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U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN PROJECT

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SYSTEMS ENGINEERING MANAGEMENT PLAN

REVISION 1

AUGUST 1990

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UNITED STATES DEPARTMENT OF ENERGY

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AUGUST 1990

Prepared by

U.S. Department of Energy
Yucca Mountain Project Office

Prepared for the Yucca Mountain Project Participants as part of the Civilian Radioactive Waste Management Program. The Yucca Mountain Project is managed by the Yucca Mountain Project Office of the U.S. Department of Energy. Yucca Mountain Project work is sponsored by the DOE Office of Civilian Radioactive Waste Management.

FOREWORD

This document is the second issue of the Systems Engineering Management Plan (SEMP) for the Yucca Mountain Project (Project). The purpose of this document is to provide a general framework and guidance for the implementation of systems engineering on the Project. The document describes the systems engineering functions and requirements for the Project. The Yucca Mountain Project Office (Project Office) and Project Participants will prepare plans and procedures that 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. Those who wish to become familiar with systems engineering are referred to various publications on the subject e.g., Chase, 1975.

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

- Principal subsystems required for mission achievement:

  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.

- Subsystems for test/evaluation:

  4. Exploratory Shaft Facility (ESF). This ESF is a test facility and may be incorporated into the repository.

  5. Surface-Based test facilities.

The structure of these subsystems will be defined in the appropriate subsystems requirements and description documents. In addition, other facilities (e.g., laboratories) and system elements (e.g., environment) will be described.

This revision to the SEMP has been changed to incorporate new guidance provided in the Office of Civilian Radioactive Waste Management (OCRWM) SEMP and to strengthen the sections dealing with the integration of specialty engineering as recommended in U.S. Department of Energy (DOE) Order 4700.1, Project Management System (PMS). Changes include the following:

- The document was reorganized and now includes major sections on Technical Baseline, Planning and Control, Systems Engineering Approach, and Integration in Chapters 3 and 5. The sections on the technical baseline were added to the basic sections recommended in DOE Order 4700.1 to be similar to the structure used in the OCRWM SEMP.

- The description of documents was moved to the appendix.

- The content guidance for requirements documents was revised to add new sections required by the OCRWM SEMP: Purpose, Design and Operations requirements, and System Configuration.

- A Site Requirements Document (STRD) and a Surface-Based Test Facilities Requirements Document (SBTFRD) were added.

- Sections were added on reliability, maintainability, integrated logistics support, and risk management to strengthen the sections recommended by DOE Order 4700.1.

- The integration sections were revised to reflect the changes to the Project Document Hierarchy. The integration sections not only include the integration of systems activities as required by the OCRWM, but also include integration of the specialty engineering (as noted above) and the integration of related management plans.

The reader is referred to the glossary located in the Quality Assurance (QA) Requirements for any document-related definition.

Impact upon this SEMP, resulting from any upper-tier documents being issued or deleted, will be reviewed and any changes completed as necessary.

YUCCA MOUNTAIN PROJECT

SYSTEMS ENGINEERING MANAGEMENT PLAN

Approved by:

Carl P. Gertz, Project Manager
Yucca Mountain Project Office

8/20/90
Date

Concurred by:

Dwight Shelor, Acting Associate Director
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Office of Civilian Radioactive
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Date

SYSTEMS ENGINEERING MANAGEMENT PLAN

EXECUTIVE SUMMARY

The Project Office, Project Participating Organizations, and all contractors will use the systems engineering approach described in this SEMP to manage, integrate, interface, and document all technical activities on the Project.

The systems approach for the Project includes the following activities:

1. Establishing the Yucca Mountain Project Technical Baseline.

2. Technical Planning and Control.

3. The Yucca Mountain Project Systems Engineering Process.

4. Integration.

These activities will be applied through successively more detailed stages of (1) defining objectives (mission), (2) requirements definition, (3) system definition, and (4) design or selection, which can provide the objectives for the next level of requirements.

The Technical Baseline activities will develop the site-specific MGDS description, the reference information base (RIB), and the site-specific requirements documents. These will evolve as successive iterations occur.

The technical planning and control activities will be done consistent with the OCRWM SEMP. Specific organizational responsibilities are defined for preparation, review, acceptance, approval, and concurrence of technical documents. Specific controls are described, including reviews, verification and validation, data qualification, and decision methodology.

Systems engineering is the process of selecting and synthesizing the application of scientific and technical knowledge to manage, integrate, and document the technical activities to:

1. Define and allocate requirements and subsystem utilization.

2. Evaluate subsystem interrelationships.

3. Translate the requirements into a system concept.

4. Subsequently demonstrate that the composite of facilities, equipment, skills, techniques, and natural environment can be effectively employed as a coherent whole to achieve stated mission and performance objectives.

Integration of the MGDS requires integration of the systems activities and the integration of related management activities. The section on the integration of systems activities discusses reliability engineering, maintainability engineering, integrated logistics support, operability assessments, risk management, life-cycle cost, performance assessment, safety/risk evaluations, impact analysis, technical data management, interface control, and configuration management. The section on related management activities describes test and evaluation, environmental programs, and performance assessment.

SYSTEMS ENGINEERING MANAGEMENT PLAN

for

YUCCA MOUNTAIN PROJECT

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1.0 INTRODUCTION

Public Law 97-425, the Nuclear Waste Policy Act of 1982 (NWPA), directs the 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 OCRWM and other organizations to fulfill the requirements of the NWPA and as amended by the NWPAA.

The 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 United States.

1.1 POLICY

DOE policy is to use systems engineering in the technical management of all major system acquisitions. Accordingly, the Director of OCRWM has directed that systems engineering be used by all organizations participating in MGDS development (DOE, 1990). This requirement includes all divisions of the OCRWM, the DOE Project Offices, federal organizations, national laboratories, and private contractors that support the Project Offices. In conformance with this policy, the Project Manager (PM), in issuing this SEMP, directs and authorizes the use of systems engineering by the Project Office, Project Participating Organizations, and all contractors. The Project Office, Project Participating Organizations, and all contractors will use the systems engineering approach described in this SEMP to manage, integrate, interface, and document all technical activities on the Project.

1.2 OBJECTIVES AND STRATEGY

The objective of the Project SEMP is to describe the way in which the Project will implement systems engineering to manage, integrate, interface, and document the technical activities of the Project. This SEMP is prepared in accordance with the guidance provided in the Project Management Plan (PMP), which incorporates by reference the OCRWM SEMP (DOE, 1990) and DOE Order 4700.1, PMS, (DOE, 1987c).

The OCRWM SEMP explicitly states that each Project Office will prepare a Project-level SEMP. The Project SEMP complies with these directives.

The OCRWM SEMP establishes minimum contents for the Project SEMP. These requirements are quoted below. The parenthetical reference indicates the section in the Project SEMP that addresses the requirements.

1. A detailed discussion of the approach to be used for implementing systems engineering. This discussion of approach will expand on the requirements set forth in the OCRWM SEMP. (Sections 3 and 5)

2. The specifications of the organizational responsibilities for implementing the systems engineering effort, including the responsibilities of the Project offices and their contractors. (Section 4)

3. The specification of the procedures to be followed in implementing systems engineering at the Project level. (Section 5)

4. The specifications for developing the Project Technical Baseline. (See Section 5. In addition, the reader should refer to the (CMP).

5. The specification of procedures for managing all activities to the technical baseline. Such procedures should include

   a. Requirements for contractor adherence to the Technical Baseline.

   b. Mechanisms for control [of] changes to the Technical Baseline.

   c. Requirements for contractor compliance with change-control procedures.

   d. Procedures for interface control.

   (Discussed briefly in Section 5 and referenced to the CMP for more detailed discussion.)

6. The specifications of reviews to be conducted, including reviews of requirements and development to ensure adherence to the Technical Baseline. These specifications shall include the scope, frequency, and organizational responsibilities for participation and presentation. (Section 5)

7. The identification of documentation to be developed and maintained, including organizational responsibility for development, review, approval, and the contents of such documents. (Section 4, Section 5, and Appendix A.)

1.3 CONTENTS OF THE SEMP

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 approach to be used in the Project. Section 4.0, Project Organization and Responsibilities, describes the responsibilities of the organizations involved in the Project. Section 5.0, Implementation, contains a description of the systems engineering activities within a framework prescribed by the OCRWM SEMP. Appendix A, Documentation, gives a brief description of major systems engineering documents. A list of the acronyms used in this SEMP is given in Appendix B, List of Acronyms.

2.0 SCOPE AND APPLICABILITY

Systems engineering will be used to manage, integrate, interface, and document the Project technical activities. The SEMP covers direct implementation, such as the identification of requirements; the relationship to closely coupled activities, such as configuration management and technical data management; and activities described in more detail in Project-Level Plans, such as design, test and evaluation, environmental programs, and performance assessment.

The Project SEMP provides general guidelines for the implementation of systems engineering by the Project Office at the Project level. The requirements defined in the Project SEMP apply to the Project Office and to all Project Participants (major Project technical Participants and support organizations) in the Project. All Participants having a responsibility for one or more portions of the Project MGDS will incorporate the provisions and requirements of this SEMP in their activities through the use of implementing plans and procedures.

The Project SEMP addresses interfaces among these technical activities both internal and external to the Project. Cooperation with other countries in waste management activities is not covered by this SEMP.

The Project SEMP is focused on the site characterization and site selection and approval phases of the MGDS, which includes all activities up to submittal of a license application (LA) to the U.S. Nuclear Regulatory Commission (NRC). If Yucca Mountain is selected to host the first repository, the SEMP will be revised, expanded, and reissued to address the LA, construction, operation, and closure and decommissioning (NRC Licensing Review and Construction of the Repository Phases).

3.0 APPROACH

The systems approach for the Project includes the following activities:

1. Establishing the Project Technical Baseline, including identifying the technical requirements (functional and physical) for the total system and further defining these requirements and their allocations to the subsystems to serve as the basis for conducting technical activities.

2. Technical Planning and Control, including integrating the scientific investigations and design activities and identifying and managing the interfaces between them; defining and managing the interfaces among the MGDS subsystems; and providing an iterative process in which the baseline is refined and updated through a series of scientific and engineering studies, tests, and associated decision.

3. The Project Systems Engineering Process, including determining how the MGDS can be effectively optimized within the constraints to most effectively satisfy technical requirements and resolve regulatory issues.

4. Integration, including incorporating specialty engineering and indicating the relationship among documentation, reviews, baselines, and management action points.

The Project's systems 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. This supports the general approach described in the OCRWM SEMP, which states:

> To support and control the technical development of the waste management system, systems engineering is applied in an ordered and iterative process that progresses through successively more detailed stages of: (1) defining objectives (mission), (2) requirements definition, (3) system definition, (4) design or selection, which can provide the objectives for the next level of requirements. (DOE, 1990)

Systems engineering is the process of selecting and synthesizing the application of scientific and technical knowledge to manage, integrate, and document the technical activities to:

1. Define and allocate requirements and subsystem utilization.

2. Evaluate subsystem interrelationships.

3. Translate the requirements into a system concept.

4. Subsequently demonstrate that the composite of facilities, equipment, skills, techniques, and natural environment can be effectively employed as a coherent whole to achieve stated mission and performance objectives.

3.1 THE YUCCA MOUNTAIN PROJECT TECHNICAL BASELINE

The technical baseline for the Project shall be prepared consistent with the direction in the OCRWM SEMP, which states,

> This baseline will consist of four distinct components:
>
> 1. The functional and technical requirements baseline, which is presented in the Waste Management System Requirements (WMSR) document and the Waste Management System Description document.
>
> 2. The design requirements baseline.
>
> 3. The system-configuration baseline.
>
> 4. The as-built-system-configuration baseline.

The Project staff uses the WMSR requirements, prepares the MGDS System Requirements (SR), and then develops, in an iterative fashion, the other baseline documents. The key technical baseline documents to be prepared are discussed below.

A detailed discussion of the management of the Project Baseline is described in the CMP.

3.1.1 SITE-SPECIFIC MGDS REQUIREMENTS

Using the generic WMSR requirements, design concepts developed for the Site Characterization Plan (SCP) — Conceptual Design Report, site specific functional analysis, and site characteristics as described in the system description and RIB, an initial allocation of requirements to various systems and components will be made. These initial requirements will be then used to develop a set of requirements for a SR at Yucca Mountain. The SR document will provide further detail of the functions to be performed and will quantify performance criteria and identify interfaces between subsystems. Following any major changes, the MGDS requirements document will be reviewed and approved by the same organizations that performed the original review and approval. Other organizations may be specifically designated to review or approve the document by the organization responsible for the document in accordance with the Quality Assurance Requirements (QAR) and the Quality Assurance Program Document (QAPD).

3.1.2 SITE REQUIREMENTS AND TEST AND EVALUATION PLANNING BASIS

The STRD will describe the functions that are expected to be performed and the information that is required to characterize the natural systems. The initial STRD (Rev. 0) will use information developed for the SCP. The Test and Evaluation Planning Basis (T&EPB) is the controlled data base, which defines the site characterization parameters that are required and on which planned tests are based. The programs to obtain the site characterization information are described in the Test and Evaluation Plan (T&EP).

The STRD will also describe the requirements for environmental compliance, environmental monitoring, and land access. The programs to obtain the monitoring data and comply with these requirements are described in the Environmental Management Plan (EMP) and associated plans and procedures.

3.1.3 ENGINEERED SUBSYSTEM DESIGN REQUIREMENTS

Based on the SR and Yucca Mountain MGDS Description (SD), additional functional analysis will be performed, and requirements will be further allocated to the subsystems and components of the MGDS. These requirements will be developed, taking into account relevant information that describes the Yucca Mountain site. The Project will approve and issue the following subsystem design requirements documents prior to initiation of an applicable subsystem design phase (i.e., conceptual, Title I, Title II, and so forth): ESF Design Requirements Document (ESFDR), Repository Design Requirements (RDR), Waste Package Design Requirements (WPDR), and Surface-Based Test Facility Design Requirements (SBTFRD). Environmental constraints and construction control requirements shall be included in these documents. These requirements documents will be updated as needed. Following any major changes, the subsystem design requirements documents will be reviewed and approved by the same organizations that performed the original review and approval, unless other organizations are specifically designated by the organization responsible for the document, in accordance with the QAR and QAPD.

3.1.4 SITE-SPECIFIC MGDS DESCRIPTION

The Project requires a site-specific MGDS description (SD) to provide a complete definition of all MGDS subsystems and the major components of those subsystems.

At the end of each design or siting phase (e.g., completion of the conceptual design for the site-characterization plan or the completion of site screening) the reference description of the site-specific MGDS will be updated by the Project. The updated description will provide a detailed definition of the site, repository, and waste-package characteristics to be used in subsequent design, siting, and performance-assessment efforts. Chapter 4 defines responsibilities for the development of the site-specific descriptions. Following any major changes, the MGDS Description document

will be reviewed and approved by the same organizations that performed the original review and approval, unless other organizations are specifically designated by the organization responsible for the document, in accordance with the QARD and QAPD.

3.1.5 REFERENCE INFORMATION BASE AND PROJECT TECHNICAL DATA BASES

The information used for design and analysis inputs shall be controlled in accordance with the Technical Data Management Plan (TDMP), which describes the approach to technical data management, including the RIB and the Project Technical Data Bases.

3.2 TECHNICAL PLANNING AND CONTROL

Technical planning and control shall be done consistent with the OCRWM SEMP (DOE, 1990), which provides guidance for the following:

- Design control process
  - Design input
  - Design preparation
  - Design output
  - Design changes
- Evaluation of system development

3.3 THE YUCCA MOUNTAIN PROJECT SYSTEMS ENGINEERING PROCESS

The Project systems engineering process uses the traditional systems engineering approach, emphasizing requirements, to guide the development of the MGDS. During the development and evaluation (D&E) 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 that performs all the necessary functions, meets all the applicable requirements, and can be properly integrated. The issues approach, which was developed as a means to focus the scientific investigations, presents a set of organizing principles that were based on specific regulatory requirements. This approach allows program activities to focus on the collection of information that is crucial to the resolution of licensing and site-selection issues.

The requirements for the MGDS are based on a variety of sources, including the NWPA and amendments, federal, State, and local regulations, OCRWM policy documents, DOE Orders, and various codes and standards. The WMSR serves as a starting point for the definition of the requirements for the Yucca Mountain MGDS. The process is shown in Figure 3-1.

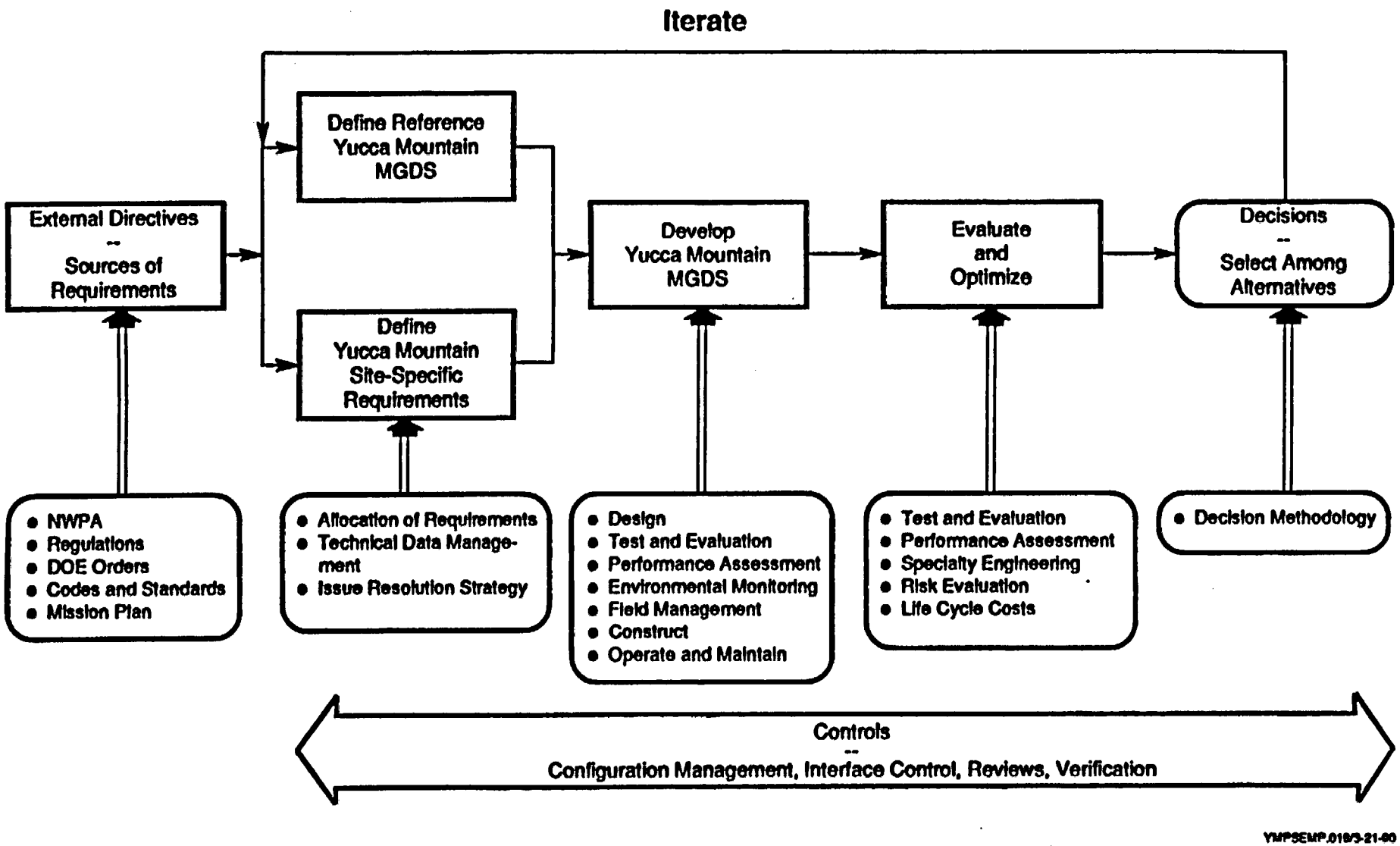

Figure 3-1. The Yucca Mountain Project Systems Engineering Process.

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.

A performance allocation process is being used to supplement the requirements allocation described above. 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 the 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.

Following the requirements definition and allocation, the systems engineering process moves to the design phase. Repository, waste package, ESF, and surface-based test facility design activities will be based on their respective design requirements documents. During the course of site characterization activities, the subsystem design efforts will draw upon the site data that is maintained in the RIB. However, 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/ optimization and reviews. 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.

Engineering disciplines, such as test and evaluation, performance assessment, risk evaluation, and life-cycle cost, will become more evident during the evaluation/optimization phase. Specialty engineering, such as reliability and maintainability, will be integrated into the process not only during this phase, but also throughout the systems engineering cycle.

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 that are sufficient for the basis of Final Procurement and Construction Design (FPCD). Thus, at the end of the site characterization, site selection, and approval phases, the system engineering process will lead to the definition of an integrated system that meets all functional and regulatory requirements.

3.4 INTEGRATION

Integration of the MGDS requires integration of systems activities, integration of related management activities, integration of Project technical activities, and integration of QA. The OCRWM SEMP focuses on integration of systems activities, particularly interface control. For the

Project, interface control is discussed in the CMP. The other integration aspects at the Project are discussed in more detail in Chapter 5, which discusses the related documents shown in Figure 3-2. The SEMP establishes the framework and management controls for the technical activities on the Project. The CMP and the TDMP are shown as annexes to the SEMP because they also broadly impact the way that the technical activities are conducted. The Performance Assessment Management Plan (PAMP) is part of the Systems WBS and describes the process used to allocate requirements and to assess performance of the MGDS. The Design Plan, the T&EP, and the EMP describe in more detail the scientific and engineering activities. The Safety and Health Plan (S&HP), the Field Management Plan (FMP), and the Technical Support Document Management Plan (TSDMP) also describe parts of the technical processes on the Project. The interactions among these documents are described below.

Although Figure 3-2 shows the Technical Document Hierarchy and the Management Document Hierarchy as separate, there are several interactions among these documents. The requirements documents in the technical hierarchy describe what the engineered systems must do and what must be known about the natural systems. The description documents describe the current concept of the systems. The RIB can be considered an extension of the MGDS description.

The ESFDR and the SBTFRD are shown below the STRD to emphasize that the prime function of these facilities is to support site characterization. An extra line is shown from the MGDS System Requirements to the ESFDR and the SBTFRD to emphasize the need for interfaces among the engineered systems for testing and the repository, waste package, and site.

The T&EPB is included below the STRD because it defines the site characterization parameters that are required by performance assessment and design. The management hierarchy uses this information to prepare individual plans (e.g., study plans) that define responsibilities, schedules, and define the procedures to be followed. As a result of the planning on how the tests will be conducted, the requirements for test facilities (i.e., the ESFDR, the SBTFRD, and the laboratory requirements) are developed. (NOTE: Laboratory requirements are not shown because they are Participant documents, and the laboratories are not intrusive on the site.) These documents would be part of work authorization packages.

The interactions among the processes described in these management plans are described below.

Technical Process Flowchart. The interactions among the Project technical processes are shown in Figure 3-3. The figure depicts the technical activities and transfers QA technical products described in the management plans for the Project. The individual management plans provide more detail on the processes.

External directives (e.g., the Mission Plan) serve as the external input and requirements for the process. The process results in the characterization of Yucca Mountain and external products include the LA, the Environmental Impact Statement (EIS), and the environmental documentation (including the determination of whether the site is suitable). Time and iterations are not shown on the figure.

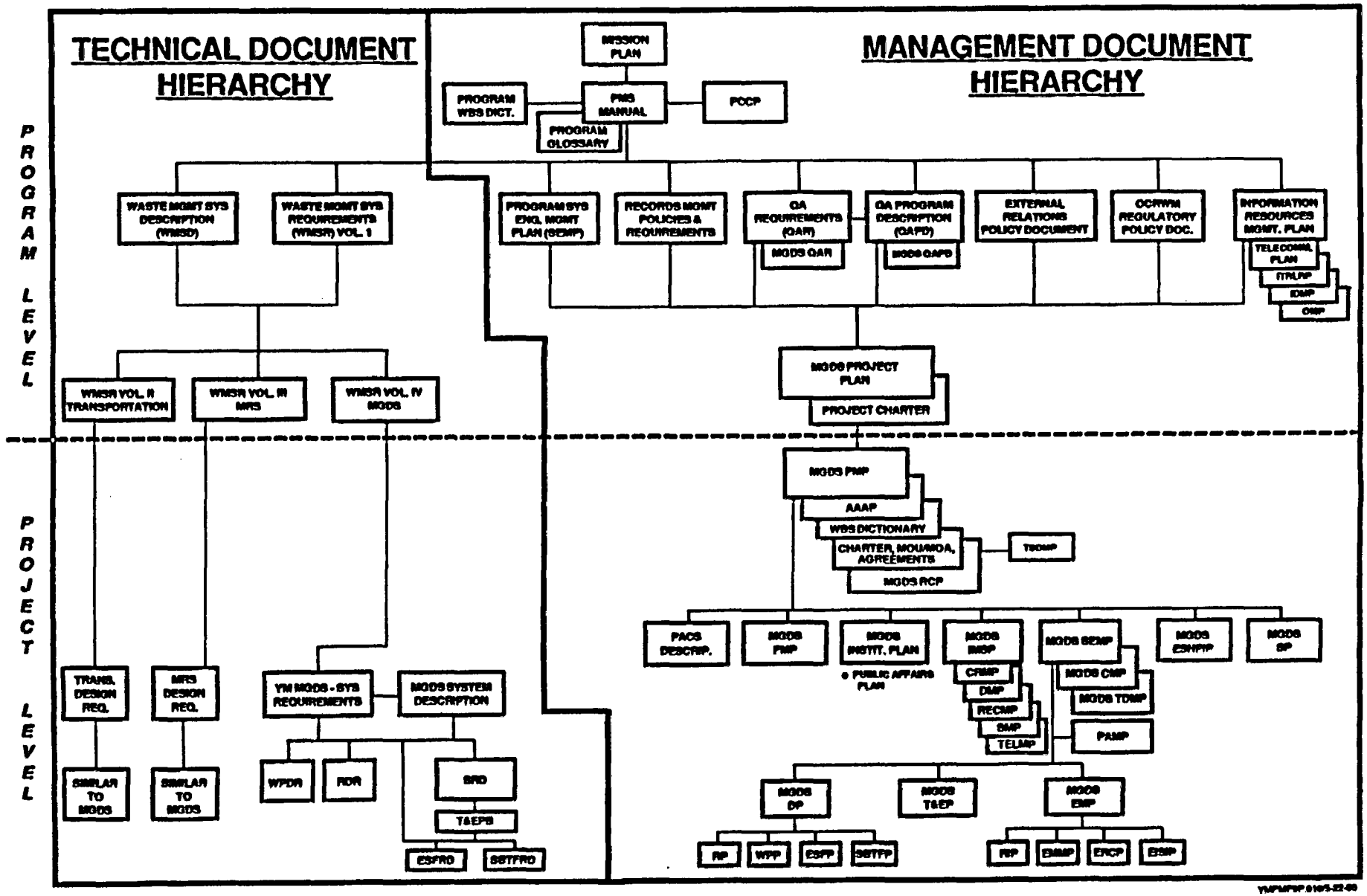

Figure 3-2. Yucca Mountain Project Document Hierarchy.

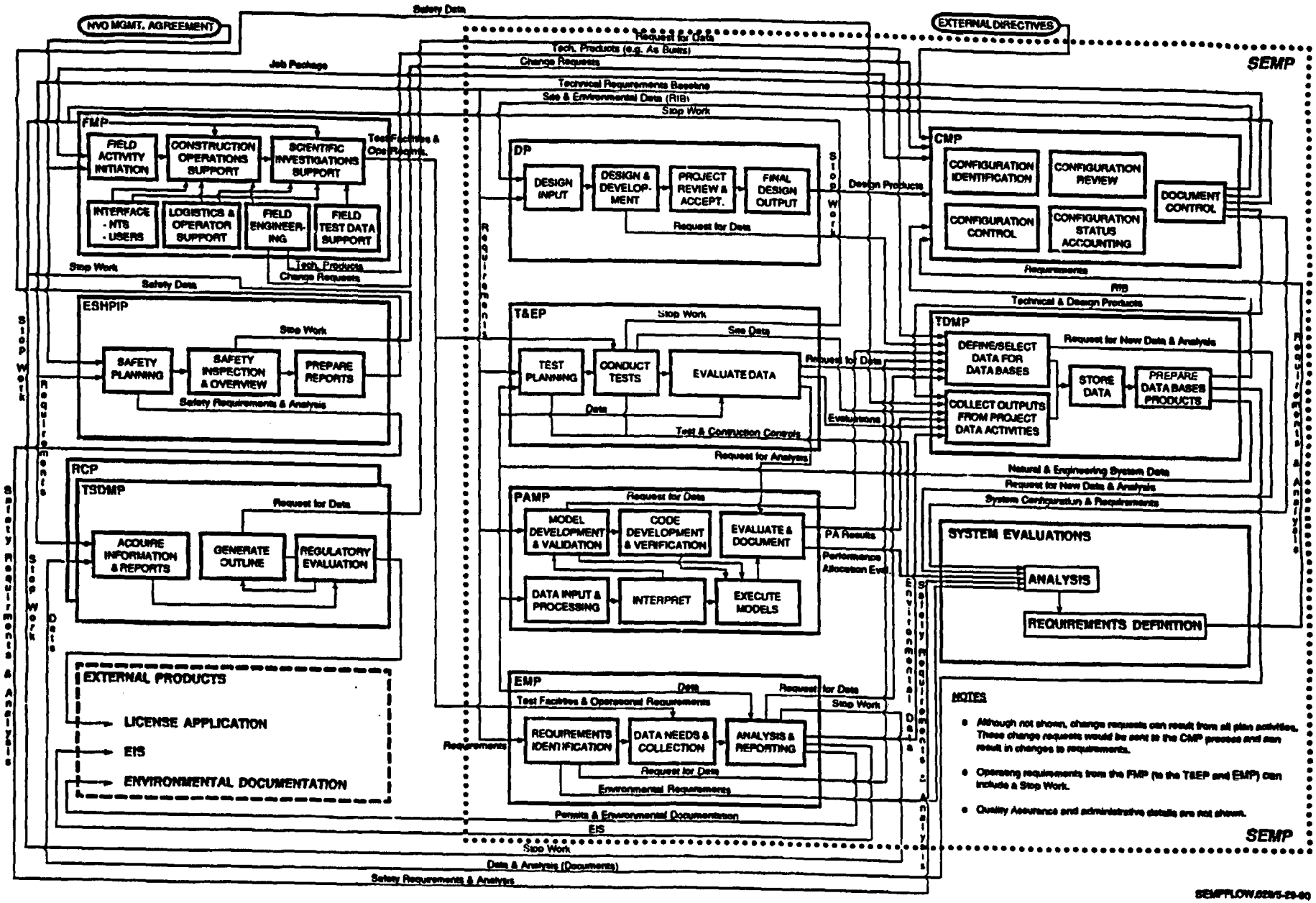

Figure 3.2 Yucca Mountain Project Technical Process Flowchart

The right side of the diagram shows the processes described by the SEMP and related plans. The left side of the diagram shows the processes described in other management plans not under the SEMP umbrella, i.e., the FMP, the S&HP, and the TSDMP. These plans are included because they deal with the development and transfer of technical products. Plans that deal with the administration, QA, and scheduling, are not shown on this diagram. Although such activities are essential for the success of the Project, they are left off this diagram in order to focus on the technical process.

The larger boxes designate which plan describes the process. The smaller boxes are activities described in the plan. The lines designate the transfer of a technical product from one process to another. Products are described in general terms. For example, requirements include all of the technical requirements that specify a product, including everything from system requirements to the T&EPB to construction specifications to interface control documentation. The Systems Evaluations box covers activities that are implemented directly from the SEMP rather than one of the lower-tier plans.

The flowchart has several major processes that deserve special mention.

- All requirements are issued after approval as described in the CMP. These requirements feed all processes and would typically be included as part of a work authorization.

- All data and evaluations are submitted into controlled data bases and Project records as described in the TDMP.

- All requirements and changes to requirements are evaluated for system impacts. However, in general all processes can identify requirements, interface controls, and changes to requirements.

- The performance assessment process and the system evaluations analyze the data generated as a result of the other processes to develop predictions of the performance and to allocate performance requirements. Performance assessment is described in the PAMP.

- The field management process describes how operations are conducted for activities conducted in the field.

- A stop work order resulting from safety, environmental, or testing evaluations would be prepared as described in the corresponding plan and implemented as described in the FMP. Stop Work Orders can also be issued for management and QA reasons for any of these processes. Similarly, holds can be established to constrain work beyond a specified point until certain prerequisites are complete.

- Design output products are accepted as described in the CMP and become part of the job package provided to the field management process for construction and operation.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

This chapter contains two sections:

1. Section 4.1 describes organizational responsibilities.

2. Section 4.2 describes responsibilities and authority for documentation.

4.1 ORGANIZATIONAL RESPONSIBILITIES

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

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

Support Organizations are responsible for implementing systems engineering in accordance with the Project SEMP and the Project implementing plans and procedures. Implementing procedures will be developed at the Participant level when necessary to apply requirements delineated in the Project SEMP. These procedures include establishing the Participant's and Support Organization's internal baseline management system for documenting the review and approval process and identification, documentation, and control of internal interfaces.

At the Project level, to facilitate Project-wide integration and coordination of systems engineering activities, an advisory group(s) (such as the Technical Systems Advisory Group) may be established by the direction of the Project Office PM and, if established, will be chaired by a member of the Project Office staff. Each Technical Project Officer (TPO) will, at the request of the Project Office PM, designate an individual or individuals to serve in this group to represent all of the technical disciplines of their organization.

4.2 RESPONSIBILITIES AND AUTHORITY FOR DOCUMENTATION

The Project Office 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 Project Baseline.

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 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 Appendix A. The organizational responsibilities for preparation, review, acceptance, and approval are provided in Table 4-1.

Changes to any portion of the systems engineering documentation will be reviewed, controlled, and issued in accordance with Project procedures, the QAR, and the QAPD. The reader is referred to the CMP for a more detailed discussion of change control and document control for the baseline.

Table 4-1. Organizational responsibilities for preparation, review, acceptance, approval, and concurrence of Yucca Mountain MGDS technical documentation

	Document	Prep	Review	Accept	Approve	Concur	Note
1.	System Engineering Management Plan	T&MSS	PO		PO	OCRWM	1, 6
2.	Yucca Mtn. MGDS Description	SNL	PO		PO		
3.	Yucca Mtn. MGDS Requirements	SNL	PO		PO	OCRWM	2, 6
4.	Repository Design Requirements	SNL	PO		PO	OCRWM	3, 6
5.	Waste Package Design Requirements	LLNL	PO		PO	OCRWM	3, 6
6.	Exploratory Shaft Facility Design Requirements	SNL	PO		PO	OCRWM	3, 6
7.	Site Requirements Document	T&MSS	PO		PO		
8.	Surface Based Test Facilities Requirements Document	T&MSS	PO		PO		

Table 4-1. Organizational responsibilities for preparation, review, acceptance, and approval of Yucca Mountain MGDS technical documentation (continued)

	Document	Prep	Review	Accept	Approve	Concur	Note
9.	Test & Evaluation Planning Basis	T&MSS/PP	PO		PO		
10.	Configuration Baseline Documents	PP	PO		PO	OCRWM	6
11.	As-Built System Configuration Baseline Documents	PP	PO		PO	OCRWM	6
12.	Systems Studies Plans	SNL	SNL		PO		
13.	Systems Study Reports	PP	PP		PO		
14.	Site and Environmental Investigation Reports	PP	PP		PO		
15.	Design Reports	PP			PO	OCRWM	
16.	Reference Information Base	SNL/PP	SNL		PO		
17.	Site Characterization Plan	PP/PO OCRWM			PO	OCRWM	4
18.	Study Plans	PP			PO	OCRWM	5
19.	Scientific Investigation Planning Document	PP	PO		PO		
20.	Engineering Plans	PP	PO		PO		
21.	Environmental Field Activity Plans	PP	PO		PO	OCRWM	
22.	Other Technical Reports	PP	PO		PO		

Table 4-1. Organizational responsibilities for preparation, review, acceptance, and approval of Yucca Mountain MGDS technical documentation (continued)

Definitions:

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.

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 the Project Office and approval by OCRWM is not required.)

2. This approval applies only to the initial release. Subsequent changes that impact WMSR, Vol. 4, must be proposed to OCRWM against that document. The Project Office will notate those requirements that are under their control. Changes to the requirements so designated must be approved by the Project Office. All other changes must be approved by the Project Participant who prepared the document.

3. OCRWM will review and concur prior to the initiation of the next design phase. Subsequent changes that impact the WMSR Vol. 4 must be proposed to OCRWM against that document. The Project Office will notate those requirements that are under their control. Changes to the requirements so designated must be approved by the Project Office. All other changes must be approved by the Project Participant who prepared the document.

Table 4-1. Organizational responsibilities for preparation, review, acceptance, and approval of Yucca Mountain MGDS technical documentation (continued)

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, and site investigation reports (SIRs) 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.

6. Concurrence directed by OCRWM SEMP (DOE, 1990). (Will be accomplished at the end of the phase, consistent with acceptance of the design report.)

7. Management plans shown in the document hierarchy (other than the SEMP) are not included in this table.

T&MSS = Technical and Management Support Services; SNL = Sandia National Laboratories; LLNL = Lawrence Livermore National Laboratory; PP = Project Participant(s); PO = Project Office; OCRWM = Office of Civilian Radioactive Waste Management.

5.0 IMPLEMENTATION

5.1 THE YUCCA MOUNTAIN PROJECT TECHNICAL 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 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. By providing a common, controlled base for all Participant work, the baseline serves as the key management tool for total Project integration. The Project Baseline consists of items established by the Project Change Control Board (CCB) and controlled using the change control process identified in the Project CMP.

The Project Baseline encompasses the cost and schedule baselines required per DOE Order 4700.1, as defined in the CMP. The Project Baseline also includes selected documents generated by technical activities as a result of implementing the systems engineering process. The Project Technical Baseline includes documents controlled by the Project CCB.

Configuration management provides the process for managing the Project Baseline. The configuration management process, including change control, is also described in the Project CMP. Baseline change classes will be used for the 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 contained in the Project CMP.

5.2 TECHNICAL PLANNING AND CONTROL

5.2.1 APPROACH TO DEVELOPMENT OF THE MGDS

The approach to development of the MGDS shall be consistent with the guidance given in the OCRWM SEMP (DOE, 1990, Section 5.3). The SEMP and all subtier plans shall follow this approach.

Technical Objectives. Technical objectives for Project activities will be established and defined in the Project implementing plans.

Technical Performance Measurement. Technical performance measurement will be performed, including analysis of the differences between the achievement to date and the technical baseline.

Documents shall be developed, reviewed, approved, and revised consistent with Project procedures described in the PMP. Reviews for technical activities are further described below. In addition, verification and validation to the qualification and decision methodology are also discussed below.

5.2.2 REVIEWS

The Project will conduct a series of documented reviews, consistent with Project policies and procedures, during the site characterization and site selection and approval phases 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 reports; 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.

There are several types of formal reviews:

1. Technical assessment review.
2. Readiness review.
3. Design review.
4. Peer review.
5. Technical review.
6. Document review.

These reviews will be conducted to meet (among others) the requirements for System Requirements Reviews, as required by DOE Order 4700.1, and are conducted to ascertain progress in defining system functional requirements and in implementing other engineering management activity.

Review procedures will be prepared as a direct implementation of this SEMP for Technical Assessment Review, Readiness Review, and Peer Review. Document review is described in the PMP. Participants may also prepare review procedures consistent with the requirements of the QAR and QAPD.

As directed in the OCRWM SEMP, before the completion of major MGDS milestones (e.g., design phases and major documents, such as the draft EIS, the Site-Suitability Report, and the Safety Analysis Report), a comprehensive technical review will be made.

5.2.2.1 Technical assessment review

The Project Office 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, including interfaces with site efforts versus design efforts; and to direct necessary changes. These reviews, in addition to ensuring that the specified requirements are satisfied, will 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.

Technical assessment reviews will be conducted in accordance with Project and Participant procedures. The independence and qualification requirements are identified in the implementing procedure. The results of the technical assessment review will be documented in Review Record Memoranda and will include the resolution of comments.

5.2.2.2 Readiness review

Readiness review is an independent, systematic documented review to determine and inform management of the readiness to advance from one phase, process, or activity into another. Readiness reviews are used to coordinate many elements and provide attention to detail to ensure that the Project is ready to proceed to the next phase, process, or activity. Readiness review can also be applied to a comprehensive review of a total Project or a particular segment of the Project.

Readiness reviews are conducted by the Project Office and 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 conducted in accordance with Project and Participant procedures. The independence and qualification requirements are identified in the implementing procedure. Readiness reviews will be documented in accordance with Project procedures.

5.2.2.3 Design review

Design reviews will be conducted upon completion of each major design phase, as a minimum. Design reviews are critical reviews conducted by the Participants to ensure that the design is correct and satisfactory. These reviews will evaluate the design to verify that (1) design inputs were correctly selected, (2) assumptions were reasonable and adequately described, (3) the appropriate design method was used, (4) design inputs were correctly incorporated into the design, (5) design outputs were reasonable compared to design inputs, and (6) the impacts on interfacing functions and subsystems have been identified. Procedures will be prepared by the responsible design organization. The requirements for reviewer qualification and independence will be identified in the implementing procedure. The results of the reviews will be documented in Review Record Memoranda and will include the comments and resolutions.

5.2.2.4 Peer review

A peer review shall be used when the adequacy of information (e.g., data, interpretations, test results, and design assumptions) or the suitability of procedures and methods essential to showing that the repository system meets or exceeds its performance requirements with respect to safety and when waste isolation cannot otherwise be established through testing, alternate calculations, or reference to previously established standards and practices.

A peer review is a means to obtain and document expert judgment in assessing the technical adequacy of work. A peer review is conducted by personnel independent of those who performed the original work and who have technical expertise in the subject matter at least equivalent to that needed for the original work. Documents, material, or data are required to undergo a Peer Review if (1) they require interpretation or judgment to verify or validate assumptions, plans, results, or conclusions or (2) they contain conclusions, material, or data that go beyond the existing state-of-the-art or are first-of-a-kind activities. Peer reviews will be documented in accordance with Project and Participant procedures and shall comply with the QAR and QAPDs. The independence and qualification requirements are identified in the implementing procedure. The results of the reviews will be documented in Review Record Memoranda and will include the comments and the resolutions.

5.2.2.5 Technical review

When a technical review is required, it shall be conducted in accordance with implementing procedures that contain specific criteria for the performance of the technical review. Any of the above four review processes may be used as technical reviews. In addition, Project and Participant technical review procedures may be used to comply with the QARD and QAPDs.

5.2.2.6 Document review

A document review is a review of a document for acceptance, concurrence, or approval. It includes management and QA reviews, which shall be conducted in accordance with Project Office and Participants' implementing procedures. The reader should refer to the PMP for further discussion.

5.2.3 VERIFICATION AND VALIDATION

Verification is the act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specified requirements.

Validation is the process of ensuring that the requirements used for the verification process are realistic and attainable.

The designs of subsystems, structures, components, and the construction and operations activities important to safety and waste isolation must be verified and validated.

Each contractor who is responsible for scientific investigation or design will identify and describe verification and validation methods to be used for each activity, subsystem, structure, or component when verification is required in the plan for the investigation or design activity. The rationale for the choice of verification method, including assumptions and decision criteria used, will be documented in the appropriate plan.

Design verification shall be accomplished by any one or a combination of the following: design reviews, alternate calculations, qualification testing, or peer review. Design reviews are normally applied in conventional processes and are conducted in accordance with Project procedures. Design verification through the use of alternate calculations and qualification testing shall be done in accordance with the QAR and QAPD. 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 shall be conducted.

Note that in special cases, the Project Office may decide to perform a verification activity. In those cases, the Participant is not relieved of verification responsibilities. However, credit may be taken for the verification activity performed if it satisfies the criteria previously established by the Participant.

5.2.4 DATA QUALIFICATION

Data qualification applies to qualification of existing data that are, or may be, included as primary data in support of licensing. Such data relate to systems, structures, and components important to safety and to characterization of natural barriers and the design and development of engineered barriers important to waste isolation and related activities.

Data qualification shall be done in accordance with approved procedures.

5.2.5 DECISION METHODOLOGY

The methodology used in making major Project decisions shall be included with the documentation describing the decision. Major decisions will be identified by the PM.

5.3 SYSTEMS ENGINEERING PROCESS

This section describes implementation of the Systems Engineering Process described in Section 3 and Figure 3-1.

5.3.1 DEFINE YUCCA MOUNTAIN SITE-SPECIFIC REQUIREMENTS

Definition of the SR begins with a site-specific functional analysis, which is based on the Project mission. The legislative, regulatory, and programmatic requirements given in the NWPA, DOE's Mission Plan, 40 CFR Part 191, 10 CFR Part 60, and any other applicable federal, State, and local regulations are used to determine how well the MGDS functions must be performed. Figure 3-1 illustrates how the requirements initiate the systems engineering process. For the Project, the full set of these requirements are identified in the SR document. However, the ESF must be designed and built prior to the complete development of the repository requirements document. Therefore, the ESF may require modification to meet repository requirements.

The definition of site-specific MGDS requirements to guide design, performance assessment, and siting activities proceeds through three integrated steps as shown in Figure 5-1. The first step includes the development of SR using requirements from the WMSR, as well as those developed by means of the site-specific 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 will be resolved. These discrepancies, identified during Project reviews, are documented and controlled in accordance with Project document review procedures.

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 legislative, regulatory, and programmatic requirements are allocated to the natural and engineered subsystems that make up the Yucca Mountain MGDS. For the Project design activities, the requirement allocations are translated into design requirements in the ESFDR, SBTFRD, RDR, and WPDR. Site requirements are given in the STRD. Technical work requirements for site characterization and monitoring activities are described in Study Plans, environmental field activity plans, and engineering plans. These documents will be prepared and approved as shown in Section 4.

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.

5.3.2 DEFINE REFERENCE YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM DESCRIPTION

The reference SD will provide a description of each natural and engineered subsystem that makes up the MGDS. As such, the SD will include references to the system and subsystem design requirements documents. The SD will be supplemented by the RIB.

5.3.3 DEVELOP YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM

The Project-related planning and requirement documents describe the specific technical information and analyses that are needed to develop and evaluate the MGDS. Figure 5-1 indicates the development process consists of design, test and evaluation, environmental monitoring, field management, construction, operation and maintenance, and performance assessment.

Technical information derived from site characterization, technical investigations, and design activities will be entered into the Project RIB and Technical Data Base. The technical information and data will be used in the iterative systems engineering process to (1) evaluate and optimize the 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 LA process.

5.3.4 EVALUATE AND OPTIMIZE

Evaluation and optimization activities support technical, managerial, and licensing decisions. Evaluation and optimization include the definition of performance measures to be used for determining that the requirements have been met and issues have been resolved. For example, Figure 5-1 indicates evaluation and optimization will include test and evaluation, performance assessment, specialty engineering, risk evaluation, and life-cycle cost. Evaluations of trade-offs will be performed to support technical decisions that optimize the Project performance on a comprehensive basis.

The technical complexity of issues in the Project and the multiple performance measures to be considered in making comprehensive decisions requires that a systematic decision methodology be used. More significant evaluations will be documented in the Project Systems Study Register.

Appropriate trade-off studies will be conducted to postulate and evaluate design alternatives to satisfy the functional requirements and performance criteria. Trade-off studies will consider all factors bearing significantly on operational and logistic support functions of the system, including types of mathematical and/or simulated models to be used for system and cost effectiveness. Trade-off studies should be accomplished at various levels or as specifically designated and approved by the PM to support the decision needs. Trade studies will be conducted in accordance with Project procedures.

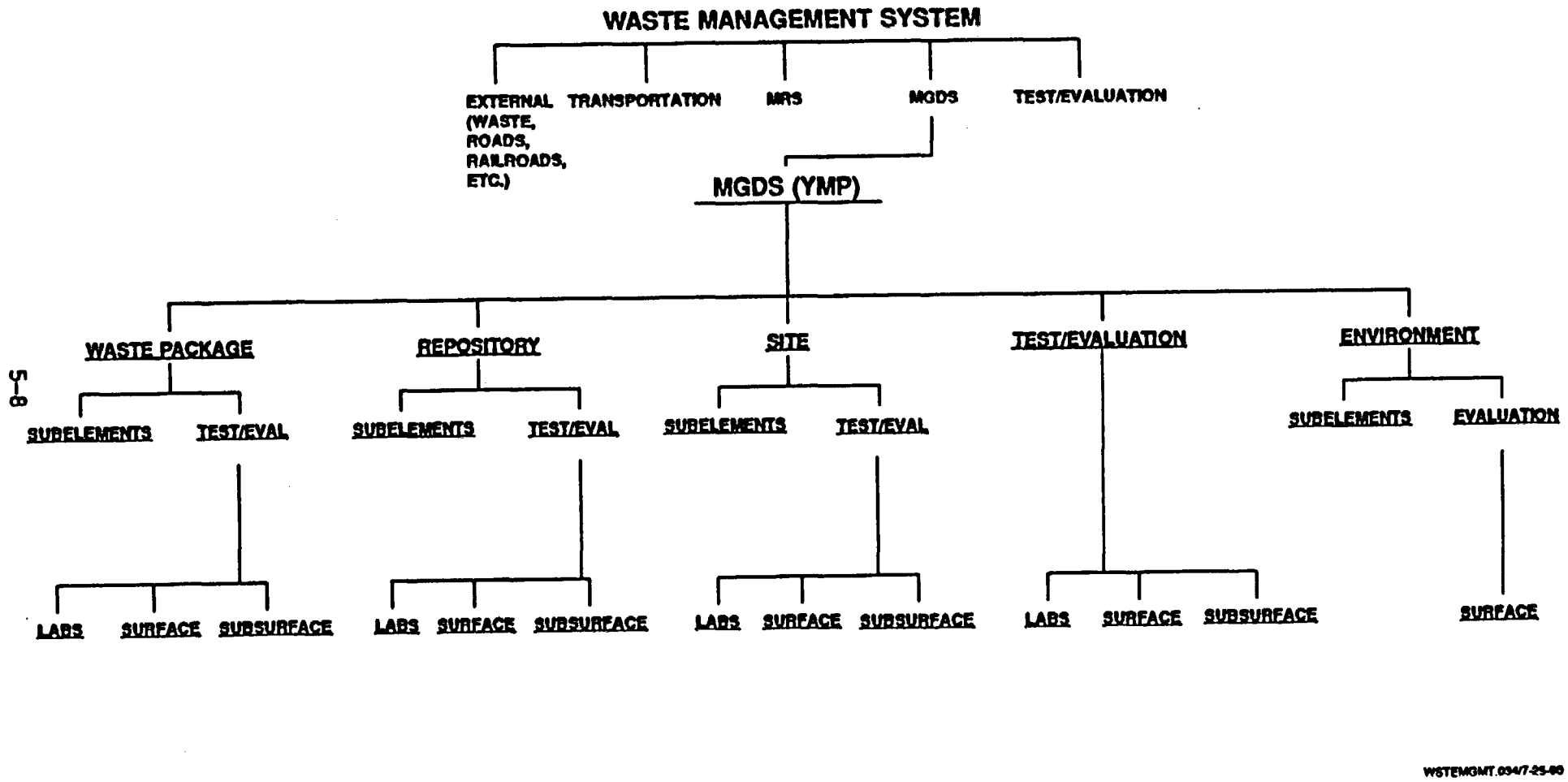

Figure 5-1. System elements of the Waste Management Program.

5.3.5 DECISIONS

The evaluations will be used to select among alternatives, to refine conceptual models, and to reduce uncertainty. These decisions will result in either changes to the requirements or construction and characterization activities which result in a revised description of system elements.

5.4 INTEGRATION ACTIVITIES

Integration activities are a major component of systems engineering on the Yucca Mountain Project.

5.4.1 INTEGRATION OF SYSTEMS ACTIVITIES

Systems engineering will be used to identify, define, develop, and document interfaces on a project. Included is the control of these interfaces to ensure that changes do not compromise the compatibility of the overall system design and function. On the 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.

5.4.1.1 Specialty engineering

5.4.1.1.1 Reliability engineering

Reliability requirements involve both preclosure and postclosure activities. Many system and subsystem reliability requirements of the Project are unique when compared with those of other large-scale developmental acquisition programs. Postclosure system performance cannot be verified by test because of the long time periods involved, so analysis of various models must be used. Further, much of the effort required to establish the reliability allocations and derive the reliability predictions will be for a natural system, not an engineered system.

Currently, in the site characterization and site selection and approval phases, most of the reliability engineering is being performed as part of the performance assessment effort as required in the Performance Assessment Management Program (PAMP). The effort has been focused on deriving a system model that will provide credibility for estimating the probability of achieving successful performance.

Reliability studies for preclosure activities will focus on equipment and processes specifically designed or uniquely applied to the MGDS. Items and processes important to safety will require reliability analyses. Logistics support analysis (LSA) will be performed to determine the scope of these analyses and certain other reliability efforts necessary for successful completion of the Project.

Reliability activities for the engineered systems will be defined in the design plans as part of the design efforts that address the following:

- A description of how the reliability program will be conducted.
- The procedures detailing how each specified reliability task will be performed and complied with.
- Identification of the organizational unit with the authority and responsibility for executing each task.
- Description of how reliability contributes to the total design.

5.4.1.1.2 Maintainability engineering

The purpose of the maintainability program is to establish maintenance requirements for each Project phase that will lead to reduced life-cycle costs (LCC) and provide data essential for management. The objective is to ensure attainment of the maintainability requirements. Each program phase has a set of requirements that will be addressed. The activity will include the following:

- An identification of the maintainability tasks to be accomplished.
- A detailed description of how each maintainability task will be performed.
- Reference to all procedures necessary to perform all required maintainability tasks.
- Identification of the organizational unit with the authority and responsibility for executing each task.
- The method by which the maintainability requirements are disseminated to Participants and suppliers.
- The methods planned for recording maintainability data.

Maintainability planning for all Project phases will be completed later during the site characterization and site selection and approval phases as part of the design activities. Maintainability planning will be involved with items and activities, such as test equipment used for site characterization, ESF testing, and reliability/performance assessment testing; ESF construction; repository construction, operation, and closure; and all equipment used for failure detection monitoring.

5.4.1.1.3 Integrated logistics support (ILS)

Logistics considerations for the Project will focus on the total support needed to provide the necessary analyses and planning to ensure the required supportability will be in place during all Project phases. Logistics considerations include manpower (both authorization and availability), training, support and test equipment, facilities, logistics data (both manuals and configuration), packaging, handling, storage, and transportation.

Later in the D&E phase, this total planning package will become unified and be used to develop supportability assessment criteria and to serve as the basis for the LSA.

The ILS effort will be jointly coordinated between all Participants and the DOE. ILS requirements will be incorporated in the proper requirements documents. ILS evaluations will be incorporated in the various hardware and software system reviews in order to verify that ILS requirements are being satisfied.

The ILS effort will define the support concept for the system life cycle and defines plans for projected manpower support in terms of numbers, skill levels, and phasing. Training support, including course plans, equipment setup, and instructor requirements, will also be defined. Training is described in the PMP and associated documents.

The logistics effort will direct the LSA toward the planning and coordination at all program levels and introduce these items into the systems engineering process, as directed by the PM.

5.4.1.1.4 Operability assessments

Operability assessments will be used to predict the engineering performance of the repository and LCC. 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 Project to evaluate design improvements, provide information to OCRWM for the evaluation of fee adequacy, and provide information for Project management. Trade-off analyses are an integral part of all technical evaluations. Trade-off analyses will be used to identify, document, and evaluate design, scientific, and operational improvements for optimizing MGDS operability performance. Operability assessments will be implemented for requirements defined in the design plans and as directed by the PM.

5.4.1.1.5 Risk management

Risk management is an organized means of identifying and measuring risk and developing, selecting, and managing options for handling these risks. Risk management on the Project is not a separate activity assigned to a risk management department, but rather is one aspect of the technical management process. Many of the systems engineering functions described in this SEMP (performance assessment, trade-off studies, and review processes) are also risk management methods. Any source of information that allows recognition of a potential problem can be used for risk identification. Risk items will be monitored and actions recommended.

The first step in risk management is to evaluate program areas for potential risks. This step will be initiated during the D&E phase at the direction of the PM or his designee and will be updated as the program progresses.

Some degree of risk will always exist in program, technical, and engineering areas. Program risks include funding, schedule, and political risks and are addressed in the PMP. Technical risks may involve the risk of meeting a performance requirement, risks in the feasibility of a design concept, or the risks associated with using state-of-the-art equipment or software. Engineering risks include reliability, maintainability, operability, and trainability concerns. Risk management on the Project will continue through all program phases.

The PM shall ensure that a risk management strategy is established and that risk is addressed during each Project phase throughout the system life cycle. The strategy shall describe how risk identification, risk assessment, risk reduction, and risk management functions will be performed. The risk assessment process is iterative and is applied to the mainstream engineering efforts for each previously identified risk as the design progresses.

The PM may direct that a separate Risk Handling Plan be prepared for each high-risk item, identifying the timing for its development and assigning originator and review responsibility. The PM may also direct that Risk Reduction Reports be prepared for each item classified as medium or high-risk.

5.4.1.1.6 Life-cycle cost

LCC is the total cost of the system over its entire life, i.e., during D&E, construction, operation, and closure/decommissioning. During the current D&E phase and up to the LA process, the LCC effort is focused on identifying and categorizing cost drivers, evaluating relative LCC differences among alternative competing concepts, and providing information that supports the cost estimates used to establish the budgets. During future phases of the program, the LCC emphasis will shift to develop LCC estimates for each alternative, develop LCC baseline cost estimates, and refine the baseline cost estimates. During the construction phase, LCC will begin its transition from primarily a design element to a control element for the Program. All decisions will still be considered in light of their effect

on LCC, but, at this point in development, LCC is more of a control tool for keeping the program on track by highlighting the effect that decisions and changes will have on total program cost.

Design to Cost (DTC) is a process that may be used at the direction of the PM with the objective of designing for lower LCC. Cost goals and thresholds may be established.

It is important to emphasize that the main objective in performing LCC analysis for the Project will not always be to provide the absolute minimum LCC. Because of the high visibility this program has achieved and the absolute need to provide containment and isolation over the required time periods, alternatives providing the minimum LCC may not be preferred. LCC evaluations will be prepared as directed by the PM.

The LCC evaluation shall determine the following:

- How the LCC/DTC process will be audited and controlled.
- Methods for determining and identifying LCC drivers and issues subject to trade-off analysis.
- Description of planned analysis methods and modeling techniques to be used.
- Recommended LCC/DTC goals and planned allocation procedures.
- Planned feedback mechanism for tracking and supporting cost-related goals and status, including proposed analysis, test, and evaluation efforts to be used as progress checks.

5.4.1.1.7 Performance assessment

Performance assessment is the set of activities needed for quantitative evaluations of repository system performance to assess compliance with regulations and to support the development of the geologic repository.

The performance assessment program will provide analyses that assist in determining site suitability, assist in guiding site testing programs, contribute to the licensing documents that will support DOE's LA, and evaluate engineering and design. Performance assessments will continue after submittal of the LA for construction authorization or through repository construction, operation, permanent closure, and decommissioning; to assist in obtaining any amendments to the LA; to ensure that the MGDS and its elements—the site, the repository, the waste package test/evaluation, and environment—are performing as expected; and to ensure that operating procedures are protecting the health and safety of workers and the public. The performance assessment program includes all the analyses and supporting activities associated with the preclosure safety and postclosure performance of the repository, as well as assessment of interfaces between the MGDS and other elements of the Civilian Radioactive Waste Management Program.

5.4.1.1.8 Safety/risk evaluations

Safety/risk evaluations are included in the PAMP. Safety/risk evaluations will be implemented in accordance with directives in the S&HP and the Design Plan and as directed by the PM.

5.4.1.2 Technical data management

Project Participants perform site characterization field and laboratory experiments, design, and various analyses and trade-off studies that are documented in

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

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

Technical data will be managed in accordance with the TDMP. Technical data that are records will be managed in accordance with the Project Records Management Plan. The Project TDMP describes the Project's technical data management system, including the flow of technical data within the Project and the relationships between Participant data-gathering activities and the Project technical data bases and the RIB. 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 contains 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 ESF Systems Description Requirements Document (SDRD) direct the development of the design for the engineered subsystems of the MGDS.

5.4.1.3 Interface control

In general, all of the approved Project plans and procedures define the Participants' responsibilities. In fulfilling these responsibilities, the responsible organizations must interact in a controlled manner. These interactions deal with the interfaces among physical systems and transfers of information among organizations. Physical interfaces deal with the form, fit, function, and transfers at the boundary of engineered and natural systems. While control of all physical interfaces requires the transfer of information, the Project also controls other organizational interfaces when information must be transferred among organizations in order to complete an

activity. This section does not address transfers (such as chain of custody transfers of samples), which result in the normal course of following a procedure.

All interfaces between organizations are to be identified and controlled. Interfaces between Participants and interfaces with outside organizations are controlled at the Project level as described in the Project CMP and implementing procedures. Project-level interfaces are described in several documents as explained below. Interfaces internal to a Participant organization are to be controlled by the Participant.

Physical System Interfaces. The Yucca Mountain Geologic Disposal System has been disaggregated into several subelements as shown in Figure 5-1. For example, the subelements of the MGDS include the site, the waste package, the repository, the environment, and test/evaluation. This disaggregation reflects decisions to rely on (or design) certain elements to perform functions in support of the overall system goals.

Note that a test/evaluation element is shown for each level. These elements are added to show that tests or evaluations are necessary to confirm that the performance requirements will be achieved. These tests or evaluations (including performance assessments) may require facilities, i.e., surface-based facilities, subsurface-based facilities, or laboratories. These facilities need not be independent, i.e., the subsurface tests will be consolidated in the ESF facility. The tests and evaluations to be performed are described in the T&EP, while the requirements for the test facilities are consolidated into design requirements documents (e.g., the ESFDR and SBTFRD). Laboratory facility requirements are the responsibility of the Project Participants. The system elements described above provide a basis for the identification of configuration items. The CMP will describe how the various configuration items that are identified will be documented and controlled.

The fact that a physical interface exists does not imply that the system can be controlled. For example, while we can change the uncertainty of our understanding of a natural system, we have little control over the system.

The physical system elements structure is similar but not identical to the Technical Requirements Hierarchy. As noted above, the test/evaluation elements can be combined and served by common facilities (i.e., the ESF and the Surface-Based Test Facilities). Environment is an element that constrains the other elements. No separate requirements documents are prepared for the environment element.

Organizational Interfaces. In addition to the physical system interfaces, an organization often requires information (e.g., results of an analysis) that is being prepared by another organization. The Project also provides for documentation and control for these interfaces, as described below.

Identification of Interfaces. The first step in interface control is to identify the Participant responsibility with respect to the system elements. The responsibilities of each of the Participants are identified in the Work Breakdown Structure (WBS) Dictionary and must be translated into the system

elements. These responsibilities are provided in Figure 5-2. The determination with respect to disaggregation within the area of a Participants' responsibilities is determined and documented by the responsible Participant.

The Participant then needs to determine where in the disaggregation he intends to control the external and internal interfaces. The controls can be applied in a modular fashion to reduce the number of interface documents required. The internal interfaces are managed by the responsible Participant. The external interfaces are identified by the Participants. The identification and schedules for completion of interface activities are maintained by the Project Office.

Documentation of Interfaces. Interfaces can be documented by several techniques: (1) as constraints imposed via technical requirements documents; (2) as management requirements imposed in management plans, e.g., study plans; (3) as interface control documents, which are referenced in the associated requirements document or T&EP; or (4) as information provided for general Project use in the RIB. All of the approved documents are administered and controlled by the Configuration Management (CM) process. The CM organization will also provide the Participants with a periodic Interface Status Report for Project-level interfaces to be used as a management tool for tracking and controlling their interface activities. Interfaces internal to a Participant organization will be tracked and controlled by the Participants' procedures.

Technical Requirements Documents. The Technical Requirements documents are structured to allocate functions to physical systems. These documents are used to define the expected product to be provided. These documents also identify the physical system interfaces and provide (as they are developed) references to the interface control documentation, which defines the negotiated interfaces.

Management Plans. This SEMP describes a general process that is to be followed by all Project technical activities. The CMP will describe how the interface control process is managed and controlled. The lower-tier plans will describe how the interfaces will be identified and how the process will be implemented. Interfaces among organizations will be identified, documented, and controlled at all levels. The management plans describe what is required as a product and may include a reference to the technical requirements documents.

Interface Control Documents. Were a description of the required interfaces is needed, Memoranda of Understanding (MOUs) can be prepared. MOUs are prepared and approved by each Participant involved. The requesting organization should initiate the MOU. When the interface has been documented, it will be noted in the Project Office records, along with the location of the documentation that controls the interface. This interface control documentation supplements the requirements by defining a consistent way for interacting systems to fulfill their requirements. The documentation also provides for control of inputs so that if the input to an evaluation changes, the output will be reevaluated.

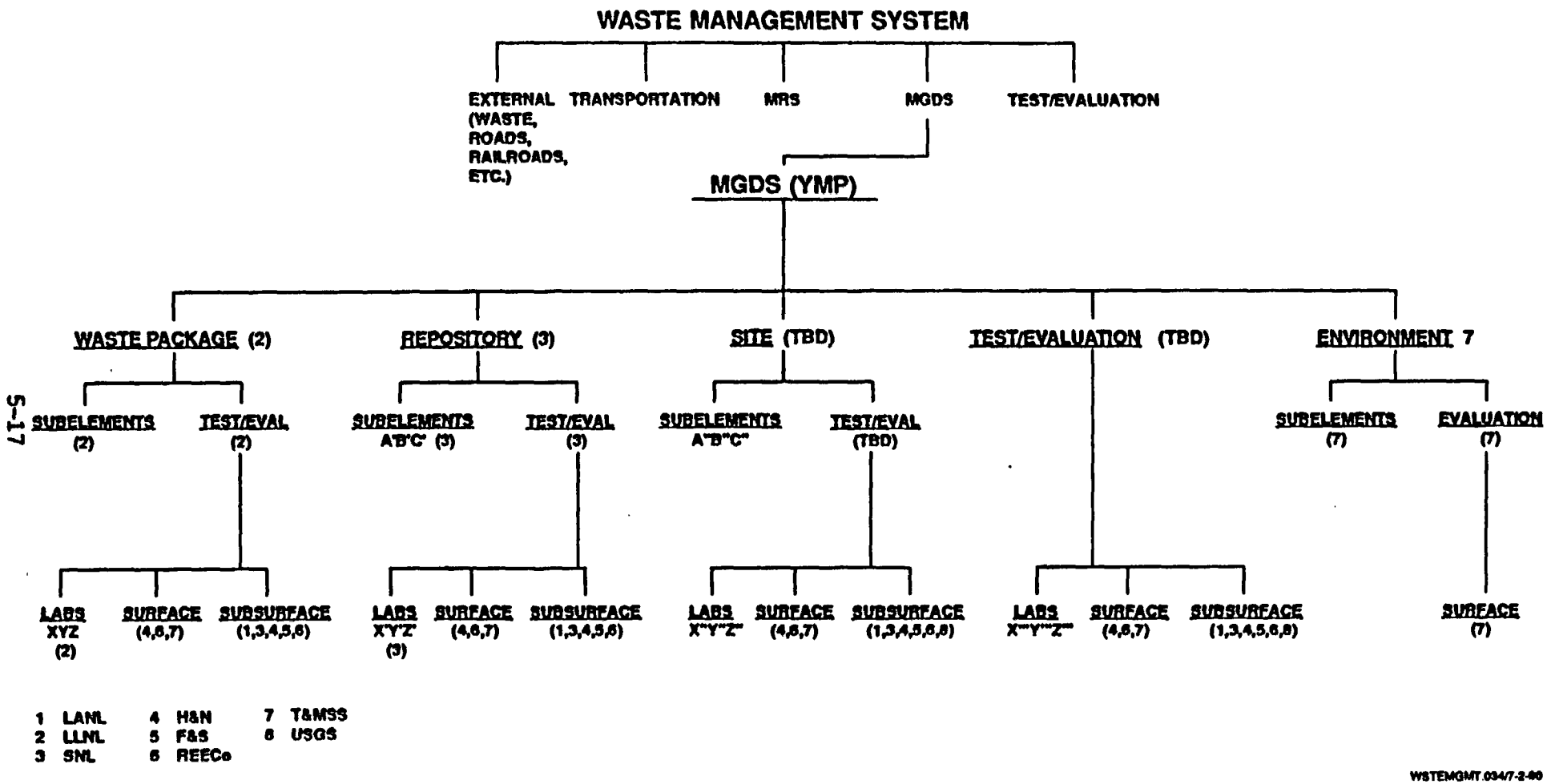

Figure 5-2. Responsibility for system elements.

Reference Information Base. The TDMP will describe how the technical data bases are used to control information transfers among organizations. Often the information required for an informational interface will be placed in the RIB. For example, an MOU could identify and define the data needed and agree that the provider would place the information in the RIB for Project use.

5.4.1.4 Configuration management

The CMP shall define the process for control of configuration items and their related documentation, including change control and interface control.

5.4.2 INTEGRATION WITH RELATED PROJECT MANAGEMENT

The 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 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.

5.4.3 INTEGRATION OF PROJECT TECHNICAL ACTIVITIES

The 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, EIS, and the Site Selection Report.

The 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 National Environmental Policy Act, DOE Orders, and DOE 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 Project will integrate the regulatory requirements, regulatory compliance activities, and scientific evaluations into Project activities, including waste package and repository design and engineering studies.

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 EMP in conformance with DOE direction.

5.4.3.1 Design

5.4.3.1.1 Repository and waste package design

The technical approach to and implementation of design activities are described in Project design plans. Repository and Waste Package design during the site characterization and site selection and approval phases 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 and waste package design will be identified in the SR. SRs and other design requirements will be incorporated into the design process by means of the Project RDR and WPDR. The description of the RDR and WPDR are in Appendix A. 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, value engineering, 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 Appendix A.

Designers will refer to the RIB and Interface Control Documents for reference information concerning (1) historical impacts of field explorations on the Yucca Mountain site and (2) planned field explorations. These

documents will contain detailed information (e.g., exploratory borehole locations, depths, sizes, type, and amount of drilling fluids) about field activities.

The physical interfaces, including underground and surface-based testing, will be managed through the use of interface control documentation.

Changes to repository design-related parts of the Project Baseline will be made according to the change control requirements defined in the CMP.

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.

5.4.3.1.2 Test facility design

The technical approach and implementation of ESF design activities are described in the Exploratory Shaft Facility Plan.

ESF design requirements will be prepared to guide the design. The ESF design requirements will be consistent with the site-specific requirements in the SR and the ESF test requirements described in study plans and engineering plans. Prototype tests may 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 RIB and interface control documents for reference information concerning historical and planned impacts of field explorations at the Yucca Mountain Site. Physical interfaces with the repository will be managed through the use of interface control documentation.

Changes to ESF-related parts of the Project Baseline will be made according to the change control requirements. Portions of the design may be modified without formal separation of the design phases.

The Surface-Based Test Facilities will follow a similar process, as described in the Surface-Based Test Facility Plan.

5.4.3.2 Test and evaluation

The Project shall develop a T&EP emphasizing site characterization consistent with the requirements of DOE Order 4700.1, Attachment III-3. It should be noted that design-specific tests are described in the appropriate design plans. The T&EP should be detailed to the extent necessary to show the rationale for the kind, amount, and schedules of the testing planned for the Project. The T&EP will be coordinated with the development of the FMP. The plan will relate the test and evaluation effort clearly to the Project's

technical risks, operational issues and concepts, performance criteria, reliability, availability, maintainability, and acquisition phase key decisions. It will explain the relationship of component, subsystem, integrated system development tests, and initial operational tests, which, when analyzed together, provide confidence that the Project is ready to proceed to the next phase of the acquisition process. As a minimum, the plan shall address the testing and evaluation to be performed in the site characterization phase, including test planning, test implementation, test management, data management, and use and evaluation.

Site characterization includes the field and laboratory work in the geological sciences. The site studies will provide data for use in the 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 Project technical data bases and the RIB.

The requirements for site characterization will be developed from the SR and the issues hierarchy. 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.

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 issues hierarchy and to demonstrate compliance with site-related requirements in the SR.

5.4.3.3 Integration of environmental program

The general organization and management of environmental activities are described in the Project EMP. Specific requirements related to the MGDS subsystems are included in the SR and in the subsystem requirements documents.

The Project will integrate environmental assessment activities with OCRWM-level and 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 Indian Tribes and a broad spectrum of public comment and involvement in efforts to mitigate the impacts of waste management.

Environmental impact analysis will consider the implications of 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. Types of these impact analyses will include air quality, water resources, radiological, soils, noise, social, cultural, archaeological, historical, aesthetic, biological, and socioeconomic effects. Results of the evaluations will also be used to identify mitigation strategies. Impact analysis is further described in the EMP.

5.4.3.4 Integration of performance assessment

Strategies for addressing waste isolation and containment requirements, including the role of performance assessment in meeting those requirements, are described in the OCRWM Performance Assessment Strategy Plan and in the SCP. Detailed descriptions of performance assessment activities are found in PAMP and implementing plans and procedures.

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 resulting from performance assessments items will be refined and documented in the RDR, ESFDR, SBTFRD, 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. Appropriate performance assessment will be included in the analyses that support proposed changes to the Project Baseline.

5.4.4 INTEGRATION WITH QUALITY ASSURANCE

This section describes the way in which Project design and scientific investigation activities will meet the interface document and control requirements in the QAR and QAPDs.

QA and systems engineering are both integral parts of the 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 Project will be in compliance with the QAR and QAPD. All Participating Organizations, including the Nevada Test Site support contractors, have developed and are implementing their own procedures in conformance with the Project QA requirements. These documents identify the requirements that apply to their organization and the measures to satisfy these requirements.

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

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APPENDIX A

DOCUMENTATION

APPENDIX A

DOCUMENTATION

NOTE: Management plans other than the SEMP shown in the document hierarchy are not described in this appendix.

1.0 SYSTEMS ENGINEERING MANAGEMENT PLAN

Project Participants may propose additions or changes to the SEMP and existing QA or administrative procedures to more effectively or efficiently implement a systems engineering requirement.

2.0 YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM DESCRIPTION

The SD will provide a detailed reference description for each MGDS subsystem. The level of detail of information included in the SD will increase with time. At a minimum, the SD will be updated at the end of each design or siting phase. The SD will include the following for each subsystem: (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.

3.0 YUCCA MOUNTAIN MINED GEOLOGIC DISPOSAL SYSTEM REQUIREMENTS

The SR will translate the Generic Requirements (GR) for an MGDS into detailed requirements for the site-specific MGDS requirements; provide identification of the requirements that the MGDS will meet; and provide a detailed allocation of each requirement to the MGDS subsystems that will work together to meet the requirement.

The SR will include the following:

1. Definition of MGDS subsystems. The MGDS subsystems defined in the WMSR will be used to develop a full site-specific definition of all MGDS subsystems and subsystem elements.

2. Purpose. The primary purpose of the system element or subsystem.

3. Applicable regulations, codes, and specifications. The SR will list the specific paragraph, section, or part of the regulations, codes, or specifications that apply to the site-specific MGDS. This SR will be a complete listing of applicable federal, State, and local laws and regulations and applicable industry codes and standards.

4. Functional requirements. The GR for the MGDS specified in the GR document will be analyzed and transformed into the basic functional requirements for an MGDS specific to a given site. Such functional requirements are to be specific descriptive statements for the basic operations that must be performed by the MGDS, its subsystems, and subsystem elements.

   The functional requirements will take into account reliability and maintainability, as well as availability requirements. Test requirements will also be included. Maintenance requirements should be analyzed as early as feasible (i.e., once the equipment and facilities to be maintained have been identified) because of their influence on the final definition of total requirements for MGDS operations and operations personnel and because of the need to identify any special maintenance equipment and facilities. Requirements for test functions and operations will be developed concurrently with the maintenance requirements. An analysis of operations, maintenance, and test functional requirements will identify the need for supporting test facilities and equipment, equipment for special activities, transportation equipment, test and activation personnel, and training.

5. Performance criteria. Each MGDS function will be analyzed for the purpose of determining the level of performance it must reach and, as appropriate, the means for assessing the performance. Criteria that define that level of performance will be developed or otherwise identified and incorporated into a set of performance criteria for each functional requirement. Performance criteria will be given in quantified (if feasible) or well-qualified terms. Initially, performance criteria will be functionally oriented, but, with successive iteration and expansion to lower MGDS levels, such criteria will specify (a) reliability and maintainability, as well as availability criteria; (b) maintenance, activation, and test criteria; and (c) criteria for personnel, training, and procedures.

6. Design and operating requirements. A listing and specification of the objectives to be used in the design of the system elements and in the planning of the operation of the system.

7. Interface control requirements. For each MGDS subsystem, the features for the subsystem that interface with other subsystems will be identified. These interfaces will be those features that must be controlled to ensure proper integration of the MGDS.

8. Constraints. The Project will define the constraints placed on the MGDS and its subsystems and subsystem elements. These constraints will be limitations imposed by the design process, interrelated subsystems, or subsystem elements; by environmental conditions within which the MGDS, its subsystems, and major subsystem elements must function; and by applicable regulations, codes, standards, and policy.

9. Assumptions. In the event any functional or performance requirements have not been defined, a description of the design-basis assumptions to be used will be provided.

10. System configuration. A description of the subsystem configuration and the relationship between subsystem elements.

These requirements will be defined in sufficient detail, using numerical values with associated tolerances, to provide the basis for the detailed design, development, and testing or otherwise form the basis for a detailed procurement specification.

4.0 REPOSITORY DESIGN REQUIREMENTS

The purpose of the RDR is to provide design requirements for the surface facilities, the shafts and ramps, and the underground facilities of the MGDS. The requirements document will include requirements in terms of functions, performance criteria, constraints, and interfaces. The RDR 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 document will include the minimum required contents for design-requirements documents as described in the OCRWM SEMP (DOE, 1990).

5.0 WASTE PACKAGE DESIGN REQUIREMENTS

The purpose of the 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 DOE, to other organizations within the Project, and to design contractors. Requirements will be derived from the SR.

The document will include the minimum required contents for design-requirements documents as described in the OCRWM SEMP (DOE, 1990).

6.0 EXPLORATORY SHAFT FACILITY DESIGN REQUIREMENTS DOCUMENT

The purpose of the 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.

The document will include the minimum required contents for design-requirements documents, as described in the OCRWM SEMP (DOE, 1990).

7.0 SITE REQUIREMENTS DOCUMENT

The purpose of the STRD is to define the functions that the site natural systems are expected to perform and the information needed to characterize the site. The document will address both site characterization and environmental activities. The document will describe the functions, performance criteria, constraints, and interfaces.

8.0 SURFACE BASED TEST FACILITIES REQUIREMENTS DOCUMENT

The SBTFRD shall describe the facilities required for Surface-Based Testing, including (1) Site Preparation/Site Installations, (2) Utilities, and (3) Facilities. If deemed appropriate, the facility requirements may be integrated with the ESF requirements. This document does not need to cover prototype testing outside of the planned extent of the controlled area.

The format of this document shall include the following information:

1. Definition of MGDS subsystem
2. Purpose
3. Applicable regulations, codes, and specifications
4. Functional requirements
5. Performance criteria
6. Design and operating requirements
7. Interface control requirements
8. Constraints
9. Assumptions
10. System configuration

9.0 TEST & EVALUATION PLANNING BASIS

The T&EPB is the controlled data base of scientific investigations and data needs on which the planned tests are based. The content of the T&EPB was derived initially from Chapter 8 of the Project SCP and the approved Study Plans. Further test requirements will be added to the T&EPB as they are developed.

The T&EPB includes (1) the rationale for scientific investigations planning, including the top-level strategies, issues hierarchy, site-specific information needs, and the performance allocation process; (2) descriptions of investigations (including rationale), studies, and activities for site characterization (including waste package environment testing and seals environment testing); (3) tables showing links between studies/activities, activities/characterization parameters, and higher-level calls for information, (e.g., issues and performance/ design parameters); and (4) relative sequencing, data feeds, and timing shown on site program schedules.

10.0 CONFIGURATION-BASELINE DOCUMENTS

As directed by the OCRWM SEMP, the configuration-baseline documents will provide all the details of the design necessary for fabrication, assembly, construction, installation, and testing of the facilities and equipment. They will include specifications and final drawings, QA provisions, test procedures and operations, and maintenance manuals. Each configuration-baseline document will include a traceability matrix that will trace the design requirements to those contained in the appropriate design requirements document. A configuration-baseline document will be developed for each system element. The configuration-baseline documents will be developed by the cognizant PM, concurred in by the cognizant OCRWM division director, and approved by the respective Project CCB.

11.0 AS-BUILT-SYSTEM-CONFIGURATION-BASELINE DOCUMENTS

As directed by the OCRWM SEMP, the as-built system-configuration documents will be updates of the respective system configuration-baseline documents. They will reflect changes to the configuration-baseline documents resulting from deviations and waivers granted during construction, equipment upgrade or replacement, and procedure modifications. Therefore, the as-built system-configuration baseline will reflect the actual system configuration of the waste management system throughout the life of the system.

12.0 PROJECT SYSTEMS-STUDIES PLAN

As directed by the OCRWM SEMP, systems studies are conducted at the Project level under the guidance of the Project SEMP to provide input for the resolution of key issues concerning system configuration, system performance, functional allocation, or major design parameters. The information resulting from these studies will provide one of the bases for reaching system decisions to meet overall project objectives.

The purpose of the systems-studies plan is to provide a well-defined, methodical approach to the definition and implementation of timely systems studies. This supersedes the System Study Register. Results of these studies will provide a sound engineering basis for reaching system decisions.

The systems-studies plan will be prepared by the PM. The plan will include the following:

1. Description of the scope of systems studies.

2. Decisions required to accomplish Project objectives and the information required to support these decisions.

3. A schedule showing when studies are required in relation to other Project activities.

4. A record of completed, ongoing, and planned systems studies.

The Project systems-studies plans will be updated periodically to ensure that the information needed to support decision making and to resolve technical issues will be available when needed. Plans for specialty engineering shall be included. The plan 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.

13.0 SYSTEMS-STUDY REPORTS

Systems study reports will be prepared to document the results of analyses pertaining to Project 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 Project 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 (including assumptions, methods, and the suitability of any computer models used); (3) identification of alternatives; (4) comparison matrix; (5) health and safety risks and impact analysis and programmatic and operational risks; (6) cost analysis, sensitivity analysis, licensability analysis; and (7) conclusions and recommendations, as appropriate. As the design becomes increasingly detailed, systems-study reports will become more definitive. Systems studies will be based on information in the Project RIB, or when evaluations depart from information in the RIB, these deviations will be explained and justified. Specialty engineering reports shall be included as described earlier in this plan.

SITE INVESTIGATION AND DESIGN REPORTS

14.0 SITE AND ENVIRONMENTAL 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.

15.0 DESIGN REPORTS

Design reports will be prepared at the end of each design phase documenting the ESF, waste package, repository designs, and Surface-Based Test Facilities. 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.

16.0 REFERENCE INFORMATION BASE

The RIB contains the reference site, design, performance, and socio-economic 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 Project with internally consistent values for use in their various activities.

17.0 SITE CHARACTERIZATION PLAN

The 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 Project expects to use technical information gathered during site characterization and design impact assessment activities to resolve the issues in the 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 basis for Participant Study Plans, technical procedures, and other technical planning documents that will be used to define and carry out the technical activities of the Project.

The T&EPB, the Site and Design Requirements Documents, the RIB, and other documents will be used to ensure that key information from the SCP is under formal change control.

18.0 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.

19.0 SCIENTIFIC INVESTIGATION PLANNING DOCUMENTS

Prior to the start of any scientific investigation, the responsible Principle Investigator will develop a Scientific Investigation Planning Document for that investigation. The document will provide a description of the work to be performed in the scientific investigation and the proposed methodology for accomplishing the work, including a discussion of the overall purpose for the work. Scientific investigations categorized as site characterization activities, as defined in the NWPA (as amended), will utilize study plans as the Scientific Investigation Planning Document.

20.0 ENGINEERING PLANS

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.

21.0 ENVIRONMENTAL FIELD ACTIVITY PLANS

Environmental Field Activity Plans will be prepared to describe environmental activities, as described in the EMP.

22.0 OTHER TECHNICAL REPORTS

Other reference documentation for the 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). These shall be developed and approved consistent with Project and Participant procedures.

APPENDIX B

LIST OF ACRONYMS

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LIST OF ACRONYMS

ACD	Advanced Conceptual Design
CCB	Change Control Board
CMP	Configuration Management Plan
D&E	Development and Evaluation
DOE	U.S. Department of Energy
DTC	Design to Cost
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESF	Exploratory Shaft Facility
ESFDR	Exploratory Shaft Facility Design Requirements
FMP	Field Management Plan
FPCD	Final Procurement and Construction Design
GR	Generic Requirements
ILS	Integrated Logistics Support
LA	License Application
LAD	License Application Design
LCC	Life-Cycle Costs
LLNL	Lawrence Livermore National Laboratory
LSA	Logistics Support Analysis
MGDS	Mined Geologic Disposal System
MOU	Memorandum of Understanding
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
OCRWM	Office of Civilian Radioactive Waste Management
PAMP	Performance Assessment Management Plan
PM	Project Manager
PMP	Project Management Plan
PMS	Project Management System
Project Office	Yucca Mountain Project Office
PP	Project Participants
QA	Quality Assurance
QAPD	Quality Assurance Program Description
QAR	Quality Assurance Requirements
RAM	Reliability, Availability, and Maintainability
RDR	Repository Design Requirements
RIB	Reference Information Base
SBTFRD	Surface-Based Test Facilities Requirements Document
SCP	Site Characterization Plan
SCP/CD	Site Characterization Plan Conceptual Design
SD	Yucca Mountain MGDS Description
SDRD	Systems Description Requirements Document
S&HP	Safety and Health Plan
SEMP	Systems Engineering Management Plan
SIR	Site Investigation Report
SNL	Sandia National Laboratories
SR	Yucca Mountain MGDS Requirements
STRD	Site Requirements Document
TDMP	Technical Data Management Plan
T&EP	Test and Evaluation Plan

T&EPB	Test and Evaluation Planning Basis
T&MSS	Technical and Management Support Services
TPO	Technical Project Officer
TSDMP	Technical Support Document Management Plan
WBS	Work Breakdown Structure
WMSR	Waste Management System Requirements
WPDR	Waste Package Design Requirements