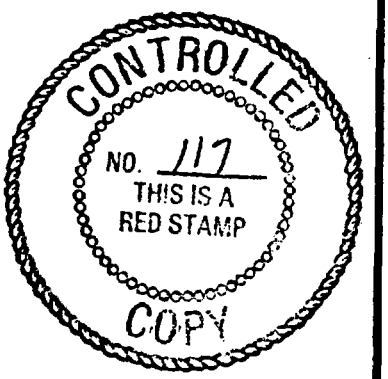
NNWSI/88-3

Nevada Nuclear Waste Storage Investigations

A U.S. DOE PROJECT



NNWSI PROJECT SYSTEMS ENGINEERING MANAGEMENT PLAN

JULY 1988

UNITED STATES DEPARTMENT OF ENERGY
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NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS PROJECT

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NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

SYSTEMS ENGINEERING MANAGEMENT PLAN

JULY 1988

Prepared by Nevada Nuclear Waste Storage Investigations (NNWSI) Project participants as part of the Civilian Radioactive Waste Management Program. The NNWSI Project is managed by the Waste Management Project Office of the U.S. Department of Energy (DOE) Nevada Operations. NNWSI Project work is sponsored by the Office of Geologic Repositories of the DOE Office of Civilian Radioactive Waste Management.

Prepared for

U.S. Department of Energy
Nevada Operations

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FOREWORD

This document is the first issue of the Systems Engineering Management Plan (SEMP) for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. The purpose of this document is to provide a general framework and guidance for the implementation of systems engineering on the NNWSI Project. The document describes the systems engineering functions and requirements for the NNWSI Project. The NNWSI Project Waste Management Project Office (WMPO) and Project Participants will prepare detailed procedures which will describe how the SEMP requirements will be implemented.

This SEMP is not meant to be a tutorial or a textbook on systems engineering methodology. Therefore, the reader is assumed to possess a rudimentary level of familiarity with the systems engineering methodology and terminology. Those who wish to become familiar with systems engineering are referred to various publications on the subject [e.g., DOC (1983); Chase (1975)].

By definition, the "Yucca Mountain Mined Geologic Disposal System (MGDS)," which is used throughout this SEMP, consists of the following subsystems:

1. Yucca Mountain Site (host for a potential repository).
2. Repository (including the surface and underground facilities, materials handling equipment including radioactive waste handling equipment, and operations).
3. Waste package.
4. Exploratory Shaft Facility (ESF).

The structure of these will be defined further in the appropriate subsystems requirements and description documents.

1.0 INTRODUCTION

Public Law 97-425, the Nuclear Waste Policy Act of 1982 (NWPA), directs the U.S. Department of Energy (DOE) to site, apply for license, construct, operate, close, and decommission a geologic repository for the permanent disposal of spent nuclear fuel and high-level radioactive waste. The DOE has established the Office of Civilian Radioactive Waste Management (OCRWM), which includes the Office of Geologic Repositories (OGR) and other organizations, to fulfill the requirements of the NWPA.

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project was established in 1977 and is currently evaluating Yucca Mountain, which is located approximately 100 miles northwest of Las Vegas, to determine the suitability of the Yucca Mountain site for the location of a radioactive waste repository in the U.S.A. Waste management-related site investigations at the Yucca Mountain site have been in progress since 1976. On the basis of these investigations and environmental assessment of the site, Yucca Mountain was designated in May 1986 by the President of the United States as one of the three sites to undergo site characterization to support the final selection process of a single repository site.

1.1 POLICY

DOE policy is to use systems engineering in the technical management of all major system acquisitions. Accordingly, the Director of OCRWM and the Associate Director for OGR have directed that systems engineering be used by all organizations participating in mined geologic disposal system (MGDS) development (DOE, 1985e). This requirement includes all divisions of the OGR, the DOE Project Offices, federal organizations, national laboratories, and private contractors that support the Project Offices. In conformance with this policy, the NNWSI Project Manager, in issuing this NNWSI Project Systems Engineering Management Plan (SEMP), directs and authorizes the use of systems engineering by the NNWSI Project Waste Management Project Office (WMPO), Project Participating Organizations, and all contractors (Section 4.0 provides detailed discussion). The WMPO, Project Participating Organizations, and all contractors will use the systems engineering approach described in this SEMP to manage, integrate, and document all technical activities on the NNWSI Project. This SEMP is incorporated by reference into the NNWSI Project Management Plan (PMP) (DOE, 1987d).

1.2 PURPOSE

The purpose of the NNWSI Project SEMP is to describe the way in which the NNWSI Project will implement systems engineering to manage, integrate, interface, and document the technical activities of the Project and to develop and manage the technical element of the Project Baseline. This SEMP is prepared in accordance with the guidance provided in DOE Order 4700.1 (DOE, 1987c), the DOE directive which provides DOE management policy.

A detailed discussion of the management of the Project Baseline is described in the Configuration Management Plan (CMP). Specifically, the SEMP defines the following:

1. The sequence of technical activities needed to establish and manage the technical element of the NNWSI Project Baseline.

2. The approach for the integration of all technical activities to ensure adherence to the approved Project Baseline.

3. The implementation of systems engineering methodology for the NNWSI Project.

4. The systems engineering documentation to be used by the WMPO to support and document technical decisions and to provide a traceable record for use in mined geologic disposal system acquisition and licensing.

This SEMP consists of five sections and two appendices. Section 1.0 (Introduction) provides introductory and policy-related information. Section 2.0 (Scope and Applicability) describes the scope of systems engineering on the Project. Section 3.0 (Approach) gives an overview of the systems engineering process to be used in the NNWSI Project. Section 4.0 (Implementation) describes the responsibilities of the organizations involved in the Project. This section also contains a detailed description of the systems engineering activities within a framework prescribed by the OCRWM and OGR SEMPs. It states the requirements for the reviews and gives an overview of the NNWSI Project Baseline and its management and describes how major Project activities will be integrated. Section 5.0 (Documentation) gives a brief description of major systems engineering documents. A list of the acronyms used in this SEMP is given in Appendix A (List of Acronyms). Appendix B (References) contains a list of the documents referenced in this SEMP.

1.3 DIRECTIVES AND REFERENCES

The DOE directives for the application of systems engineering to all technical activities of the NNWSI Project are identified in the OCRWM Program Management System Manual (DOE, 1986a), the OCRWM Mission Plan (DOE, 1985c), the OCRWM SEMP (DOE, 1985d), and the OGR SEMP (DOE, 1985e). The OGR SEMP explicitly states that each Project Office will prepare a project-level SEMP. The NNWSI Project SEMP complies with these directives and incorporates, by reference, the requirements of the following documents:

1. NNWSI Project Management Plan, NNWSI/88-2

2. NNWSI Project Administrative Procedures

3. NNWSI Project Quality Assurance Plan, NNWSI/88-9

2.0 SCOPE AND APPLICABILITY

Systems engineering will be used to manage, integrate, and document the NNWSI Project technical activities. These activities include the geosciences; engineering; identification and development of functional and physical performance requirements and their allocation to the MGDS; reviews; issues resolution analyses; environmental investigations; socioeconomics; transportation; and technical aspects of the quality assurance, regulatory and licensing activities.

The NNWSI Project SEMP provides general guidelines for the implementation of systems engineering by the WMPO at the Project level. The requirements defined in the NNWSI Project SEMP apply to the WMPO and to all Project Participants (i.e., Participating Organizations, Nevada Test Site (NTS) Support Contractors, and subcontractors) in the NNWSI Project. All Participants having a responsibility for one or more portions of the Yucca Mountain MGDS will incorporate the provisions and requirements of this SEMP in their activities through the use of implementing procedures.

The requirements of the NNWSI Project SEMP apply to all technical activities that must be performed to develop the Yucca Mountain MGDS, including the following:

1. Scientific investigations, including site characterization, socioeconomic and environmental investigations, and transportation studies.

2. Design and test activities related to development of the waste package and repository.

3. Performance assessment studies, including Performance Confirmation.

4. Design, construction, operation, and decommissioning of the ESF.

The NNWSI Project SEMP addresses interfaces among these technical activities both internal and external to the NNWSI Project.

The NNWSI Project SEMP, like the OGR SEMP, is focused on the Development and Evaluation (D&E) phase of the MGDS, which includes all activities up to submittal of a License Application (LA) to the U.S. Nuclear Regulatory Commission (NRC). A description of this phase and, if it is selected as the first repository, the subsequent three phases that the Yucca Mountain MGDS will go through, is given in Figure 2-1. The NNWSI Project systems engineering activities during the D&E phase of the Project, however, are facilitated by a complete overview of all the phases that the Yucca Mountain MGDS may have to go through. If Yucca Mountain is selected to host the first repository, this SEMP will be revised, expanded, and reissued to address the construction, operation, and closure and decommissioning phases.

MGDS PROGRAM PHASES	NNWSI PROJECT TECHNICAL ACTIVITIES
DEVELOPMENT AND EVALUATION	o CONCEPTUAL DESIGN IN SUPPORT OF SITE CHARACTERIZATION o ESF DESIGN, CONSTRUCTION, AND TESTING o SITE CHARACTERIZATION AND TECHNICAL INVESTIGATIONS o DEFINITION OF PERFORMANCE CONFIRMATION PROGRAM o ADVANCED CONCEPTUAL DESIGN o LICENSE APPLICATION DESIGN o EIS PREPARATION o LICENSE APPLICATION
CONSTRUCTION	o PERFORMANCE CONFIRMATION PROGRAM o FINAL PROCUREMENT AND CONSTRUCTION DESIGN o CONSTRUCTION AUTHORIZATION o CONSTRUCTION o APPLICATION FOR LICENSE AMENDMENT TO OPERATE REPOSITORY o DEVELOP AND SUBMIT LICENSE AMENDMENT TO OPERATE
OPERATION	o REPOSITORY OPERATION o PERFORMANCE CONFIRMATION PROGRAM o APPLICATION FOR LICENSE AMENDMENT TO CLOSE REPOSITORY o SUBMIT LICENSE AMENDMENT TO CLOSE REPOSITORY
CLOSURE AND DECOMMISSIONING	o REPOSITORY CLOSURE o REPOSITORY DECOMMISSIONING o APPLICATION FOR TERMINATION OF LICENSE o LICENSE TERMINATION

Figure 2-1. MGDS program phases

3.0 APPROACH

The NNWSI Project's systems engineering approach is to coordinate and balance the technical activities to achieve an integrated MGDS that will meet all of the MGDS technical requirements and the DOE and NRC site-selection and licensing requirements.

The systems engineering approach includes the following activities:

1. Identifying the technical requirements (functional and physical) for the total system specified in regulatory and generic requirements documents and DOE orders; and further defining these requirements and their allocations to the subsystems to serve as the basis for conducting technical activities.

2. Integrating the scientific investigations and design activities and identifying and managing the interfaces between them.

3. Defining and managing the interfaces among the MGDS subsystems.

4. Determining how the MGDS can be effectively optimized within the legislative, regulatory, and programmatic constraints to most effectively satisfy technical requirements and resolve regulatory issues.

3.1 THE NNWSI PROJECT SYSTEMS ENGINEERING PROCESS

The NNWSI Project systems engineering process uses the traditional systems engineering approach, emphasizing requirements, to guide the development of the Mined Geologic Disposal System (MGDS). During the Development and Evaluation phase, this requirements-oriented approach will be augmented by an issue resolution strategy process. The requirements approach provides a comprehensive framework for developing a system which performs all the necessary functions, meets all the applicable requirements, and can be properly integrated. The issues approach presents a set of organizing principles that allow program activities to focus on the collection of information that is crucial to the resolution of licensing and site selection issues. These two processes are shown in simplified form in Figure 3-1 and are discussed in more detail below.

3.1.1 THE REQUIREMENTS PROCESS

As indicated in Figure 3-1, the requirements for the MGDS are based on a variety of sources, including the Nuclear Waste Policy Act and amendments, Federal, state, and local regulations, OCRWM policy documents, DOE Orders, and various codes and standards. The OGR technical baseline document, Generic Requirements for a MGDS (GR), serves as a starting point for the definition of the requirements for the Yucca Mountain MGDS.

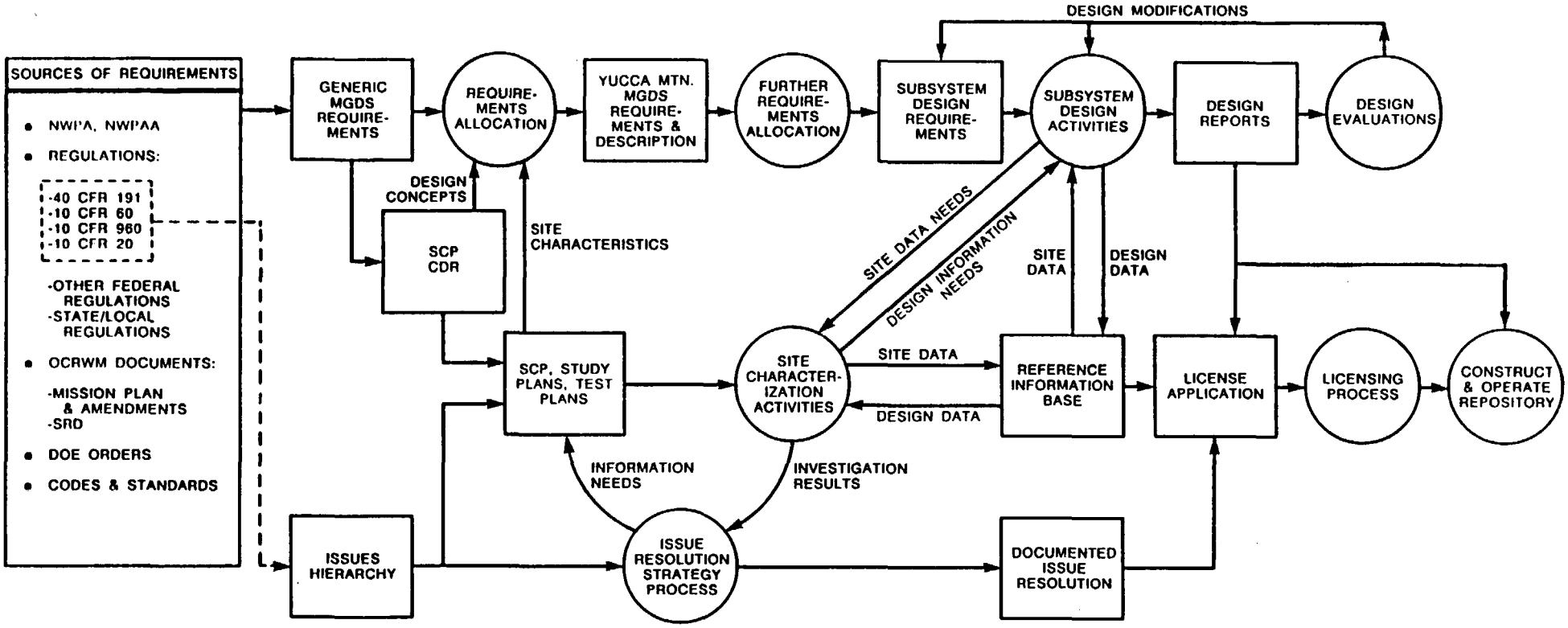


Figure 3-1. The Nevada Nuclear Waste Storage Investigations Project systems engineering process and issues hierarchy process.

Using the generic requirements, the design concepts developed for the Site Characterization Plan - Conceptual Design Report, and the site characteristics described in the Site Characterization Plan (SCP), an initial allocation of requirements to various subsystems and components will be made to develop a set of requirements for a MGDS at Yucca Mountain and a corresponding description of the system. The Yucca Mountain MGDS Requirements (SR) will provide further detail of the functions to be performed, and will quantify performance criteria and identify the interfaces between subsystems to the extent practicable. The Yucca Mountain MGDS Description (SD) will provide a complete definition of subsystems and major components. The SR and the SD will be used to further define design requirements and to assist in the development of the site characterization requirements.

Based on the SR and SD, additional functional analysis will be performed and requirements will be further allocated to the subsystems and components of the Yucca Mountain MGDS. Design requirements and maintenance, operations, and test requirements will be defined for each subsystem. These requirements will be developed taking into account all relevant information of the Yucca Mountain site. The NNWSI Project will issue the following subsystem design requirements documents for OCRWM approval: ESF Design Requirements (ESFDR), Repository Design Requirements (RDR), and Waste Package Design Requirements (WPDR). These will be updated as needed, with special emphasis on changes required before the start of each design phase.

ESF, repository, and waste package design activities will be based on their respective design requirements documents and the documents that provide the description of the system. During the course of site characterization activities, the subsystem design efforts will draw upon the site data that is maintained in the Reference Information Base (RIB). However, as indicated in Figure 3-1, it is anticipated that there will be an interaction with site characterization activities as the design activities identify the need for additional data and as the issue resolution process requires additional design details. The responses to any such requests will be entered into the RIB for subsequent usage.

The subsystem designs will be subject to periodic evaluation and reviews as outlined in Sections 4.2.4 and 4.2.5. The outcome of such reviews may necessitate the modification of the designs or of the design requirements. Any such changes will be managed by the change control process outlined in Section 4.3.2.

The repository and waste package design efforts will be directed at developing license application designs that are necessary for the purposes of obtaining a license and which are sufficient for the basis of Final Procurement and Construction Design (FPCD). Thus, at the end of the D&E phase, the system engineering process will lead to the definition of an integrated system that meets all functional and regulatory requirements.

3.1.2 THE ISSUE RESOLUTION STRATEGY PROCESS

The issues hierarchy provides a framework for representing issues related to regulatory requirements for siting and licensing a MGDS and for describing the work that needs to be completed during site characterization to resolve those issues. As shown in Figure 3-1, the issues hierarchy is

focused on the key set of regulations that are of interest in the siting and licensing of a MGDS. It does not address other requirements on the system, such as functional or operational requirements, or requirements derived from the other sources shown in Figure 3-1.

The issue resolution strategy process builds on the issues hierarchy through a performance-allocation process followed by investigations, analysis, evaluations, and issue resolutions. It should be noted that while the performance allocation process is related to the requirements allocation described above, and must be coordinated with it, it is a separate exercise. Performance allocation includes identification of functions that system elements will be expected to perform, but only those related to issue resolution. It also involves the assignment of specific quantitative goals to measures and parameters, but only in the sense of developing a testing program to establish expected performance, not in the sense of setting firm requirements.

The issue resolution strategy process will provide information needs that will guide the site characterization program and will provide documented resolution of the licensing and siting issues. As site characterization proceeds, it is anticipated that the issue resolution strategy process will provide information that is vital to the development of requirements and designs. Likewise, as the designs evolve, they will provide a more detailed basis for the performance allocation and issue resolution process.

3.2 DOCUMENTATION

The documentation of the NNWSI Project technical activities is critical to the application of systems engineering methodology. The NNWSI Project systems engineering documentation includes technical plans and documents such as systems requirements, subsystems design requirements, system description, test plans, test procedures, facility plans, study reports, and similar supporting documents. Figure 3-2 illustrates the documents which are necessary to implement the NNWSI Project systems engineering process. The NNWSI Project systems engineering documentation is described in Section 5.0.

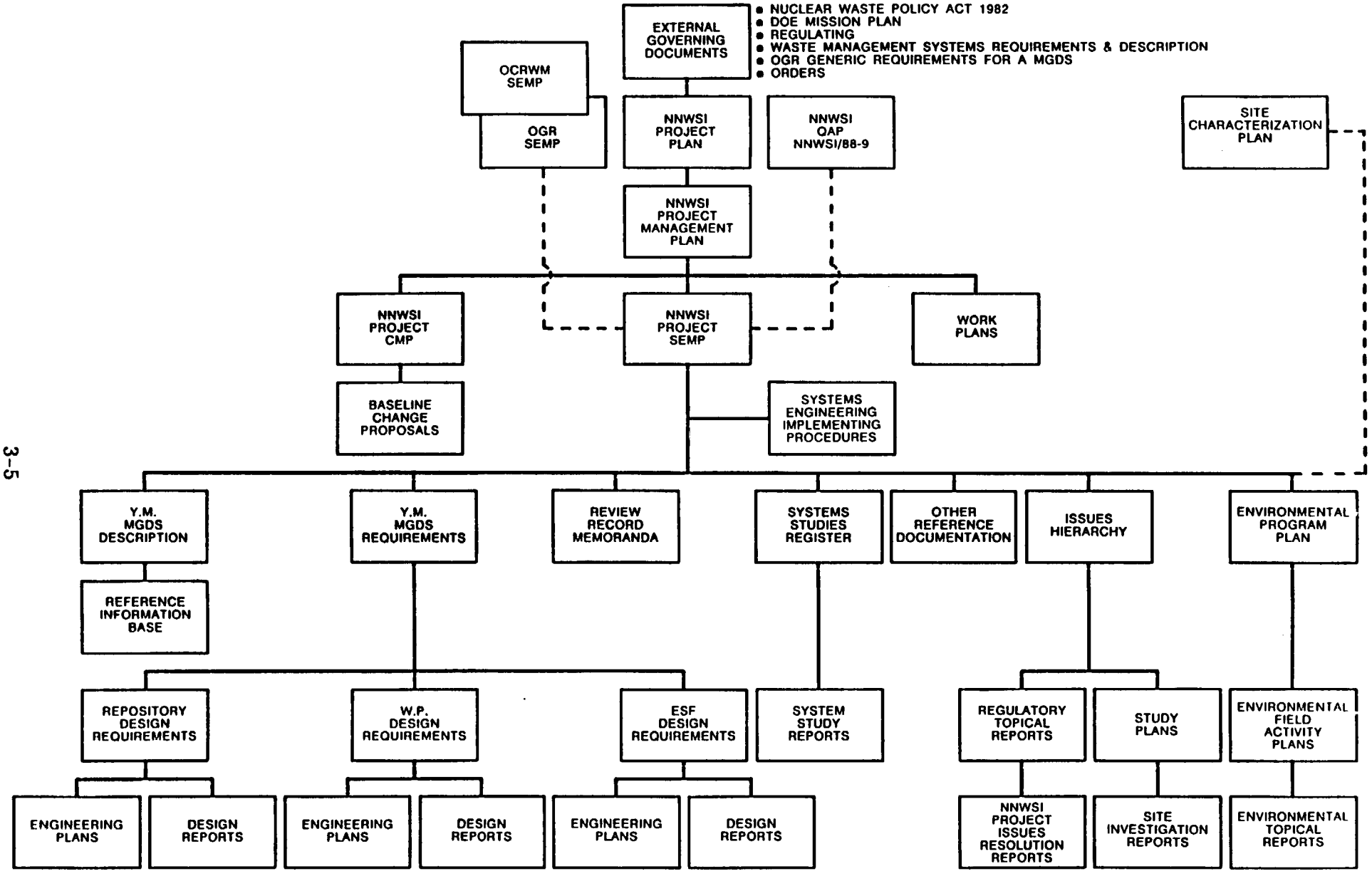


Figure 3-2. Nevada Nuclear Waste Storage Investigations Project systems engineering-related document hierarchy.

4.0 IMPLEMENTATION

The NNWSI Project is a multifaceted project with many physical, functional, and organizational interfaces. The various technical tasks must be identified, planned, and executed as a cohesive, integrated series of events. Formal monitoring and documenting of these activities is required to ensure proper communication and control.

This section describes the systems engineering process to be implemented on the NNWSI Project. Section 4.1 describes the organizational responsibilities. Section 4.2 describes the activities that are performed as part of the systems engineering process. Section 4.3 describes the Project Baseline and its management. Section 4.4 describes the integration of the Project activities.

4.1 ORGANIZATIONAL RESPONSIBILITIES

The technical responsibilities of the organizations which make up the NNWSI Project are discussed in the NNWSI PMP. The following addresses the systems engineering aspects of the organization.

The WMPO is responsible for management of the NNWSI Project and will function as the policy and decision maker for the NNWSI Project in implementing the systems engineering process described in this SEMP. The WMPO will use the Technical and Management Support Services (T&MSS) contractor to assist in managing, integrating, and documenting the NNWSI Project technical activities. Accordingly, the WMPO will direct the development and issuance of implementing procedures at both the Project and Participant level to implement the requirements delineated in this SEMP.

Participating Organizations and Nevada Test Site (NTS) support contractors are responsible for implementing systems engineering in accordance with the NNWSI Project SEMP and the NNWSI Project Administrative Procedures. Implementing procedures will be developed at the Participant level when necessary to apply requirements delineated in the NNWSI Project SEMP. These procedures include establishing the Participant's internal baseline management system for documenting the review and approval process and identification, documentation, and maintenance of internal interfaces.

At the Project level, to facilitate Project-wide interfacing, integration, and coordination of systems engineering activities, an advisory group will be established under the direction of the WMPO Project Manager (PM) and will be chaired by a member of the WMPO staff. Each Technical Project Officer (TPO) will, at the request of the WMPO PM, designate an individual or individuals to serve on this group to represent all of the technical disciplines of their organization. This group will provide a focal point for systems engineering by (1) facilitating the interorganizational interfacing, (2) serving as a consultative and advisory body for WMPO, and (3) assisting in the Project-wide implementation of the SEMP.

At the Participant level, individual group members shall be responsible for coordinating the implementation of systems engineering at their respective organizations.

4.2 ACTIVITIES

The system engineering process, described in Section 3.0, provides an orderly process for the management, integration, and documentation of the technical activities required to transform the program mission into an operational system. The technical activities include both the scientific and engineering disciplines.

This section describes the purpose of each step in the process, the policies that apply, and the reviews and documentation needed to monitor and record the Project's resolution of technical issues.

4.2.1 DEFINE REFERENCE YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM DESCRIPTION

The reference Yucca Mountain MGDS Description (SD) will provide a description of each natural and engineered subsystem that makes up the MGDS. The subsystems consist of the site, ESF, repository, and waste package. As such, the SD will include references to the system and subsystem design requirements documents.

4.2.2 DEFINE YUCCA MOUNTAIN SITE-SPECIFIC REQUIREMENTS

The definition of site-specific MGDS requirements to guide design, performance assessment, and siting activities proceeds through three integrated steps. The first step includes the development of MGDS requirements using requirements from the GR, as well as those developed by means of the tuff site functional analysis. This will include program-level legislative, regulatory, and programmatic requirements; and additional applicable state and local requirements. Requirements, determined as a result of the issues analysis will be compared to those developed by the above techniques, and discrepancies resolved.

The second step involves the allocation of the total system requirements developed in the first step to the subsystems and components that make up the site-specific MGDS.

The final step involves the identification of the technical information (and essential technical work) needed to demonstrate compliance with requirements and resolve any technical issues.

Definition of the Yucca Mountain MGDS Requirements (SR) begins with a site-specific functional analysis which is based on the project mission, as defined in the Mission Plan, and which is consistent with the MGDS functional hierarchy given in the GR. The legislative, regulatory, and programmatic requirements given in the NWPA, DOE's Mission Plan, 40 CFR Part 191, 10 CFR Part 60, 10 CFR Part 960, and any other applicable Federal, State, and local regulations are used to determine how well the MGDS functions must be performed. For the NNWSI Project, the full set of these requirements are identified in the SR document. The site selection and licensing requirements have also been organized into the NNWSI Project IH.

The legislative, regulatory, and programmatic requirements are allocated to the natural and engineered subsystems that make up the Yucca Mountain MDGS. In addition, the requirements in the NNWSI Project IH are allocated to these subsystems. For the NNWSI Project design activities, the requirement allocations are translated into design requirements in the ESFDR, RDR, and WPDR. NNWSI Project site characterization activities are translated into technical work requirements by means of study plans and engineering plans.

4.2.3 DEVELOP YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM

The Project-related planning and requirement documents (see Figure 3-2) describe the specific technical information and analyses that are needed to develop and evaluate the MGDS and to resolve each issue in the NNWSI Project IH. This process includes the definition of performance measures to be used for determining that the requirements have been met and issues have been resolved. Technical information derived from site characterization, technical investigations, and design activities will be entered into the Project RIB. The technical information and data will be used in the iterative systems engineering process to (1) evaluate and optimize the Yucca Mountain MGDS, (2) further define and guide technical work, (3) make the determination that sufficient information exists for issue resolution, and (4) ensure that the systems design and the issue resolution are consistent and adequate. Ultimately, this information and data will be used in the license application process.

4.2.4 EVALUATE AND OPTIMIZE

The purpose of evaluation and optimization activities is to ensure the preparation of comprehensive and consistent technical information for use in technical, managerial, and licensing decisions. Performance of the MGDS will be evaluated using several measures. Evaluation of trade-offs in the measures will be done to support technical decisions that optimize the NNWSI Project performance on a comprehensive basis. This section is divided into five subsections. The decision analysis subsection describes plans to ensure adequate information is available for consistent and comprehensive decisions. The remaining four subsections are an overview of plans for technical analysis to evaluate NNWSI Project performance measures in the areas of performance assessment, safety, operability, and impacts.

4.2.4.1 Decision methodology

The technical complexity of issues in the NNWSI Project and the multiple performance measures to be considered in making comprehensive decisions requires that a systematic decision methodology be used. This methodology will seek to ensure that consistent and comprehensive technical evaluations are performed and that they are adequate for decision-making purposes.

The decision methodology can be divided into three tasks: (1) the identification of potential improvements to NNWSI Project performance; (2) evaluation of the potential improvements; and (3) implementation of significant improvements. Potential improvements to current project activities will be identified as part of the development, execution, and review of scientific investigation plans, design activities, and change control activities. The goal of evaluation activities is to examine potential improvements to project

performance in a manner that is comprehensive, consistent, and appropriate for the magnitude of the potential performance gain. Implementation of potential improvements involves a decision to make a change and to conduct a review of the performance gain due to the improvement after implementation.

This activity will directly support the resolution of issues. More significant evaluations will be documented in the NNWSI Project Systems Study Register. Information from other evaluations will support the Project Baseline. Documentation of technical evaluations will also be designed to support the license application.

4.2.4.2 Performance assessment

Performance assessment is a method of predicting the postclosure performance of the repository in containment and isolation of radionuclides. This technique will be used for the evaluation of performance in comparison to system requirements and evaluation of design improvements. Performance assessment will also be used to evaluate the adequacy of scientific investigations. Potential improvements to repository postclosure performance will be documented and subjected to further evaluation under decision methodology, operability assessment, safety/risk analysis, and impact analysis activities.

4.2.4.3 Safety/risk evaluations

This performance measure includes public and worker health and safety during the preclosure period of repository operations. These evaluations will include radiological and nonradiological risks to workers and the public based on guidance on preclosure safety assessment methodology from OCRWM. This activity will identify potential design improvements to meet exposure and release limits, support both implementation of the "as low as reasonably achievable" (ALARA) philosophy of operation and the identification of items important to safety. Design improvements with potential to affect safety/risk measures will be documented and subjected to further evaluation under the decision methodology, operability assessment, and impact analysis activities.

4.2.4.4 Operability assessments

Operability assessments will be used to predict the engineering performance of the repository and life-cycle cost. Operability assessments include technical risk assessment; reliability, availability, and maintainability (RAM) analyses; life-cycle cost; and trade-off analysis. Technical risk assessment is used to evaluate and manage the development of new technologies or novel applications of proven technology. These risks include the possibility that the application will fail to meet design or performance objectives or cause significant cost overruns or schedule delays. RAM analyses seek to identify and mitigate operational problems in design. This method is accomplished by the use of failure analysis techniques to allocate system performance objectives to subsystems and components. Life-cycle cost analysis is used to predict the financial performance of the repository. The technique will be used by the NNWSI Project to evaluate design improvements, provide information to OGR for the evaluation of fee adequacy, and provide information for NNWSI Project management. Trade-off

analyses are an integral part of all technical evaluations. Sensitivity analysis techniques will be used to identify, document, and evaluate design, scientific, and operational improvements for optimizing MGDS operability performance.

4.2.4.5 Impact analysis

Impact analysis will consider the implications of NNWSI Project activities. The purpose of this activity is to show that the MGDS can meet applicable requirements for offsite impacts and to evaluate incremental impacts due to changes in the Project Baseline. Examples of these impact analyses will include environmental, social, cultural, archaeological, historical, aesthetic, biological, and socioeconomic effects. Results of the evaluations will also be used to identify mitigation strategies. These strategies would be documented for further evaluation by the decision methodology, safety/risk evaluation, and operability assessment activities.

4.2.5 REVIEWS

The NNWSI Project will conduct a series of formal reviews, consistent with NNWSI Project policies and procedures, during the D&E phase of the Project to evaluate scientific investigations and design activities. These reviews will assess the adequacy and consistency of the system requirements documentation, subsystem requirements documentation, and issue resolution documentation; determine the adequacy of the scientific investigation activities, as well as the system and subsystem designs in meeting requirements; identify technical deficiencies and risks at the earliest point in time; determine the status of technical activities relative to plans; and define actions necessary to resolve technical, schedule, or cost deficiencies.

These reviews are separated into two distinct categories:

1. Verification reviews (Section 4.2.5.1) performed by the Participants to verify system and subsystem designs; construction plans; and testing and scientific investigation activities.

2. Technical assessment review and readiness reviews (Sections 4.2.5.2 and 4.2.5.3, respectively) performed by WMPO at specified intervals to assess technical progress.

   Note that in special cases, the WMPO may decide to perform a verification activity. In those cases, the Participant is not relieved of his verification responsibilities, however, he may take credit for the activity performed.

4.2.5.1 Verification review

Verification is the process of reviewing, confirming, or substantiating data, analysis, and hardware and software design by one or more acceptable methods to ensure that (1) items meet specified safety and performance criteria, and (2) the site data and analysis accurately characterize the site.

The designs of subsystems, structures, components, and the construction and operations activities important to safety and waste isolation must be verified. The degree of verification will be commensurate with the quality level assigned. Consequently, standard verification requirements will be defined that are applicable to all NNWSI Project scientific investigation and design items. Items or activities that are identified as important to safety and waste isolation may have additional requirements defined for verification.

Each contractor who is responsible for scientific investigation or design will identify and describe in study plans, and engineering plans, verification methods to be used for each activity, subsystem, structure, or component, where verification is required.

There are four acceptable methods by which to conduct verification reviews that may be used singularly or in combination: design reviews, alternate or simplified calculations, performance of a suitable testing program, and peer review. The first three methods are normally applied in conventional processes in accordance with good engineering practice or scientific methods. When designs, design activities, or scientific activities involve use of untried or state-of-the-art data collection or analysis procedures and methods or when detailed technical criteria and requirements do not exist or are being developed, a peer review may be conducted.

The rationale for the choice of verification method, including assumptions and decision criteria used, will be documented in the appropriate engineering plan or study plan.

4.2.5.2 Technical assessment review

As required by the OGR SEMP, the WMPO will conduct reviews at the Project level to assess site-specific MGDS requirements; to determine the adequacy of subsystem designs with regard to meeting the MGDS requirements, to identify technical deficiencies at the earliest point in time, including interfaces with site efforts versus design efforts; and to direct necessary changes. At a minimum, technical assessment reviews may be conducted by the WMPO upon completion of each major design phase and significant site characterization activity.

These reviews, in addition to ensuring that the specified requirements are satisfied, will evaluate the progress toward risk reduction/resolution; assess the compatibility of the physical and functional interfaces among facilities, hardware, software, personnel, and procedures; and assess the adequacy of the scientific investigation efforts.

Results of the technical assessment review will be clearly documented in Review Record Memoranda and will include resolution of all comments.

4.2.5.3 Readiness review

Readiness reviews are conducted by the WMPO with support from the designated Participants as required. They are to be planned, performed, and documented at determined hold-point phases of design, construction, testing,

and operation of a facility (or other activity) as a means of providing visible, objective, and independent evidence that

1. Work activity prerequisites have been satisfied.

2. Administrative and technical procedures have been reviewed for adequacy and appropriateness, and have been issued/released.

3. Personnel have been suitably trained and qualified.

Readiness reviews will be documented in accordance with Project policies and procedures.

4.3 THE NNWSI PROJECT BASELINE

DOE Order 4700.1 defines a baseline as a "quantitative expression of projected costs, schedule, or technical progress to serve as a base or standard for performance of an effort." The NNWSI Project Baseline is needed for Project execution, control, decision-making, and reporting. It provides the criteria against which Project progress is measured and supplies a traceable record of the design and siting process.

4.3.1. DESCRIPTION OF NNWSI PROJECT BASELINE

The Project Baseline constitutes a set of controlled information that WMPO has placed or will place under configuration management (i.e., change control). Specifically, Project Baseline documentation will generally have one or more of the following characteristics:

1. It defines the configuration of all or part of the MGDS, functionally or physically.

2. It characterizes processes that result in the definition of the MGDS configuration.

3. It dictates requirements to be fulfilled by the MGDS.

4. It delineates the organization of NNWSI Project activities, the schedules planned to meet Project objectives, or the budget authorized for performance of the work.

5. It defines the organization of the Project objectives necessary to address regulatory compliance and licensing, the strategies to be used in the pursuit of the objectives, or the Project's demonstration of fulfillment of the objectives.

The NNWSI Project Baseline consists of two elements: management and technical. Each element has unique characteristics, which are described below.

The management element of the NNWSI Project Baseline encompasses the cost and schedule baselines required per DOE Order 4700.1, by including the

following: Work Breakdown Structure (WBS), WBS Dictionary, budget baseline, cost plans, and major milestone schedules.

The technical element of the NNWSI Project Baseline includes selected documents generated by technical activities as a result of implementing the systems engineering process. The types of documents to be included in the technical element are requirements documents, description documents, interface control documents, documents describing how site characterization and technical investigation activities are conducted, and the NNWSI Project RIB.

4.3.2. MANAGEMENT OF NNWSI PROJECT BASELINE

Configuration management provides the process for managing the NNWSI Project Baseline. The configuration management process, which is further described in the NNWSI Project CMP, consists of four elements:

1. Configuration Identification, which consists of identifying the documents selected for configuration management.

2. Change Control, which ensures that when a baseline is established, all changes are thoroughly evaluated and approved before implementation.

3. Status Accounting, which keeps track of pending and approved changes for Project management visibility, and catalogs and distributes documents contained in the Project Baseline.

4. Configuration Audits, which ensure that configuration management records are accurate and complete.

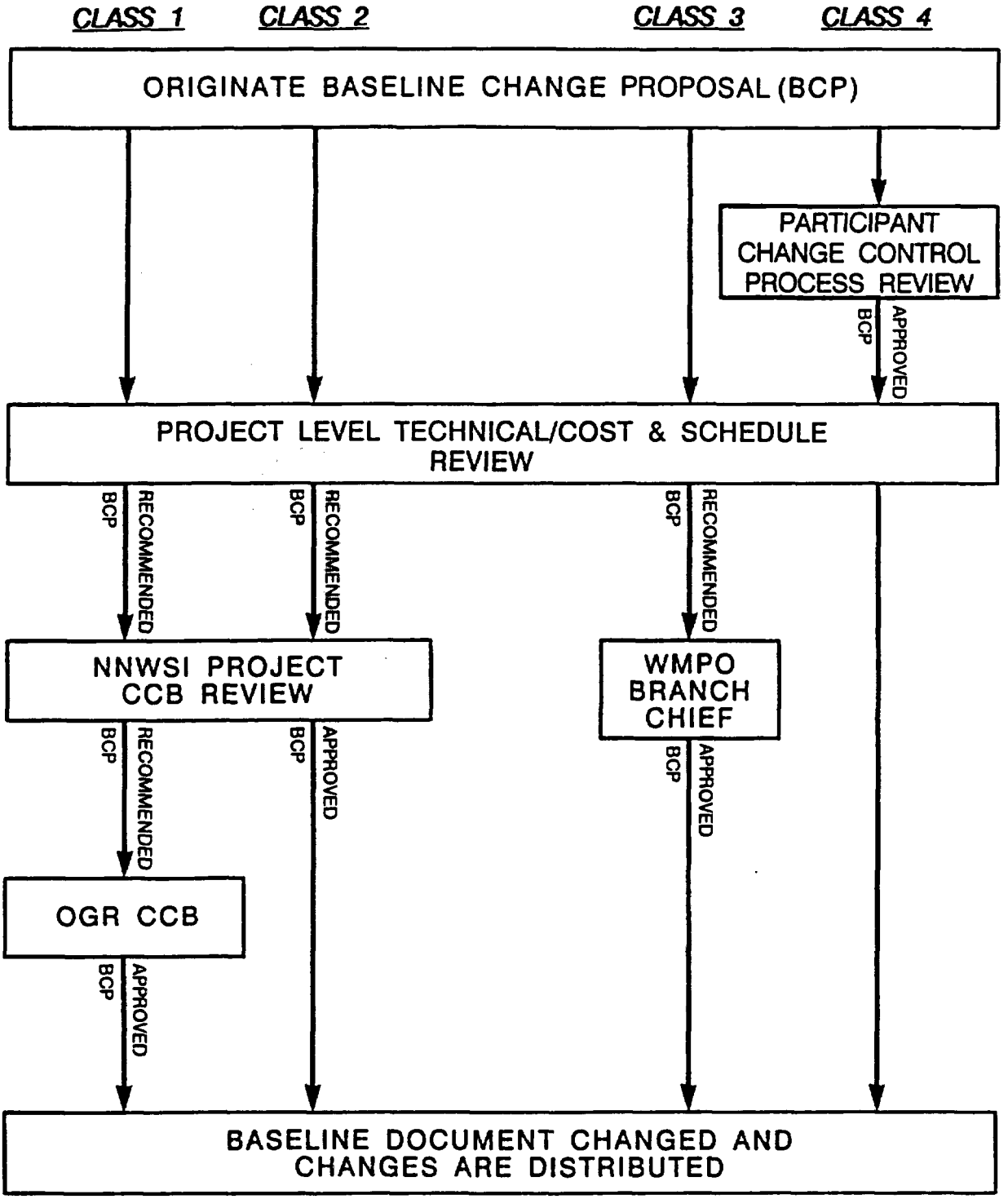
The change control process governed by the NNWSI Project CMP is briefly described here.

Four change classes will be used for the NNWSI Project. The classification assigned to a proposed change will dictate the level of Project management that must approve it. If different classifications result from impact evaluation, the highest classification level will apply for approval. The criteria and approval authority for each class is shown in Table 4-1. The NNWSI Project change review process for class 1, 2, and 3 changes is shown in Figure 4-1. For class 1 changes, the NNWSI Project Change Control Board (CCB) action is to accept or reject a recommendation to forward the proposed change to the OGR CCB for approval or disapproval. For class 2 changes, the NNWSI Project CCB approves or disapproves a proposed baseline change for implementation. For class 3 changes, the affected WMPO Branch Chief approves or disapproves the proposed change. For class 4 changes, the participant TPO approves or disapproves the proposed change.

If a proposed change affects	Then the change is	Then the approval authority is
• OGR Baseline • OGR policy and positions	Class 1	OGR Change Control Board (CCB)
• WBS responsibility of more than one WMPO Branch Chief • NNWSI policy or positions	Class 2	NNWSI Project CCB
• WBS responsibilities of one WMPO Branch Chief and two or more project participants	Class 3	WMPO Branch Chief affected by the change
• Only one project participant	Class 4	Technical Project Officer of affected participant

Table 4-1. Change classification and approval

(PROJECT ORIGINATED)



CCB	CHANGE CONTROL BOARD
NNWSI	NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
OGR	OFFICE OF GEOLOGIC REPOSITORIES
WMPO	WASTE MANAGEMENT PROJECT OFFICE

Figure 4-1. Baseline change flow.

4.4 INTEGRATION ACTIVITIES

Integration activities, including systems integration and technical integration are a major component of systems engineering on the NNWSI Project. Systems integration is a process to ensure that Project interfaces are defined, developed, documented, and controlled at an appropriate level within the NNWSI Project. Technical integration is a process to ensure that the appropriate technical disciplines are utilized to perform and integrate the various Project technical tasks.

4.4.1 SYSTEMS INTEGRATION

Systems integration is a process used to identify, develop, and document interfaces on a project. Included in systems integration is the control of these interfaces to ensure that changes to these interfaces do not compromise the compatibility of the overall system design and function. On the NNWSI Project, the scientific investigations and the design process will be integrated to ensure that (1) data generated support design and performance assessment needs, and (2) total system requirements are satisfied.

Interfaces will be identified, developed, documented, and controlled at the system, subsystem, and component level. These interfaces may be both functional and physical in nature. Interface requirements will be identified in the requirements documents for the system, subsystem, or component. Interface control drawings will be used to document both the functional and physical interfaces. The RIB will be used to document the interfaces between scientific investigation activities and design and performance assessment activities. Documents that identify interfaces will be controlled through the baseline management process.

4.4.2 TECHNICAL INTEGRATION

Technical integration is a process to ensure that the appropriate technical disciplines are utilized to perform the technical activities on a project and that these activities have been integrated with one another. A Project Baseline will be developed to manage the requirements and products of these technical activities.

4.4.2.1 Input to major program documentation

The NNWSI Project technical activities are defined in a process that starts with system requirements and issues as described in the SR and NNWSI Project IH. The system requirements and the requirements developed from the NNWSI Project IH are compared and correlated to assure completeness and compatibility. It then proceeds through design development, issues resolution strategy, and performance allocation, resulting in a detailed description of the site characterization and evaluation, design, and performance assessment tasks needed to develop a MGDS that meets system requirements.

As shown in Figure 4-2, NNWSI Project Participants perform site characterization field and laboratory experiments, design, and various analyses and trade-off studies that are documented in

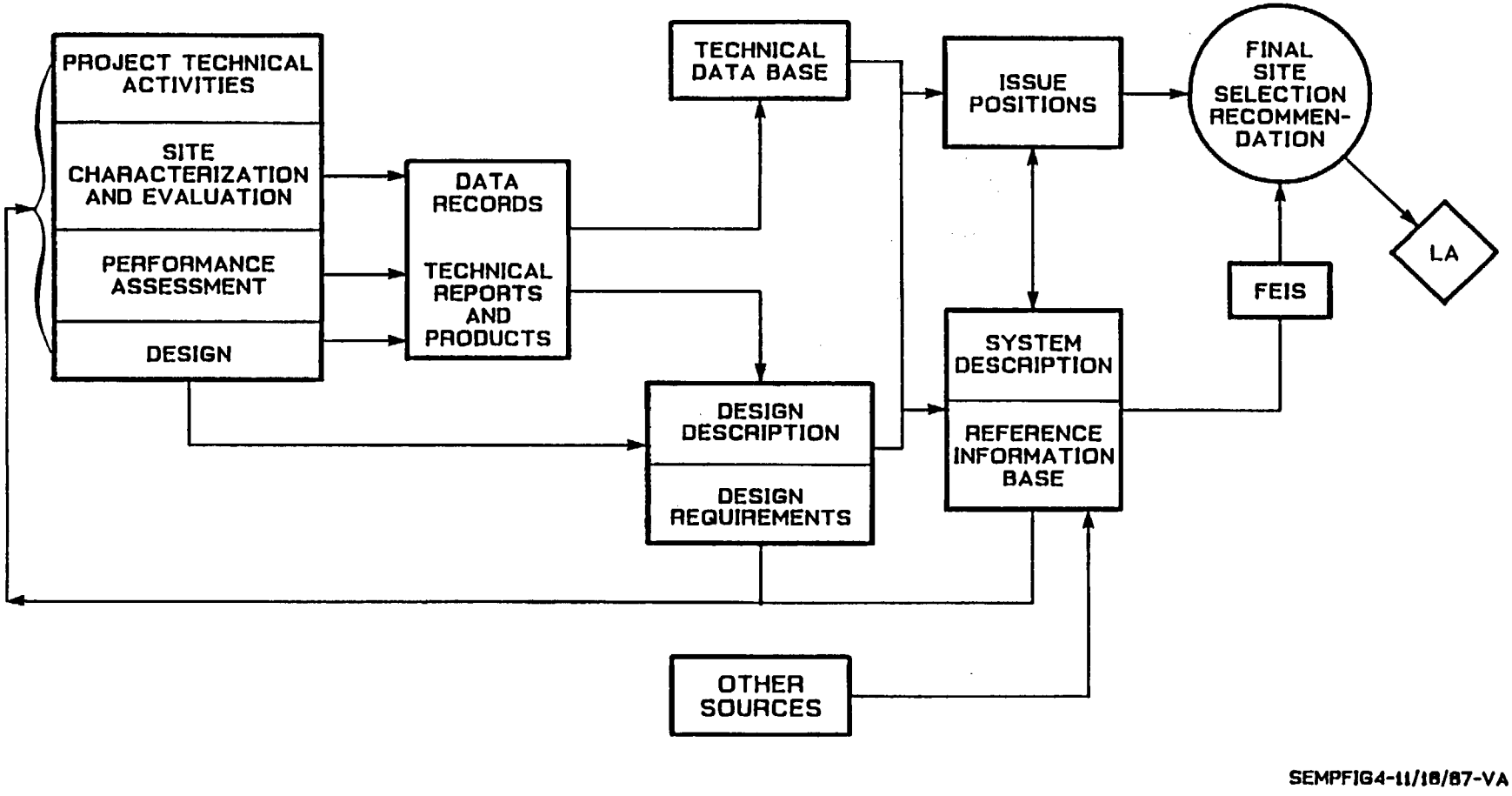


Figure 4-2. Flow of Project technical information.

1. Data records containing experiment and test results reduced to a useable form.

2. Associated technical reports and other products that interpret data or contain the results of studies and analyses.

Technical data records will be managed in accordance with the NNWSI Project Records Management Plan. Selected information from data records maintained by Participants, technical reports, and other technical products are candidates for entry into the RIB and the SD. The RIB and the SD contain information about the performance of the subsystems that make up the MGDS and the evolving descriptions of the natural and engineered parts of the MGDS.

Project designers use information from the RIB to develop the configuration of the engineered subsystems of the MGDS. This physical configuration is contained in the design descriptions included in the design reports for the advanced conceptual design (ACD), license application design (LAD), and FPCD. Design requirements contained in the RDR, WPDR, and ESFDR direct the development of the design for the engineered subsystems of the MGDS.

Data from the RIB also provide the information for the development of the Project's positions on the resolution of the technical issues including those described in the NNWSI Project IH. These positions are documented in Issue Resolution Reports. Data from the RIB and reference designs are used in performance assessment to provide an iterative feedback on how design and site are used to meet regulatory requirements, and to provide final input to the Safety Analysis Report (SAR) that is part of the license application.

During the ACD and early-LAD design phases of the MGDS development, the information flow cycle just described is repeated. Information from the SD, RIB, and the Regulatory Topical Reports (RTRs) that form the basis for Issue Resolution Reports is used to further refine site characterization and evaluation, performance assessment, and design activities. The iterative nature of the development process for Project positions, SD, and RIB will lead to the development of an MGDS with a high likelihood of meeting the phased system mission objectives and system requirements in addition to site-selection and licensing requirements.

The NNWSI Project Issue Resolution Reports, SD, Environmental Topical Reports (ETRs), and RIB will be the principal sources of information for the Final Environmental Impact Statement (FEIS). Toward the end of the LAD phase, information from these documents will be used to support the DOE site-selection process, and license application to the NRC.

4.4.2.2 Integration of site characterization

Site characterization includes the field and laboratory work in the geological sciences. The site studies will provide data for use in the NNWSI Project's design and performance assessment activities, as well as for characterization of the natural subsystem of the MGDS. The results of site characterization activities will be incorporated in the RIB.

The requirements for site characterization will be developed from the SR and the NNWSI Project IH. As part of the process, performance allocation will be used to identify site data, including the required accuracy and precision needed for design and performance assessment.

Functional models of the physical and chemical processes that must be addressed in design and performance assessment will be developed from descriptive models of the site. The functional models will be used in design and performance assessment activities to define MGDS design parameters and requirements. Performance assessment activities will use the models to evaluate natural (site) and engineered subsystem performance.

Interfaces between the site and engineered parts of the MGDS will be identified. The RIB will serve to communicate and document the information needs between site characterization activities and design and performance assessment. Scientific investigation interfaces will be discussed in the documents describing how the investigations will be conducted, such as the Study Plans. The Site Atlas and the Field Activities Plan will contain reference information for the interface between (1) inter-Project and intra-Project surface-based testing activities, and (2) surface-based site characterization and ESF-based scientific investigations.

Periodic reviews of site characterization activities will provide ongoing evaluation of the performance allocations and issue resolution strategies developed to resolve site-related issues in the NNWSI Project IH and to demonstrate compliance with site-related requirements in the SR.

The NNWSI Project will integrate site activities with OCRWM-level, OGR-level, and NNWSI Project-level activities by participation in coordinating groups. NNWSI Project-level coordinating groups and Project participation in OCRWM- and OGR-level groups will meet the requirements in Section 4.4.2.11.

4.4.2.3 Integration of repository design

The technical approach to repository design will be described in NNWSI Project planning documents, including detailed descriptions of repository design activities found in work plans. Repository design during the D&E phase of MGDS development will be conducted in three activities:

1. Site Characterization Plan Conceptual Design (SCP/CD).

2. Advanced Conceptual Design (ACD).

3. License Application Design (LAD).

System requirements that guide repository design will be identified in the SR, and will include those resulting from design-related parts of the NNWSI Project IH. System requirements and other design requirements will be incorporated into the design process by means of the NNWSI Project RDR. The description of the RDR is in Section 5.2.4. Performance allocation of requirements in the SR document will be used to identify site information needed to support repository design. The initial performance allocation will be accomplished prior to ACD and reflected in the SCP and the RDR.

Systems studies will be performed to support the development of the MGDS. These studies will include trade-off studies, cost-effectiveness analyses, and other supporting analyses. These studies will identify alternatives for meeting MGDS functional requirements, evaluate the alternatives under consideration, and provide formal documentation to support decisions in the development of the MGDS. Systems study reports to evaluate and select design alternatives are described in Section 5.2.8.

Repository designers will refer to the Site Atlas and the Field Activities Plan for reference information concerning (1) historical impacts of field explorations on the Yucca Mountain site (Site Atlas), and (2) planned field explorations (Field Activities Plan). These documents will contain detailed information (e.g., exploratory borehole locations, depths, sizes, type, and amount of drilling fluids, etc.) about field activities.

The physical interface between the repository and the ESF (including underground testing) will be managed through the use of interface control documentation of the Repository-ESF in the RDR and ESFDR. Interfaces between design and information gathering site characterization activities will be managed through the use of the NNWSI Project RIB. The interface between repository and waste package design will be managed through the use of the interface control documentation of the Repository-Waste Package in the RDR and WPDR. Interfaces among repository subsystems, components, structures, and facilities will be managed by appropriate interface control documentation in the RDR. Interfaces between the repository, and external entities or systems will be defined and managed through the RDR. Interfaces between the site and the repository will be managed through the use of the NNWSI Project SR, RIB, and RDR.

Changes to repository design-related parts of the technical element of the NNWSI Project Baseline will be made according to the requirements in Section 4.3.2. Design products, design drawings, and products that are not amenable to inclusion in the RIB (other reference documentation) will be managed according to the requirements in Section 4.3.2.

Periodic technical assessment reviews will be conducted to evaluate the status of the developing MGDS design. Where possible, these reviews will be conducted in conjunction with scheduled repository design verification reviews.

The NNWSI Project will integrate repository design activities with OCRWM-level, OGR-level, and NNWSI Project-level activities by participation in coordinating groups. NNWSI Project level coordinating groups and Project participation in OCRWM- and OGR-level groups will meet the requirements in Section 4.4.2.11.

4.4.2.4 Integration of waste package design

The technical approach to waste package design will be described in planning documents for waste package design, fabrication, and prototype testing. Detailed descriptions of waste package design activities are found in the Work Plans.

Site-specific definitions, functional requirements, performance criteria, constraints, and interfaces for the Waste Package Subsystem will be documented in the SR. These system requirements will be further developed in the WPDR to guide the design process. A description of the WPDR is in Section 5.2.5. The performance allocations and design goals established for the Waste Package Subsystem will be reviewed throughout the D&E phase.

System studies to evaluate and select design alternatives are described in Section 4.4.2.3.. The system studies and other waste package design analyses resulting from the performance allocation process described in SCP Chapter 8, the RDR, and the WPDR will be documented in design reports or system study reports. Systems study reports are described in Section 5.2.8.

Interfaces between waste package design, performance assessment activities, and information gathering activities associated with site characterization will be managed through the use of the NNWSI Project RIB. The interfaces between waste package and repository design activities will be managed through the use of the interface control documentation of the Waste Package-Repository in the RDR and the WPDR. Interfaces among waste package components will be managed by appropriate interface control documentation in the WPDR. Interfaces between the waste package, and external entities or systems will be defined and managed through the use of the WPDR. Interfaces between the site and the waste package will be managed through the use of the NNWSI Project SR, RIB, and WPDR.

Changes to waste package design-related parts of the technical element of the NNWSI Project Baseline will be made according to the requirements in Section 4.3.2.

Periodic technical assessment reviews of the Waste Package Subsystem will be conducted in accordance with OGR and NNWSI Project SEMP requirements. Where possible, these reviews will be conducted in conjunction with previously scheduled waste package design verification reviews.

The NNWSI Project will integrate waste package design activities with OCRWM-level, OGR-level, and NNWSI Project-level activities by participation in coordinating groups. NNWSI Project-level coordinating groups and Project participation in OCRWM- and OGR-level groups will meet the requirements in Section 4.4.2.11.

4.4.2.5 Integration of Exploratory Shaft Facility design

ESF design, construction, and inspection activities are scheduled to progress through the following phases:

1. Conceptual.
2. Title I.
3. Title II.
4. Title III.

During the Conceptual phase, an ESFDR document will be prepared. A description of the ESFDR is in Section 5.2.6. The ESF design requirements

will be developed by functional analysis which will be consistent with the ESF generic requirements described in Appendix E to the GR, the site-specific requirements in the SR, and the ESF test requirements described in study plans and engineering plans. Prototype tests will be written for tests and experiments designed to demonstrate new experimental techniques to be employed in the ESF. Functional requirements allocation will be used to develop design specifications for ESF subsystems assemblies and components.

ESF designers will refer to the Site Atlas and the Field Activities Plan for reference information concerning historical and planned impacts of field explorations at the Yucca Mountain Site. Functional interfaces within the ESF and with the MGDS and site characterization activities will be identified, documented, and controlled. Physical interfaces with the repository will be managed through the use of interface control documentation of the Repository-ESF in the RDR and ESFDR. Interfaces between design and information gathering activities associated with site characterization will be managed through the use of the Project RIB. Interfaces between the ESF and the site will be managed through the use of the NNWSI Project SR, RIB, and the ESFDR.

Changes to ESF-related parts of the technical element of the NNWSI Project Baseline will be made according to the requirements in Section 4.3.2.

The NNWSI Project will integrate ESF design/testing activities with OCRWM-level, OGR-level, and NNWSI Project-level activities by participation in coordinating groups. NNWSI Project-level coordinating groups and Project participation in OCRWM- and OGR-level groups will meet the requirements in Section 4.4.2.11.

4.4.2.6 Integration of performance assessment

The technical basis for performance assessment to demonstrate compliance with SR and to resolve performance assessment issues in the NNWSI Project IH is discussed in Section 8.3.5 of the NNWSI Project SCP, and associated plans and technical procedures. Detailed descriptions of performance assessment activities are found in the Work Plans.

The requirements against which preclosure and postclosure MGDS performance are measured will be taken from the SR. The assessments of preclosure and postclosure performance will use applicable properties that are traceable to the RIB. Performance assessment results will be used to identify the systems, structures, and components important to safety as well as barriers important to waste isolation. The preclosure performance assessment process will use risk assessment to identify the repository structures and components that are important to safety. Risk assessment studies will identify the release and exposure scenarios associated with items important to safety. Requirements for the design of these items will be refined and documented in the RDR, ESFDR, and WPDR for incorporation into the design.

Assessments of impacts on preclosure and postclosure performance will be a part of system studies that evaluate design alternatives for the engineered parts of the MGDS. The plans for performance assessment and other systems studies are described in study plans and engineering plans.

Performance assessment results will be used as appropriate in periodic reviews of performance allocation to meet SR requirements and the strategy for resolving the issues in the NNWSI Project IH. Appropriate performance assessment will be included in the analyses that support proposed changes to the NNWSI Project Baseline.

The NNWSI Project will integrate performance assessment activities with OCRWM-level, OGR-level, and NNWSI Project-level activities by participating in coordinating groups. NNWSI Project-level coordinating groups and Project participation in OCRWM- and OGR-level groups will meet the requirements in Section 4.4.2.11.

4.4.2.7 Integration of environmental and socioeconomic assessment

The general organization and management of environmental and socioeconomic assessment activities are described in the NNWSI Project Environmental Program Plan (EPP). Specific requirements related to the MGDS subsystems are included in the SR and further definitized in the subsystem requirements documents.

Periodic environmental and socioeconomic assessment studies are described in the Annual Socioeconomic Studies Plan, Cultural Resources Studies Plan, Biological Studies Plan, Environmental Impact Statement Implementation Plan, Environmental and Socioeconomic Monitoring and Mitigation Plans, Meteorological Monitoring Plan, and Radiological Monitoring Plan. The system studies and other environmental and socioeconomic assessments, resulting from the performance allocation process documented in the EPP, will be described in scientific investigation plans and procedures. These studies will use information that is traceable to the RIB and will be based on the requirements in the SR.

Scientific investigation interfaces will be discussed in the documents that describe how the investigation will be carried out.

The NNWSI Project will integrate environmental and socioeconomic assessment activities with OCRWM-level, OGR-level, and NNWSI Project-level activities by participation in coordinating groups. The Project also participates in the DOE's ongoing program of consultation and cooperation with the states and affected Indian Tribes and a broad spectrum of public comment and involvement in efforts to mitigate the socioeconomic impact of waste management. NNWSI Project-level coordinating groups and Project participation in OCRWM- and OGR-level groups will meet the requirements in Section 4.4.2.11.

4.4.2.8 Integration with Project management

The WMPO will use the systems engineering methodology to manage the NNWSI Project's Baseline and to integrate all technical activities. To carry out the entire Project effectively and efficiently, it is desirable that the technical activities be carried out within budgetary and schedule constraints. The DOE policies require that a management element of the Project Baseline consisting of the Project's budget and schedule be maintained and managed by the WMPO.

The NNWSI Project is a complex project that must combine aspects of research and development with engineering to develop a safe, cost-effective, licensable MGDS. Managing the resources and schedule of the Project in a way that will accomplish the Project's mission requires decisions made with full cognizance of cost, schedule, and technical ramifications. Systems engineering's roles in (1) the definition and management of the technical element of the NNWSI Project Baseline, and (2) definition and management of the interfaces among the Project's technical activities will provide Project management with the perspective and information needed to make informed decisions.

4.4.2.9 Integration with regulatory and institutional

The NNWSI Project will use a systems engineering approach to maintain close coordination between the regulatory activities, scientific investigations, engineering and design activities, cost and scheduling activities, and the environmental and socioeconomic impact assessment activities that will provide information required for the LA, Environmental Impact Statement (EIS), and the Site Selection Report.

The NNWSI Project regulatory function is responsible for identifying and interpreting applicable regulatory requirements specified by the NRC (10 CFR Part 60), the U.S. Environmental Protection Agency (EPA) (40 CFR Part 191), the DOE (10 CFR Part 960), the National Environmental Policy Act, DOE Orders, and OGR policy regarding environmental protection and nuclear safety, and other applicable Federal, State, and local statutes and for establishing the Project's regulatory compliance strategy. The NNWSI Project will integrate the regulatory requirements, regulatory compliance activities, and scientific evaluations into Project activities, including waste package and repository design and engineering studies.

The NNWSI Project will integrate the regulatory and institutional activities with other Project activities. Examples of integration activities are as follows:

1. Identification of issues that will have to be resolved to demonstrate compliance with regulations.

2. Development of the regulatory compliance strategy jointly with the scientific and systems staff and development and documentation of the issue resolution process.

3. Coordination of all regulatory agencies interactions with the DOE, as well as with Project Participants.

4. Identification and management of the development of supporting documents needed for the LA and the EIS.

5. Provision of timely direction and interpretation of regulatory requirements during preparation of requirements documents, site characterization and study plans, and engineering and design plans and studies.

6. Development of the EPP in conformance with the issue resolution process and DOE direction.

4.4.2.10 Integration with quality assurance

Quality Assurance (QA) and systems engineering are both integral parts of the NNWSI Project. Systems engineering ensures that the technical work of the Project is adequate to demonstrate compliance with licensing requirements. In addition, 10 CFR Part 60 requires that QA be used to ensure that this technical work has been done in a way that will lead to a product that is defensible in a licensing proceeding.

The systems engineering approach to be used on the NNWSI Project will be in compliance with NNWSI Project QA Plan, NNWSI/88-9 (DOE, 1988b), which includes the QA requirements identified for use on the NNWSI Project. All Participating Organizations, including the NTS support contractors, have developed and are implementing their own QA Program Plans (QAPP) and procedures in conformance with NNWSI/88-9. These documents identify the requirements that apply to their organization and the measures to satisfy these requirements.

The NNWSI Project SEMP incorporates by reference the QA requirements established in NNWSI/88-9. These requirements include provisions for the control of scientific investigations, design input, review and approval of design documents, change control, and design interface control.

The NNWSI Project SEMP describes the process whereby the NNWSI Project will identify and manage interfaces among Project technical activities. This description is intended to describe the way in which Project design and scientific investigation activities will meet the interface document and control requirements in NNWSI/88-9.

4.4.2.11 Integration with coordinating groups

Coordinating groups are an important part of technical integration in the NNWSI Project. OCRWM-level, OGR-level, and NNWSI Project-level coordinating groups will be used to support technical integration activities. Project participation in OCRWM- or OGR-level coordination groups will be in accordance with directives by the OCRWM or OGR. Participation in Project-level coordinating groups will be in accordance with requirements in this SEMP.

The formation of Project-level coordinating groups will be at the direction of the WMPO and the performance of these groups will be coordinated by the WMPO. To minimize duplication and conflicts, and to ensure integration of the various groups, a charter will be prepared and submitted to WMPO for WMPO approval. This charter will address items such as purpose, responsibilities, period of performance, and reporting requirements. In addition, coordinating groups will be periodically evaluated by the WMPO to determine their benefit and contribution to the Project.

5.0 DOCUMENTATION

5.1 RESPONSIBILITIES AND AUTHORITY

The WMPO is responsible for ensuring the systematic development of all documentation required to implement this SEMP and for ensuring that those documents that require baselining are identified, installed, and controlled as part of the NNWSI Project Baseline.

5.2 NNWSI PROJECT SYSTEMS ENGINEERING DOCUMENTATION

Systems engineering documentation plays a critical role in defining what will be done and how it is organized. It provides the controls for the conduct of the work, and it records the products of the work. These documents are identified and developed, changes to them are arranged, and their status is continually accounted for in accordance with the NNWSI Project SEMP and appropriate implementing procedures. Brief descriptions of systems engineering documentation that will support the Project-wide implementation of this SEMP are contained in this section and the organizational responsibilities for preparation, review, acceptance, and approval are provided in Table 5-1.

5.2.1 SYSTEMS ENGINEERING MANAGEMENT PLAN

The NNWSI Project SEMP will provide for integration of technical tasks and for the development and management of the technical element of the Project Baseline.

5.2.1.1 Systems engineering implementation procedures

Project Participants may propose additions, or changes, to existing quality assurance, or administrative procedures when analysis has shown that the existing procedures do not adequately implement a systems engineering requirement.

5.2.2 YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM DESCRIPTION

The level of detail of information included in the Yucca Mountain MGDS Description (SD) will increase with time. The SD will be updated as necessary during each phase of MGDS development and at the end of each design or siting phase. At a minimum, the SD will include the following: (1) The purpose of the subsystem, including its role in meeting safety requirements, if appropriate; (2) A description of the subsystem, including, as appropriate, dimensions, important characteristics, and reference data to be used in describing the subsystem; and (3) A physical description of the subsystem features that interface with other subsystems.

5.2.3 YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM REQUIREMENTS

The Yucca Mountain MGDS Requirements (SR) document is based on the GR and provides a description of the functions to be performed by the

Table 5-1. Organizational responsibilities for preparation, review, acceptance, and approval of Yucca Mountain MGDS technical documentation

Document	Prep	Review	Accept	Approve	Note
System Engineering Management Plan	T&MSS	WMPO		OCRWM	1
System Description	SNL	WMPO		OCRWM	2
Site Subsystem Description	SNL	WMPO		OCRWM	2
Repository Subsystem Description	SNL	WMPO		OCRWM	2
Waste Package Subsystem Description	LLNL	WMPO		OCRWM	2
ESF Subsystem Description	T&MSS	WMPO	WMPO		
System Requirements	SNL	WMPO		OCRWM	3
Repository Design Requirements	SNL	WMPO		OCRWM	3
Waste Package Design Requirements	LLNL	WMPO		OCRWM	3
Exploratory Shaft Design Requirements	T&MSS	WMPO		OCRWM	3
Systems Studies Register	SNL	SNL		WMPO	
Systems Study Reports	PP	PP	WMPO		
Site Investigation Reports	PP	PP	WMPO		
Design Reports	PP	WMPO	OCRWM		
Reference Information Base	SNL/PP	SNL	WMPO	OCRWM	2
Issues Hierarchy	PP	PP	WMPO		
Regulatory Topical Reports	PP	WMPO	OCRWM		
Site Characterization Plan	PP	WMPO		OCRWM	4
Study Plans	PP	WMPO	OCRWM		5
Engineering Plans	PP	WMPO	WMPO		
Issues Resolution Reports	T&MSS	WMPO	OCRWM		

Table 5-1. Organizational responsibilities for preparation, review, acceptance, and approval of Yucca Mountain MGDS technical documentation (continued)

Accept: This term indicates that the document is suitable for use by Project personnel. It does not indicate authentication of the technical data or interpretations contained in the document, nor does it relieve the preparer of responsibility for the defense of the technical data or interpretations.

Approve: This term indicates agreement with form, tenor, and details of administrative and management documents. Use of this term does not relieve the document preparer of the responsibility to fulfill contractual obligations.

Concurrence: This term indicates agreement that the document is suitable for use by Project personnel. Although not used in the table, this term is defined to provide a complete set of project definitions for project actions with respect to endorsement of documents.

Review: A documented traceable review of the documents. For the purposes of this chart, reviews performed by parties other than the preparer do not relieve the preparer of the responsibility for verification activities, nor do they take the place of such verification activities.

Notes:

1. This approval applies to the primary document (i.e. since appendices are included for the convenience of the project, their acceptance will be by WMPO, and approval by OCRWM is not required.)

2. Approval of OCRWM required at the initial release and at the completion of each design or siting phase. Changes during the phase must be approved by the preparing Project Participant.

3. This approval applies only to the initial release. Subsequent changes which impact the GR must be proposed to OCRWM against that document. WMPO will notate those requirements which are under their control. Changes to the requirements so designated must be approved by WMPO. All other changes must be approved by the Project Participant who prepared the document.

4. The document will neither be controlled nor baselined. Substantive changes, including additional data, as described in the study plans, engineering plans, system descriptions, design reports, system study reports, site investigation reports, etc., will be provided to OCRWM at six month intervals for potential inclusion in the semiannual SCP progress reports.

5. OCRWM review and acceptance will be obtained prior to proceeding with the work; however, only substantive changes need be submitted to OCRWM for acceptance.

prospective MGDS at Yucca Mountain; an identification of the requirements that the MGDS will meet; and a detailed allocation of each requirement to the MGDS subsystems that will work together to meet the requirement.

As required by the OGR, the SR will also define the physical subsystems that make up the Yucca Mountain MGDS. The system requirements associated with MGDS function will also be allocated to the physical subsystems of the MGDS.

The SR will be used by NNWSI Project Participants in the development of design and site characterization requirements that direct Project technical work.

5.2.4 REPOSITORY DESIGN REQUIREMENTS

The purpose of the Repository Design Requirements (RDR) is to provide design requirements for the surface facilities, the shafts and ramps, and the underground facilities of the Yucca Mountain MGDS. The requirements document will include requirements in terms of functions, performance criteria, constraints, and interfaces. The RDR will provide

1. A basis for monitoring, reviewing, and controlling the repository subsystem design during ACD, LAD, and FPCD.

2. A basis for identification and evaluation of methods of shaft, ramp, and underground opening construction that will minimize disturbance of the natural barriers.

3. Data to be used in assessment of whether construction, operation, closure, and decommissioning of the MGDS will impair the ability to meet the performance objectives stated in 10 CFR Part 60.

4. The basis for defining the underground facilities, equipment, and operations.

5. The basis for defining the surface facilities, equipment, and operations.

6. A basis for defining resources requirements.

7. Identification of intra-repository and extra-repository interfaces.

5.2.5 WASTE PACKAGE DESIGN REQUIREMENTS

The purpose of the Waste Package Design Requirements (WPDR) is to define the functions of the MGDS allocated to the waste package subsystem; define how and how well those functions are to be performed; and define what environment the waste package must function in, what the waste package is to contain, how the package will be handled and under what conditions the waste package must function. The requirements document will include requirements in terms of functions, performance criteria, constraints, and interfaces. This information will be used by the Project to communicate design requirements for the waste package designs to OGR, to other organizations

within the Project, and to design contractors. Requirements will be derived from the SR.

5.2.6 EXPLORATORY SHAFT FACILITY DESIGN REQUIREMENTS

The purpose of the Exploratory Shaft Facility Design Requirements (ESFDR) is to provide design requirements for the surface and underground facilities that make up the ESF. The requirements document will include requirements in terms of functions, performance criteria, constraints, and interfaces. The ESFDR will provide the following:

1. A basis for monitoring, reviewing, and controlling the design, construction, and testing phases of the ESF.

2. Identification and evaluation of methods of shaft construction that will minimize disturbance of the MGDS subsystems that will serve as natural barriers after MGDS closure and decommissioning.

3. Data to be used in assessment of whether construction of the exploratory shaft will impair the repository performance objectives stated in 10 CFR Part 60.

4. Definition of underground test areas to achieve integration of the ESF into repository design.

5. Definition of surface facilities to support shaft construction and operation, underground testing, and test data handling and to minimize environmental disturbance to the area.

6. Definition and control of the interfaces between the ESF and the other subsystems of the MGDS.

The design requirements will be correlated explicitly with the MGDS subsystem structure and requirements in the SR.

5.2.7 SYSTEMS STUDY REGISTER

A register of the systems studies that support MGDS development or that aid in selection from design alternatives will be prepared. In addition to including a list of the studies planned, completed, and in progress, the register will specify (1) what decision, alternative, or uncertainty each study will support; (2) when the results of each study are needed in relationship to other Project activities; and (3) the work scope for each study. The register will also include a list of systems studies that have been completed. For those studies, it will cite as applicable, the following:

1. The study scope and subject.
2. The document author(s).
3. The document title.
4. The institutional author.
5. Any identifying document number, including any revision designator.
6. The date of completion.

5.2.8 SYSTEMS STUDY REPORTS

Systems study reports will be prepared to document the results of analyses pertaining to Yucca Mountain MGDS functions and requirements, design, development and operation, alternative costs, risk and impact assessments, and subsystem trade-offs. The content of a systems study report may be the result of a specific analysis, or it may be derived from working papers, internal memoranda, minutes of meetings, or final reports. System studies may address different levels of detail of the Yucca Mountain MGDS at different stages of its development. The detailed reporting of data may, therefore, vary considerably. The content of the systems study reports will include (1) subject function and performance criteria, (2) evaluation methodology, (3) identification of alternatives, (4) comparison matrix, (5) risk and impact analysis, (6) cost analysis, and (7) conclusions, as appropriate. As the design becomes increasingly detailed, systems study reports will become more definitive. Systems studies will be based on information in the NNWSI Project RIB; or where evaluations depart from information in the RIB, these deviations will be explained and justified.

5.2.9 SITE INVESTIGATION AND DESIGN REPORTS

5.2.9.1 Site investigation reports

Site investigation reports (SIRs) shall be prepared at the end of each site investigation study, documenting the results of the investigation. The reports will present data and results and give an interpretation of the data.

5.2.9.2 Design reports

Design reports will be prepared at the end of each design phase documenting the ESF, waste package, and repository designs. The design reports will (1) describe how the reference design meets the requirements at a level of detail appropriate to the design phase, (2) document the design alternatives considered and how the reference design was selected, and (3) provide the basis for the design process.

5.2.10 REVIEW RECORD MEMORANDA

The results of each of the technical reviews described in Section 4.2.5 that are conducted in the NNWSI Project will be recorded in a Review Record Memorandum. The memorandum will (1) summarize the topic of the review, (2) list the documentation used to support the review process, and (3) indicate the conclusions and any actions arising from the review. The Review Record Memorandum will also list the date and place of the review and provide a list of participants.

5.2.11 REFERENCE INFORMATION BASE

The Reference Information Base (RIB) contains the reference site, design, performance, and socioeconomic and environmental information about the MGDS. The information will be used to support the various analyses necessary for site characterization, environmental evaluation, design, and

performance assessment. The RIB will provide investigators in the NNWSI Project with internally consistent values for use in their various activities. The RIB will provide for interface requirements between the site and the other three subsystems: waste package, repository, and exploratory shaft facility.

5.2.12 OTHER REFERENCE DOCUMENTATION

Other reference documentation for the NNWSI Project will include data and drawings that are to become part of the Project Baseline but which are not amenable to inclusion in the RIB (e.g., design drawings, Site Atlas, and large Interactive Graphics Information System products). Although this information will not be included in the RIB, it will be referenced in the RIB.

5.2.13 ISSUES HIERARCHY

The OGR issues hierarchy (IH) was developed to provide a common basis for all Project Offices to plan the site characterization program. The OGR IH is modified to reflect the specific needs of the Project (NNWSI Project IH), and is used in preparing the study plans and SCPs for each site to be characterized and in reporting the status of site characterization activities via semi-annual progress reports.

The issues in the IH are defined as the questions relating to the performance of the MGDS that must be resolved to demonstrate compliance with the applicable Federal regulations and standards (including 10 CFR Part 60, 10 CFR Part 960, 40 CFR Part 191, and 10 CFR Part 20).

The IH provides a comprehensive framework for representing the siting and licensing requirements of the regulations. Each issue is a question related to the suitability of the site and performance of the repository and its subsystems that must be answered to demonstrate compliance with the applicable requirements. The NNWSI Project system requirements and the requirements developed from the NNWSI Project IH are compared and correlated to assure completeness and compatibility.

5.2.14 REGULATORY TOPICAL REPORTS

Regulatory Topical Reports (RTRs) are documents that integrate the data/information and conclusions presented in SIRs, design reports, performance assessment reports, and other lower level issues resolution support products, including the RIB, into concise reports that document NNWSI Project positions and approaches on specific regulatory requirements and technical concerns. RTRs will summarize the data/information and conclusions of these supporting technical reports. RTRs will be of sufficiently narrow scope to permit review by very specific, well-focused regulatory audiences. The RTRs will serve as a vehicle through which the DOE establishes and communicates its developing technical information basis for demonstrating compliance with the regulatory requirements. These reports will serve as the basis for interaction between the DOE and the NRC staff, allowing early NRC comment on the developing positions.

Preparation of these reports will begin as soon as availability of lower-level supporting documents will permit in order to facilitate the earliest possible agreement with the DOE and NRC on Project positions on these topics.

The RTRs will, in many cases, serve as the basis for Project Issue Resolution Reports in which information and conclusions presented in the RTRs and other lower-level resolution support products are integrated into comprehensive reports that document the Project resolution of an issue.

5.2.15 SITE CHARACTERIZATION PLAN

The NNWSI Project SCP provides the status of project data and plans to date. Chapter 8 of the SCP contains a detailed description of the Project performance allocation to MGDS subsystems, and the strategy by which the NNWSI Project expects to use technical information gathered during site characterization and design impact assessment activities to resolve the issues in the NNWSI Project Issues Hierarchy. Chapter 8 defines the studies and activities that are expected to satisfy the information needs in the Issues Hierarchy. These studies and activities which are expected to satisfy the information needs, serve as the initial basis for Participant study plans, technical procedures, and other technical planning documents which will be used to define and carry out the technical activities of the NNWSI Project.

The Issues Hierarchy defines issues which must be resolved to demonstrate compliance with key regulatory requirements. Other detailed requirements that the disposal system must satisfy, such as functional requirements, are included with the Yucca Mountain System Requirements Document. As the definition of the requirements progresses, the requirements and Issues Hierarchy will be compared and correlated to ensure consistency and completeness in each.

5.2.16 STUDY PLANS

Study plans specify the site characterization testing program in detail and are the documents by which the site characterization work is controlled. These documents reference the WBS dictionary to provide traceability from the work performed to the cost center. Details of studies, tests, and analyses will be presented in study plans. Content requirements for study plans will include rationales for the selected number, location, duration, and timing of tests. Reasonable alternatives not selected will also be identified and the reasons for not selecting them summarized. Information on interrelationships and interferences among tests and the ESF design and construction will be included. Plans may be more defined and detailed for early phases and less defined and detailed for later phases.

5.2.17 ENGINEERING PLANS

NNWSI Project Engineering Plans present the Project approach to engineering design activities. Details of the major design activities, studies, and analyses will be presented in the plans. These documents will

be used to control engineering work. They will reference the WBS Dictionary to provide traceability from work performed to the cost center.

5.2.18 NNWSI PROJECT ISSUES RESOLUTION REPORTS

NNWSI Project Issues Resolution Reports are reports that document the Project approach and position with respect to the resolution of Issues in the IH. These reports are prepared using information from the RIB and RTRs. The specific content of Project Issue Resolution Reports is determined by the WMPO based on recommendations of supporting staff and contractors.

5.2.19 ENVIRONMENTAL PROGRAM PLAN

The Environmental Program Plan (EPP) presents a summary of the NNWSI Project's overall program for identifying from the regulations the pertinent environmental issues and information needed, as well as the studies and documents necessary to resolve these issues and satisfy the regulations.

5.2.20 BASELINE CHANGE PROPOSAL

Baseline Change Proposals (BCPs) are documents which convey as complete a description as possible of any proposed changes to the Project Baseline, and include cost, schedule, and technical impacts as appropriate. BCPs will be formally submitted, evaluated, and controlled. The NNWSI Project CMP provides a detailed description of the BCP.

5.3 DOCUMENTATION REVISIONS

Changes to any portion of the systems engineering documentation will be reviewed, controlled, and issued in accordance with Project procedures. Changes to baseline documentation will be made in accordance with Section 4.3.2.

APPENDIX A

LIST OF ACRONYMS

ACD	Advanced Conceptual Design
ALARA	As Low As Reasonably Achievable
BCP	Baseline Change Proposal
CCB	Change Control Board
CMP	Configuration Management Plan
D&E	Development and Evaluation
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPP	Environmental Program Plan
ESF	Exploratory Shaft Facility
ESFDR	Exploratory Shaft Facility Design Requirements
ETR	Environmental Topical Reports
FEIS	Final Environmental Impact Statement
FPCD	Final Procurement and Construction Design
GR	Generic Requirements for a Mined Geologic Disposal System
IH	Issues Hierarchy
LA	License Application
LAD	License Application Design
MGDS	Mined Geologic Disposal System
NNWSI	Nevada Nuclear Waste Storage Investigation
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NWPA	Nuclear Waste Policy Act
OCRWM	Office of Civilian Radioactive Waste Management
OGR	Office of Geologic Repositories
PM	Project Manager
PMP	Project Management Plan
QA	Quality Assurance
QAPP	Quality Assurance Program Plan

LIST OF ACRONYMS (continued)

RAM	Reliability, Availability, and Maintainability
RDR	Repository Design Requirements
RIB	Reference Information Base
RTR	Regulatory Topical Reports
SAR	Safety Analysis Report
SCP	Site Characterization Plan
SCP/CD	Site Characterization Plan Conceptual Design
SD	Yucca Mountain MGDS Description
SEMP	Systems Engineering Management Plan
SIR	Site Investigation Report
SR	Yucca Mountain MGDS Requirements
T&MSS	Technical and Management Support Services
TPO	Technical Project Officer
WBS	Work Breakdown Structure
WMPO	Waste Management Project Office
WPDR	Waste Package Design Requirements

APPENDIX B

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