwater levels (FY94). A report on the hydrologic properties of tuff is scheduled for completion in FY95. Between FY97 and FY00, a report on unsaturated zone fracture flow is scheduled for development. In addition, this work will contribute to the development of a topical report on the potential for a water table rise that would inundate the repository (i.e., UZ saturation). Work on this report will begin in FY94, and it will be completed by FY98.

The objective of the regional investigations is to describe the hydrologic system of the region by developing models of hydrologic flow. Specific studies will collect data on regional runoff and streamflow and the regional system of groundwater flow. The subjects of these studies will include the measurement of regional groundwater elevations, ground-water recharge at Fortymile Wash, and evapotranspiration. Regional hydrochemical tests and analyses will also be performed between FY94 and FY99. This work will be used to support the development of a topical report on the potential for changes to hydrologic conditions. Work on this report will begin in FY97 and it will be completed in FY99. Also, the results of this work will be used to develop a saturated zone hydrology model and an surface water hydrology model. Each of these models is scheduled for completion by FY99.

In order to design the facilities to prevent or reduce hazards from surface water to acceptable levels, the DOE is assessing the flood and debris hazards at and near the potential repository surface facilities. Work includes determining the magnitudes and frequencies of major flood events that have the potential to occur during repository operation. The DOE is identifying all potential areas of inundation, determining the quantities and size characteristics of debris transported by flooding, and monitoring surface-water runoff. This work directly aids the prediction of flooding phenomena at YM (three additional continuous-recording gauges were installed in washes on the eastern slope of YM during FY93). This work is ongoing and will contribute to a report on rainfall simulation that is scheduled for completion in FY95. It will also contribute to the development of a topical report on flooding. This report is scheduled for completion in FY96. The DOE is also developing conceptual models that consider the characteristics of the surrounding area in terms of precipitation and other meteorological data and their relationship to surface runoff and infiltration.

Models under development by the DOE include: regional models for the surface-water system and the saturated system and site models for the surface-water system, the saturated system, and the unsaturated

system. Work related to the site hydrologic system includes: defining the local hydraulic properties (including recharge and discharge for the groundwater flow system), the magnitude and direction of groundwater flow; and synthesis of hydrologic, geologic, hydrochemical, and geophysical data into a model for qualitative analysis of how the system is functioning. Unsaturated zone hydrologic activities include: determining the effective hydraulic conductivity, storage properties, and transport properties pertinent to flow and transport as functions of moisture content, obtaining measurements of water chemistry distributions to help quantify the rate of water movement in the unsaturated zone, determining the present *in situ* hydrologic properties of the unsaturated zone hydrogeologic units and structural features, conducting hydrologic tests in the Exploratory Studies Facility; determining (*in situ*) the extent to which nonsorbing tracers diffuse into the water-filled pores of the Topopah Spring welded unit; describing the prewaste emplacement gas-flow field; and several other activities related to modeling the unsaturated zone. Saturated zone hydrologic activities includes determination: of the hydrogeologic nature of relevant structural features; the time and spatial variation of the potentiometric surface; and the character, magnitude, and causes of water-level fluctuations. Much of this work will contribute to the development of the aforementioned report on the cause of the steep hydrologic gradient observed north of YM. This report will be completed by the end of FY95. In addition, this work will contribute to the development of a topical report on the potential for structural deformation or tectonic activity to affect the groundwater flow system. Work on this report will begin in FY97 and it will be completed by the end of FY99.

The DOE Performance Confirmation efforts focus on compliance with the requirements in 10 CFR 60.137. This will include development of a performance confirmation strategy and guidelines document, an interim test plan, an operations plan, and a contingency plan. The DOE also intends to develop design requirements to ensure the effectiveness of performance confirmation tests and corroborate information obtained during site characterization pertaining to the waste package environment. No specific dates have been identified for these activities in current DOE schedules.

In summary, the DOE high-level waste (HLW) site characterization hydrology program consists of approximately 25 separate studies that involve on the order of 100 separate activities. All of this work is directed toward developing a hydrologic database that can be used to evaluate whether 10 CFR Part 60 performance and design requirements have been met. The DOE plans to complete hydrologic site characterization by FY99, submit a license application (LA) to the Nuclear Regulatory Commission (NRC) before the end of FY01, and receive the NRC's LA analysis before the end of FY04.

NRC HYDROLOGIC SYSTEM

I. OVERVIEW

The NRC mission in the Hydrologic System portion of the Geologic Setting Program is to review and evaluate the DOE hydrologic site characterization data acquisition, technical analyses of hydrologic data, and the integration of this information into assessments of specific-site criterion, engineered barrier performance, geologic setting performance, and the overall site systems performance, to determine if the DOE has acceptably demonstrated compliance with the requirements of 10 CFR Part 60. To accomplish this mission, the staff is conducting preclicensing consultation and developing 15 Compliance Determination Method (CDM) plans for the NRC License Application Review Plan (LARP) that cover the hydrology of the YM site and region. In addition, the staff is developing technical guidance in areas where uncertainties are believed to be key to performing an adequate evaluation of the DOE performance assessments (PA). The strategy is designed to allow the staff to use the insight it gains from its preclicensing consultations, and LARP development to support a timely (18-month) review of hydrologic issues important to the DOE's LA.

In particular, during preclicensing consultation, the staff is conducting focused technical reviews of surface water hydrologic issues, unsaturated zone hydrologic issues, and saturated zone hydrologic issues. These reviews involve analysis of the DOE study plans, DOE topical reports, DOE site characterization progress reports, annotated outlines (AO) of the DOE LA and the DOE preliminary analysis of total system performance. These reviews are directed towards the resolution of both preclosure and postclosure issues, providing timely guidance to the DOE in order to avoid unnecessary delays in the DOE program, as well as to facilitate a timely NRC review of the DOE LA.

The development of guidance to the DOE is primarily the result of a systematic analysis of 10 CFR Part 60 of key hydrologic technical uncertainties (KTU). A KTU is an uncertainty that could have a significant impact on subsystem performance (waste packages, engineered barriers, and the site) as well as NRC analysis of the DOE total system performance. Primarily, these uncertainties pertain to characterizing and modeling unsaturated zone hydrologic conditions, processes, and flow. Guidance is directed towards the resolution of KTUs, providing timely input to the DOE on KTU in order to avoid unnecessary delays to the DOE program, as well as to facilitate a timely NRC review of the DOE LA.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

The NRC Hydrologic System Program has the lead responsibility for the systematic analysis of fifteen regulatory requirements under 10 CFR Part 60. Of these fifteen requirements, one is the performance objective for the geologic setting [i.e., Groundwater Travel Time(GWTT)], eleven are favorable or adverse hydrologic conditions, one pertains to performance confirmation activities, and two are LA content requirements. This work is done to ensure that all uncertainties (technical, regulatory, and institutional) have been clarified either through rulemaking, the development of regulatory guides, or other forms of guidance documents, in a time frame that is not disruptive to the development of the NRC LARP (FY94-FY00), and to DOE site characterization program for hydrology (FY89-FY99), or the DOE schedule for the development of a LA (FY92-FY01). To date, four of these regulatory requirements will require detailed guidance to the DOE.

First, the staff has identified two major uncertainties with respect to the GWTT sub-system performance objective [10 CFR 60.113 (a)(2)]. The first relates to uncertainty about the definition of "... disturbed zone ...," and the other relates to the definition of "... fastest path" In addition, CNWRA's current analysis has raised concerns about the utility of GWTT in unsaturated conditions, because only liquid pathways, and not potential gas pathways, are considered. Also, questions have been raised about whether or not postclosure effects on GWTT are adequately covered by the concept of "... disturbed zone ...". Resolution of these uncertainties will require mathematical definitions that will be, in technical terms, the bases for an acceptable modeling strategy. To address these uncertainties, the staff is identifying the technical approaches available to assess GWTT. This work is scheduled to be complete by the end of FY94. It is anticipated that this activity will indicate the need for detailed technical guidance. Since guidance development is generally a two-year activity, this technical guidance should be completed in FY96. In addition, the scheduling of this work is intended to parallel the DOE schedule of providing the NRC with their analysis of GWTT. The first DOE analysis will be provided in a technical report in FY94, and other analyses will accompany the DOE Site Suitability Evaluation and its LA AO. Each of these documents will be provided annually for NRC review and comment.

In addition to guidance development for GWTT, regulatory analysis (by NRC and CNWRA) has indicated that guidance to the DOE concerning three other regulatory requirements will be needed. The first of these regulatory requirements deals with the nature and rates of hydrologic processes operating in the Quaternary that, when projected, would not adversely affect waste isolation [10 CFR 60.122(a)(1)]. The uncertainties involve the lack of consensus on the nature of and interpretation of paleohydrological evidence from the Quaternary that may indicate extraordinary recharge rates during the Quaternary. Reoccurrence of similar recharge rates in the future could have an adverse affect on the unsaturated zone of the groundwater flow system. The DOE began investigating Quaternary regional hydrology in FY91. This work is expected to be completed by FY00. Work on NRC guidance will begin as early as FY95, and an analysis report will be developed in FY96 and a final guidance document will be available in FY98.

Also, guidance will need to be developed with respect to evaluating the potential for perched water bodies to form and saturate parts of the repository [10 CFR 60.122(c)(23)]. This guidance is needed because, for the DOE to satisfy this regulatory requirement, the potential for future perched water bodies must be predicted. To accomplish this, future climates must be predicted. Such predictions contain many uncertainties regarding both methods and approaches for collecting and evaluating the information. In addition, the predictions of perched water bodies will depend on a knowledge of the flow behavior of the unsaturated fractured rock for different flux rates through the mountain. At present, there is much uncertainty about how to collect unsaturated hydrologic property data for fractures and how to model unsaturated fracture flow. The DOE is currently working on preliminary predictions of flooding at the YM site. In FY94 and FY95 they will complete their shallow unsaturated zone drilling program. As part of a systematic drilling program, they will continue deep unsaturated zone drilling. Data from this work will feed into the development of a saturated zone hydrologic model and an unsaturated zone hydrologic model. Both of these models are scheduled for completion in FY01. NRC work on perched water guidance will begin in FY96, an analysis report will be developed in FY97, and a final guidance document will be available to the DOE in FY98.

Further, guidance will need to be developed that addresses the evaluation of effects of structural deformation, such as uplift, subsidence, folding, or faulting that may adversely affect the regional groundwater flow system [10 CFR 60.122(c)(4)]. For example, the origin of the large hydraulic gradient located north of YM is unknown. If the feature causing the gradient has a tectonic origin, then other such

features could occur (possibly downgradient from the site) over the next 10,000 years, potentially resulting in an elevated water table and a shortening or elimination of the unsaturated zone. These analyses will be very important to performance assessment and the DOE will need NRC guidance concerning the development of credible scenarios. Beginning in 1994, the DOE will be placing emphasis on studies that support investigations of the unsaturated zone hydrology and the steep hydraulic gradient that is located to the north of the site. This work will continue through FY96 and a preliminary report will be issued by the DOE in FY97. NRC work on this guidance will begin in FY97, an analysis report will be developed in FY98, and a final guidance document will be available in FY99.

Finally, the remaining 11 regulatory requirements will need some guidance concerning the level of detail or the information that will be needed to address each of the 11 regulatory requirements. This guidance will be provided to the DOE through the development of revisions to the NRC LA Format and Content Regulatory Guide (FCRG). This guide was first issued in FY91, and will be revised as needed. Current plans are to develop a revision in FY94 and make it available to the DOE in FY95. Another FCRG revision may be needed prior to the termination of the DOE site characterization program in FY99.

B. Develop License Application Review Plan and Supporting Technical Assessment Capability

1. Develop Hydrologic System License Application Review Plans

During FY93, Compliance Determination Strategies for all 15 CDMs were completed. During FY94, the staff will prepare CDMs (with acceptance criteria) for the 15 hydrologic system LARP sections. Between FY95 and the receipt of the DOE LA (FY01), the staff will be revising CDMs as necessary. The sequencing and completion of the LARP sections coincides with guidance development needed for specific regulatory requirements, availability of assessment methods for specific regulatory requirements, and the need to provide timely input to the DOE on KTU in order to avoid unnecessary delays to the DOE program. During this period, the DOE will develop two AOs of their LA per year. These AOs will be reviewed, in the context of the LARP, for completeness by the NRC staff. Also, the DOE plans to develop eight topical reports, one for each Potentially Adverse Condition (PAC) in 10 CFR 60.122, between FY95 and FY00. The NRC review of these reports will require staff consideration of issues pertinent to the development of CDMs for the applicable requirements (see the discussion in section C for more information on the NRC review of the DOE topical reports).

In FY94, the following hydrologic system review plan CDMs will be completed:

- Hydrologic System Description (CDM 3.1.2)
- Flooding (CDM 3.2.2.5)

Also, during FY94, the DOE will develop a topical report on the potential for flooding of the underground facility. When this report is received, the NRC staff will conduct a review and develop a Safety Evaluation Report (SER) that will address the sufficiency of the DOE approach to addressing this 10 CFR Part 60 requirement. The review of this topical report will be key to finalizing LARP Section 3.2.2.5

In FY95, the following hydrologic system review plan CDMs will be completed:

- Potential for Unsaturated Zone Saturation (CDM 3.2.2.11)

In FY96, the following hydrologic system review plan CDMs will be completed:

- Hydrologic System Performance Confirmation (CDM 8.1.2)
- Nature and Rates of Hydrogeologic Processes (CDM 3.2.2.1)
- Human Activity and Groundwater (CDM 3.2.2.6)

Also, during FY96, the DOE will develop a topical report on the potential for foreseeable human activity to adversely affect the groundwater flow system (i.e., Human Activity and Groundwater). When this report is received, the NRC staff will conduct a review and develop a SER that will address the sufficiency of the DOE approach to addressing this 10 CFR Part 60 requirement. The review of this topical report will be key to finalizing LARP Section 3.2.2.6.

In FY97, the following hydrologic system review plan CDMs will be completed:

- GWTT Substantially Exceeding 1000 years (CDM 3.2.2.3)
- Integrated Natural System Response to the Maximum Design Thermal Loading (CDM 3.1.5)
- Changes in Hydrologic Conditions (CDM 3.2.2.9)

Also, during FY97, the DOE will develop a topical report on: (i) the potential for the water table to rise high enough to inundate an underground facility located in the unsaturated zone (i.e., Unsaturated Zone Saturation); and (ii) the potential for landslides, subsidence, or volcanic activity of such magnitude that large-scale surface water impoundments could be created that could change the regional groundwater flow system (i.e., Natural Phenomena and Groundwater). When these reports are received, the NRC staff will conduct a review of each and develop a SER that will address the sufficiency of the DOE approach to addressing each of these 10 CFR Part 60 requirements. The review of these topical reports will be key to finalizing LARP Sections 3.2.2.7 and 3.2.2.11.

In FY98, the following hydrologic system review plan CDMs will be completed:

- Unsaturated Zone Hydrologic Conditions (CDM 3.2.2.4)
- Natural Phenomena and Groundwater (CDM 3.2.2.7)
- Complex Engineering Measures (CDM 3.2.2.10)

Also, during FY98, the DOE will develop a topical report on the potential for groundwater conditions that would require complex engineering measures. When this report is received, the NRC staff will conduct a review and develop a SER that will address the sufficiency of the DOE approach to addressing this 10 CFR Part 60 requirement. The review of this topical report will be key to finalizing LARP Section 3.2.2.10.

In FY99, the following hydrologic system review plan CDMs will be completed:

- Structural Deformation and Groundwater (CDM 3.2.2.8)

- Perched Water Bodies (CDM 3.2.2.12)

Also, during FY99, the DOE will develop a topical report on the potential for (i) structural deformation affecting the groundwater flow system, (ii) changes in hydrologic conditions that would affect radionuclide migration, and (iii) the potential for perched water bodies. When these reports are received, NRC staff will conduct a review of each and develop a SER that will address the sufficiency of the DOE approach to addressing each of these 10 CFR Part 60 requirements. The review of these topical reports will be key to finalizing LARP Sections 3.2.2.8, 3.2.2.9, and 3.2.2.12.

In FY00, the following hydrologic system review plan CDM will be completed:

- Assessment of Compliance with the GWTT Performance Objective (CDM 3.3)

2. Hydrologic System Code and Model Development

In support of uncertainty reduction and the development of CDMs needed to develop 15 individual LARP chapters, the staff has identified 6 regulatory requirements for which CDMs are not readily available. They have technical uncertainties associated with them which pose a high risk of noncompliance with the performance objectives of 10 CFR Part 60. These six requirements are as follows:

- Natural Phenomena and Groundwater (CDM 3.2.2.7)
- Changes in Hydrologic Conditions (CDM 3.2.2.9)
- Perched Water Bodies (CDM 3.2.2.12)
- Structural Deformation and Groundwater (CDM 3.2.2.8)
- Assessment of Compliance with GWTT Performance Objective (CDM 3.3)
- Human Activity and Groundwater (CDM 3.2.2.6)

Of these six CDMs, the NRC staff will need to develop an independent understanding to evaluate the DOE assumptions in order to determine compliance with CDMs 3.2.2.9, 3.2.2.7, and 3.2.2.8. These models are considered state-of-the-art" in that both the collection of data (primarily in the unsaturated zone), its meaning, and the availability of acceptable codes to evaluate site data are relatively new to the scientific community. Because of this, the NRC is going to have to develop expertise and knowledge about unsaturated flow in order to effectively evaluate assumptions in DOE codes to make licensing decisions. This work will begin in FY94 and will continue through the end of the DOE site characterization site program (FY99) and the development of DOE saturated and unsaturated zone hydrologic models and codes (FY00). Preliminary CDMs for each of these LARP chapters will be developed between FY97 and FY98, and final CDMs for these chapters will be developed by FY00.

Furthermore, the analysis of GWTT and perched water (CDMs 3.3, 3.2.2.5, and 3.2.2.12) will require the development of independent codes as well as some independent data collection, because both the DOE and the NRC approaches to modeling unsaturated flow conditions with respect to the two requirements will be very controversial and will result in uncertainties that will significantly effect the analysis of the total systems performance objective. The DOE current program is involved in determining whether

fractures and/or fracture systems are barriers to or conduits for liquid water flow. This work is key to developing conceptual models of the site.

In addition, of the remaining nine CDMs being developed, six will utilize simple off-the-shelf codes to assess the DOE compliance. Each of these codes will be exercised in order to assure their effectiveness in determining the credibility of the DOE compliance demonstration. The remaining three CDMs will not require any analysis by codes.

Finally, the development of a CDM for the overall performance of the site (CDM 6.1) will require the integration of hydrologic modeling of both saturated and unsaturated conditions. This integration requires both the development of codes and supporting data. This work began in FY90 and will continue through FY00. (For details see Appendix G — Overall Systems Performance).

C. Conduct Prelicense Application Reviews and Quality Assurance Audits

The staff will continue to conduct Quality Assurance (QA) audits in response to statutory requirements or agreements between the NRC and the DOE. Generally, this will take the form of observation audits of DOE internal and contractor activities in the area of hydrology. The NRC will conduct one audit per year between FY94 and FY01 (when the DOE submits its LA).

The staff will continue to review the DOE Semi-Annual Progress Reports. Not only is this a statutory responsibility, but it is also a mechanism through which the DOE reports changes to its ongoing hydrologic programs and the results from those programs. The DOE hydrologic characterization program consists of approximately 25 separate studies, that involve on the order of 100 separate activities. All of this work is directed towards developing a hydrologic database that is sufficient to demonstrate whether 10 CFR Part 60 performance and design requirements have been adequately addressed. The DOE plans to complete hydrologic characterization by FY00. Periodic reviews of this information will allow the staff to: (i) provide guidance to DOE on the acceptability of any proposed changes, (ii) identify if results from the DOE work are acceptable, and (iii) determine what additional work may be needed in the development of independent modeling activities, the FCRG, and the LARP.

In addition, the DOE is preparing AO of their LA on a semi-annual basis. The staff has agreed with the DOE to carry out semi-annual reviews of the DOE AO. The semi-annual review of the AO is carried out to provide the DOE with prelicense application guidance on whether or not the staff believes that the DOE is appropriately interpreting the Hydrologic-System-related requirements of 10 CFR Part 60 and on what additional hydrologic information is needed in the AO to address the specific 10 CFR Part 60 requirement. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions described above with the DOE to ensure that the NRC regulations are understood.

The staff will also review other DOE documents including study plans and topical reports. Study plan reviews include those reviews related to studies not previously submitted to the NRC for review as well as revisions to previously submitted study plans. There are approximately 25 study plans in the hydrology area. Approximately 15 have been reviewed. It is anticipated that between FY94 and FY00, the staff will continue to review about six study plans per year, one of which will be a detailed review. In addition, the staff will conduct reviews for DOE responses to staff study plan reviews and other document reviews to assess progress towards resolution of open-items.

During the prelicensing period, the DOE will develop topical reports that address specific NRC

requirements. The NRC will then conduct formal reviews in accordance with the Department of High-Level Waste Management (DHLWM) Topical Report Review Plan resulting in the development of staff Safety Evaluations (SE) for specific issues of concern to the repository program. The DOE intends that these SEs would document resolutions reached at the staff level and would be referenced in the LA should the YM site be found suitable. The intent of the staff review is to resolve issues at the staff level and provide guidance to DOE on what, if any, changes are needed in its ongoing program as well as address issues related to sufficiency of the DOE site characterization program. To date, the DOE has indicated that topical reports will be issued to address each of the eight potentially adverse hydrologic issues contained in 10 CFR Part 60. These topical reports include:

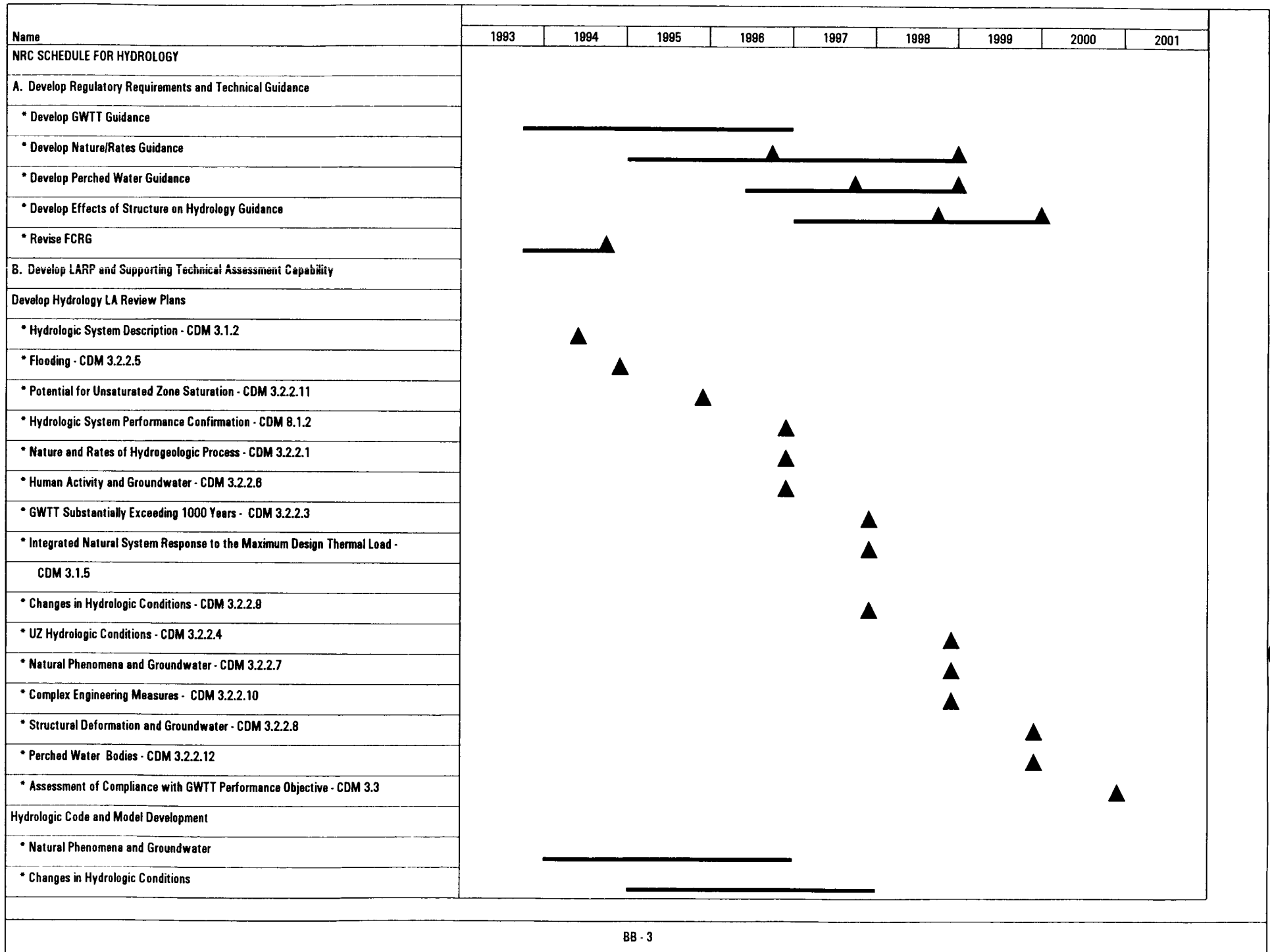
- Flooding
- Human Activities and Groundwater
- Natural Phenomena and Groundwater
- Structural Deformation and Groundwater
- Changes to Hydrologic Conditions
- Complex Engineering Measures and Groundwater
- Potential for Unsaturated Zone Saturation
- Perched Water Bodies

It is anticipated that these reports will be issued periodically between FY94 and FY99. Review of these reports and the development of SERs enable the staff to provide guidance at appropriate points in the DOE program, and helps to ensure that the hydrologic information in the DOE LA will be complete and of sufficient quality so that NRC can conduct its review with little or no additional information.

Finally, in addition to study plans and topical reports, the DOE has identified additional technical reports to address specific study plan objectives and performance topics. To date, there are approximately 16 such reports that will be developed between FY94 and FY00. Also, the DOE will periodically be issuing a total systems analysis report. Much of this report requires analysis of flow and transport in both saturated and unsaturated conditions. The review of these programs will aid in the development and possible revision of CDMs related to hydrology and PA and assist the staff in determining topics where guidance is needed.

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
DOE SCHEDULE FOR HYDROLOGY									
* Develop/Update Study Plans and Complete Hydrology Site Characterization	▲	▲	▲	▲	▲	▲	▲	▲	
* TSPA									
* Early Site Suitability Evaluations (1/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	
* Annotated Outline (2/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Semi Annual Progress Reports	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Performance Confirmation									
* Develop UZ hydrology Model									
* Develop SZ Hydrology Model									
* Report on SZ Hydrology Description									▲
* Report on SZ Model Users Manual									
* Surface Water Hydrology Model									▲
* Develop Postclosure PA Model									
* Complete WP/EBS PA Model									
* Develop Preclosure PA Model									
* Report on Hydrochemistry of SZ									▲
* Report on Hydrochemistry in the ESF									▲
* Report on Gas Flow in UZ									▲
* Report on Evaluation of Steep Hydrologic Gradient									▲
* Report on Infiltration Rates at Yucca Mt. (Chlorine 36)									▲
* Report on Perched Water Bodies									▲
* Report on SZ Cross-hole and Tracer Tests									▲
* Report on Hydrologic Properties of Tuff									▲
* Report on Evaluation of UZ Fracture Flow									▲
* Report on Potential for UZ Saturation									▲
* Report on Changes to Hydrologic Conditions									▲
* Report on Rainfall Simulation									▲
* Report on Flooding									▲

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Report on Structural Deformation and Groundwater									
* Report on Natural Phenomena and Groundwater									
* Report on Calico Hills Diffusion Tests									
* Report on Human Activity and Groundwater									
* Report on Evaluation of Past Discharge									
* Report on GWTT									
* Report on Disturbed Zone									
* Report on Complex Engineering Measures and Groundwater									



Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Perched Water Bodies					_____	_____			
* Structural Deformation and Groundwater					_____	_____			
* Assessment of Compliance with GWTT Performance Objective		_____	_____						
* Human Activity and Groundwater		_____	_____						
* 10 CFR 60.111/112/113 Integration						_____	_____		
C. Conduct Pre-LA Reviews and QA Audits									
* QA Audits (1/yr.)		▲	▲	▲	▲	▲	▲	▲	▲
* Semi-Annual Progress Report Reviews (2/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Annotated Outline Reviews (2/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* TSPA									
* ESSE (1/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	
* Study Plan Reviews (8/yr.)									
* Topical Report Reviews:									
* Flooding	_____	▲							
* Human Activity and Groundwater			_____	▲					
* Natural Phenomena and Groundwater				_____	▲				
* Structural Deformation and Groundwater					_____	▲			
* Changes to Hydrologic Conditions						_____	▲		
* Complex Engineering Measures and Groundwater					_____	▲			
* Potential for Unsaturated Zone Saturation				_____	▲				
* Perched Water Bodies						_____	▲		
* Technical Report Reviews:									
* Hydrochemistry of SZ							▲		
* SZ Hydrology Description								▲	
* Hydrologic Properties of Tuff Matrix				▲					
* Hydrochemistry in the ESF							▲		
* Results of Calico Hills Diffusion Tests							▲		
* Gas Flow in the UZ		▲							

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Evaluation of UZ Fracture Flow							▲		
* SZ Tracer Tests			▲						
* Evaluation of Steep Hydrology Gradient			▲						
* Infiltration Rates at Yucca Mt.							▲		
* Rainfall Simulations					▲				
* Evaluation of Past Discharge					▲				

APPENDIX C
THE NATURAL SYSTEMS OF THE GEOLOGIC SETTING
GEOCHEMICAL SYSTEM

DOE GEOCHEMICAL SITE INVESTIGATIONS PROGRAM

The U.S. Department of Energy (DOE) is conducting investigations to evaluate the suitability of geologic environment for siting a High-Level nuclear waste (HLW) repository at Yucca Mountain (YM). The program consists of investigations to develop an understanding of the present and expected groundwater and rock chemistry characters important to radioactive waste isolation. These geochemical characteristics of the host rock and the environment at YM can affect the migration of radionuclides to the accessible environment, the capability of the waste packages to isolate waste, and the response of the geologic setting to the perturbation caused by the HLW repository. Overall, the geochemistry program is designed to provide the information needed for developing a model of the geochemical conditions and processes at the site and to supply the geochemical information needed for the resolution of performance and design issues.

The development of a geochemical model for the site requires data from other disciplines. For example, geologic and hydrologic investigations are intended to provide information on the configuration of potential transport pathways in the rock matrix, fracture networks, and fault zones. Geochemical characteristics expected along these pathways will be determined. These characteristics include distribution coefficients describing the extent to which radionuclides will be absorbed. The distribution coefficients obtained from static sorption studies will be supported by information from the studies on dynamic transport. Retardation factors calculated from distribution coefficients will then be coupled with groundwater flow velocities to describe the rates of radionuclide migration to the accessible environment.

Geochemical investigations support model development and include a range of activities. These investigations are aimed at determining the geochemical properties of tuff (the host rock type) and the geochemical environment at YM. This effort will include detailed analyses of the chemistry of water/rock interactions with temperature changes from emplaced radioactive waste. Other studies will focus on investigating natural sites that have geochemical conditions similar to that of YM and existing radionuclide activity such that sorption and migration can be measured (i.e., natural analogs). Overall, the geochemical investigations will provide a better understanding of chemical and physical changes in the environment that could affect radionuclide transport or the viability of the engineered barrier system (EBS) (e.g., waste package). Results of the geochemical investigations will support development of an overall geochemical model and a radionuclide transport model. The DOE plans to develop these models simultaneously in three phases (preliminary, interim, and final) with milestones scheduled for FY94, FY97 and FY99, respectively.

The DOE effort to develop a groundwater geochemistry model is planned to begin in FY93, and will continue through FY01. The purpose of this model is to (i) explain the present ground-water composition resulting from interactions of water with minerals, (ii) predict the future variations in groundwater chemistry under anticipated and unanticipated conditions, and (iii) integrate with and support other modeling efforts in the geochemistry program. The emphasis of this effort will be to develop a mechanistic description of the current groundwater chemistry by integrating the unsaturated and saturated zone data with the processes of water infiltration, water flow, and mineralogic changes. Future changes in these properties and processes will be assessed to evaluate the chemistry of water interactions with the emplaced waste during the post-emplacment period. Reports on groundwater conditions not reducing and groundwater conditions in the host rock that can affect the EBS are planned to be completed in FY96, and FY00, respectively. A report on geochemistry of the unsaturated zone will also be completed in FY00.

To collect the necessary data during site characterization, the geochemistry program consists of 8 investigations (20 separate studies that involve approximately 50 separate activities that are directed at describing the present and expected geochemical conditions of the region and the site). One of these investigations addresses water chemistry within the potential emplacement horizon and along flow paths to the accessible environment. One of its objectives is to develop the groundwater chemistry model. The second investigation addresses mineralogy, petrology, and rock chemistry in the potential emplacement horizon and along potential flow paths to the accessible environment. The third investigation is concerned with the stability of minerals and glasses. The results from this work will be used in developing a conceptual model of mineral and glass evolution at YM to predict future mineral evolution through both natural processes and the thermal loading induced by the waste emplaced in the repository.

For the remaining five investigations in the geochemistry program, the objective is to develop a database on the retardation of radionuclides along potential flow paths to the accessible environment. Of those investigations, three will include laboratory studies of radionuclide retardation by (i) sorption; (ii) precipitation from solution; and (iii) the physical processes of dispersion, diffusion, and advection. A DOE report on particulate transport is planned to be developed from FY95-FY97 and another on physical processes affecting transport will be developed from FY97-FY99. The results of the retardation laboratory studies will be integrated in a fourth investigation, by means of numerical models, to address retardation by all processes along flow paths to the accessible environment. A report in integrated radionuclide transport is planned to be developed from FY97-FY99. Three-dimensional (3D) transport models and other multidimensional process codes will be used in this effort to determine, characterize, and quantify the cumulative effects of all significant processes, physical and geochemical, that may affect or control radionuclide transport at YM. The last investigation in the geochemistry program will investigate the retardation of gaseous radionuclides. Potential retardation mechanisms for gaseous radionuclide species will be identified and used to estimate rates of transport. A report on gas transport of radionuclides is planned for the FY95-FY97 timeframe.

Other work includes investigations of radionuclide retardation by sorption processes. The purpose of this work is to investigate and model the effect of sorption on radionuclide retardation as a consequence of rock and mineral composition and biologic activity. Part of this task includes batch sorption studies, which began in FY91 and will continue until FY99. This activity will provide sorption coefficients for key radionuclides as a function of solid phase composition, groundwater composition, waste element concentration, and the presence of particulates and colloids. The DOE also plans to complete a report on geochemical processes that reduce sorption and rock strength in FY98.

Work is also being done to consider radionuclide retardation by precipitation processes. These studies will provide information to determine the effect of radionuclide solubility on radionuclide transport under conditions representative of YM. This task includes the determination of solubilities for dissolved species of important waste elements and a determination of the stability of waste element colloids along flow paths from the repository to the accessible environment. A report on solubility of radionuclides in YM water was initiated in FY92 and is expected to be completed in FY97. In addition, work on colloid behavior began FY92 and will end in FY99. This work will entail a determination of the formation and stability of waste element colloids, the development of models to calculate natural colloid concentrations and stability, and describe the disposition of the waste elements species as the colloids break up. DOE plans to develop a biologic and colloid transport model in the FY93 to FY98 time frame.

Radionuclide retardation and rates of movement resulting from dispersive, diffusive, and advective processes will also be studied. Here, the DOE plans to conduct dynamic transport column experiments

to determine the rate of movement of radionuclides along potential flow paths (to the accessible environment) used in performance assessment scenarios. The results of these studies will support modeling of radionuclide transport.

Results of the aforementioned geochemical investigations will provide a basis for constructing an integrated geological-geochemical conceptual model of YM which will be used to develop a sensitivity analysis to determine parameters important for radionuclide transport. Specific work will include an analysis of all processes that may affect transport (e.g., geochemical transport processes, physical transport processes, particulate transport heat-load effects, gas transport, and coupled phenomena) and calculations of radionuclide transport from the repository to the accessible environment using the aforementioned integrated geophysical-geochemical conceptual model of YM. Another relevant task includes developing a strategy to demonstrate the validity/applicability of laboratory-generated geochemical data and transport calculations using the aforementioned integrated conceptual model of YM. A reports on calcite/silica and history of geochemical alterations are planned to be completed in FY94 and FY95, respectively.

There will be an additional geochemical modeling effort is focused on developing and verifying computer codes used in performance assessment. This effort, which will be conducted in accordance with applicable Quality Assurance (QA) procedures, will include development of tools to predict behavior of the waste package environment, site geochemistry, and waste package performance assessment. The existing EQ3/6 code will be expanded to include capabilities for nuclear waste applications by adding new submodels relevant to geochemical reactions between the waste package and repository geochemical environment. This effort includes documentation and limited validation of software. A DOE activity focusing on speciation measurement and the EQ3/6 database began in FY91 and will continue in FY98.

In summary, the DOE HLW site characterization geochemistry program consists of approximately 20 separate studies that involve on the order of 50 separate activities. All this work is directed toward developing a geochemical data base and models that can be used to evaluate 10 CFR Part 60 performance and design requirements have been met. The DOE plans to complete geochemical site characterization by FY99, submit a license application (LA) to the NRC before the end of FY01, and receive NRC license application analysis before the end of FY04.

NRC GEOCHEMICAL SYSTEM

I. OVERVIEW

The mission of the U.S. Nuclear Regulatory Commission (NRC) in the Geochemical System portion of the Geologic Setting Program is to review and evaluate the DOE geochemical site characterization data acquisition, technical analyses of geochemical data, and the integration of this information into assessments of specific site criteria, engineered barrier performance, geologic setting performance, and the overall site systems performance, to determine if the DOE has acceptably demonstrated compliance with the requirements of 10 CFR Part 60. To accomplish this mission, the staff is conducting preclicensing consultation and developing 10 Compliance Determination Methods (CDM) plans for the NRC License Application Review Plan (LARP) that cover the geochemistry of the YM site and region. In addition, the staff is developing technical guidance in areas in which uncertainties are believed to be key to performing an adequate evaluation of the DOE performance assessments. The strategy is designed to allow the staff to use the insight it gains from its preclicensing consultations and LARP development to support a timely (18 months) review of geochemical issues important to the DOE LA.

In particular, during preclicensing consultation, the staff is conducting focused technical reviews on geochemical issues through analysis of DOE study plans, topical reports, site characterization progress reports, annotated outlines (AO) of DOE LA, and, the DOE preliminary analysis of total system performance. These reviews are directed towards the resolution of both preclosure and postclosure issues, providing timely guidance to the DOE in order to avoid unnecessary delays in their program, as well as facilitate a timely NRC review of the DOE license application.

The development of guidance to DOE is primarily the result of a systematic analysis of 10 CFR Part 60 of key geochemical technical uncertainties (KTU). A KTU is one that could have a significant impact on NRC analysis of DOE's total system performance, as well as subsystem performance (waste packages, engineered barriers, and the site). Geochemical uncertainties identified to date include (1) the nature and rates of geochemical processes (2) geochemical conditions which promote precipitation (3) groundwater conditions and geochemical processes which affect the EBS, and (4) gaseous movement of radionuclides. Guidance is directed toward the resolution of key technical uncertainties, providing timely input to DOE on key technical uncertainties in order to avoid unnecessary delays to the DOE program, as well as to facilitate a timely NRC review of DOE's license application.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

The NRC geochemical system program has the lead responsibility for the systematic analysis of nine regulatory requirements under 10 CFR Part 60. Of these nine requirements, seven are favorable or adverse geochemical conditions, one pertains to performance confirmation activities, and one is a LA content requirement. This work is done to ensure that all uncertainties (technical, regulatory, and institutional) have been clarified either through rulemaking, the development of regulatory guides, or other forms of guidance documents, in a time frame that is not disruptive to the development of the NRC LARP (FY94-FY00), and to the DOE site characterization program for geochemistry (FY89-FY99) or the DOE schedule for the development of a LA (FY92-FY01). To date, six of these regulatory requirements will require detailed guidance to the DOE.

A KTU identified which requires guidance relates to the favorable condition in 10 CFR 60.122(b)(1). This requirement states the nature and rates of geochemical processes operating during the Quaternary, when projected, would either favor or at a minimum would not adversely affect isolation. The KTU relates to whether the processes operating through the Quaternary that may affect waste isolation can be identified and whether the rates of these processes can be established via age determination methods presently available. This issue needs to be investigated further by the staff in order to determine acceptable approaches for compliance. DOE began investigating Quaternary geochemistry in FY89. This work is scheduled to be completed by FY98. Work on NRC guidance will begin in FY95, and an analysis report will be developed in FY96 and a final document issued in FY97.

Another KTU identified by the staff pertains to the favorable condition in 10 CFR 60.122(b)(3)(i) through (iii). These requirements refer to geochemical conditions that promote precipitation of radionuclides, inhibit the formation of colloids and complexes, and inhibit transport of radionuclides by colloids and other means. It is uncertain what geochemical conditions will inhibit the formation of particulates, colloids, and inorganic or organic complexes. Further staff analyses will need to be conducted in order to resolve this uncertainty and to provide DOE with guidance on approaches that are considered acceptable to the staff. The DOE began investigating radionuclide transport in FY88. This work is scheduled for completion in FY99. Work on NRC guidance will begin in FY97, and an analysis report will be completed in FY98, and a final document issued in FY99.

The potentially adverse condition in 10 CFR 60.122(c)(7), which requires an analysis of groundwater conditions in the host rock that adversely affect the EBS, also contains a KTU identified by the staff. This uncertainty relates to the nature of groundwater chemistries in the unsaturated zone and how they will affect the stability of waste packages and the underground facility. As a result, the staff will have to initiate efforts focussed on predicting the groundwater chemistry of the unsaturated zone, and determine the chemical effects on waste package material in order to gain a sufficient understanding of the technical issues necessary to review the DOE efforts. The DOE began investigating groundwater conditions in the host rock affecting the EBS in FY87. This work is scheduled for completion by the end of FY99. This guidance should be completed well in advance of the FY00 completion date for DOE's report on groundwater conditions that affect the EBS. Work on this report is expected to begin in FY96, and an analysis report will be completed in FY97, and a final document issued in FY98.

Another KTU identified by the staff pertains to the potentially adverse condition in 10 CFR 60.122(c)(8), which requires an analysis of geochemical processes that would reduce sorption of radionuclides, result in degradation of rock strength, or adversely affect the performance of the EBS. It is uncertain how to predict the effects of geochemical processes on the performance of the EBS and on the sorptive properties of the host rock. In-depth staff analyses of these issues are necessary to resolve these uncertainties so guidance can be provided to DOE, and NRC staff can effectively review the DOE license application. This guidance should be available to DOE for use in its efforts regarding the characterization of geochemical processes affecting sorption and rock strength, which will culminate in a report to be completed by FY00. Also, a KTU identified by the staff pertains to mineral assemblages that, after thermal loading, will have equal or an increased capacity to inhibit radionuclide migration after thermal loading. The specific uncertainty pertains to understanding the effects of thermal alteration (e.g., dewatering) on sorption or on permeability. The DOE has been investigating stability of mineral assemblages since FY88. This work is scheduled for completion in FY98. Work on NRC guidance will begin in FY96. An analysis report will be completed in FY97 and a final document will be issued in FY98.

The last uncertainty identified for the geochemical program pertains to the potentially adverse condition in 10 CFR 60.122(c)(24), which requires an analysis of the potential for movement of nuclides in a gaseous state through the unsaturated zone to the accessible environment. Here, it is uncertain how gaseous radionuclides will interact with solids and liquids in the geologic medium. To date, the DOE has not begun work on this study plan. It is anticipated that the DOE work on this subject will begin in FY95 and would be completed in FY97. Work on this NRC guidance will begin in FY97, and an analysis report will be completed in FY98 and a final document in FY99.

An ongoing rulemaking, "Clarification of Assessment Requirements for the Siting Criteria and Performance Objectives," (i.e., "60.112/60.122 rulemaking) will resolve several uncertainties concerning the investigation and analysis of siting criteria and their relationship to the post-closure performance objectives. This rulemaking was published as a draft for public comment in FY93 and should be finalized late in FY94.

Finally, the remaining two regulatory requirements will need some guidance concerning the level of detail, or the information that will be needed to address each of the two regulatory requirements. This guidance will be provided to DOE through the development of revisions to the NRC LA Format and Content Regulatory Guide (FCRG). This guide was first issued in FY91, and will be revised as needed. Current plans are to develop a revision in FY94. Another revision may be necessary prior to completion of the DOE site characterization program in FY99.

B. Develop LARP and Supporting Technical Assessment Capability

1. Develop Geochemical System License Application Review Plans

During FY93, Compliance Determination Strategies (CDS) for all nine geochemical LARP sections will be completed. During FY94, the staff will begin the development of CDMs (including review methods and acceptance criteria) for each of the nine LARP sections. Between FY95 and the receipt of the DOE license application (FY01) the staff will be revising CDMs as necessary. The sequencing and completion of the LARP sections coincides with guidance development needed for specific regulatory requirements, availability of assessment methods for specific regulatory requirements, and the need to provide timely input to the DOE on KTU in order to avoid unnecessary delays to the DOE program. During this period, the DOE will develop two AOs of their LA per year. These annotated outlines will be reviewed, in the context of the LARP, for completeness by the NRC staff. Also, between FY95 and FY00, DOE plans to develop four topical reports, one for each Potentially Adverse Condition (PAC) in 10 CFR 60.122. NRC review of these reports will require staff consideration of issues pertinent to the development of CDMs for the applicable requirements (see the discussion in Section C for more information on NRC review of DOE topical reports).

In FY94, the following geochemical system review plan CDM will be completed:

- Geochemical System Description (CDM 3.1.3)

In FY95, the following geochemical system review plan CDMs will be completed:

- Geochemistry Performance Confirmation (CDM 8.1.3)
- Not Reducing Groundwater Conditions (CDM 3.2.3.6)

Also, during FY95, the DOE will develop a topical report on the potential for oxidizing conditions in the host rock. When this report is received, the NRC staff will conduct a review and develop a SE (safety evaluation) which will address the sufficiency of the DOE approach to addressing this 10 CFR Part 60 requirement. The review of this topical report will be key to finalizing LARP Chapter 3.2.3.6.

In FY96, the following geochemical system review plan CDM will be completed:

- Mineral Assemblages (CDM 3.2.3.3)

In FY97, the following geochemical system review plan CDM will be completed:

- Gaseous Radionuclide Movement (CDM 3.2.3.7)

Also, during FY97, the DOE will develop a topical report on the potential for gaseous radionuclide movement. When this report is received, the NRC staff will conduct a review and develop a SE that will address the sufficiency of the DOE approach to addressing this 10 CFR Part 60 requirement. The review of this topical report will be key to finalizing LARP Chapter 3.2.3.7..

In FY98, the following geochemical system review plan CDM will be completed:

- The Nature and Rates of Geochemical Processes (CDM 3.2.3.1)

In FY99, the following geochemical system review plan CDM will be completed:

- Geochemical Conditions (that promote precipitation) (CDM 3.2.3.2)

In FY00, the following geochemical system review plan CDMs will be completed:

- Groundwater Conditions and the Engineered Barrier System (CDM 3.2.3.4)
- Geochemical Processes (that would reduce sorption of radionuclides) (CDM 3.2.3.5)

Also, during FY00, the DOE will develop a topical report on the potential for (i) geochemical conditions that would adversely affect the EBS (i.e., waste packages and the underground facility), and (ii) geochemical processes affecting sorption, rock strength, waste packages and the underground facility. When these reports are received, the NRC staff will conduct a review and develop a SE that will address the sufficiency of the DOE approach to addressing each of these 10 CFR Part 60 requirements. The review of these topical reports will be key to finalizing LARP Chapters 3.2.3.4 and 3.2.3.5..

2. Geochemical System Code and Model Development

In support of uncertainty reduction and the development of CDMs needed to develop ten individual LARP chapters (discussed previously in section 1 of the appendix), the staff has identified six regulatory requirements for which CDMs are not readily available. They have technical uncertainties associated with them, which pose a high risk of noncompliance with the performance objectives of 10 CFR Part 60. These six requirements are as follows:

- Nature and Rates of Geochemical Processes (CDM 3.2.3.1)

- Geochemical Conditions that Promote Precipitation of Radionuclides, Inhibit Colloid formation (CDM 3.2.3.2)
- Mineral Assemblages (CDM 3.2.3.3)
- Groundwater Conditions and the Engineering Barrier System (CDM 3.2.3.4)
- Geochemical Processes (that would reduce sorption, rock strength, and EBS performance) (CDM 3.2.3.5)
- Gaseous Radionuclide Movement (CDM 3.2.2.7)

Of these six CDMs, the NRC staff will need to develop an independent understanding to evaluate the DOE assumptions in order to determine compliance with CDMs 3.2.3.3 and 3.2.3.7. However, these codes are considered state-of-the-art" in that collection of data (primarily in the unsaturated zone), interpretation of its meaning, and the availability of acceptable codes to evaluate site data are relatively new to the scientific community. Because of this unfamiliarity, the NRC will need to have to develop expertise and knowledge about radionuclide transport in the unsaturated zone in order to effectively utilize the DOE codes to make licensing decisions. This work will begin in FY94 and will continue through the end of the DOE site characterization site program (FY99), and the development of DOE geochemical models and codes (FY00). Preliminary compliance determination methods for each of these regulatory requirement chapters will be developed between FY94 and FY97, and final compliance determination methods for each of these regulatory requirement chapters will be developed by FY00.

Furthermore, the analysis of the nature and rates of geochemical processes (CDM 3.2.3.1), precipitation, colloids, organics, sorption, (CDMs 3.2.3.2 and 3.2.3.5) and the effects of the geochemical environment on waste packages and other aspects of the EBS (CDMs 3.2.3.4 and 3.2.3.5) will require the development of independent codes as well as some independent data collection because both the DOE and NRC approaches to modeling unsaturated flow conditions with respect to the four requirements will result in KTUs which may significantly affect the analysis of the total systems performance objective. The DOE current program is involved in determining radionuclide retardation under both near- and far-field conditions, as well as geochemical environmental conditions and processes that will affect waste packages and the EBS. This work is key to developing conceptual geochemical models of the site.

In addition, one of the remaining two CDMs (CDM 3.2.3.6, Not Reducing Groundwater Conditions) being developed, will utilize simple off-the-shelf codes to assess the DOE compliance. These codes will be exercised in order to assure their effectiveness in determining the credibility of the DOE compliance demonstration. The remaining CDM (CDM 3.1.3, Site Description) will not require any analysis by codes.

Finally, the development of a CDM for the overall performance of the site (CDM 6.1) will require the integration of geochemical modeling of both near- and far-field conditions (i.e., 60.111/112/113 Integration). This integration requires both the development of codes and supporting data. This work began in FY90 and will continue through FY00. (for details see Appendix G — Overall Systems Performance).

C. Conduct Prelicense Application Reviews and Quality Assurance Audits

The staff will continue to conduct Quality Assurance (QA) audits in response to statutory requirements or agreements between the NRC and DOE. Generally, these audits will take the form of observation audits of DOE internal and contractor activities in the area of geochemistry. The NRC will conduct one audit per year between FY94 and FY01 (when DOE submits its LA).

The staff will continue to review the DOE Semi-Annual Progress Reports. Not only is this review a statutory responsibility, but it is also a mechanism by which DOE reports results and highlights changes to its ongoing geochemical programs. The DOE geochemical characterization program consists of approximately 20 separate studies that involve on the order of 50 separate activities. All this work is directed towards developing a geochemical database that is sufficient to demonstrate if 10 CFR Part 60 performance and design requirements have been adequately addressed. The DOE plans to complete geochemical characterization by FY00. Periodic reviews of this information will allow the staff to: (i) provide guidance to DOE on the acceptability of any proposed changes, (ii) identify if results from the DOE work are acceptable, and (iii) determine what additional work may be needed in the development of independent modeling activities, the FCRG, and the LARP.

In addition, DOE is preparing AO of their LA on a semi-annual basis. The staff has agreed with DOE to carry out semi-annual reviews of the DOE AO. The semi-annual review of the AO is carried out to provide DOE with prelicensing application guidance on whether or not the staff believes that the DOE is appropriately interpreting the Geochemical System related requirements of 10 CFR Part 60, and on what additional geochemical information is needed in the AO to address the specific 10 CFR Part 60 requirement. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions described above with the DOE to ensure that the NRC regulations are understood.

The staff will also review other DOE documents, including study plans and topical reports. Study plan reviews include those reviews related to studies not previously submitted to NRC for review as well as revisions to previously submitted study plans. There are approximately 20 study plans in the geochemical area. Approximately four have been reviewed. It is anticipated that between FY94 and FY00, the staff will continue to review about four study plans per year, two of which will be detailed reviews. In addition, the staff will conduct reviews of DOE responses to staff study plan reviews and other document reviews to assess progress towards resolution of open items.

Also, during the prelicensing period, the DOE will develop topical reports that address specific NRC requirements. NRC will then conduct formal reviews in accordance with the Department of High-Level Waste Management (DHLWM) Topical Report Review Plan resulting in the development of staff Safety Evaluations (SE) for specific topics of concern to the repository program. The DOE intends that these SE would document resolutions reached at the staff level and would be referenced in the LA should the YM site be found suitable. The intent of the staff review is to resolve issues at the staff level and provide guidance to the DOE on what, if any, changes are needed in its ongoing program as well as address topics related to the sufficiency of the DOE site characterization program. To date, the DOE has indicated that topical reports will be issued to address each of the four potentially adverse geochemical condition topics contained in 10 CFR Part 60. These topical reports include:

- Not Reducing Groundwater Conditions,
- Gaseous Radionuclide Movement,

- Groundwater Conditions and the Engineered Barrier System, and
- Geochemical Processes (that would reduce sorption of radionuclides)

It is anticipated that these reports will be issued periodically between FY94 and FY00. Review of these reports and the development of SEs enable the staff to provide guidance at appropriate points in DOE's program, and helps to ensure that the geochemical information in the DOE LA will be complete and of sufficient quality so that the NRC can conduct its review with little or no additional information.

Finally, in addition to study plans and topical reports, the DOE has identified additional technical reports to address specific study plan objectives and performance topics. To date, there are approximately 16 such reports, which will be developed between FY94 and FY00. Also, the DOE will be issuing on an 18-month cycle, a total systems performance analysis (TSPA) report. Much of this report requires analysis of radionuclide transport in both saturated and unsaturated conditions as well as geochemical conditions that affect the EBS. The review of these programs will aid in the development and possible revision of CDMs related to geochemistry and performance assessment, and assist the staff in determining topical areas where guidance is needed.

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
DOE SCHEDULE FOR GEOCHEMISTRY									
* Develop / Update Study Plans and Complete Geochemistry Site Characterization	▲	▲	▲	▲	▲	▲	▲	▲	
* TSPA	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Annotated Outline (2/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Semi Annual Progress Reports	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Geochemical Model Development		▲			▲			▲	
* Radionuclide Transport Model		▲			▲			▲	
* Groundwater Chemistry Model									
* Report on Groundwater Conditions Not Reducing					▲				
* Report on Groundwater Conditions in Host Rock Affecting EBS									▲
* Report on Geochemistry of Unsaturated Zone									▲
* Report on Geochemical Processes Affecting Transport				▲					
* Report on Physical Processes Affecting Transport									▲
* Report on Particulate Transport									▲
* Report on Integrated Radionuclide Transport									▲
* Report on Gas Transport of Radionuclides									▲
* Report on Coupled Phenomena and Radionuclide Transport									▲
* Batch Sorption Studies									
* Report on Geochemical Processes that Reduce Sorption / Rock Strength									▲
* Report on Solubility of Radionuclides in Yucca Mtn. Water									▲
* Colloid Behavior									
* Biologic and Colloid Transport Model									
* Report on Calcite Silica									
* Report on History of Chemical Alterations									

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
NRC SCHEDULE FOR GEOCHEMISTRY									
A. Develop Regulatory Requirements and Technical Guidance									
* Nature and Rates of Geochemistry Processes				————▲	————▲				
* Geochemical Conditions that Promote Precipitation						————▲	————▲		
* Groundwater Conditions that Affect EBS				————▲	————▲				
* Geochemical Processes that Adversely Affect EBS				————▲	————▲				
* Mineral Assemblages				————▲	————▲				
* Movement of Radionuclides as Gas						————▲	————▲		
* 80.112/80.122 Rulemaking	————▲								
* Revise FCRC	————▲								
B. Develop LARP & Supporting Technical Assessment Capability									
Develop Geochemistry LA Review Plans									
* Geochemical Subsystem Description - CDM 3.1.3		▲							
* Geochemical Performance Confirmation - CDM 8.1.3			▲						
* Not Reducing Groundwater Cond. - CDM 3.2.3.8			▲						
* Mineral Assemblages - CDM 3.2.3.3				▲					
* Gaseous Radionuclide Movement - CDM 3.2.3.7					▲				
* Nature and Rates of Geochemical Processes - CDM 3.2.3.1						▲			
* Geochemical Conditions (that Promote Precipitation) - CDM 3.2.3.2							▲		
* Groundwater Conditions and the EBS - CDM 3.2.3.4								▲	
* Geochemical Processes (that would Reduce Sorption, Rock Strength, EBS) - CDM 3.2.3.5								▲	
Geochemistry Code and Model Development:									
* Nature and Rates of Geochemical Processes					————	————			
* Geochemical Conditions that Promote Precipitation						————	————		
* Mineral Assemblages				————					
* Groundwater Conditions and the EBS							————	————	
* Geochemical Processes that Reduce Sorption							————	————	

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Gaseous Radionuclide Movement			—————▲						
* 60.111/112/113 Integration	—————								
C. Conduct Pre-LA reviews and QA Audits	—————								
* QA Audits (1/yr.)	—————								
* Semi-Annual Progress Rpt. (2/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Annotated Outline Reviews (2/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* TSPA	▲	▲		▲		▲			▲
* ESSE (1/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	
* Study Plan Reviews (4/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Topical Report Reviews:									
* Not Reducing Groundwater Conditions				—————▲					
* Gaseous Radionuclide Movement					—————▲				
* Groundwater Conditions and the EBS							—————▲		
* Geochemical Processes that Reduce Sorption, Rock Strength/EBS							—————▲		
* Technical Report Reviews									
* Solubility of Radionuclides in Yucca Mtn. Water				▲					
* Geochemistry of Unsaturated Zone							▲		
* Physical Processes Affecting Transport						▲			
* Particulate Transport				▲					
* Geochemical Processes Affecting Transport		▲							
* Integrated Radionuclide Transport						▲			
* Coupled Phenomena and Radionuclide Transport					▲				
* Calcite / Silica	▲								
* History of Chemical Alteration			▲						

APPENDIX D

THE NATURAL SYSTEMS OF THE GEOLOGIC SETTING

METEOROLOGICAL/CLIMATOLOGICAL SYSTEM

DOE METEOROLOGICAL/CLIMATOLOGICAL PROGRAM

The Department of Energy (DOE) is characterizing the present and paleoclimate (both regional and local), and meteorological conditions at Yucca Mountain (YM) to provide a baseline for determining changes in climate that potentially affect the waste isolation capabilities of the site, and to determine the relations between climatic conditions and hydrologic characteristics in the vicinity of YM during and since the Quaternary. Overall, the program is designed to provide the climate and meteorological information required for the resolution of design and performance issues.

The objective of the DOE program is to provide information that can be used to assess the long-term variability of past climates and provide the basis for estimating future climatic episodes. This analysis will also provide the basis for determining the potential effects of future climate conditions on hydrologic conditions. The determination of the nature, probability, and timing of future climate scenarios will be derived from either a linked global-regional modeling approach, or a separate empirical modeling approach, or both.

To collect the necessary data during site characterization, the climatology and meteorology program consists of approximately 8 studies that involve approximately 24 separate activities that are designed to provide data on past and present climate conditions, predict future climate conditions, provide input that can be used to determine the effects of climate changes on the site hydrologic system (surface-water system, the hydrologic conditions in the unsaturated zone, and the hydrologic conditions in the saturated zone).

As part of site characterization, several activities provide a baseline for determining the changes in climate that may affect the waste isolation capabilities of the site [see Major Milestone (MM) Schedule for Develop/Update Study Plans and Complete Site Characterization, Develop Site Characterization Model, Eolian History of YM, and Summary of Modern Flooding Events]. These activities include the development of a synoptic characterization of the modern regional climate to provide a baseline and a background for the interpretation of climatic variation. In addition, the DOE is establishing the nature, timing, duration, and amplitude of paleoclimate changes based on paleontologic, stratigraphic-sedimentologic, chemical, and mineralogic analyses of lacustrine sediments in or near southern Nevada. Further, the DOE is determining aspects of past vegetation changes, evaluating the paleoenvironmental record at YM and its surroundings in light of inferred paleoclimate history of the southern Great Basin (see MM Schedule for Develop Paleoclimatologic Model and Develop Paleohydrology Model). The DOE will provide data syntheses in the formats required for future climate and paleohydrology investigations, and estimating values for climatic parameters for the YM area with special emphasis on the next 10,000 years [see MM Schedule for Total System Performance Assessment (TSPA), Develop Paleohydrology Model, Future Hydrology Due to Climate, and Future Flooding and Debris Movement]. This information will be summarized in final reports in Paleoclimate and Implications of Lake, Playa, and Marsh Deposition in FY95.

During FY93, there has been significant work related to climatology and meteorology. Data collected from five water stations are being analyzed, and a new weather station is being installed, bringing the total to nine stations. Additional rain gauges were installed to increase the spatial coverage of the network. The network now contains 120 gauges. Weather satellite data are being analyzed to determine the origin, movement, and intensity of precipitation events affecting YM. In ongoing paleoenvironmental work, the shallow deposits of the northern third of YM will be completed, and mapping in the other areas will begin. Data collection at two analog-recharge sites is also being completed. In addition, regional

paleoflood evaluations are being performed for the YM using map data, digital landscape models, and aerial/satellite images. A preliminary report on the development of a paleohydrologic model is being prepared and is scheduled for completion in FY94. Also, the DOE is developing a topical report on the potential for changes to the site hydrologic conditions due to changes in climate. Work on this report will begin in FY94, and it is scheduled for completion in FY96. Performance Confirmation activities will be conducted but are not yet scheduled (see Appendix G for the DOE program description).

In summary, the DOE high-level waste (HLW) site characterization program consists of approximately 8 separate studies, which involve on the order of 24 separate activities. All of this work is directed toward developing a meteorologic/climatologic database that can be used to demonstrate that 10 CFR Part 60 performance and design requirements have been met. The DOE plans to complete meteorologic/climatologic site characterization by FY99, submit a license application to the U.S. Nuclear Regulatory Commission (NRC) before the end of FY01, and receive a NRC license application analysis before the end of FY04.

NRC METEOROLOGICAL/CLIMATOLOGICAL SYSTEM

I. OVERVIEW

The NRC mission in its Meteorologic/Climatologic System is to review and evaluate the DOE meteorologic/climatologic site characterization data acquisition, technical analysis of meteorologic/climatologic data, and the integration of this information into assessments of engineered barrier performance, geologic setting performance, and the overall site systems performance, to determine if the DOE has acceptably demonstrated compliance with the requirements of 10 CFR Part 60. To accomplish this mission, the staff is conducting prelicensing consultation and developing four individual review plans for the NRC License Application Review Plan (LARP). In addition, the staff is developing technical guidance regarding a Key Technical Uncertainty (KTU). A KTU is an uncertainty which could have a significant impact on the analysis of the DOE total system performance as well as subsystem performance (waste packages, engineered barriers, and the site). The strategy is designed to allow the staff to use the insight it gains from its prelicensing consultations and LARP development to support a timely (18 month) review of meteorologic and climatologic topics important to the DOE license application.

In particular, during prelicensing consultation, the staff is conducting focused technical reviews of the implications of lake, playa, and marsh deposits, modern flooding events, future flooding and debris movement, and eolian history of YM. These reviews involve analysis of the DOE study plans, topical reports, site characterization progress reports, annotated outlines (AO) of the DOE license application, and the DOE preliminary analysis of total system performance. These reviews are directed towards the resolution of both preclosure and postclosure issues, providing timely guidance to the DOE in order to avoid unnecessary delays in the DOE program, as well as to facilitate a timely NRC review of the DOE LA.

The development of guidance to the DOE is primarily the result of a systematic analysis of 10 CFR Part 60 for meteorological and climatological KTUs. Primarily, these uncertainties pertain to analyzing paleoclimate characterization data and predicting future climate changes. Guidance is directed towards the resolution of KTUs providing timely input to the DOE on KTUs in order to avoid unnecessary delays to the DOE program, as well as to facilitate a timely NRC review of the DOE LA.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

The NRC Meteorologic/Climatologic System has the lead responsibility for the systematic analysis of four 10 CFR Part 60 Regulatory Requirements. Of these requirements, one is the favorable condition regarding annual potential evapotranspiration and another is the potentially adverse condition on changes to the hydrologic system from climate. The two remaining requirements pertain to performance confirmation activities, and LA content. This work is done to ensure that all uncertainties (technical, regulatory, and institutional) have been clarified through either rulemaking, the development of regulatory guides, or other forms of guidance documents, in a time frame that is not disruptive to the development of the NRC LARP (FY94-FY98), and to the DOE site characterization program for meteorology and climatology (FY88-FY99), or the DOE schedule for the development of a LA (FY92-FY01). To date, only one of these regulatory requirements will require detailed guidance to the DOE.

The KTU for the meteorologic and climatologic system pertains to the inability to validate long-term predictions using classical scientific testing based on measured data. As a result, the DOE plans to develop its own validation methodology. Due to the importance of this topic to the DOE demonstration of compliance with 10 CFR Part 60 performance objectives, NRC plans to provide guidance to DOE on this matter in FY95 to ensure DOE efforts are consistent with the regulatory intent of these requirements. This activity is being conducted as part of the overall system performance effort (See Appendix G).

B. Develop LARP and Supporting Technical Assessment Capability

1. Develop Meteorologic/Climatologic License Application Review Plans

During FY93, the staff will complete all four Compliance Determination Strategies (CDS) for the meteorologic/climatologic system. During FY94, development of individual Compliance Determination Methods (CDMs) will be initiated. The Description of the Climatological and Meteorological Systems (CDM 3.1.4), and Annual Potential Evapotranspiration (CDM 3.2.4.1) are planned to be completed in FY94. In FY95, the CDM for Performance Confirmation (CDM 8.1.4) will be completed. In FY98, the staff will develop the CDM regarding Changes to the Hydrologic System from Climate (CDM 3.2.4.2). Between FY98 and the receipt of the DOE LA (FY01) the staff will revise these review plans as necessary. The sequencing and completion of the LARP chapters coincides with guidance development needed for specific regulatory requirements, availability of assessment methods for specific regulatory requirements, and the need to provide timely input to the DOE on KTU in order to avoid unnecessary delays to the DOE program. During this period, the DOE will develop two annotated outlines of its LA per year. These AOs will be reviewed, in the context of the LARP, for completeness by the NRC staff. Also, as part of developing a site characterization model in FY96, DOE plans to develop one topical report on climatology and meteorology site characterization issues. NRC review of this report will require staff consideration of topics pertinent to the development of CDMs for the applicable requirements (see the discussion in Section C for more information on the NRC review of DOE topical reports).

2. Meteorologic/Climatologic System Code and Model Development

In support of uncertainty reduction and the development of CDMs needed for four individual LARP chapters, the staff has identified one regulatory requirement for which CDMs are not readily available. This requirement, dealing with the Potentially Adverse Condition: Changes to Hydrologic System From Climate (CDM 3.2.4.2), has a KTU associated with it, which poses a high risk of noncompliance with the performance objectives of 10 CFR Part 60.

The NRC staff will need to develop an independent understanding to evaluate the DOE assumptions in order to determine compliance with this CDM. These models, are considered state-of-the-art in that the collection of data, its meaning, and the availability of acceptable codes to evaluate site data are relatively new to the scientific community. Because of this unfamiliarity, the NRC is going to have to develop expertise and knowledge about climatology/meteorology in order to effectively evaluate assumptions in the DOE codes to make licensing decisions. This work will begin in FY96 and will continue through to the end of the DOE site characterization site program (FY99), and the development of the DOE climatology/meteorology models and codes (FY00). CDMs for this chapter will be developed in FY98.

In addition, of the remaining three CDMs being developed, one (CDM 3.2.4.1) will utilize simple off-the-shelf codes to assess the DOE compliance. Each of these codes will be exercised in order to assure their effectiveness in determining the credibility of the DOE compliance demonstration. The remaining

two CDMs will not require analysis by codes.

Finally, the development of a CDM for the overall performance of the site (CDM 6.1, Assessment of Compliance for Cumulative Releases of Radioactive Materials) will require the integration of climatic and hydrologic changes (i.e., 60.111/112/113 Integration). This integration requires both the development of codes and supporting data. This work began in FY90 and will continue through FY00. (For details see Appendix G — Overall Systems Performance).

C. Conduct Prelicense Application Reviews and Quality Assurance Audits

The staff will continue to conduct quality assurance (QA) audits in response to statutory requirements or agreements between the NRC and DOE. Generally, these audits will take the form of observation audits of DOE internal and contractor activities in the area of meteorology/climatology. The NRC will conduct one audit per year between FY94 and FY01 (when the DOE submits its LA).

The staff will continue to review the DOE Semi-Annual Progress Reports. Not only is this review a statutory responsibility, but it is also a mechanism through which the DOE reports changes to its ongoing meteorology/climatology programs and the results from those programs. The DOE meteorology and climatology characterization program consists of approximately 8 separate studies, that involve on the order of 24 separate activities. All this work is directed towards developing a meteorology/climatology database sufficient to demonstrate whether 10 CFR Part 60 performance and design requirements have been adequately addressed. The DOE plans to complete meteorology and climatology characterization by FY00. Periodic reviews of this information will allow the staff to: (i) provide guidance to DOE on the acceptability of any proposed changes, (ii) identify if results from the DOE work are acceptable, (3) determine any additional work that may be needed in the development of independent modeling activities, the Format and Content Regulatory Guide (FCRG), and the LARP.

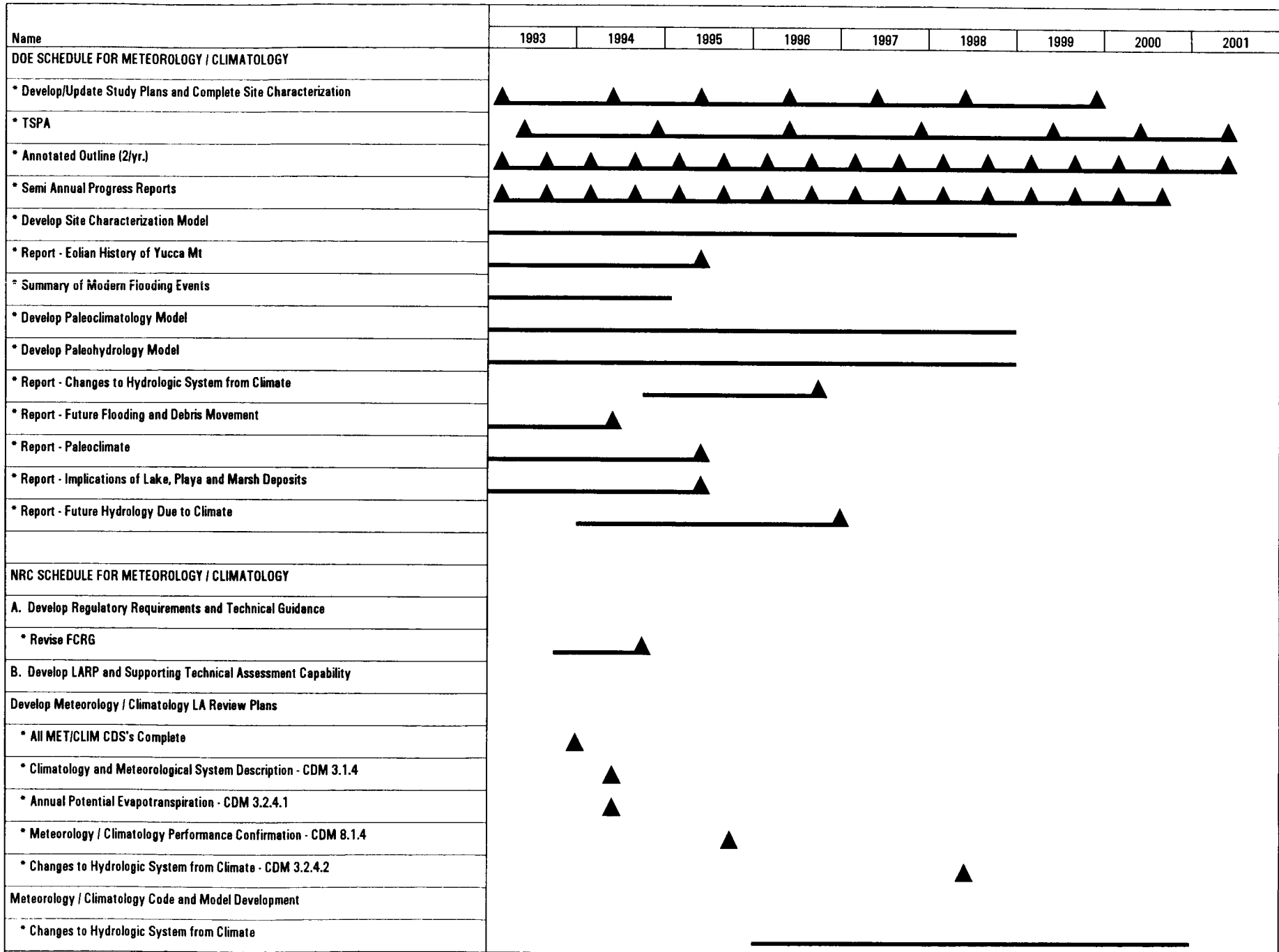
In addition, the staff has agreed with the DOE to carry out semi-annual reviews of the DOE AO. The semi-annual review of the AO is carried out to provide DOE with pre-LA guidance on whether or not the staff believes the DOE is appropriately interpreting the Meteorologic/Climatologic System related requirements of 10 CFR Part 60 and what meteorologic/climatologic information is needed in the AO to address the specific 10 CFR Part 60 requirements. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions with DOE described above to ensure that the NRC regulations are understood.

The staff will also review other DOE documents including study plans and topical reports. Study plan reviews include reviews related to studies not previously submitted to the NRC for review as well as revisions to previously submitted study plans. There are approximately eight study plans in the meteorology/climatology area. To date, four have been reviewed. It is anticipated that between FY94 and FY99, the staff will continue to review approximately one study plan per year. In addition, the staff will also conduct reviews for DOE responses to staff study plan reviews and other document reviews to assess progress towards resolution of open-items.

During the prelicensing period, the DOE will develop topical reports that address specific NRC requirements. These reports will be reviewed by NRC in accordance with the Division of High-Level Waste Management Topical Report Review Plan resulting in the development of a staff Safety Evaluation (SE) for specific topics of concern to the repository program. The DOE intends that these SEs would document resolutions reached at the staff level and would be referenced in the LA, should the YM site

be found suitable. The intent of this staff review is to resolve questions at the staff level and provide guidance to the DOE on what, if any, changes are needed in its ongoing program, as well as address topics related to the sufficiency of the DOE site characterization program. To date, the DOE has indicated that topical reports will be issued to address topics regarding potentially adverse condition requirements in 10 CFR Part 60. These are planned to include changes to the hydrologic system from climate, and future flooding and debris movement. The latter is being considered primarily as part of the NRC Hydrologic System Program; however, it will involve consideration of meteorology and climatology. These reports are all expected to be reviewed between FY94 and FY98.

Finally, in addition to study plans and topical reports, the DOE has identified technical reports to address specific study plan objectives and performance topics. These topics include: (i) Implications of Lake, Playa, and Marsh Deposits, (ii) Eolian History of YM, and (iii) modern flooding events. Also, the DOE will be issuing a total systems analysis report every 18 months. Aspects of this report requires analysis of DOE interpretations of future climate scenarios. The review of these documents will aid in the development and possible revision of CDMs related to meteorology/climatology and performance assessment, and assist the staff in determining topics where guidance is needed.



Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* 10 CFR 60.111/112/113 Integration	<hr/>								
C. Conduct Pre-LA Reviews and QA Audits	<hr/>								
* QA Audits (1/yr.)	▲▲▲▲▲▲▲▲▲▲								
* Semi-Annual Progress Report (2/yr.)	▲▲▲▲▲▲▲▲▲▲								
* Annotated Outline Reviews (2/yr.)	▲▲▲▲▲▲▲▲▲▲								
* Study Plan Reviews (1/yr.)	▲▲▲▲▲▲▲▲▲▲								
* ESSE (1/yr.)	▲▲▲▲▲▲▲▲▲▲								
Topical Report Reviews:									
* Changes to Hydrologic System from Climate	<hr/>								
* Flooding	<hr/>								
Technical Report Reviews:									
* Implications of Lake, Playa, and Marsh Deposits	▲								
* Eolian History of Yucca Mt.	▲								
* Summary of Modern Flooding Events	▲								
* TSPA									

APPENDIX E
GEOLOGIC REPOSITORY OPERATIONS AREA

DOE GEOLOGIC REPOSITORY OPERATIONS AREA PROGRAM

INTRODUCTION

The long-term objectives of the geologic repository operations area (GROA) program of the U.S. Department of Energy (DOE) is to design, construct, operate, and close a repository at the Yucca Mountain (YM) site after determining the suitability of the site. To accomplish these objectives, the GROA program has been, is, and will be gathering data to characterize the site and to be used in the design, construction, and operations of the GROA. As more data are gathered, both the ESF and GROA designs will evolve through a design cycle that the DOE labels Title I, Title II, and Title III, but which can be thought of as conceptual, feasibility, and construction designs.

The development of the Exploratory Studies Facility (ESF). This is a major effort for the DOE GROA program in terms of gathering data for the characterization of the site and the design of the ESF and the GROA. The development of the ESF mirrors that of the GROA in that, as more data are acquired, the ESF is progressing through a cycle of design changes. In late FY92, construction started on portions of the ESF.

The DOE has produced a number of design reports in the area of repository and ESF design, construction, and operations. At the current time, most of the reports are focusing on the ESF related topics. Design reports recently submitted for NRC review are related to the selection of an ESF alternative. For example, the ESF alternatives study and the Calico Hills Risk Benefit Analysis were developed by the DOE as a precursor to the selection of the ESF option. A number of technical reports have also been written on topics such as thermal and thermo-mechanical analytical aspects (i.e., thermal loading) of repository design and performance.

The DOE continues to release technical reports related to the GROA and the ESF design activities. Examples of recent reports considered the following topics: how to determine the structural support needed for typical rock conditions; what cutters should be used to maximize the tunnel-boring machine performance; and how will the changes in temperatures and stresses caused by emplacing high-level waste impact the repository preclosure and postclosure performance. It is expected that the DOE and its contractors will continue to issue such reports as the site characterization and ESF and GROA designs progress in FY94.

The DOE GROA program is currently conducting activities related both to the ESF and to the GROA. The following paragraphs describe the activities of the DOE GROA program. The ESF activities are described first, and, because of their dependence on the outcome of the ESF activities, the GROA activities are described next.

ESF ACTIVITIES

The DOE proposed a plan for an Exploratory Shaft Facility (ESF) in the Site Characterization Plan (SCP) in 1988. As a result of comments by the U.S. Nuclear Regulatory Commission (NRC), the Nuclear Waste Technical Review Board (NWTRB), and others, and the results of an ESF Alternatives Study, the DOE decided to enlarge the ESF and to change the excavation and access methods for underground construction. The name of the facility was subsequently changed to Exploratory Studies Facility (ESF). A Title I design for the preferred ESF configuration was completed in FY91 by the DOE contractor, Raytheon Services/Nevada (RSN).

In early FY91, the DOE had RSN start ESF Title II design, which had been divided into ten design packages to allow for phased design and construction. Such a phased approach is intended to give the DOE flexibility in terms of budgeting, scheduling, and level of effort for the ESF design and construction. For example, Design for Package 1A is complete and that part of the ESF is under construction. Packages 1B and 2 have undergone 90 percent design reviews in FY93, and other packages are in lesser stages of completion or have not begun yet because of later startup dates. The DOE plans to have all ESF design and significant portions of its construction completed by mid FY96, with other ESF drifting continuing until late FY97.

Because of recent information on the contact elevation between geologic units in the Topopah Spring (TSw1 and TSw2), the potential width of the Ghost Dance Fault (and associated potential difficulties in construction and potential impacts on performance of the repository) and changes proposed to the waste package design (much heavier than originally contemplated), new changes to the ESF design are currently being considered by the DOE. The changes, if adopted, would affect the ongoing ESF activities to some extent, and new concepts or different combinations of original concepts for the repository design could be chosen.

The ESF design packages are currently in different stages of completion and construction, and the data acquisition for the design packages is proceeding in parallel. Some of this data acquisition is related to the geological site investigations described in Appendix A, while other data are being gathered specifically for the design and construction of the ESF. The recently proposed changes in the ESF design will also probably result in changes in the activities that have been planned for site data acquisition.

The information obtained for the design and during construction of the ESF can be used for site characterization and for the design of the GROA. In addition, the DOE plans to start *in situ* testing in the ESF in mid FY96. The results of this ESF testing will be used later to characterize the site for the GROA and also in the design of the GROA. The DOE is also considering large size *in situ* heated block testing outside the ESF in preparation for the ESF testing.

As new data are gathered during site characterization and construction of the ESF, the DOE will probably be changing the ESF design to take advantage of the new information. It is expected that the DOE will use the SCP Progress Reports to report on the information obtained and the design changes made to the ESF and the corresponding changes to the GROA design.

As design changes are made, the DOE is expected to keep track of the changes through a design control process to make sure that all changes and the overall design of the ESF comply with the hierarchy of requirements that apply to the ESF. In addition to tracking the changes resulting from new data, the DOE is using the design control process to track the changes that are resulting from a decision to place all contract work under the new Management and Operations (M&O) contractor. The design control process is being used to track the evolution of the Title I design and early portions of the Title II designs (designed by RSN) to the completed Title II designs, which are now being designed by the M&O contractor.

GROA ACTIVITIES

The activities for the GROA (i.e., repository design) will follow a structure similar to that being used for the ESF. That is, data will be specifically gathered for characterization of the site for the GROA, design of the repository, and demonstration of compliance with the performance objectives. Data from the ESF *in situ* tests conducted between FY96 and FY00 are an example of such data. As with the ESF, some of the geological site characterization activities described in Appendix A will be used in GROA design. The DOE activities in the area of study plans related to rock mechanics topics are discussed under the Geoengineering section of the DOE geological site investigations program.

As in the case of the ESF design, the DOE is expected to use a cycle of evolving designs for the GROA. An SCP Conceptual Design Report was issued in 1987. Recently, changes to the GROA design have been proposed, and therefore it is expected that the DOE will make changes to the existing configurations of the Advanced Conceptual Design (Repository Title I design) of the GROA started in FY92. The DOE plans to complete this design in mid FY96 and then start on the License Application Design (Repository Title II design), which the DOE plans to complete in 2001.

The design of the GROA is essential to the development of an Environmental Impact Statement (EIS), which will be submitted with the LA in 2001. A draft EIS is planned to be completed by FY99. This EIS will be developed to conform to the Nuclear Waste Policy Act, as amended, the National Environmental Policy Act, and other appropriate regulations. The EIS will focus on environmental impacts resulting from construction and operation of the high-level waste (HLW) repository at the proposed YM site.

The DOE will also conduct Performance Confirmation for the GROA systems and components focusing on compliance with the requirements in 10 CFR 60.137. This effort will include development of a performance confirmation strategy and guidelines document, an interim test plan, an operations plan, and contingency plan. The DOE also intends to develop design requirements to ensure the effectiveness of performance confirmation tests and corroborate information obtained during site characterization pertaining to the waste package environment. No specific dates have been identified for these activities in current DOE schedules.

NRC GEOLOGIC REPOSITORY OPERATIONS AREA PROGRAM

I. OVERVIEW

The mission of the U.S. Nuclear Regulatory Commission (NRC) in the GROA has two parts. The first part is to evaluate the DOE performance objectives-based design and construction of the GROA to determine if the DOE has acceptably demonstrated compliance with the requirements in 10 CFR Part 60, and the second part is to ensure that the repository is operated safely. Only the first part will be discussed here. The second part is discussed in Appendix H, Repository Operations.

To accomplish the goal set forth for the first part of the mission, the staff is conducting preclicensing consultation with the DOE and developing a review strategy and capability by preparing Compliance Determination Methods (CDMs) for review of repository design that will be integrated in the License Application Review Plan (LARP). The major focus of the preclicensing consultation is on the DOE development of the ESF and characterization of the site. During this preclicensing consultation, the staff is conducting focused technical reviews on GROA design and construction-related regulatory topics. These reviews include the staff's reviews of SCP, design, and construction of the ESF, and the site characterization activities including study plans, technical reports, and topical reports. These preclicensing reviews are intended to provide early identification of concerns that could become potential licensing topics. Staff will also participate in evaluation of DOE responses during these technical reviews.

The staff is developing fourteen individual review plans relevant to GROA design and construction for the LARP. These plans include development of a compliance determination computer code to review the DOE LA and assess performance of underground facilities subjected to repetitive seismic and thermal loads. This computer code is intended to provide independent modeling capability to the staff to address the Key Technical Uncertainties (KTUs) relevant to GROA design and construction that have been identified through systematic regulatory analysis of 10 CFR Part 60. This code considers each near-field significant process and the coupled effects between these significant processes in detail for use both in repository design and in providing input to repository performance assessment (PA). The coupled code will provide input to the subsystem PA code EBSPAC, iterative performance assessment (IPA) codes SOTEC and SEISMO, and total system PA code TPA. This code will receive some input from SOTEC and seismic hazard code SEISM1, and will interact with various PA auxiliary analysis codes. In addition, the staff has been and will be developing technical guidance documents relevant to thermal loads, repository seals, ESF design, and seismic design.

The CDMs in conjunction with preclicensing consultation, development of technical guidance regarding repository design, and performance-related topics and confirmatory research, will provide the staff with tools needed to evaluate the DOE demonstration of compliance with 10 CFR Part 60.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

The Repository Operational Criteria (ROC) studies conducted in FY91-92 identified preclosure regulatory uncertainties in 10 CFR Part 60 and the corresponding need for major and minor rulemakings and other regulatory guidance development. The staff is currently involved in a major rulemaking task entitled "Design Basis Events", intended to reduce the uncertainty with the meaning of the phrase "important to safety" and the applicability of 10 CFR Part 20 requirements during the preclosure period. This

rulemaking activity, although started on the staff's own initiative, also addresses concerns expressed by the DOE in its petition for rulemaking. The DOE, in its petition, recommended rulemaking and proposed its preferred approach to resolving the regulatory and technical uncertainties in the existing rule. However, the staff's approach is fundamentally different from the DOE recommended approach. Following publication of this rulemaking, estimated to be completed by the end of FY94, the staff anticipates the need to develop follow-on regulatory guidance related to repository design and radiological health and safety. These guidance documents will be developed in the FY94-95 time frame. This rulemaking and associated technical positions impact not only repository design but also ESF design, construction, and operations. In the FY95 time frame, the staff may need to provide guidance on "retrievability" for input to the DOE repository design. Regulatory uncertainties identified in the GROA area will require a major rulemaking on radiological emergency planning as well as several minor rulemakings. Such activities will be taken up during FY94-98 depending on the availability of resources.

Consideration of dynamic effects on underground openings is an important part of repository design during several of the project phases. During the preclosure period, dynamic analysis is important to ensure worker health and safety during operations and to assess stability required for possible waste retrieval operations. Postclosure concerns potentially impacted by dynamic events include activation of existing faults, premature waste package failure caused by excessive rock deformation, seal failure, and collapse of openings or movement of rock in such a way as to develop preferential pathways for radionuclide release. Seismic design of the repository is likely to be a highly contentious issue because of the complex geology of the YM site. Also at YM, the zone above the water table is not dry but is reported to contain perched water held up by low-permeability strata. The potential for earthquake-induced drainage of such water into the repository needs careful assessment and consideration in engineering design. There is currently a concerted effort by the American Society of Civil Engineers to address the technical topics related to this topic. Keeping this concern in mind, resources are budgeted to start developing the technical position on repository seismic analysis and design in the FY97-98 time frame. However, this schedule may have to be accelerated because of the fact that ESF construction has already started and the DOE will be needing guidance in this area to factor the staff's views on this issue before starting the advanced conceptual design of the repository. The development of this technical position will be supported by the results obtained from the Seismic Rock Mechanics Research Project. This effort will take into account the DOE conceptual repository design. One potentially important technical issue is the rock mass weakening phenomenon due to the cumulative effects of repetitive episodes of earthquakes, which ongoing NRC research has identified as a potential concern. Furthermore, the assumption that the ground motion at depth is smaller than at the surface is not always true. A highly attenuating, thick near-surface layer could decrease the ground motion at the surface. In addition to the above, procedures need to be in place for conducting onsite inspections of ESF and related GROA systems.

Additional guidance will be provided to the DOE through the development of revisions to the NRC LA Format and Content Regulatory Guide (FCRG). This guide was first issued in FY91 and will be revised as needed. Current plans are to develop a revision in FY94 and make it available to the DOE in FY95.

B. Develop LARP and Supporting Technical Assessment Capability

1. Develop GROA License Application Review Plans

During FY93, the staff will complete the preparation of all the Compliance Determination Strategies (CDSs) in the area of radiation protection, repository design, construction, and analyses, and will provide

the needed support to other sections as appropriate. The staff is currently developing the example CDM for Review Plan 4.3, Assessment of Compliance with Design Criteria for Shafts and Ramps.

During FY94, a consistency/integration review of 14 CDSs relevant to GROA design and construction will be conducted. CDSs will be examined for consistency of content and form. This review will include the integration and consolidation of KTUs. The preclosure performance objectives CDSs will be revised and updated. Throughout FY94-95, the staff will continue revision of other CDSs in response to changes in regulatory and technical program knowledge. After the Design Basis Events rulemaking is completed, the staff will develop the CDS on Assessment of Compliance with Criteria for Design Basis Events.

Beginning in FY94, the staff will begin focusing on Chapter 4 of LARP. In FY94, the staff intends to complete three CDMs (Details of Review Plans are given in the FCRG):

- Description of the GROA Structures, Systems, and Components: Shafts and Ramps (CDM 4.1.2)
- Description of the GROA Structures, Systems, and Components: Surface Facilities (CDM 4.1.1)
- Assessment of Compliance with Design Criteria for Shafts and Ramps (CDM 4.3)

The remaining review plans for the GROA design and construction requirements will be completed during FY95-98. A proposed schedule for the completion of the development of these review plans is as follows:

In FY95, the following GROA review plan CDMs will be completed:

- Description of the GROA Structures, Systems, and Components: Underground Facility (CDM 4.1.3)
- Description of the GROA Structures, Systems, and Components: Radiation Protection Systems (CDM 4.1.4)
- Assessment of Compliance with Design Criteria for Surface Facilities (CDM 4.2)

In FY96, the following GROA review plan CDMs will be completed:

- General Description of the Facility (CDM 1.1)
- Interfaces Between Structures, Systems, and Components (CDM 4.1.5)
- Assessment of Compliance with Design Criteria for the Underground Facility (CDM 4.4)

In FY97, the following GROA review plan CDMs will be completed:

- Assessment of Integrated GROA Compliance with the Performance Objectives: Protection Against Radiation Exposures and Releases of Radioactive Material to Unrestricted Areas CDM (4.5.1)

- Assessment of Integrated GROA Compliance with the Performance Objectives: Retrievability of Waste (CDM 4.5.2)

In FY98, the remaining GROA review plan CDMs will be completed:

- Assessment of Compliance with Criteria for the Controlled Used Area (CDM 3.2.6)
- Performance Confirmation Program for the Structures, Systems, and Components of the Geologic Repository Operations Area (CDM 8.2)
- Radiation Protection During Performance Confirmation (CDM 8.4)

2. GROA Code and Model Development

Thermal load has been recognized by the DOE as one of the most important topics that will impact on the repository program. This recognition by the DOE is a direct result of the development of the staff's technical position on thermal loads. The spatial scale of interest is primarily the near-field, which includes both emplacement borehole and emplacement drift scales. The near-field complex environmental conditions at the repository horizon include mechanically disturbed jointed rock, elevated temperature, and thermally induced mechanical, hydrological, and chemical processes—including phase changes of groundwater. Ground motions due to earthquakes, underground weapons effect testing, etc., are superimposed on the *in situ* stresses, thermal loads, and thermally induced phenomena in a repository. It is necessary to have appropriate conceptual models and associated computer codes describing the coupled phenomena to effectively determine compliance with various regulations. After providing guidance to the DOE on thermal load, the staff has maintained a modest program in this area.

In FY92, the staff initiated investigations on the effects of thermally induced coupled mechanical-hydrological-chemical (TMHC) processes on repository design and performance through participation in the international cooperative project—DECOVALEX (acronym for the DEvelopment of COupled models and their VALidation against EXperiments in nuclear waste isolation). During FY93-94, a series of laboratory experiments will be performed to study the effects of mechanical loading on joint fluid flow and fluid pressures. The specific goals of this study are to have a better understanding of, and to develop the capability for, predicting fracture flow. During FY94-95, the effects of thermal-mechanical and thermal-hydrologic coupling will be investigated. During FY96-97, the effects of thermal-mechanical-hydrological (TMH) coupling for single rock joints and jointed rock mass will be studied. The study of the effects of TMH coupling for jointed rock mass will include vaporization, condensation, and dripping effects on joint and rock matrix behavior. These study results, along with the results of the seismic rock mechanics research project, will be used for conceptual model and computer code development to support the design and analysis verifications of the GROA and to provide inputs for PA of the engineered barrier system (EBS) and the total repository system under repetitive seismic and thermal loads.

Code development activities will utilize existing computer codes. During FY93, a critical review of existing computer codes was completed. The results of this study will provide the basis for selecting a code that will require the least amount of development work to address the TMH issue. The development work is expected to continue until FY98. Currently, based on the understanding gained from the literature search, the staff has decided to spend little resources on the modeling of chemical effects because of its lack of significance to the pre-closure performance. However, if EBS and PA staff require inputs for postclosure PA and if the long-term chemical effects are determined to be significant, more work in this

area may be needed. The understanding gained from the TMH laboratory tests and seismic rock mechanics research project will be used to assist the model development effort. Also the results of the tests and the seismic rock mechanics research project will be used for final model validation and code verification. The understanding of the TMH effects gained from the laboratory test results and independent review capability gained using the verified computer code will provide the needed capability for the staff to evaluate the DOE demonstration of compliance with 10 CFR Part 60. This coupled code will provide input to the subsystem PA code EBSPAC, IPA codes SOTEC and SEISMO, and total system PA code TPA. This code will receive some input from SOTEC and seismic hazard code SEISM1, and will interact with various PA auxiliary analysis codes. It is also expected that the knowledge gained through the experimental and developmental effort will assist the staff in streamlining its review of ESF activities relevant to the TMHC processes, including the effect of repetitive seismic loads. The staff is expected to incorporate the results of this study into LARP and/or guidance documents in a phased manner.

C. Conduct Pre-License Application Reviews and Quality Assurance Audits

The staff will continue to conduct quality assurance (QA) audits in response to statutory requirements or agreements between NRC and DOE. Generally, these audits will take the form of observation of DOE audits of its internal and contractor activities in the GROA area.

The staff will continue its review of the DOE Semi-Annual Progress Reports. Not only is this review a statutory responsibility, but it is also the mechanism through which the DOE reports changes to its ongoing GROA programs and results from those programs. Reviews of this information will allow the staff to: (i) provide guidance to the DOE on the acceptability of any proposed changes; (ii) identify if results from the DOE work are acceptable; and (iii) determine what additional work may be needed in the development of independent modeling activities, the FCRG, and the LARP.

In addition, the staff has agreed with the DOE to carry out semi-annual reviews of the DOE Annotated Outline (AO). The semi-annual review of the AO is carried out to provide the DOE with pre-License Application (LA) guidance on whether or not the staff believes that the DOE is appropriately interpreting the GROA-related requirements of 10 CFR Part 60 and on what information is needed to complete a high-quality LA. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions with the DOE described above to ensure that the regulations are properly implemented.

The staff will also review other DOE documents including study plans and topical reports. Study plan reviews include reviews related to studies not previously submitted to NRC for review as well as revisions to existing study plans. There are approximately twenty study plans pertaining to the GROA. At present, only a few of these study plans have received Phase I review and none have undergone Phase II review. The remainder will be reviewed during FY94-00. In addition, the staff will also conduct reviews of DOE responses to staff study plan reviews and other DOE documents to assess the possible resolution of staff open items. Review of site characterization results is included in the review of the various reports that the DOE will use to present such information to the NRC.

In supporting ESF Title II and repository Title I and II design efforts, the staff will continue its review of the DOE design reports (in the areas of worker radiological safety, seals system design, ESF and repository design, and thermal and thermo-mechanical analyses) as they become available and provide pertinent comments to the DOE for consideration. This review will continue through FY98. During

FY93-94, ESF Title II Design Activity Packages 1 and 2 will be reviewed. Every design package will have two stages of DOE internal review during which the staff is given the opportunity to observe the DOE review process. These are the 50- and 90-percent design reviews. The staff selects the topics of greatest significance from the point of view of radiological health and safety and long-term waste isolation and conducts QA and technical audits. Onsite visits to observe the ongoing laboratory and field tests and ESF construction (including access) will be conducted whenever appropriate to ensure that the suitable operating procedures are followed closely. Significant findings during these onsite visits and subsequent reviews will be brought to the DOE attention. All the open-items from the Site Characterization Analysis (SCA) will be kept in mind while the observation reviews and site visits are performed.

Repository Title I and II design reviews will follow a similar process as the ESF design reviews; however, these reviews will occur during FY93-FY96, and from FY96 to FY01, respectively. It should be noted that the NRC precicensing review of the DOE ESF and repository design packages are iterative in nature. New topics may come up during observation of design reviews, technical exchanges, and site visits. Therefore, the staff should keep sufficient flexibility in its program to be able to effectively react to the immediate needs of the situation.

The staff selectively reviews major design reports such as the GROA Conceptual Design Report and other topical reports as appropriate. In addition, the DOE is preparing AO of their LA on a semi-annual basis. The staff has agreed with the DOE to carry out semi-annual reviews of the DOE AO. The semi-annual review of the AO is carried out to provide the DOE with preclicense application guidance on whether or not the staff believes that the DOE is appropriately interpreting the GROA-related requirements of 10 CFR Part 60 and on what additional GROA information is needed in the AO to address specific 10 CFR Part 60 requirements. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions described above with the DOE to ensure that the NRC regulations are understood. Activities related to the NRC review of the DOE study plans in the area of rock mechanics are discussed in the DOE geological subsystem description (see Appendix A).

The NWTRB is actively following the DOE ESF and repository program. The NWTRB holds frequent meetings on various technical topics such as thermal load, ESF layout, alternative repository concepts, etc. The staff follows these meetings closely and participates as observers in such meetings as appropriate. The staff also reviews the periodic NWTRB reports submitted to the U.S. Congress. The staff will continue a level-of-effort activity in this area during FY94-98.

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
DOE SCHEDULE FOR GROA									
* ESF Collar/Portal Construction	▲								
* ESF In-Situ Test Phase									
* ESF Site Construction									
* Complete Ramp/Drifting Design		▲							
* Ramp/Drifting Construction									
* ESF Title II Design		▲							
* ESF Drifting / Title III Design						▲			
* Repository Title I Design					▲				
* Repository Title II Design									▲
* Issue Draft EIS							▲		
* Issue Final EIS									▲
NRC SCHEDULE FOR GROA									
A. Develop Regulatory Requirements and Technical Guidance									
* SCP Related Open Issues Related to ESF and GROA				▲					
* "Design Basis Events" Rulemaking		▲							
* Repository Seismic Design and Analysis Technical Position									▲
* Repository Design Technical Positions									▲
* Radiological Health and Safety Technical Positions									▲
* Retrieval Guidance									▲
* Radiological Emergency Planning									▲
B. Develop LARP and Supporting Technical Assessment Capability									
Develop GROA LA Review Plans									
* Complete all GROA CDS's	▲								
* General Description of the Facility - CDM 1.1					▲				
* Assessment of Compliance with Criteria for the Controlled Use Area - CDM 3.2.6							▲		
* Surface Facilities - CDM 4.1.1		▲							

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Review Repository Title II Design (Design Audit)	_____								
* Review Site Characterization Results (Major Review)	_____								
* NWTRB Reports	_____								



APPENDIX F
THE ENGINEERED BARRIER SYSTEM

DOE WASTE PACKAGE PROGRAM

The goal of the U.S. Department of Energy (DOE) Waste Package program for the Engineered Barrier System (EBS) is to develop, assess the effectiveness of, and document a design for a waste package and its associated EBS for spent fuel and solidified High-Level Waste (HLW) that meets the applicable regulatory requirements for a geologic repository. The DOE schedule provided is based on activities in three areas related to EBS development. These areas are: EBS Design [including Advanced Conceptual Design (ACD) and License Application Design (LAD)], the DOE materials testing program, and waste form sufficiency. These areas are associated with three phases in the DOE program: (i) a brief pre-ACD, and longer periods for (ii) ACD, and (iii) LAD.

The pre-ACD phase focuses on defining the requirements and identifying feasible design options. The ACD phase involves developing and evaluating the feasible design options, culminating with the selection of one primary and one alternative conceptual design at the start of the LAD. During this phase, material selection takes place. Prototype fabrication and testing of waste package components will also be conducted during the ACD phase. The LAD phase will result in a detailed design of the preferred options (primary and alternative), fabrication studies on full-scale models, and an analysis to verify that all requirements are satisfied.

NRC ENGINEERED BARRIER SYSTEM

I. OVERVIEW

The mission of the U.S. Nuclear Regulatory Commission (NRC) mission in the EBS program is to evaluate the U.S. Department of Energy (DOE) waste package and EBS to determine if the DOE has acceptably demonstrated compliance with the requirements of 10 CFR Part 60. To accomplish this mission, the staff is conducting prelicensing consultation and developing seven individual review plans for the License Application Review Plan (LARP) that cover the waste package and the Engineered Barrier System (EBS). The strategy is designed to allow the staff to use the insight it gains from its prelicensing consultations to support its review of the license application. This review includes the staff's review of ongoing DOE site characterization activities as well as the development of independent computer models such as EBSPAC.

In particular, the staff work being conducted today is in the area of EBSPAC which is a set of computer models for analyses of the subsystem performance assessment. This program is composed of a number of codes addressing: spent fuel dissolution, stress corrosion cracking, partially failed containment, crevice corrosion, pitting corrosion, galvanic corrosion, and radiolysis effects. EBSPAC is applicable in both the prelicensing and licensing phases of the program. With respect to the prelicensing phase, the staff is using EBSPAC to conduct evaluations of ongoing DOE design work. EBSPAC is also identifying for DOE those parameters the staff believes are important in the performance of the waste package. For the licensing phase, the use of EBSPAC will be incorporated into the individual review plan 5.4, Assessment of Compliance with the Engineered Barrier System Performance Objective, and will comprise part of the Compliance Determination Method (CDM) (i.e., review method and acceptance criteria) that the staff will use to determine the acceptability of the DOE demonstration of compliance.

The work being conducted today in pre-licensing consultation, coupled with the staff's license application (LA) review, combine to build a review process that allows the staff to gain confidence to determine if the DOE demonstration of compliance with 10 CFR Part 60 is acceptable. This confidence cannot be gained by solely conducting the licensing reviews. Rather, it is dependent upon, and strongly supported by, the staff's work during prelicensing consultation. Therefore, although EBSPAC will eventually become part of individual review plan 5.4, its development and implementation today allow the staff to gain confidence that the level of review conducted during licensing is well supported by the experience and confidence gained during the prelicensing consultation process.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

The staff has determined that there is not a well-established technical basis for the subsystem requirements for the waste package substantially complete containment (SCC) and EBS release which supports their use as valid and achievable standards. This lack of a technical basis diminishes the requirements' usefulness as valid and achievable standards. Additionally, the staff has identified three major regulatory uncertainties related to the EBS: (i) uncertainty about the meaning of the term SCC, (ii) uncertainty about the need for a technical linkage between the EBS release rate limits and the Environmental Protection Agency (EPA) standard release limits, and (iii) uncertainty with respect to the time period of applicability of the 10 CFR Part 60 requirement for control of criticality within the repository. These uncertainties

were identified during the systematic regulatory analysis of 10 CFR Part 60. Current work for this program activity focuses on establishing a technical basis for the EBS subsystem performance requirements and reducing these uncertainties.

To address questions about the technical basis and achievability, the staff has an effort underway to assess what the state of technology can achieve in terms of waste package containment and EBS release. For the waste package containment assessment, the staff has chosen a representative waste package design and repository environment and is conducting a failure analysis to determine the expected waste package lifetime. This analysis will be documented in a Waste Package Containment Analysis Report in FY93 that will either enhance the technical basis for the rule and validate the containment requirement as an appropriate minimum performance standard, or, if problems develop, indicate the need for rulemaking. NRC research activities related to this activity include five corrosion studies. Two such studies, one on pitting corrosion data for estimating long term container stability and potential problems in microbiological corrosion are planned for FY93. The remaining studies which cover localized corrosion mechanisms, stress corrosion cracking, and long term tests, are planned to take place between FY93 and FY96. Based on the results of the waste package containment analysis, the staff will analyze what the representative EBS can achieve in limiting radionuclide release. The preliminary results of this analysis will be documented in the Release Rate Analysis Report planned in late FY95. Similar to the waste package containment analysis, these results will either enhance the technical basis for the rule and validate the annual EBS release rate limits as appropriate minimum performance standards or indicate the need for rulemaking.

It is essential that the technical basis development work be completed in a timely fashion to avoid any serious adverse impacts on the DOE waste package development program. The DOE initiated work on the waste package Advanced Conceptual Design (ACD) beginning in FY92 and selected three materials for further research and testing in support of design development. The basis for the DOE waste package ACD is the existing regulatory structure of the subsystem performance requirements. If the staff's technical basis development activities indicate the need for rulemaking to change these requirements, this could have a significant adverse impact on the DOE waste package development program. Should a rulemaking be needed, it is generally a 2-year activity. A waste package containment-related rulemaking initiated in FY94, on the basis of the results of the Waste Package Containment Analysis Report, would likely not be completed until FY96. Similarly, any needed rulemaking related to EBS release rate limits, on the basis of the Release Rate Analysis Report, in late FY95, probably would not be completed until FY97. Recognizing that the DOE plans to select its material and its preferred design before the end of ACD (June 1996), it is imperative that the regulatory framework be established as soon as practicable to reduce the potential for any adverse impacts on the DOE waste package program.

In addition to the need for enhancement of the technical basis for the engineered subsystem performance requirements, there are regulatory uncertainties associated with these requirements. Specifically, for the waste packages, there is uncertainty about the meaning of the term SCC of radionuclides within the waste packages. Further, there is a question of whether there should be a technical linkage between the EBS release rate limits and the EPA standard release limits to ensure consistency between these institutional requirements. There is a related uncertainty as to whether compliance with the EBS requirement does, in fact, enhance confidence that the EPA standard will be met. Regarding the uncertainty related to waste package SCC, the staff is currently developing the methodology and approaches for providing numerical guidance to the meaning of SCC; a preferred approach will be identified in FY94. Subsequent plans are to develop the guidance for incorporation into a staff technical position or in the LARP during FY94-96. As the staff noted in its review of the DOE Site Characterization Plan (SCP), the staff and the DOE

disagree on the meaning of SCC and this meaning remains an unresolved issue. Since interpretation of the meaning of SCC can significantly impact the DOE testing and design program for the waste package, it is important that this issue be resolved in a timely fashion, particularly since the DOE has already initiated (beginning FY92) waste package ACD and narrowed the choice of materials under consideration for waste package design. Failure to provide the necessary guidance on the meaning of SCC to DOE in FY94, may prolong waste package ACD and delay the DOE planned initiation of waste package LAD, in FY96. Accordingly, it is important to stabilize the regulatory framework on this matter.

Regarding the uncertainty related to existing EBS release rate limits in 10 CFR Part 60 and their relation to the now-remanded EPA standard, the staff intends to examine the possible need to establish a closer technical relationship between these EPA and NRC requirements that would facilitate the fundamental purpose of the subsystem requirements (i.e., enhance confidence that the EPA standard will be met) and help ensure consistency between NRC and EPA standards. The staff will decide this issue in FY94, and if the decision is in favor of a closer relationship, further work in developing this relationship would depend on promulgation of the final EPA standard to completely resolve the identified uncertainty.

Assuming the availability of the final EPA standard and initiation of rulemaking in FY94 to revise the EBS performance requirements, final requirements would likely not be promulgated until FY96. If this activity becomes necessary, it may adversely affect the DOE plans for completion of waste package ACD and related materials testing and delay initiation of LAD beyond June 1996. Although this impact may be unavoidable, staff priorities should focus on defining the regulatory framework as rapidly as possible.

For the regulatory uncertainty on criticality control, the staff must clarify the regulatory requirement for the applicable levels of criticality control in all phases of the repository life. When the staff completes its analysis later in FY93, it will be documented in staff guidance. This guidance is necessary to support the DOE waste package ACD, because any needed criticality control between features (e.g. neutron-absorbing components) would need to be incorporated into the waste package design. Recognizing that waste package ACD was initiated beginning in FY92, it is important to provide the DOE with the necessary guidance on this issue during the current fiscal year (FY93) so that the DOE has a clear understanding of those ancillary requirements that can affect waste package design.

A rulemaking, Clarification of Assessment Requirements for the Siting Criteria and Performance Objectives, will resolve several uncertainties concerning the investigation and analysis of siting criteria and their relationship to the postclosure performance objectives. This rulemaking was published as a draft for public comment in FY93 and should be finalized late in FY94.

Another important reason for reducing all these regulatory uncertainties is the need to support the staff's preclicensing reviews of the DOE activities, which are discussed under (3) below. If there is uncertainty about the meaning of the requirements of 10 CFR Part 60, the guidance that the staff provides to the DOE could be subject to change after the uncertainty is reduced. This potential change may impact the DOE program and lessen the chances for the DOE development of a high-quality LA.

In FY93-94, the staff is scheduled to revise the EBS information in the draft Format and Content Regulatory Guide (FCRG) to prepare it for publication as a final guide in FY94. In the future, staff plan to update the FCRG based on rulemaking activities, LARP work, and additional information identified throughout the staff's development and implementation of analysis methods. It is important that this revision be accomplished in a timely manner for the DOE to continue program development. DOE's Annotated Outline for the Repository LA AO will be enhanced by the availability of this information.

B. Develop LARP and Supporting Technical Assessment Capability

1. Develop EBS License Application Review Plans

During FY93 the staff continued preparing the EBS individual review plans for the LARP by completing compliance determination strategies (CDSs) for all EBS requirements. The staff will also begin to develop the CDMs for waste package SCC that will reflect the staff's planned resolution of this regulatory uncertainty. In FY94, the staff will begin development of the CDMs for EBS release. The CDMs for waste package SCC and EBS release will be incorporated in Review Plan 5.4, Assessment of Compliance with the Engineered Barrier System Performance Objectives, which is planned for completion in FY96 after the technical basis development and uncertainty reduction activities discussed in Item A.

The remaining planned review plans for the other EBS requirements will be completed during FY94–FY98. A proposed schedule for the completion of these review plans is as follows:

- Description of Engineered Systems and Components that Provide a Barrier Between the Waste and the Geologic Setting (CDM 5.1) in FY94.
- Assessment of Compliance with the Design Criteria for the Waste Package and its Components (CDM 5.2) in FY95.
- Radioactive Material Description (CDM 2.5) in FY96.
- Assessment of Compliance with the Engineered Barrier System Performance Objectives (CDM 5.4) and Performance Confirmation for the EBS (CDM 8.3) in FY96.
- Assessment of Compliance with the Design Criteria for the Post Closure Features of the Underground Facility (CDM 5.3) in FY97.
- Radiation Protection (CDM 5.5) in FY98.

The Performance Confirmation effort will require the staff to consider the adequacy of the DOE Performance Confirmation plans, which must be submitted with the LA (See Appendix G for the DOE program description). Staff will focus on whether the DOE plans for conducting monitoring, laboratory, field, and *in-situ* experiments during the period from site characterization to permanent closure will produce the necessary data to provide confidence in the design assumptions used in DOE EBS performance assessments.

2. EBS Code and Model Development

The staff will continue development of its independent assessment capability (i.e., computer codes) to assess compliance with the waste package containment and EBS release rate subsystem requirements. Ultimately, EBSPAC will be used as the CDM for individual review plan 5.4. Much of this work will be carried out in FY93–95. Code development is also needed to provide the staff with the capability to carry out its SCC and release rate analyses to assess the validity and implementability of those parts of the regulation. Therefore, early development of this capability is needed in order for the staff to validate its regulatory requirements.

In the long term, these codes will be useful in supporting the review of the DOE ongoing and future Iterative Performance Assessment (IPA) program and design work, for compliance with the subsystem performance objectives. Code development in support of the review of the DOE IPA program is generally referred to as development of the EBSPAC group of computer codes. A series of detailed models in EBSPAC will provide the bases for the development of the simplified source term models to be incorporated in the SOTEC computer code. SOTEC will provide the source terms for total repository system performance assessment. Both EBSPAC and SOTEC are used to conduct the staff's ongoing (i.e. IPA Phase 2) and planned IPA. In addition, EBSPAC will be used to identify parameters important to performance that the staff may identify to the DOE as those that need to be addressed in ongoing site characterization activities related to material testing.

The EBSPAC group of codes includes a sizable number of individual models that are being developed and updated. In the near-term (FY93), initial versions of the spent fuel dissolution, crevice corrosion and pitting corrosion model will be developed. Work on stress corrosion cracking models will also be initiated in FY93 and carried over to FY94. Additional FY94 activities will include evolution or development of glass waste dissolution, partially failed container, and transient wetted area models. These models must be developed early to support the conduct of NRC staff IPA, review of DOE IPAs, and development of the technical bases for the engineered subsystem performance assessments.

From FY95-98, the staff expects to develop other needed models for incorporation into EBSPAC, in accordance with the following schedule:

- Thermohydraulics and fluid flow model, radiolysis model, mass transport model in FY95
- Geochemical effects of elevated temperatures model, and galvanic corrosion model in FY96
- General corrosion model, and mechanical stress model in FY97
- Material transformation model, and alternative corrosion mechanisms models in FY98

The staff has also identified research needs to support model development related to the DOE candidate waste package materials. Some of this research has been undertaken and is ongoing.

C. Conduct Preliminary Application Reviews and Quality Assurance Audits

The staff will continue to conduct certain reviews and quality assurance (QA) audits in response to statutory requirements or agreements between the NRC and DOE. The success of this part of the program is closely related to the staff's ability to resolve the uncertainties discussed above so that clear and unambiguous guidance can be provided to the DOE.

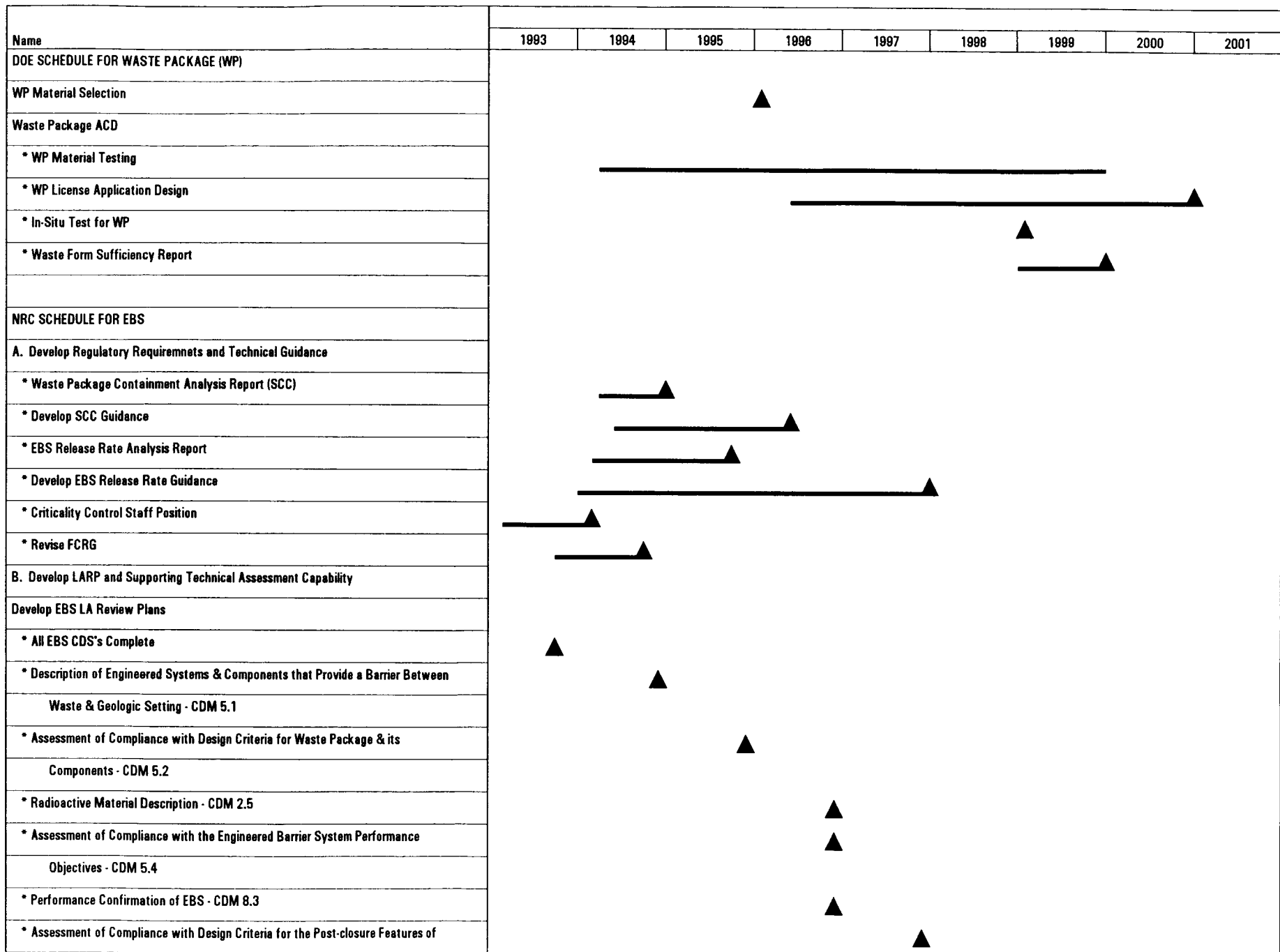
The staff will continue its review of the DOE Semi-Annual Progress Reports. Not only is this review a statutory responsibility, but it is also the mechanism through which DOE reports changes to its ongoing materials program and results from that program. Reviews of this information will allow the staff to: (i) provide guidance to the DOE on the acceptability of any proposed changes; (ii) identify if results from DOE's work are acceptable; and (iii) determine what additional work may be needed in the development of EBSPAC, the FCRG, and the LARP.

In addition, the staff has agreed to carry out semi-annual reviews of the DOE AO. The semi-annual review of the AO is carried out to provide the DOE with pre-LA guidance on whether or not the staff

believes that the DOE is appropriately interpreting the EBS requirements of 10 CFR Part 60 and on what EBS information is needed for a complete and high-quality LA. The staff believes that the complexity of developing a first-of-a-kind repository warrants the types of interactions described above with the DOE to ensure that the staff's regulation is understood. The staff will also continue its program of observation of DOE audits of its internal and contractor activities in the EBS area.

The staff will also review other DOE documents, including study plans and an unspecified number of topical reports throughout prelicensing, according to submittal and review schedules agreed to by the staff and DOE. These reviews will facilitate resolution of technical topics and concerns related to the waste package program, including those topics remaining from the staff's review of the SCP. The DOE has identified a number of specific reports related to the EBS that the staff will review. These reports include: Barrier Materials Selection Report (FY93); Updated Waste Package Report (FY96); Waste Package Advanced Conceptual Design Report (FY96); Waste Package Characteristics Report (FY98); and Waste Form Sufficiency Report (FY00). Review and comment on these reports enable the staff to provide guidance at appropriate points in the DOE program to help ensure that the EBS information in the DOE repository LA will be of high quality.

Just as important, review of these reports will provide direction to the staff in the development of its computer codes, EBSPAC and SOTEC, for independent assessment capability. Although a majority of the work being done in the code development area is independent of the DOE program, development of some components and refinement of these codes are dependent upon progress in the DOE waste package program, including selection of materials for the various waste package components. For example, the DOE Barrier Materials Selection Report will identify those materials under consideration for waste package ACD and, correspondingly, permit the staff to focus on these materials and their related models (e.g. hydrogen embrittlement of titanium) in the further development of the EBSPAC and SOTEC codes. EBSPAC and SOTEC will be developed and refined as the DOE makes decisions about materials selection and package design. Package design features will be obtained from the staff's review of the DOE Updated Waste Package Report, Waste Package Advanced Conceptual Design Report, and Waste Package Characteristics Report. Also, in the case of the Waste Form Sufficiency Report, the staff has statutory responsibilities under Section 114(a) of the Nuclear Waste Policy Act as amended to provide comments to the DOE on its waste form proposal, before the submittal of the LA.





APPENDIX G
OVERALL SYSTEM PERFORMANCE

DOE PERFORMANCE ASSESSMENT PROGRAM

The U.S. Department of Energy (DOE) defines performance assessment (PA) as the activities for quantitative analysis of repository preclosure safety and postclosure performance necessary to support development of the repository system and assess compliance with the technical criteria in 10 CFR Part 60 (DOE, 1990). A culminating activity will be the development of a total system model and code. This model will be supported by more detailed models that conceptually and numerically describe the processes, events, and conditions relevant to the High-Level Waste (HLW) repository, as well as incorporating significant design information. This includes will involve calculations of performance objectives in the 10 CFR Part 60 technical criteria. This effort includes the preclosure performance objectives in 10 CFR 60.111, design criteria in 10 CFR 60.130 through 135, and postclosure performance objectives in 10 CFR 60.112 and 113. An integrated understanding of repository performance will be iteratively developed as more site characterization data becomes available and as designs mature and are modified to incorporate acquired site data.

PAs will provide significant input to major DOE program documents including: the Safety Analysis Report, Environmental Impact Statement (EIS), and the Site Recommendation Report. The DOE will conduct on an iterative basis, early site suitability evaluations every two years to look for potential major flaws in the site. PAs will also provide input to testing and design programs and PA results will be necessary to meet major milestones of these programs. Other DOE tasks that will provide input to PA include waste package and repository design, surface based drilling, and *in situ* and laboratory testing during site characterization.

The current DOE work breakdown structure divides postclosure PA activities into the following areas: Total System Performance Assessment (TSPA), Waste Package PA Repository Performance Assessment, Site PA, 3-dimensional (3D) Modeling and Mapping Capabilities, Development and Validation of Flow and Transport Models, and Performance Confirmation.

The TSPA effort will serve to integrate physical process sub-models and data into computational models for prediction of total system postclosure performance and to assess if the Yucca Mountain (YM) site will meet the overall system performance objective in 10 CFR 60.112. There will also be efforts to identify radionuclide release scenarios for use in the modeling effort. Initially, classes of scenarios will be identified and modified as necessary, and mathematical models will be constructed for these scenario classes. The scenario classes will then be screened based on their relative consequences, and the resulting scenarios will be used in further PA modeling efforts. These submodels will be integrated into a total systems that which will provide estimates of potential radionuclide releases in the form of a complementary cumulative distribution function (CCDF), which will be used to demonstrate compliance with the 10 CFR 60.112 performance objective. TSPA will also include calculation of potential public doses resulting from radionuclide transport through the groundwater pathway as well as gaseous ¹⁴C release. DOE's initial TSPA (Barnard, et al., 1992) for the Yucca Mountain Site was completed in FY92 and their second iteration is scheduled for issuance in early FY94. DOE plans to perform and document updated TSPAs every 2 years until 2001.

Waste Package PA will integrate physical process submodels and data into computational models for prediction of long-term waste package performance including single-package performance under local conditions, combined performance of all waste packages, probabilistic distributions of overall performance and characterization of uncertainties. This effort will concentrate on demonstrating whether the waste package subsystem will meet the performance objectives for the waste package and engineered barrier

system in 10 CFR 60.113. An estimate of long-term release from the waste package (i.e., source term) will be generated for use in the TSPA. Codes for waste package PA will need to be developed, verified, validated, and documented. Validation of waste package PA codes is planned to begin in FY00 and end in 2001. Methodologies for considering uncertainties in these analyses will also need to be developed. A peer review of the waste package PA activities will also be conducted to add confidence to the results. Additional discussion of waste package activities can be found in the Waste Package Program description.

Activities for Repository PA will serve to integrate physical process submodels and data into computation models for prediction of repository performance and compliance demonstration for radionuclide release limits in 40 CFR Part 191 and 10 CFR Part 60 requirements for preclosure radiological safety (10 CFR 60.111 and 10 CFR Part 20), waste retrieval (10 CFR 60.111), and seals (10 CFR 60.134).

Site PA activities will integrate physical process submodels and data into computational models for prediction of site performance and assessment of compliance with the groundwater travel time (GWTT) requirement in 10 CFR 60.113(a)(2), favorable and potentially adverse conditions in 10 CFR 60.122, and high level findings listed in 10 CFR Part 960. The DOE plans to submit a report of results from a GWTT workshop in FY94, as well as a report on GWTT for the Draft Environmental Impact Statement (DEIS) and a final report on GWTT in FY98. Three-dimensional modeling and mapping capabilities will be developed to support this and other PA activities.

Fluid flow and radionuclide transport models necessary to resolve a number of open topics will be developed and validated in accordance with applicable quality assurance (QA) procedures. The DOE has planned for this activity to be completed by FY98. The validation effort will include conducting experiments and analyses as necessary to ensure the conceptual models and their mathematical and numerical representations correctly account for the physical processes embodied in the models. This activity will require an effort to coordinate validation needs with applicable site characterization work. The DOE is currently working on defining its concept of model validation. To date, the issue of validation remains a question to be addressed in the HLW program, and the DOE has participated in international efforts to define validation such as HYDROCOIN, INTRAVAL, and DECOVALEX. A report on the DOE validation methodology is planned to be published in FY94.

Performance Confirmation efforts focus on compliance with the requirements in 10 CFR 60.137. These efforts will include development of a performance confirmation strategy and guidelines document, an interim test plan, an operations plan, and contingency plan. The DOE also intends to develop design requirements to ensure the effectiveness of performance confirmation tests and corroborate information obtained during site characterization pertaining to the waste package environment. No specific dates have been identified for these activities in current DOE schedules.

The DOE groups the schedule for PA activities into three phases: the early site investigation phase, EIS phase, and the Safety Analysis Report (SAR) phase. It is expected that PA activities will also be significant during the performance confirmation period following waste emplacement. Tasks occurring in the early site investigation phase include early surface-based testing, the Exploratory Studies Facility (ESF) and the advanced conceptual design for the waste package and repository. This period begins in 1989 and continues to the end of FY97. Primary goals of the early site investigation phase include development of PA capability to support total system PA and model basic repository processes and design concepts; evaluation of the importance of potentially adverse conditions to safety and waste isolation in early site-suitability analyses; evaluation of ESF design and surface-based testing efforts using PA results to indicate processes that must be better understood through data collection efforts and subsequent

modeling changes; determination of constraints on the Advanced Conceptual Design (ACD) and assessment of its impact on design details; review of waste package and repository ACD requirements with PA needs; preparation for (and support of) EIS scoping; and development of codes and models to be used for DEIS PA.

The EIS phase includes completion of PAs for the draft EIS, analyses for waste package and repository License Application Designs (LAD), surface based testing, and *in situ* testing at depth. (It should be noted that the requirements for PA for the license application (LA) may be different from the requirements for PA for the EIS, because the scope, such as performance period, for the LA is mandated by regulation, but the scope for the EIS depends on topics raised by the proceedings. This phase begins in FY98 and continues until FY99. Primary objectives of this phase include completion of assessments to support the DEIS, continued analyses for early site evaluations of potentially adverse conditions, and completion of preparation for analyses (and development of methodology) to support the SAR and the comprehensive site-suitability analysis.

In the SAR phase, PAs for the SAR, repository and waste package LADs, and Site Recommendation Report are to be completed. This period begins in late FY99 and continues until issuance of the LA in late 2001. Primary objectives of this phase are to complete conceptual model validation in preparation for the LA, conduct comprehensive site-suitability analyses for the site recommendation, support the performance confirmation test plan, and assist in the response to public comments, as needed, to develop the Final Environmental Impact Statement.

As part of the DOE site investigations program, there will be an effort to assess the future resource potential at YM and determine the likelihood and consequences of inadvertent human intrusion into the geologic disposal system. Studies conducted to support this effort include laboratory, surface-based and ESF tests, studies, and investigations to evaluate the existence of energy, mineral, land, and groundwater resources at and near the site. These data will be analyzed quantitatively and qualitatively to determine the likelihood and consequences of potential future extraction efforts. This work will begin in FY92 and a report on Natural Resources is planned to be completed by October of FY95.

The U.S. Environmental Protection Agency (EPA) effort to revise its HLW disposal standards in 40 CFR Part 191, which were remanded by a federal court in 1986, will impact the DOE [and Nuclear Regulatory Commission (NRC)] PA program. With the passage of the Energy Policy Act of 1992, the National Academy of Sciences (NAS) has been tasked to review topics pertinent to the EPA standard and make recommendations to the EPA by FY94.

NRC OVERALL SYSTEM PERFORMANCE

I. OVERVIEW

The broad programmatic goals of the NRC PA program are: (i) to establish and maintain a suitable regulatory structure for the licensing of a HLW repository, (ii) to interact with DOE during the licensing and precicensing periods to assure a timely, effective evaluation of the LA for the repository, and (iii) to aid in the technical integration of the overall HLW program, by providing input and feedback to NRC HLW management and to other NRC HLW programs. Activities designed to achieve these broad goals are conducted under the NRC PA program in three program areas: Develop Regulatory Requirements and Technical Guidance, Develop Technical Assessment Capability for Conducting Repository Licensing Reviews, and Conduct Precense Application Reviews and QA Audits.

A primary activity in the development of regulatory requirements and technical guidance is interaction with EPA on the finalization of its HLW standards and the conforming of 10 CFR Part 60 to the revised EPA standard; this effort includes participating in the initiatives mandated by the Energy Policy Act of 1992. In addition, in order to clarify technical procedures and to expedite the licensing process, the staff plans to issue technical guidance in several critical areas, such as: method of constructing a CCDF for cumulative release; method for selection screening and definition of scenarios; methodology for model validation; and use of formal techniques for elicitation of expert judgment.

The main emphasis in developing a technical assessment capability for conducting licensing reviews is the development of an independent analytical capability to conduct total system and subsystem PAs, which can be used to review results of the DOE PAs for the LA. This effort will involve integration of various scientific, technical, and modeling efforts in the NRC HLW program to develop quantitative estimates of repository performance that can be compared with quantitative performance standards in 10 CFR Part 60 and 40 CFR Part 191. This work will be done in iterative phases until the DOE submits its LA. Such work will play a major role in the NRC licensing program for the disposal of HLW.

Precense application reviews and QA audits will emphasize review of DOE technical and programmatic documents. PA staff are also involved in precicensing consultations with the DOE and will develop five individual Compliance Determination Methods (CDMs) for the License Application Review Plan (LARP). The aforementioned NRC PA technical assessment capability will also be used to evaluate the DOE site characterization efforts and their iterative performance assessments for the Yucca Mountain site.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

Two future rulemakings are planned that will require PA involvement. In general, the duration of a rulemaking effort is two years. The first rulemaking will conform 10 CFR Part 60 to the EPA HLW regulations in 40 CFR Part 191. Scheduling for this effort is contingent upon actions from the NAS and the EPA. The recent Energy Policy Act of 1992 has called for the NAS to review topics relevant to developing the standards and to provide EPA with recommendations by the end of FY94. EPA will then have 1 year to implement the NAS recommendations into revised standards. At that time the NRC will be able to initiate the conforming amendments that will serve to establish consistency between the revised EPA standard and the NRC regulations. Any delays by the NAS or EPA in implementing this schedule will impact NRC efforts to begin the rulemaking. Current information seems to indicate at least a 1-year

delay in this schedule.

The second regulatory guidance effort that will be supported by NRC PA includes Substantially Complete Containment. The meaning of this phrase, which is part of the NRC performance objectives for particular barriers [in 10 CFR 60.113(a)(1)(ii)(A)], needs to be clarified in order for both the DOE and NRC technical staff to fully understand the intended scope of the requirement. Considerable work has already been done in preparation for this effort. This regulatory guidance effort should be completed by the end of FY94.

A rulemaking currently under development, "Clarification of Assessment Requirements for the Siting Criteria and Performance Objectives," will resolve several uncertainties concerning the investigation and analysis of siting criteria and their relationships to the postclosure performance objectives. This rulemaking was published as a draft for public comment in FY93 and should be finalized late in FY94.

The NRC PA staff has identified a number of topics for which technical guidance to the DOE is needed to clarify NRC regulatory intent. In FY94 and FY95, the staff plan to provide guidance to the DOE on a number of important PA topics. Other guidance may be developed to provide suggestions for enhancing confidence in modeling efforts. PA-related topics that have been identified for clarification by NRC guidance include: (i) use of formal techniques for eliciting expert judgement; (ii) method for selection, screening, and definition of scenarios; (iii) method of constructing the overall CCDF for compliance demonstration; (iv) acceptable validation process for PA models; and (v) approaches for estimating scenario probabilities.

Guidance on the formal use of expert judgment is needed because the DOE has acknowledged its intention to use formal elicitation in PA when there are data needs and the sources for the information are impractical or unavailable for use. The NRC staff has not incorporated expert elicitation in any licensing proceeding and has cautioned the DOE to rely on objective data to the fullest extent possible. The need for guidance on the use of this process stems from the variability in methods for conducting expert elicitation, the importance of its application to PA results, and legal concerns regarding its use in the licensing hearings. An initial draft of this guidance is expected to be complete in FY94, and the final will be complete in FY95. It is necessary to complete this guidance as soon as possible since the DOE is beginning to use expert judgment to obtain information for PA modeling.

Another area of staff concern is the DOE use of the term "scenario." In a comment on the DOE Site Characterization Plan (SCP), the NRC staff commented that the DOE site characterization program might not acquire all the necessary data for PA activities used to support its LA. This concern related to inconsistencies in the DOE use of the term "scenario" and its approaches to inclusion or exclusion of scenarios in the demonstration of compliance with 10 CFR Part 60 and 40 CFR Part 191. Since the DOE plans to use a preliminary scenario analysis to define and screen a set of scenario classes on which its performance allocation tables are based, there is a concern that the site characterization program based on the SCP performance allocation tables may not be adequate. The anticipated NRC guidance will help to define the term "scenarios" and address the staff's concern. This guidance, anticipated to be completed in FY94, will also address the topic of constructing scenarios from fundamental causative events and processes and screening the resulting scenarios for inclusion in the PA they support.

The CCDF is a distribution of the total cumulative releases of radionuclides from a repository system, which are obtained as the result of the TSPA modeling. The CCDF of radionuclide releases will be used by the DOE as a fundamental indication of whether compliance with the EPA release limits in

40 CFR Part 191 has been attained. There are a number of important considerations that go into developing a meaningful CCDF. NRC guidance, anticipated to be completed in FY94, is considered important due to the central role of the CCDF in the licensing process. A key concern is that the DOE include in the CCDF the information needed by the NRC staff to evaluate the safety of the repository.

Validation of the models used in a PA is likely to be a major issue in the licensing of a HLW repository, because the demonstration of compliance will be made entirely using predictive PA models. Of course, the case for licensability will be supported by extensive qualitative and quantitative evidence provided by site characterization, laboratory studies, natural analogues, etc. Because the usual procedures for validation of engineering models, comparison of predictions to experimental results, is precluded for the time periods of interest for the repository, an alternative, which will provide an acceptable degree of validation (partial validation) is needed. Currently, and in the past, this topic has been the subject of considerable discussion among international modeling experts. Previous efforts to arrive at a consensus have not been fruitful. It is important that guidance on validation be produced as soon as possible since the DOE is already using models that will have to be validated in some manner and because even partial validation of models is likely to require experiments over long times. The DOE plans to issue a report on its model validation methodology in early FY94.

Scenario probabilities play a central role in the construction of the CCDF representing repository performance. Methods for determining the probabilities of future states of the repository environment (e.g., faulting, climate change, volcanism) are not well established, especially for the long time periods of repository performance. Guidance on procedures for developing scenario probabilities and the scientific and technical investigations needed to support such probability estimates is needed to clarify the staff's expectations on these matters and enhance confidence in modeling. Such guidance will need to be developed in concert with the appropriate earth science or engineering disciplines.

Potential areas for additional guidance in the FY96 and FY97 time frame include uncertainty analysis, requirements for source term models, flow models, and radionuclide migration models for TSPA, and dose models for the EIS PA. This guidance should be timely for DOE to complete development of its TSPA for the LA, which is planned to begin in FY98.

The staff plans to provide guidance regarding the definition of the disturbed zone in 10 CFR Part 60 which currently lacks clarity sufficient to implement the relevant regulations in 10 CFR Part 60. PA staff will support this guidance effort by providing information on how various definitions of the disturbed zone impact the uncertainty in estimates of performance of the repository. The current GWTT effort is even considering the elimination of the term "disturbed zone." DOE plans to issue a report on their proposed definition of the disturbed zone definition in FY94, and guidance is planned to be developed by FY95, if needed.

B. Develop LARP and Supporting Technical Assessment Capability

1. Develop Overall System Performance License Application Review Plans

In FY93 the staff will complete preparation of Compliance Determination Strategies (CDSs) for all PA requirements. Development of CDMs in FY94 will result in completion of CDM 6.1, Assessment of Compliance with the Requirement for Cumulative Releases of Radioactive Materials; CDM 6.2, Assessment of Compliance with Individual Protection Requirements; CDM 6.3, Assessment of Compliance with the Groundwater Protection Requirements and CDM 3.4, Effectiveness of Natural

Barriers Against the Release of Radioactive Material to the Environment. In addition, PA will complete CDM 8.5, Analysis of Changes from Performance Confirmation Baseline in FY94.

Compliance Determination Method (CDM) development (including development of review methods and acceptance criteria) is a proactive effort that allows the staff to consider the topics of regulatory compliance determination and plan the review effort prior to initiation of the licensing process. In FY95, the CDM for Assessment of Compliance with the Groundwater Protection Requirements (CDM 6.3) will be completed. In FY96, PA will contribute to development of the CDM for Assessment of Compliance with Criteria for Favorable Combinations and Potentially Adverse Conditions (CDM 3.2.5) and complete the CDM for Assessment of Compliance with Individual Protection Requirements (CDM 6.2). In FY97, the CDM for Assessment of Compliance with the Requirement for Cumulative Releases of Radioactive Materials (CDM 6.1) will be completed.

2. Overall System Performance Code and Model Development

A key element in the development of a technical assessment capability for conducting repository licensing reviews is Iterative Performance Assessment (IPA). IPA consists of the conduct of a PA by an interdisciplinary team of professionals. In the current Phase 2 IPA, the team is comprised of professional staff from the Office of Nuclear Material Safety and Safeguards (NMSS), the Office of Nuclear Regulatory Research (RES), and the CNWRA. PA is comprised of: (i) modeling and computation to estimate the performance of the repository and important subsystems of the repository, and (ii) auxiliary analyses, which are often conducted on a finer level of detail and on narrower topics. The purpose of the auxiliary analyses is to evaluate assumptions used in obtaining the estimates of performance, to synthesize data into parameter sets used as input to computer codes for estimating performance, and to consider alternative conceptual models. These PAs are conducted iteratively as more refined models and additional site data are developed. The primary purpose of IPA is to develop and maintain: (i) the staff capability, (ii) an array of quantitative tools, (iii) the scientific and technical currency, and (iv) the staff, support, and management infrastructure required to conduct these assessments.

This assessment capability is expected to be used during the LA evaluation and prior to that time to provide an independent evaluation of the DOE estimates of repository performance. The ongoing efforts in IPA are expected to contribute significantly to other regulatory products identified in this plan. These contributions include: (i) technical insights and practical experience to assist in the development of regulatory guidance; (ii) ongoing evaluation of the DOE site characterization activities and PA program; and (iii) insights into the definition and resolution of technical topics and prioritization of NRC and DOE program activities, including HLW research. IPA provides quantitative information that helps to determine the importance of various topics, activities, data, and models. However, these quantitative estimates must always be considered in the context of the scientific bases that support them and the judgment of the analysts that derived them. Early phases of IPA have focussed on developing the technology and analytical teams to execute PA at the NRC. Subsequent phases of IPA are expected to focus more on evaluation of DOE IPA and their implications for site investigations and design. Each iteration of a PA requires considerable resources and staff dedicated to the activity on a continuing basis.

Development of models and codes for IPA covers the various component disciplines of PA including: geology, hydrology, geochemistry, climate, waste package, waste form behavior, repository mechanics, thermohydraulics, and corrosion science. These various disciplines will be integrated through a program of TSPA, which requires additional developmental work in various areas including scenarios, sensitivity and uncertainty analysis, and simulation methods. Currently, phase 2 is planned to be completed in late

FY93 and phase 3 should begin in FY94 with subsequent phases continuing every 2 years thereafter.

Development of models and codes for PA will also include completion of EBSPAC in FY98. A series of detailed models in the EBSPAC code will provide the bases for the development of the simplified source term models to be incorporated in the SOTEC computer code, which will be developed during FY93 to FY00. SOTEC will provide the source terms for total repository system PA. Both EBSPAC and SOTEC are used to conduct the staff's ongoing and planned IPA; SOTEC will be used to provide estimates of performance, while the intended use of EBSPAC will be for auxiliary analyses. Both codes will be used to review the DOE IPA program in FY94, FY96, FY98, and FY01. In addition, EBSPAC will be used to identify parameters important to performance that the staff may identify to the DOE to address in ongoing site characterization activities related to material testing.

C. Conduct Pre-License Application Reviews and Quality Assurance Audits

QA audits will be conducted in accordance with agreements between the NRC and DOE. Pre-licensing reviews will be conducted to help the staff resolve uncertainties early to expedite evaluation of the LA and other programmatic documents. In those cases in which topics have been identified and clear guidance can be provided to the DOE, the staff will do so to further expedite the licensing process, while adequately discharging its regulatory mandate. DOE products that are of particular interest for pre-license review include reports on model validation methods, GWTT workshop, disturbed zone definition, pre-waste emplacement GWTT and updates of the DOE TSPA (every 2 years beginning in FY95). These reports discuss topics of importance and concern to the PA staff as indicated by the aforementioned guidance efforts planned in FY95 for partial model validation and disturbed zone definition.

Additional document reviews will be conducted of DOE progress reports, which will be submitted to the staff every 6 months. Other reactive activities include review of the various DOE study plans for Site Characterization at YM. The review of these plans is important to NRC since these plans specify the scientific methods that DOE plans to use to conduct site characterization investigations, which will be used to support its LA. All study plans will receive a minimum cursory review by the PA staff. Approximately 30 such study plans are expected in FY93, and the same number is anticipated in the following years.

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1. DOE, 1990. *Performance Assessment Strategy Plan for the Geologic Repository Program*. U.S. Department of Energy, Washington D.C.
2. Barnard, R. W., M. L. Wilson, H. A. Dockery, J.H. Gauthier, P.G. Kaplan, R.R. Eaton, S.W. Bingham, and T.H. Robey. 1992. *TSPA 1991: An Initial Total-System Performance Assessment for Yucca Mountain*. SAND-91-2795. Albuquerque, NM: Sandia National Laboratory (SNL).

Name										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	
DOE SCHEDULE FOR PERFORMANCE ASSESSMENT										
* Total System PA for LA							_____	_____	_____	_____
* Total System PA for DEIS					_____	_____				
* Report on Preclosure PA								▲		
* Verify/Validate WP PA Codes/Models									_____	
* Report on GWTT Workshop	_____	▲								
* Report on Pre-Waste-Emplacement GWTT for DEIS				_____	_____	_____	▲			
* Final Report Pre-Waste-Emplacement GWTT				_____	▲					
* Report on Disturbed Zone Definition	_____	▲								
* Develop/Validate Flow & Transport Models					_____	_____	_____			
* Prepare/Publish Validation Methodology				_____	▲					
* Conduct WP PA for ACD				_____	_____	▲				
* Iterative PA's										_____
* Evaluate WP PA for LAD						_____	_____	_____		
* Report on Natural Resources								▲		
NRC SCHEDULE FOR OVERALL SYSTEM PERFORMANCE										
A. Develop Regulatory Requirements and Technical Guidance										
* EPA Promulgates New HLW Standard				_____	_____	▲				
* Conforming Rulemaking for New EPA Standard						_____	_____	▲		
* Support Rulemaking on Substantially Complete Containment	_____	▲								
* Expert Elicitation Guidance				_____	_____	▲				
* Guidance on Definition of Scenarios	_____	▲								
* Guidance on Construction of CCDF	_____	▲								
* Guidance on Model Validation				_____	_____	▲				
* Guidance for Enhancing Confidence in Modeling				_____	_____	_____	▲			
* Guidance on Uncertainty Analysis						_____	_____	▲		
* Guidance on Requirements for TSPA Source Term Model						_____	_____	▲		

Name										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	
* Guidance on TSPA Flow Models										
* Guidance on Radionuclide Migration for TSPA										
* Guidance on Dose Modeling for EIS PA										
* Support Guidance on Disturbed Zone										
B. Develop LARP and Technical Assessment Capability										
Develop Overall System Performance LA Review Plans										
* All PA CDSs Complete										
* Effectiveness of Natural Barriers Against the Release of Radioactive Material to the Environment - CDM 3.4										
* Analysis of Changes from Performance Confirmation Baseline - CDM 8.5										
* Integrating Technical Uncertainties in PAC/FAC CDS's										
* Assessment of Compliance with Groundwater Protection Requirements - CDM 6.3										
* Assessment of Compliance with Individual Protection Requirements - CDM 6.2										
* Assessment of Compliance with the Requirement for Cumulative Release of Radioactive Material - CDM 6.1										
Overall System Performance Code and Model Development										
* Conduct IPA										
* Scenario Development										
* Complete Development of EBSPAC Code										
* Develop Source Term Code										
* Develop TSPA Systems Code										
* Develop Flow and Transport Code										
C. Conduct Pre-LA Reviews and QA Audits										
* Review ACD										
* Review Report on Model Validation										
* Review Report on GWTT Workshop										
* Review Report on Disturbed Zone Definition										
* Review Final Report on Pre-Waste Emplacement GWTT										

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
	* Review Updates of DOE TSPA								
* Progress Report Reviews	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Study Plan Reviews	▲	▲	▲	▲	▲	▲	▲	▲	▲

APPENDIX H
REPOSITORY OPERATIONS

DOE REPOSITORY OPERATIONS PROGRAM

The U.S. Department of Energy (DOE) will develop repository operating concepts and provide input to the design and safety analysis. Activities under the heading Repository Operations include all efforts to: develop repository operating concepts and perform trade-off and optimization studies, determine operating modes for all systems and equipment, and provide input to the design and safety analyses of the repository through definition of modes and limits of operation for all systems and equipment, procedures for assembly, emplacement, monitoring, and retrieval of waste, and maintenance and testing requirements of the operation facility. Included in the determination of operating modes are: waste receipt, interim storage, packaging, and handling; waste package fabrication, preparation, repair, emplacement and records, maintenance for emplaced wastes, and retrieval, seal and backfill emplacement; hauling, storage, and disposal of mined material; waste control safeguards; site physical security and nuclear material safeguards; acceptance testing and readiness reviews; maintenance and logistics support; and, personnel training and staffing. A preliminary operations plan is scheduled to be developed by FY97 and the final plan will be completed by FY00. To date, the DOE has outlined some of its operations activities in its Work Breakdown Structure. The DOE focus includes maintenance and operation of the Exploratory Studies Facility (ESF), field operations, records management, and occupational safety concerns. Expanded discussion of these and other areas are anticipated in the aforementioned operations plans.

Planned work efforts regarding maintenance and operation of the ESF pertain to systems necessary for transportation of personnel and materials onto the site and into underground areas as well as systems necessary for removal of excavated material from underground areas to storage areas. These efforts include designation of necessary equipment and preparation of operations and maintenance manuals. Part of the ESF operations will utilize an integrated data collection system to automatically record, control, store, and transfer data acquired during ESF tests. Other work will involve operation and maintenance of components for subsurface ventilation, communications, instrumentation, utilities, and emergency systems.

The DOE plans to set up a field operations center to provide overall project coordination of field activities. This coordination will include development and implementation of administrative controls for field activities. The Field Operations Center will provide management for operational, logistical, and administrative support to the Yucca Mountain (YM) Site Office including staffing, services, materials, equipment, and supplies.

The DOE will develop a records management system that conforms to DOE quality assurance (QA) requirements (DOE/RW-0214), QA for civilian radioactive waste management (DOE/RW-0194P), records management policies (ANSI/ASME NQA-1), QA requirements for nuclear facilities, and the Licensing Support System (LSS). This system will serve to receive, retain, and protect documents and records through an authorized system for receiving, controlling, filing, accessing, tracking, retrieving, distributing, and storing such materials. Local Records Centers and a Centralized Records Facility as identified and authorized by the Yucca Mountain Project Office (YMPO) will be established. Procedures, plans, and training will be developed and implemented to describe the operations of these facilities and the authorized process for recording information.

The DOE plans to address occupational safety concerns relating to repository operations through consideration of the following concerns: hazard abatement; posting of signs or instructional materials; proper handling, storage, and transportation requirements for explosives or hazardous materials; selection and use of barricades, warning systems, and personal protective equipment and proper use of these items;

industrial hygiene; hazard communication; and traffic control.

The DOE current efforts focus on site characterization and data gathering. The design of the repository is still in a conceptual stage. A number of alternatives are still being considered. Therefore, the DOE is not expected to spend significant resources in developing a program for repository operations until after the design, construction, and initial operations of the ESF. However, DOE is expected to develop details of repository operations in the plan that will be submitted to U.S. Nuclear Regulatory Commission (NRC) as a part of the license application.

NRC REPOSITORY OPERATIONS PROGRAM

I. OVERVIEW

The mission of the NRC in the Repository Design, Construction, and Operations area has two parts. The first part is to evaluate DOE's performance objectives based design and construction of the geologic repository operations area to determine if the DOE has acceptably demonstrated compliance with the requirements in 10 CFR Part 60, and the second part is to ensure that the repository is operated safely. Only the second part will be discussed here. The first part is discussed in Appendix E, Geologic Repository Operations Area.

To accomplish the goal set forth for the second part of the mission, the staff is developing a review strategy and capability by preparing ten review plans for the operations of repository to be integrated in the License Application Review Plan (LARP). These review plans, in conjunction with the effort in the prelicensing consultation will allow the staff to gain confidence to determine if the DOE demonstration of compliance with 10 CFR Part 60 is acceptable. The NRC repository operations program must evaluate the DOE procedures, plans and information regarding planned activities and processes; maintenance; testing; radiation protection; organizational structure; management and administrative controls; procedure development; records and reports; training programs; schedules; and operating controls.

Review of the DOE maintenance activities will focus on maintenance of structures, systems, and components important to safety and retrievability at the geologic repository operations area (GROA). Such activities will include those conducted at surface facilities, shafts and ramps, and underground facilities.

The NRC review of operations regarding the DOE radiation protection program will emphasize the health physics program at the repository and the DOE description of specialized facilities, equipment, and instrumentation that will be used to monitor and control internal and external radiological exposure to workers and members of the public during normal operations and anticipated operational occurrences as required by 10 CFR Part 20 and during radiological emergencies as required by 10 CFR Part 60. Such equipment may include that which is needed to perform radiation and contamination surveys, sampling or airborne radioactive material, area and personnel radiation monitoring during normal operation and accident conditions, and respiratory equipment and other protective clothing identified by the DOE in its plans. The NRC staff will also consider the DOE procedures for conducting radiation surveys, personal dosimetry, decontamination, and conformance with the concept of as low as reasonably achievable (ALARA) from 10 CFR Part 20 and defined in Regulatory Guide 8.8 and 8.10. The NRC will also consider the DOE descriptions and plans for effluent monitoring and concentration estimation of radioactive gases, particulates, solids, and liquids within facilities and in the external environment.

The DOE planned organizational structure, management, and administrative controls will also be considered in the NRC review of the License Application (LA). This review will include attention to personnel functions, responsibilities, and authorities as well as qualification requirements for different positions. Such information is important for assessing whether planned management structures, administrative activities, and planned schedules are compatible with planned operations such that worker and public health and safety are maintained.

The NRC repository operations program will consider whether the DOE has provided all the necessary procedures needed for GROA operations. These procedures will include general operating procedures, emergency procedures for various postulated occurrences (i.e., fires, explosions, earthquakes), start-up activities, testing, retrieval and storage activities, and performance confirmation efforts.

The DOE program for maintaining records and reports will also be considered by the NRC staff. The NRC will aim to ensure the DOE program, as described, will be able to maintain a complete history of receipt, handling, storage, and disposition of radioactive waste; construction records, reports of deficiencies of the site records of permanent closure; records of tests using radioactive wastes (conducted during construction or emplacement); and site inspections. The DOE approach for permanent preservation of site records including site data, site characterization experiment data, construction records, and performance confirmation results will also be reviewed.

The DOE descriptions and plans for training personnel will need to be considered to ensure compliance with the applicable requirements of 10 CFR Part 60 to ensure protection of public and worker health. Such training efforts could include equipment installation instruction, instrumentation use and control functions, methods of dealing with equipment malfunctions, decontamination procedures, and emergency procedures. Other areas pertaining to maintaining radiation safety through training include basics on sources of radiation, contamination control, biological effects, use of monitoring equipment, and criticality control. Methods for ensuring the effectiveness of training will also be assessed in the NRC staff's review of the DOE training program.

Operational controls and limits are important to the DOE analysis of health and safety since they serve as the baseline normal operating conditions that will be used in the analyses to determine adequate protection of public and worker health if the facility operates within such specified limits. These limits include all aspects of operation that are important to safety, retrievability, and isolation. Such limits must be identified and justified by the DOE in its operations plans. These limits will include numerical values and other pertinent data. The NRC staff will need to determine if all the appropriate limits have been identified and whether those selected by the DOE have an adequate technical basis and are consistent with the DOE repository design and operations plans.

II. PROGRAM DESCRIPTION

A. Develop Regulatory Requirements and Technical Guidance

Regulatory requirements and technical guidance for repository operations are not planned at this time. A number of NRC guidance documents have been developed for reactors and independent spent fuel storage installations that may be, at least partially, applicable to the repository operations. Many of these guidance documents are in the area of radiation protection and health and safety procedures. During FY95-98, a systematic effort will be made by the staff to examine the possibility of either adopting or modifying these guidance documents to be applicable to the High-Level Waste (HLW) program. Additional guidance will be provided to the DOE through the development of revisions to the NRC LA Format and Content Regulatory Guide (FCRG). This guide was first issued in FY91 and will be revised as needed. Current plans are to develop a revision in FY94 and make it available to the DOE in FY95.

B. Develop LARP and Supporting Technical Assessment Capability

During FY93, the staff will continue preparing the repository operations review plans for the LARP by completing review strategies for all the repository operations requirements. Development of review strategies for the review plans will be completed during FY93. During FY94, a consistency/integration review of ten CDS relevant to repository operations will be conducted. The development of the CDMs for repository operations requirements will be completed during FY95-98. A tentative schedule for the development of these review plans is as follows (Details of CDMs are given in the FCRG).

In FY95, the following Repository Operations Review Plan CDMs will be completed:

- Plans for Conduct of Normal Activities (CDM 7.1)
- Organizational Structure, Management and Administrative Controls (CDM 7.3)

In FY96, the following Repository Operations Review Plan CDMs will be completed:

- Description of Radiation Protection Program (CDM 7.2)
- Procedure Development (CDM 7.4)
- Preservation of Records (CDM 7.9)

In FY97, the following Repository Operations Review Plan CDMs will be completed:

- Records and Reports (CDM 7.5)
- Training Programs (CDM 7.6)
- Schedules for Operations (CDM 7.7)

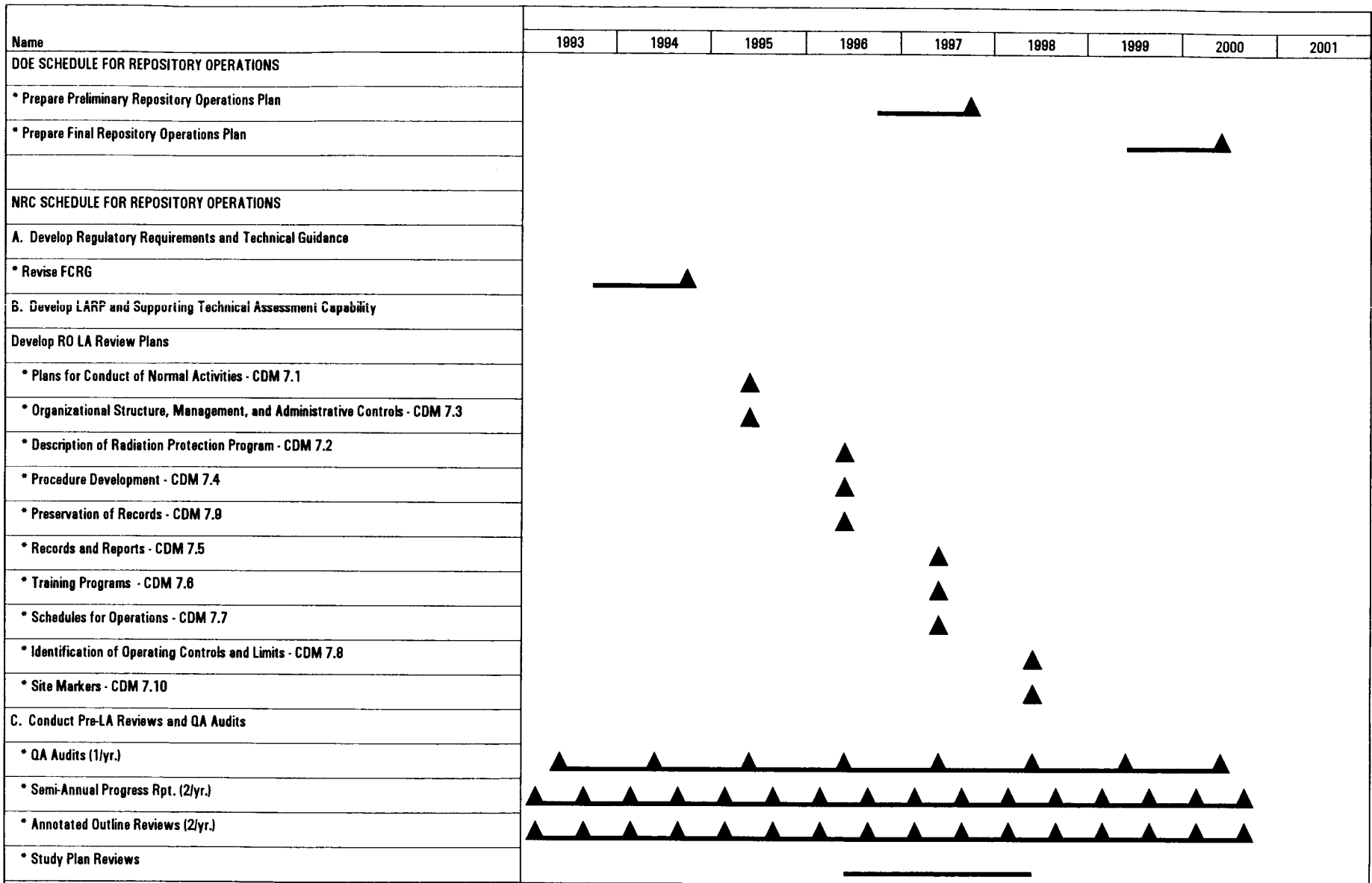
In FY98, the following Repository Operations Review Plan CDMs will be completed:

- Identification of Operating Controls and Limits (CDM 7.8)
- Site Markers (CDM 7.10)

C. Conduct Pre-License Application Reviews and Quality Assurance (QA) Audits

The staff will continue its prelicensing consultation in the area of repository operations consistent with the DOE planning and activities. The DOE will include a construction and operations plan as part of its repository design. The NRC expects to review the initial and final repository operations plan during the License Application Design (LAD) period (FY96-98). In addition, the DOE is preparing annotated outlines (AO) of its LA on a semi-annual basis. The staff has agreed with the DOE to carry out semi-annual reviews of the DOE AO. The semi-annual reviews of the AO are carried out to provide the DOE with prelicense application guidance on whether or not the staff believes that the DOE is appropriately interpreting the repository operations related requirements of 10 CFR Part 60 and on any additional repository operations information needed in the AO to address specific 10 CFR Part 60

requirements. The staff believes that the complexity of developing a first-of-a-kind repository warrants the type of interactions described above with the DOE to ensure that NRC regulations are understood.



APPENDIX I
NONSYSTEM SPECIFIC AREAS

DOE PROGRAM FOR NONSYSTEM SPECIFIC AREAS

In addition to the repository systems discussed in the preceding appendices, there are other requirements and specifications that the U.S. Department of Energy (DOE) must address in its repository License Application (LA). These requirements include: land ownership and control, security and safeguards, emergency planning, and other miscellaneous topics. Many of these topics are in areas in which the DOE has yet to provide much information on its plans for demonstrating compliance with regulatory requirements.

Land Ownership and Control

In land ownership and control, 10 CFR Part 60 is specific about the requirements that must be met. Prior to initiation of site characterization and construction or operation of the repository, the DOE must gain proper legal access to and control of the land needed for these activities. The DOE will have to acquire licenses, titles, withdrawal agreements, cooperative agreements, and any other agreements necessary to obtain access to the land needed for the proposed repository. Access and control of the land will include assessment and termination of any conflicting resource rights or interests. Condemnation may be used if negotiations are unsuccessful. The DOE will then evaluate the extent to which its jurisdiction and control of water rights in the area serve to prevent adverse human actions that could significantly reduce the geologic repository's capability for isolation of waste. This evaluation will include an assessment of any existing rights needed by the DOE to preclude such human actions. The DOE began to develop its land ownership and control plan in FY91 and will complete it by early FY95. The DOE plans to prepare and submit its land withdrawal application between FY96 and FY01.

The land acquisition and control effort will entail gaining an understanding of current laws and regulations and those proposed for revision that could impact rights to lands required for a proposed repository and transportation routes. Actions proposed or under consideration by departments, agencies, or individuals that would impact the acquisition of lands needed for the repository activities will be identified. Other land managers in the adjacent areas will be included in the DOE land and water control activities in order to ensure noninterference with the conduct of repository-related activities. The proper documentation needed for land acquisition will be prepared, and compliance monitoring and reporting will be conducted.

Safeguards and Physical Security

Topics relating to security and safeguards will be addressed by the DOE including a physical security plan and a certification of safeguards in the LA. At this time, no specific schedules or plans for such activities have been identified. However, the staff anticipates that these topics will be addressed in future iterations of the DOE Annotated Outline (AO) for the LA.

Nuclear Material Control Program

The DOE will provide a description of its nuclear material control and accounting program. At this time, no schedules are available for this activity.

Emergency Planning

The DOE will be required to meet the requirements for emergency planning that will be published in the future by the U.S. Nuclear Regulatory Commission (NRC). The DOE will address topics relating to emergency actions in a plan submitted in the LA. Current DOE plans include establishment of emergency medical and fire prevention services, an emergency medical helicopter, emergency detection systems, and coordination of evacuation procedures with local and state entities, as necessary. At this time, no specific schedules for these activities have been identified.

Information Summaries

The DOE will prepare summaries of the information it provides in the body of its LA on Site Characterization Work Conducted, the Status of the Resolution of NRC Objections to LA Submittal, and Compliance with Performance Objectives of 10 CFR Part 60 and Performance Assessment (PA) results.

Other General Information

The DOE will develop several other topics that are characterized as general information for inclusion in the LA. These topics are:

- General Description of the Facility
- Basis for Licensing Authority
- Schedules
- Identification of Agents and Contractors
- Material Incorporated by Reference
- Use of NRC Staff Technical Positions
- Requirements for Further Technical Information
- License Specifications

THE NRC PROGRAM FOR NONSYSTEM SPECIFIC AREAS

The NRC requires the DOE to address all regulatory requirements from 10 CFR Part 60 applicable to the repository LA. In addition, the DOE has agreed to provide information on several related topics specified in the Format and Content Regulatory Guide (FCRG). These requirements and specifications were enumerated previously for the DOE program. The NRC plans to prepare for reviewing these areas are discussed in the following sections.

I. LAND OWNERSHIP AND CONTROL

The NRC plans to review the DOE documentation of land and water use controls submitted with its LA for a high-level waste (HLW) repository. This review will emphasize completeness of the information submitted. The NRC will ensure that all the needed permits for land and water use have been obtained by the DOE. In addition, the adequacy of the controls obtained in light of planned land and water use activities will be assessed. Maps indicating existing land and water use will be reviewed in order to ensure the DOE has conducted a thorough analysis of the impact of existing land and water use on the ability of the repository to isolate waste.

The staff has completed the Compliance Determination Strategy (CDS) for land ownership and control. The Compliance Determination Method (CDM 9.0) including review procedure and acceptance criteria will be completed in FY95. No additional activities are planned regarding assessment and review capability in this area.

The NRC staff will monitor progress of the DOE efforts to gain access to land and water rights and interactions with other landowners through review of semi-annual progress reports and AO submissions. In addition, a review will be conducted of the DOE Land Ownership and Control Plan, which is anticipated to be completed in FY95. No other activities specific to review of the DOE land and water control are planned.

There are currently no plans for prelicense application reviews or quality assurance (QA) audits. However, document reviews of the DOE AO will be conducted.

II. SECURITY AND SAFEGUARDS PROGRAM

10 CFR 60.21(b)(3) requires DOE to certify that it will provide the geologic repository operations area such safeguards as it requires at comparable surface facilities to promote the common defense and security. The information provided in this certificate should be adequate to assure common defense and security, as the NRC has determined that any licensed materials at the geologic repository operations area are not attractive targets for theft or diversion, and that the DOE, acting under the same Atomic Energy Act authority as the NRC, has provided adequate safeguards at facilities where HLW (including spent nuclear fuel) has been handled and stored.

10 CFR 60.21(b)(4) requires the DOE to develop a physical security plan for protection against radiological sabotage. In this requirement, the NRC acknowledges that the radiation hazards associated with spent fuel make it an unattractive target for theft or diversion and therefore no information needs to be submitted on these aspects of a physical security

program. The scope of the physical security review is concerned primarily with radiological sabotage, as defined in 10 CFR 73.2 to be those "deliberate acts...which could directly or indirectly endanger the public health and safety by exposure to radiation."

The NRC staff is preparing a rulemaking on physical protection of spent fuel at sites other than nuclear power reactors. The staff has also been working on a NUREG providing interim licensing criteria for the evaluation of physical protection plans for certain storage of spent fuel. However, instead of publishing it as a NUREG, there is a possibility of publishing it as a regulatory guide along with the proposed rule.

The staff has completed separate CDSs on the topics of Certification of Safeguards and Physical Security Plan and plans on completing separate CDMs in FY94 on those topics (CDM 1.4 and CDM 1.5). This information will provide guidance to both the staff and the DOE.

There are currently no plans for prelicense application reviews or QA audits. However, document reviews of the DOE AO will be conducted.

III. NUCLEAR MATERIAL CONTROL PROGRAM

10 CFR 60.21(c)(10) requires the DOE to provide a description of the nuclear material control and accounting program. This topic is limited to consideration of the DOE plans and procedures for inventory control and accounting of the HLW, which includes spent nuclear fuel and other radioactive waste forms, that may be disposed of at the geologic repository. It is not concerned with the related subjects of safeguards certification or plans intended to prevent radiological sabotage. These topics are covered separately.

There are currently no plans to develop regulatory guidance or technical guidance on this topic. However, the staff plans on developing a CDM in FY94 on the topic of Nuclear Material Control (CDM 2.7). This document will provide guidance to both the staff and the DOE.

There are currently no plans for prelicense application reviews or QA audits. However, document reviews of the DOE AO will be conducted.

IV. EMERGENCY PLANNING

The NRC has reserved 10 CFR 60 Subpart I for regulations pertaining to emergency planning criteria that will be developed prior to the DOE submittal of the LA. The staff intends to adopt, as far as is practicable, the emergency planning regulations in 10 CFR Part 72. This adoption will be done through a rulemaking during FY97 and FY98. Review guidance development will be dependent upon the completion and implementation of the rulemaking. CDM 11.0, Emergency Planning, will be completed in FY96.

V. INFORMATION SUMMARIES

The following are topics which will summarize information contained elsewhere in the LA:

- Site Characterization Work Conducted (CDM 1.6.1)
- Status of the DOE Resolution of NRC Objections (CDM 1.6.2)
- Statement of Compliance with the Performance Objectives of 10 CFR Part 60 and Summary of PA Results (CDM 1.7)

The staff is requiring that the DOE provide information on these three topics in the LA because of their overall importance to a determination of acceptability of the LA. The staff anticipates that the individual review plans for these activities will be completed in FY96. No DOE programs are dependent on NRC guidance beyond what is in the FCRG and the review plans in the License Application Review Plan (LARP). The staff does not anticipate that information on these topics will appear in the AO for the LA until shortly before LA submittal. At that time, the staff will review those parts of the AO.

VI. OTHER GENERAL INFORMATION

The nine review plans listed below represent other regulatory requirements from 10 CFR 60.21 for general information to be included in the LA. The staff anticipates that the individual review plans for these activities will be completed in FY95 and FY96. No DOE programs are dependent on NRC guidance beyond what is in the FCRG and the review plans in the LARP. The staff anticipates that the DOE will discuss these activities in the AO for the LA. However, by their nature, these are not areas in which a major resource expenditure would be necessary to carry out the review.

- General Description of the Facility (CDM 1.1):

This is a requirement from 10 CFR 60.21(b)(1), which calls for a general description of the repository and the activities to take place there.

- Basis for Licensing Authority (CDM 1.2):

This requirement also comes for 10 CFR 60.21(b)(1) and is self-explanatory.

- Schedules (CDM 1.3):

This requirement from 10 CFR 60.21(b)(2) requires that the DOE provide proposed schedules for construction and receipt of waste. The staff will review these schedules and receipts in terms of the relationship of these schedules to the activities described in the LA.

- Identification of Agents and Contractors (CDM 2.1):

This requirement is an expansion of a requirement from 10 CFR 60.21c(1)(ii)(F)(15) for information concerning activities at the geologic repository operations area GROA. Preparation for this study involves staff familiarization with the Federal Acquisition Regulations concerning qualification and disqualification of contractors and with information on barred or otherwise disallowed organizations.

- **Material Incorporated by Reference (CDM 2.2):**

Preparation for review of the LA in this area will involve staff review of the DOE AO for the LA, and of other DOE reports. Through these reviews, the staff should be able to familiarize themselves with some of the material incorporated by reference in the LA. This familiarization will enhance the staff's ability to review the LA in the mandated time frame.

- **Use of NRC Staff Technical Positions (CDM 2.3):**

The staff needs to maintain a listing of all currently active Staff Technical Positions and make them available to reviewers. Maintaining this listing will be an ongoing process throughout the prelicensing period, which will be documented in a review plan.

- **Requirements for Further Technical Information (CDM 2.4):**

The staff will develop a review plan that will provide reviewers with guidance on determination of the action to be taken in response to indications in the LA that the DOE has determined that additional information, currently unavailable, is needed to demonstrate compliance with a particular regulatory requirement, or where the DOE provides additional information, as discussed in Section 2.4 of the FCRG.

- **License Specifications (CDM 2.6):**

The staff will develop a review plan for reviewing license specifications, the requirements for which are described in 10 CFR 60.43. It is anticipated that this review plan would be one of the last prepared because the staff believes that through the prelicensing process and the development and review of the DOE AO, it will have a better understanding of the entire repository program and the potential topics that would affect the development and review of license specifications.

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
DOE SCHEDULE FOR NON-SYSTEM AREAS									
* Develop Land Ownership and Control Plan	—————▲								
* Prepare/Submit Land Withdrawal Application				—————▲					
* Develop Physical Security Plan							—————▲		
* Develop Emergency Actions Plan							—————▲		
NRC SCHEDULE FOR NON-SYSTEM AREAS									
A. Develop Regulatory Requirements and Technical Guidance									
* Regulatory Guidance on Emergency Planning					—————▲				
* Regulatory Guidance on Physical Protection	—————▲								
B. Develop LARP and Supporting Technical Assessment Capability									
* Complete CDSs	▲								
* General Description of the Facility - CDM 1.1					▲				
* Basis for Licensing Authority - CDM 1.2					▲				
* Schedules - CDM 1.3					▲				
* Certification of Safeguards - CDM 1.4		▲							
* Physical Security Plan - CDM 1.5		▲							
* Site Characterization Work Conducted - CDM 1.6.1					▲				
* Status of DOE Resolution of NRC Objections - CDM 1.6.2					▲				
* Statement of Compliance with the Performance Objectives and Summary of Performance Assessment Results CDM 1.7					▲				
* Identification of Agents and Contractors - CDM 2.1				▲					
* Material Incorporated by Reference - CDM 2.2		▲							
* Use of NRC Staff Technical Positions - CDM 2.3					▲				
* Requirements for Further Technical Information - CDM 2.4			▲						
* License Specifications - CDM 2.6		▲							
* Nuclear Material Control - CDM 2.7		▲							
* Land Ownership and Control - CDM 9.0				▲					

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001
* Emergency Planning - CDM 11.0				▲					
C. Conduct Pre-LA Reviews and QA Audits									
* Semi-Annual Progress Reports	▲	▲	▲	▲	▲	▲	▲	▲	▲
* Annotated Outline (1/yr.)	▲	▲	▲	▲	▲	▲	▲	▲	▲
* SCP Open-Item Reviews	▲	▲	▲	▲	▲	▲	▲	▲	▲
* DOE Land Ownership and Control Plan				—▲					
* DOE Physical Security Plan								—▲	
* DOE Emergency Actions Plan								—▲	