SOFTWARE QUALITY ASSURANCE PLAN

Supporting the

Yucca Mountain Project Exploratory Shaft Facility

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Yucca Mountain Project
Exploratory Shaft Facility

SOFTWARE QUALITY ASSURANCE PLAN

Abstract

This Software Quality Assurance Plan has been written by Fenix & Scisson of Nevada to govern its use of commercially acquired and existing computer software in support of the Yucca Mountain Project High-Level Waste Management Program for the Department of Energy in support of its license application. Other requirements dictate necessary controls related to the software environment (hardware, operating system, configuration), control of input (data, parameters), and management of output in order to maintain the integrity of this plan. In the event that it becomes necessary to develop software in-house, FSN will prepare a separate software quality assurance plan for that software consistent with the requirements of NNWSI/88-9.

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CONTENTS

1.0 INTRODUCTION 1

1.1 PURPOSE 1
1.2 OBJECTIVES 1
1.3 APPLICABILITY 1
1.4 SCOPE 2

2.0 RESPONSIBILITIES 4

2.1 PROJECT MANAGER 4
2.2 COMPUTER CERTIFICATION TECHNICAL OFFICER 4
2.3 COMPUTER CERTIFICATION RECORDS SPECIALIST 4
2.4 LEAD DISCIPLINE ENGINEER 4
2.5 QUALITY ASSURANCE REPRESENTATIVE 5
2.6 USERS 5
2.7 INDEPENDENT REVIEWER 5
2.8 RESPONSIBLE DISCIPLINE ENGINEER 5

3.0 SOFTWARE QA PROGRAM REQUIREMENTS 6

3.1 SOFTWARE ENVIRONMENTAL CONFIGURATION MANAGEMENT 10

3.2 SOFTWARE CONFIGURATION MANAGEMENT 10

3.2.1 Configuration Requirement 10
3.2.2 Configuration Identification 10
3.2.3 Configuration Change Control 11
3.2.4 Configuration Status Accounting 11

3.3 CLASSIFICATION/AUTHORIZATION PHASE 11

3.3.1 Software Requirements Specification 12
3.3.2 Software Requirements Review Plan 13
3.3.3 Software Requirements Review 13
3.3.4 Software Requirements Review Report 14

3.4 SOFTWARE ACQUISITION AND EVALUATION PHASE 14

3.4.1 Software Design Description 15
3.4.2 Software Design Description Review 15
3.4.3 Software Design Description Review Report 16
3.4.4 User Documentation 16
3.4.5 User Documentation Review 17
3.4.6 User Documentation Review Report 17
3.4.7 Test Documentation (with Test Cases) 18
3.4.8 Test Documentation Report 18
3.4.9 Software Verification and Validation Plan 18

3.4.10 Software Verification and Validation Plan Review 19
3.4.11 Software Verification and Validation Plan Review Report . . . 20
3.4.12 Media Control and Security 20
3.4.13 Software Design and Testing Final Review 20
3.4.14 Software Design and Testing Final Review Report 21

3.5 INSTALLATION AND CHECKOUT PHASE. 21

3.5.1 Installation Test 21
3.5.2 Software Verification and Validation Activities 22
3.5.3 Software Verification and Validation Report 22
3.5.4 Software Verification and Validation Review 23
3.5.5 Software Verification and Validation Review Report 23

3.6 OPERATION AND MAINTENANCE (ERROR CONTROL) PHASE 23

3.7 ACCESS CONTROL 24

3.7.1 Access Authorization Form 25
3.7.2 Certified Run Operation 25
3.7.3 Certified Run Reviews 26
3.7.4 Access Control Log Folder 26
3.7.5 Certified Run Output 26

3.8 REPORTING 27

4.0 REFERENCES TO RUNS 27

5.0 CONTROL OF SOFTWARE CONFIGURATION MANAGEMENT DOCUMENTATION 27

6.0 REFERENCES . . . . . 27 - 28

GLOSSARY OF TERMS AND DEFINITIONS . . . . . 29 - 33

LIST OF ACRONYMS 34

ATTACHMENT 1 STANDARD FORM 185, SOFTWARE SUMMARY 35

ATTACHMENT 2 SOFTWARE PRODUCER FORM . . . . . 36 - 39

LIST OF FIGURES

Figure 1 Classified Software SQAP Requirements 3
Figure 2 Software Life Cycle Model 7
Figure 3 Software Life Cycle Model Reviews 8
Figure 4 Software Life Cycle Process 9

1.0 INTRODUCTION

1.1 PURPOSE

This Software Quality Assurance Plan (SQAP) governs specific uses of commercially acquired and existing computer software by Fenix & Scisson of Nevada (FSN) in support of the Yucca Mountain Project High-Level Waste Management Program for the Department of Energy. Specific uses are defined in the Applicability and Scope sections to follow. The direction expressed in this plan is consistent with and responsive to the software quality assurance requirements of 10 CFR 50, Appendix B, NUREG-0856, NNWSI/88-9 (Section III and Appendix H) and the FSN Quality Assurance Program Plan, QAPP-002 (Section 3.0 and Appendix H). The intent of this SQAP is to assure that work performed using computer software is traceable, reproducible and of value in supporting the licensing activities of the U. S. Nuclear Regulatory Commission (NRC).

FSN will implement the requirements of this plan by issuing Procedures for software classification, approval, acquisition, verification/validation, operation and maintenance (change control) and application. Each procedure shall identify QA Records to be generated and maintained in accordance with FSN records management procedure PP-50-01.

1.2 OBJECTIVES

This plan establishes requirements for software activities which include the acquisition, management, control, documentation and use of software in order to achieve a high degree of benefit of use. Requirements that specify needed activities, documentation and reviews are the means by which this plan assures that software usage is traceable, reproducible, and of benefit. Of necessity, these requirements affect management of hardware, software, input, output, and reporting in order to achieve these goals.

1.3 APPLICABILITY

The detailed requirements set forth in this plan apply to computer software used to produce or manipulate data which is used directly in site characterization and the design, analysis, performance assessment, and operation of Exploratory Shaft Facility (ESF) structures, systems, and components. The extent to which these requirements apply is related to the nature, complexity, and importance of the software application.

The FSN method of classification will be based on the following three categories:

- *Scientific and Engineering software (SES)* - This category of software will be used to produce or manipulate data for site characterization or ESF structures, systems, and components design. This category includes complex scientific, engineering, and mathematical modeling codes and codes that use a numerical method. Trivial calculations and electronic

calculations are not included in the SES category. Trivial calculations are computations which could be done on paper or with an unprogrammed calculator.

- o *Calculational Non-SES software* - This category of software will not be used to produce or manipulate data for site characterization or ESF structures, systems, and components design. Some examples of this category are spreadsheet programs, statistical packages, graphics packages, pre- and post-processors, mesh programs, and mathematical libraries.

- o *Noncalculational software* - This category includes, but is not limited to, compilers, word processors, operating systems, interfaces, driver routines, and other manifest-product software.

The FSN procedure, PP-80-04, will establish the methodology for application of the requirements of this plan to computer programs in each of these categories. Figure 1 establishes the criteria for the application of the requirements of this plan to FSN software as classified above.

1.4 SCOPE

This plan covers computer software used on: (1) any work on deliverables in support of NRC licensing for Quality Assurance (QA) Level I and II activities, and, (2) other work that is deemed by Project Management as critical and requiring similar quality assurance.

DESCRIPTION	SES	NON-SES	NONCALC
3.3 CLASSIFICATION/AUTHORIZATION	x	x	x
3.3.1 Software Requirements Specification (SRS)	x	x	
3.3.2 SR Review Plan (SRRP)	x	x	
3.3.3 SR Review (SRR)	x	x	
3.3.4 SR Review Report	x	x	
3.4 SOFTWARE ACQUISITION & EVALUATION (SA&E)	x	x	
3.4.1 Software Design Description (SDD)	x		
3.4.2 SDD Review (SDDR)	x		
3.4.3 SDDR Report (SDDRR)	x		
3.4.4 User Documentation (UD)	x	x	
3.4.5 UD Review (UDR)	x	x	
3.4.6 UD Review Report (UDRR)	x	x	
3.4.7 Test Documentation (TD)	x	x	
3.4.8 TD Report (TDR)	x	x	
3.4.9 Software Verification & Validation Plan (SVVP)	x		
3.4.10 SVVP Review (SVVPR)	x		
3.4.11 SVVP Review Report (SVVPRR)	x		
3.4.12 Media Control & Security (MC&S)	x	x	
3.4.13 Software Design & Testing Final Review (FR)	x	x	
3.5 INSTALLATION AND CHECKOUT			
3.5.1 Installation Test (IT)	x	x	
3.5.2 SV&V Activities (SVVA)	x		
3.5.3 SV&V Activities Report (SVVAR)	x		
3.5.4 SV&V Activities Report Review (SVVARR)	x		
3.5.5 SV&V Review Report (SVVRR)	x		
3.6 OPERATION AND MAINTENANCE (ERROR CONTROL)	x	x	x
3.7 ACCESS CONTROL	x	x	x
3.7.1 Access Authorization Form (AAF)	x	x	x
3.7.3 Certified Run Review (CRR)	x	x	x
3.7.4 Access Control Log (ACL)	x	x	x
3.7.5 Certified Run Output (CRO)	x	x	x

FIGURE 1

Classified Software SQAP Requirements

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The Project Manager (PM) is responsible for: (1) the overall implementation of this plan and its associated implementing procedure(s), (2) overview and monitoring of all disciplines to ensure compliance with this plan, and (3) assigning the organizational and functional responsibilities necessary to implement this plan.

2.2 COMPUTER CERTIFICATION TECHNICAL OFFICER

The Computer Certification Technical Officer (CCTO) is that individual designated by Project Management responsible for assuring that Configuration Management activities related to computer hardware, software, data output and access control are performed and recorded in accordance with this plan and its implementing procedures. The CCTO shall be assisted by the Computer Certification Records Specialist (CCRS) in accomplishing the record-related duties for which he/she is responsible. The CCTO is responsible for the SQA activities as defined in this plan; and is responsible for any acquisitions and computer technical work specifically related to hardware and software required to implement this plan. The CCTO shall ensure that any computer related operations/acquisitions are done in accordance with applicable DOE requirements and FSN procedures.

2.3 COMPUTER CERTIFICATION RECORDS SPECIALIST

The CCRS is that individual designated by Project Management responsible for: (1) maintaining all records related to the software certification process, (2) distributing and transmitting all required reports and records, (3) performing configuration management and access control logging activities, (4) reviewing and inspecting all forms for accuracy and completeness, (5) maintaining authorized signature list for all activities in support of this plan, and (6) reporting findings in a proper manner to the FSN Project Design Manager as directed by the CCTO.

2.4 LEAD DISCIPLINE ENGINEER

The Lead Discipline Engineer (LDE) is responsible for identifying appropriate Responsible Discipline Engineers (RDEs) as necessary and for providing objective evidence that computer software has the traceable record established, been validated, verified and documented before it is used in its intended application as defined in Section 3.4.9 of this Plan. The LDE shall assure that reviews required by technical staff in this plan are conducted and reported according to this plan under the direction of the CCTO and shall approve all software baselines.

2.5 QUALITY ASSURANCE REPRESENTATIVE

The Quality Assurance Representative (QAR) is responsible for verifying objective evidence that activities and documents required by this plan are being accomplished by the appropriate individuals in accordance with this plan.

2.6 USERS

Engineers or other designated persons who are assigned the task of running software on a certified system for creating a deliverable item are responsible for assuring their activities are in accordance with this plan and its implementing procedures.

2.7 INDEPENDENT REVIEWER

An Independent Reviewer is a designated individual or organization who performs an evaluation of the validity, accuracy and adequacy of a particular activity. The technical qualification of the individual shall be at least equivalent to that needed for the original work under scrutiny. The individual or organization must not be the originator or one who developed the original software.

2.8 RESPONSIBLE DISCIPLINE ENGINEER

The Responsible Discipline Engineer (RDE) is responsible for providing adequate test cases for use in verifying and validating software and for performing other activities as directed in this plan and its implementing procedures. The RDE is also responsible for determining the classification of the software.

3.0 SOFTWARE QA PROGRAM REQUIREMENTS

GENERAL REQUIREMENTS

Software QA program activities are divided into four (4) categories: software environmental configuration management, software configuration management, access control, and reporting. Each of these activities are required in order to assure traceability, reproducibility, and benefit of software usage. QA requirements for data management are provided in FSN procedure PP-80-03.

Specific life cycle model elements (phases) defined in this plan are shown in Figure 2. The specific reviews, documents, and activities associated with each phase of the FSN life cycle are described in Figure 3. The specific methodology for the application of the SQA requirements of this plan to FSN software is provided in the software classification and authorization procedure (PP-80-04).

For the FSN site characterization and design effort, computer software used to perform analysis in support of the license application, as defined in the scope of paragraph 1.4, shall be controlled in accordance with this plan and its implementing procedures.

Figure 4 describes the specific requirements for each process step to be followed in the selection, acquisition, evaluation, test, and configuration management of FSN software. These steps will be followed in the sequence specified.

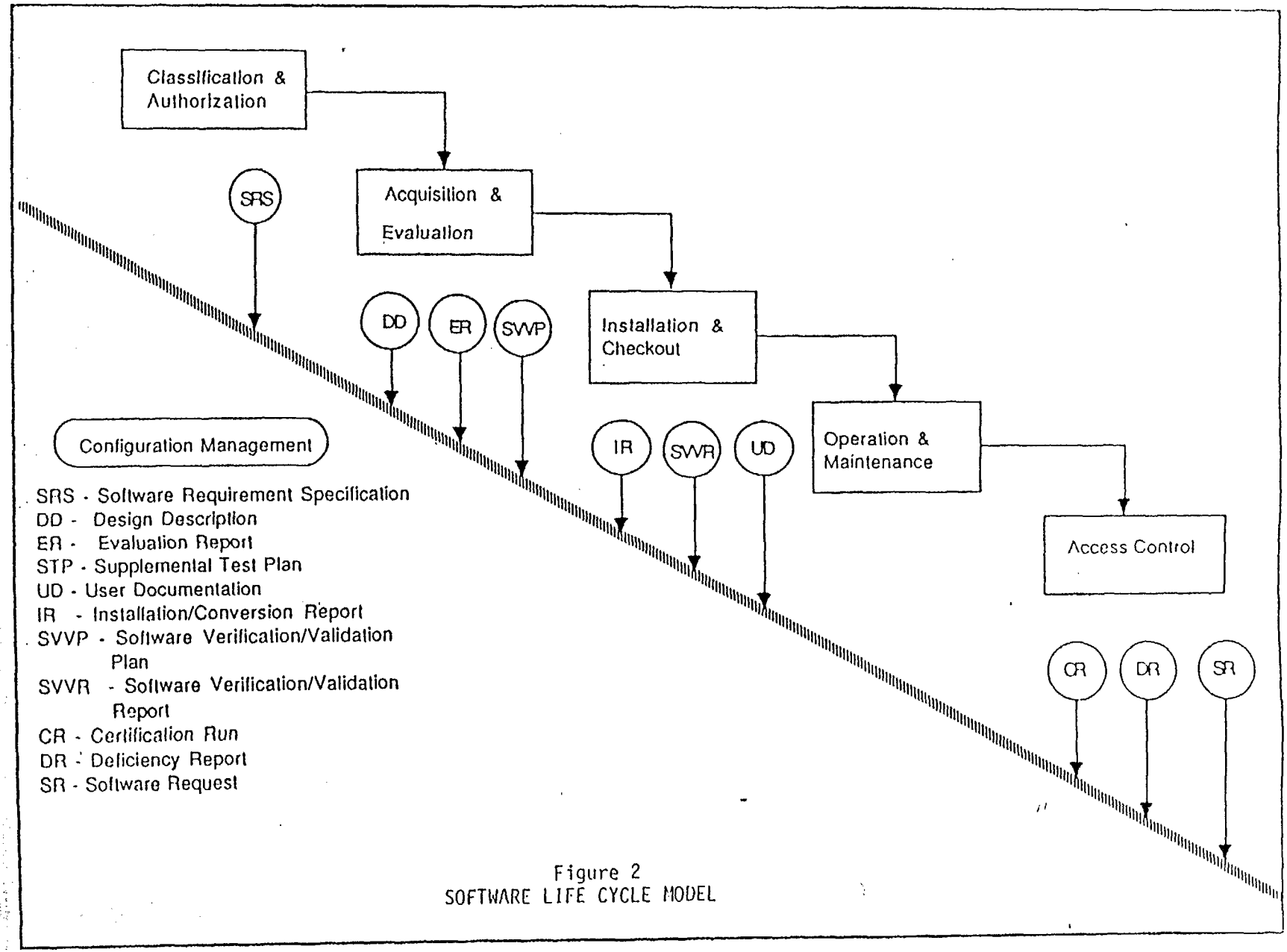
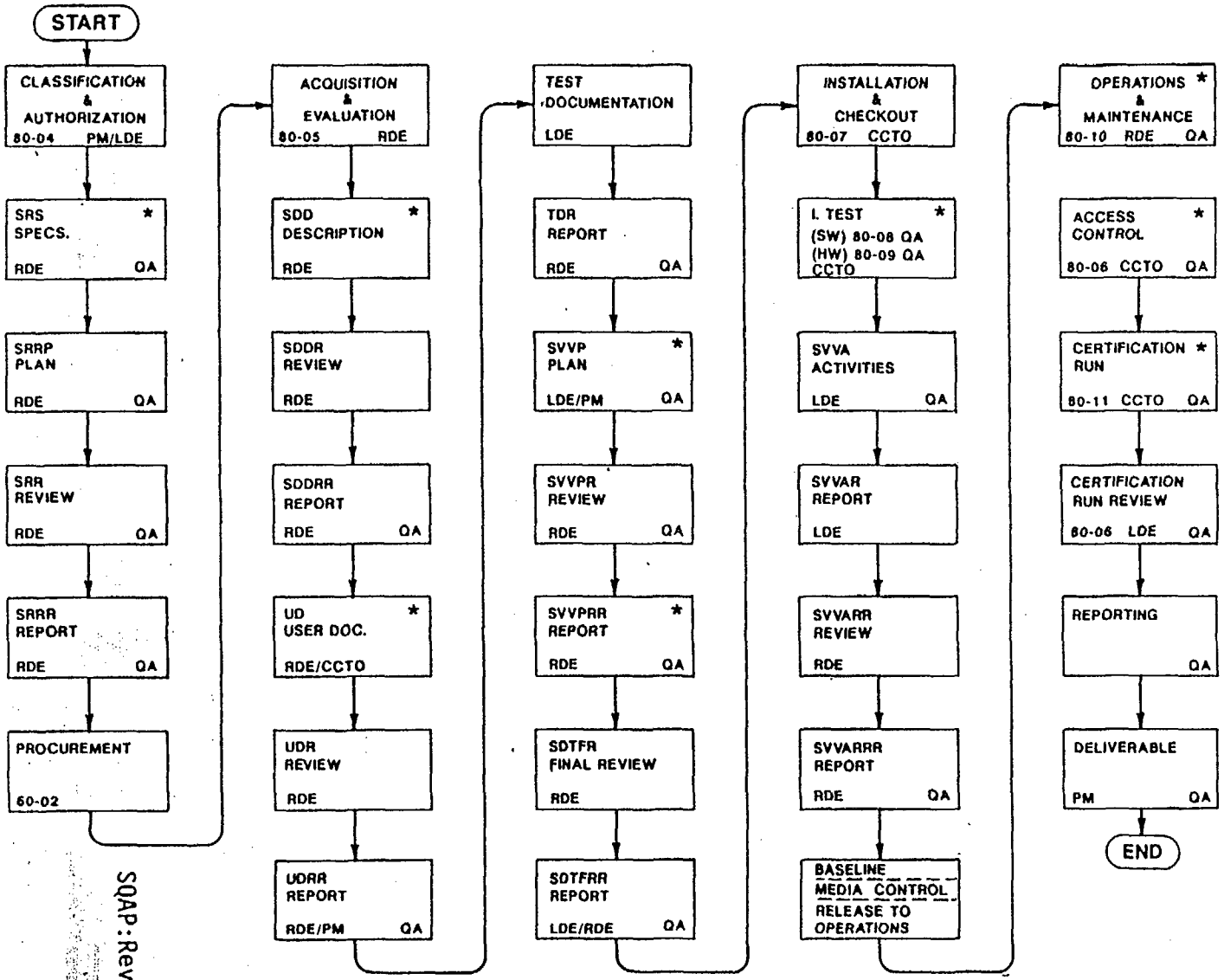


Figure 2
SOFTWARE LIFE CYCLE MODEL

Phases	Software Baseline Documentation	Required Reviews
Classification And Authorization	o Software Authorization Form o Software Requirements Specifications o Software Producer Form o Software Summary (#185)	o Software Requirements Review
Acquisition And Evaluation	o Design Desc. o Test Documents (w/Test Cases) o User Documents o Software V&V Plan	o Design Desc. Review o User Documents Review o SV&V Plan Review o FINAL REVIEW
Installation And Checkout	o Software Configuration Management Log o Software Certification Form o Hardware Certification Form o Software Verification & Validation Report	o Software Verification & Validation Review
Operation And Maintenance	o Transfer Recipient Log o Access Authorization Form	
Access Control	o Access Control Log o Access Control Log Folder o Access Authorization Form o Deficiency Report o Software Request	o Certified Run Review

FIGURE 3

Software Life Cycle Model Reviews



LOG

NAME _____
VERSION # _____
PATCH → REV. NO. _____
BASELINE NO. _____
DATE _____
DESCRIPTION _____
STATUS _____ USE/HOLD
AUTHORIZATION _____
SRS-SPECS. _____
SRRR-REPORT _____
SDDRR-REPORT _____
UDRR-REPORT _____
TEST DOC.-REPORT _____
SVVPRR-REPORT _____
SDTFRR-REPORT _____
SVVARRR-REPORT _____
ACL _____
CERT. RUN # _____
HW CERT. # _____
SW CERT. # _____
CERT. RUN REVIEW _____
DELIVERABLE _____
DATA _____
REFERENCES _____

SOFTWARE SUMMARY REPORT
(STD. FORM 185)

QA RECORD FOLDER
50-01

CONFIGURATION MANAGEMENT

★ REQUIRED

Fig. 4

SOFTWARE LIFE CYCLE PROCESS

SPECIFIC REQUIREMENTS

3.1 SOFTWARE ENVIRONMENTAL CONFIGURATION MANAGEMENT

The original Software Environment Configuration (SEC) description shall be entered in the Software Environment Configuration Management Log (SECML). Entry into the SECML establishes the baseline of the environment (see also section 3.7). Changes to the SEC whether for repair, upgrade, or re-configuring will be described in the SECML and shall be tested for proper functionality by the CCTO. If repairs are needed or if changes are made, a hold is placed on the SEC until the changes are tested for proper functionality and certified by the CCTO. A hold status will not permit any certified runs to be performed. Software packages affected by an SEC hold will need to be re-certified prior to certification use. Hold status and its removal can only be done by the CCTO.

3.2 SOFTWARE CONFIGURATION MANAGEMENT

For the FSN site characterization and design effort, computer software used to perform analysis in support of the license application, as defined in the scope of paragraph 1.4, shall be controlled in accordance with this plan and its implementing procedures. Auxiliary software used to support primary analysis software shall be controlled at a level commensurate with the complexity of that software as determined by the CCTO and RDE. All available documentation from the software sources shall be obtained for commercial or existing auxiliary software.

It is recognized that source code is generally not available and controls are limited to unique version identification and user-related manuals.

3.2.1 Configuration Requirement

The FSN software configuration management system uniquely identifies all baselines and systematically controls, and records changes and modifications to software products to assure positive identification of software and control of all software baseline changes, a brief chronology of the software versions, including descriptions of changes made between versions. The software configuration management system requirements are specified in this section and the methodology for application of these requirements is specified in PP-80-01, Software Configuration Management.

3.2.2 Configuration Identification

The FSN Software Configuration consists of the individual configuration documents (e.g. SRS, SDD, SVVP, SVVR, UD, etc.) that are approved and controlled as each phase of the FSN software life cycle is completed. Figure 3 specifies the FSN configuration documentation that identify the software configuration and identifies the life cycle phase that results in the required software baseline. The assigned RDE prepares the required configuration documentation at the

completion of each life cycle phase and submits the document or code to the LDE for approval. Upon approval, the CCTO establishes the configuration item baseline and enters the baseline into the FSN Software Library (refer to Section 5.0 of this plan). The CCTO shall uniquely identify by label or otherwise mark each configuration document and item, indicate changes to each by revision or version number and provide traceability between the identification numbers of all other configuration documents that make up the software package.

Changes to each configuration item shall be approved by the LDE and the PM and the software configuration baseline reviewed by the CCTO in accordance with procedure PP-80-01 and the requirements of section 3.2.3 of this software QA plan.

3.2.3 Configuration Change Control

Changes to baseline software configuration items shall be systematically evaluated and approved in accordance with procedure PP-80-01 to assure that the impact of a change is assessed prior to updating the baseline, that required action is documented and appropriate information concerning the change or its impact on previous results is transmitted to all affected organizations. This documentation shall contain a description of the change, the identification of the originating organization, the rationale for the change, software discrepancies and sources (if applicable), and the identification of affected baselines and software configuration items and appropriate corrective actions. The change shall be formally evaluated by the CCTO and the LDE and approved by the LDE and PM. The CCTO shall control all changes in accordance with PP-80-01 to assure that only appropriate changes are made to software baselines and software configuration items.

3.2.4 Configuration Status Accounting

The information that is needed to manage software configuration items shall be recorded and reported in the SCML in accordance with PP-80-01. This information shall include a listing of the approved configuration identification, the status of proposed changes to the configuration, the implementation status of approved changes, and all information to support the functions of configuration identification, and configuration control. In accordance with Section 2.3, the CCRS shall assure that the SCML maintains and tracks the status of all records of the software certification process.

3.3 CLASSIFICATION/AUTHORIZATION PHASE

The LDE will obtain a software authorization in accordance with PP-80-04 for either the acquisition of software or use of existing software from the Project Manager for certification use. Certification is the process of controlling both computer system software and hardware to allow the independent repetition of the entire computation on a Controlled Computer System isolated from engineering

computer networks. All software to be used for certified runs shall be qualified as dictated in the following sections of this plan. The LDE will supply the following information on a Software Authorization Form and its accompanying information for entry into the Software Configuration Management Log (SCML):

- o Name
- o Statement of purpose
- o Stated/intended scope of use
- o Justification of need
- o TYPE--acquired or existing
- o Primary or Auxiliary designation
- o QA Level or special consideration(s)
- o Technical Contact
- o Project Manager signature
- o Software Summary Form (Form 185, see Attachment 1)
- o Software Requirements Specification
- o Software Requirements Review Plan
- o Software Producer Form for acquired software (Attachment 2)
- o Other information as determined necessary by the CCTO

Changes and updates to the Software Authorization Form shall be approved by the LDE and logged in the SCML by the CCRS.

3.3.1 Software Requirements Specification

The Software Requirements Specification shall be prepared by RDE for acquired or existing software.

A specific capability of software can be called a requirement only if its achievement can be verified by a prescribed method. A Software Requirements Specification (SRS) shall be prepared, reviewed and approved. The SRS shall address the following:

- o **Functionality** - the functions the software are to perform

- o **Performance** - the time-related issues of software operation such as speed, recovery time, response time, etc.

- o **Design constraints imposed on implementation** - any elements that will restrict design options

- o **Attributes** - non-time-related issues of software operation such as portability, correctness, security, maintainability, etc.

- o **External interfaces** - interactions with other participants, hardware and other software.

The requirements shall possess the following characteristics:

- o A format and language that is understood by the programming organization and the user.

- o Each requirement shall be defined such that its achievement is capable of being verified and validated objectively by a prescribed method, for example, inspection, demonstration, analysis, or test.

- o Adequate definition to provide for the response of the software to the identified input data.

The Software Requirements Specification shall be reviewed by the LDE and approved by the PM according to the Software Requirements Review Plan. The results of the SRS Review shall be documented in the Software Requirements Review Report.

3.3.2 Software Requirements Review Plan

The RDE shall prepare a Software Requirements Review Plan (SRRP) which shall be the basis for reviewing the purpose, scope and requirements of the target software (or its proposed development) to assure completeness and integrity. The SRRP shall identify the participants and their specific responsibilities during the review and in the formatting, preparation and distribution of the Software Requirements Review Report. The SRRP shall also contain a method and timetable for review comment resolution and identify the personnel responsible for such activities. The CCTO shall be a part of the review process for reviewing performance, design constraints imposed on implementation, attributes and external interfaces. The SRRP shall also identify how this information shall be entered into the SCML.

A Software Requirements Review Plan shall be prepared for acquired or existing software.

3.3.3 Software Requirements Review

The Software Requirements Specification shall be subject to a Software Requirements Review according to the SRRP. The RDE shall provide for an independent review of the SRS in accordance with FSN procedure DC-09. This review shall assure that the requirements are complete, verifiable and consistent. The review shall also assure that there is sufficient detail available to complete the software design. The completion of this activity shall be recorded in the SCML.

The Software Requirements Review shall be conducted for acquired or existing software.

3.3.4 Software Requirements Review Report

The RDE shall document the results of the Software Requirements Review in a Software Requirements Review Report that identifies all comments received during the review and all deficiencies identified in the review. The report shall provide a plan for corrective action, a timetable for the resolution of the review comments and the personnel responsible for this resolution. After the Software Requirements Specification has been updated to correct any deficiencies (if necessary) it shall be logged into the SCML, and will be used to update the baseline for the software design effort.

The Software Requirements Review Report shall be prepared for acquired or existing software. Software shall be procured in accordance with PP-60-02.

3.4 SOFTWARE ACQUISITION AND EVALUATION PHASE

Software products obtained from internal or external sources shall be acquired, evaluated and qualified in accordance with procedure PP-80-05 to assure that the applicable requirements of this plan are invoked and implemented. The procedure shall include provisions for qualification of direct transfers of software products included as part of a procured or contracted service, (i.e. geophysical logging) and software embedded with instrumentation procured by FSN.

The assigned RDE shall initiate transfer and verify that the software was transmitted correctly and that all documentation specified on the software producer form (Attachment 2) are accounted for. Following verification of correct transfer, the CCTO shall install the initial version of the software on the target hardware and document the initial conversion results in accordance with PP-80-07. Such documentation shall describe necessary code changes as well as the results of sample test case problems included with the acquired software package. The initial version of the software shall be identified and logged in the SCML.

Existing software design, user and test documentation shall be evaluated by the RDE to determine its adequacy and completeness based on the Software Requirement Specification established in 3.3.1 above. The RDE shall prepare an evaluation report (see Section 3.4.14) describing the results of the evaluation and identify

additional design, user or test documentation necessary to demonstrate the ability of the software to provide acceptable results in accordance with the SRS. The report shall be approved by the LDE.

For acquired and existing software, the design and implementation activities have normally been completed by other software producers. All available documentation from the software supplier shall be requested by the RDE by submitting the Software Producer Form (attachment 2) with the acquisition request or purchase order. It is recognized that the source code is generally not available and documentation is usually limited to unique version identification and user-related manuals. However, if the following required documentation is not available or insufficient, the RDE shall prepare the documentation:

- Software Design Description
- Technical description of the software with respect to control flow, data flow, control logic, and data structure;
- Code assessment and support documentation and descriptions of mathematical models and numerical methods as required by NRC publication NUREG-0856; Final Technical Position of Documentation of Computer Codes for High-Level Waste Management;
- Continuing documentation, code listing, and software summary forms as required by NUREG-0856.

3.4.1 Software Design Description

During this phase for software the software design shall be documented by means of a Software Design Description (SDD) and systematically reviewed. The design description shall specify the overall structure (control and data flow), and the reduction of the overall structure into physical solutions (algorithms, equations, control logic, and data structures). The design shall be described in a manner that is easily traceable to the software requirements.

Testing activities necessary to evaluate the software for its adherence to the specified requirements shall be determined based on a review of existing test documentation. Design-based test cases shall be generated if not available.

3.4.2 Software Design Description Review

The RDE shall conduct a Software Design Description Review (SDDR). This review shall evaluate the technical adequacy of the design approach, and assure that the design complies with all the requirements in the requirements documentation.

For acquired software, this requirement will be satisfied with the receipt and approval of the Software Producer Description Form. If the design approach is not adequately documented and the source code is not available preventing

evaluation of the design approach, the software will be controlled to prevent use until the design description has been prepared or until a design description waiver is prepared that describes the limited design documentation available, justification for use and the restrictions for use of the software as determined by application-specific validation testing. The decision to use limited-use-software shall be approved by the LDE and PM. The justification for use and documentation of applicable restrictions shall be maintained with the software and distributed to all users and appropriate entry made into the SCML. The limits of use for such software shall be marked or otherwise identified with all application results.

3.4.3 Software Design Description Review Report

The RDE shall document the results of the Software Design Description Review in a Software Design Description Review Report that identifies all review comments received and all deficiencies identified in the review. The report shall provide a plan for corrective action, a timetable for the resolution of the review comments and the personnel responsible for this resolution. After the SDD has been updated to correct any deficiencies (if necessary), the Software Design Description Review Report shall be logged into the SCML. The format of the report, the reviewers, and the approvers shall be as specified by the LDE.

The Software Design Description Review Report shall be prepared for acquired or existing software.

3.4.4 User Documentation

Under the direction of the RDE, User Documentation shall be prepared for existing software in accordance with NUREG-0856 and shall include a description of:

- Installation Instructions and/or procedures
- Program considerations and options
- Anticipated error situations and how the user can correct them
- Internal and external database files, their input sequence, structures, units, and description of the allowable and tolerable ranges for inputs and outputs
- Input and output options, defaults, and formats
- System interface features and limitations
- Information for obtaining user and maintenance and support
- Sample problems

- Description of Test Results

For acquired software, all available user documentation shall be obtained from the software supplier. If user documentation is not forthcoming, is unavailable or is insufficient, the RDE shall prepare the documentation consistent with the criteria above.

Auxiliary software used to support primary analysis software shall be controlled at a level commensurate with the complexity of that software as determined by the CCTO and RDE. All available documentation from the software sources shall be obtained for commercial or existing auxiliary software. It is recognized that source code is generally not available and controls are limited to unique version identification and user-related manuals.

3.4.5 User Documentation Review

The User Documentation Review (UDR) shall be performed by the RDE to determine the technical adequacy of the documentation approach and design as described in draft versions of the User Documentation. The following documents are UDR requirement criteria:

1) The methods used to validate that the software product matches the user documentation

2) Test plans, test procedures, and test cases to assure that all user documentation is tested in conjunction with the software.

The UDR may be performed independently of other reviews or in conjunction with the Software Design Description Review.

3.4.6 User Documentation Review Report

The RDE shall document the results of the User Documentation Review in a User Documentation Review Report that identifies all comments received and all deficiencies identified in the review and provides a plan for corrective action. The report shall provide a plan for corrective action, a timetable for the resolution of the review comments and the personnel responsible for this resolution. After the User Documentation has been updated to correct any deficiencies (if necessary), the User Documentation Review Report shall be logged into the SCML and the User Documentation approved by the PM. The documentation shall be identified and labeled to directly relate to the software version that the documentation supports.

The format of the report, the reviewers, and the approvers shall be as specified by the LDE.

The User Documentation Review Report shall be prepared for acquired or existing software.

3.4.7 Test Documentation (with Test Cases)

The LDE shall ensure that during this phase sufficient testing of the design/code has been done to evaluate whether the completed software adheres to the requirements or not. These tests shall be documented as described in PP-80-05.

Test plans, test cases, their use, and alternative testing methods shall be documented in the Software Verification and Validation Plan and made available for future use by submitting them to the CCTO.

Testing and its documentation shall be done for acquired or existing software.

3.4.8 Test Documentation Review and Report

The RDE shall conduct a Test Documentation Review and document the results of the review in a Test Documentation Review Report that identifies all comments received and all deficiencies identified in the review and provides a plan for corrective action. The report shall provide a plan for corrective action, a timetable for the resolution of the review comments and the personnel responsible for this resolution. After the Test Documentation has been updated to correct any deficiencies (if necessary), the Test Documentation Review Report shall be logged into the SCML.

3.4.9 Software Verification and Validation Plan

The Software Verification and Validation Plan (SVVP), with cases, shall describe the tasks and criteria for accomplishing the verification and validation of the software. The plan shall also specify the hardware and system software configuration pertinent to the software. The plan shall be organized in a manner that allows traceability to both the software requirements and the software design. Prior to use for a licensing activity, verification and validation of the final version of the software product shall be accomplished by an independent individual or organization, one who did not work on the original software. The results of all verification and validation activities shall be documented.

Software verification activities shall be performed to an extent proportional to the critical importance of the software. Software verification shall be performed to assure that the software requirements are implemented in the software design, and the software design is implemented in code. Appropriate methods such as inspection, analysis, test, or demonstration shall be applied to accomplish verification objectives.

Software validation activities are performed to demonstrate that the model as embodied in the computer software is a correct representation of the process or system for which it is intended. This is accomplished by comparing software results against verified and traceable data obtained from laboratory experiments, field experiments or observations, or in situ testing. Specific sets of data used in the validation process shall be identified and justification shall be made for their use.

When data are not available from the sources mentioned above, alternative approaches used shall be documented. Alternative approaches may include peer review and comparisons with the results of similar analysis performed with verified software.

The SVVP shall describe the overall plan for the verification and validation of the software and shall be approved by the LDE and FSN QA. Testing shall be performed using input conditions necessary to exercise the software, check boundary conditions and provide a suitable benchmark or sample problem for installation. The tasks, methods, and criteria for verification and validation shall be described. The SVVP shall specify minimum test documentation requirements. The SVVP shall be made official by filing with the CCTO for future use. In some cases, software validation is not possible until the designed item is constructed. If software validation testing is not possible for a specific design application until the designed item is constructed, a validation waiver shall be prepared that describes the limited validation available, justification for use, and the restrictions for use of the software.

The decision to use limited-use-software shall be approved by the LDE and PM. Justification for use and documentation of applicable restrictions shall be maintained with the software and distributed to all users and appropriate entry made into the SCML. The limits of use for such software shall be marked or otherwise identified with all applicable results. However, in these cases it must be validated prior to being used to support licensing.

The SVVP shall be subject to the Software Verification and Validation Plan Review.

3.4.10 Software Verification and Validation Plan Review

The Software Verification and Validation Plan Review (SVVPR) shall be conducted in accordance with FSN procedure DC-09 by the RDE and is an evaluation of the completed Software Verification and Validation Plan (SVVP) and is performed to evaluate the adequacy and completeness of the verification and validation methods defined in the SVVP.

The SVVPR shall address, as a minimum, the following:

- All verification and validation methods, along with completion criteria to assure traceability to, and compatibility with, the functional and performance requirements expressed in the SRS

- o Reports to adequately document results of all reviews, audits, and tests based on the requirements listed in the SVVP
- o Adequate descriptions of the software configuration to be tested, including test support software and hardware
- o Test plans and test design to assure that all requirements are tested
- o Test procedures and test cases to assure that test inputs and success criteria are adequately defined sufficient to identify unintended functions that could degrade the software performance and that test instructions are clear and concise
- o A test schedule identifying which tests are to be done, when, and by whom

3.4.11 Software Verification and Validation Plan Review Report

The RDE shall document the results of the SVVPR in a Software Verification and Validation Plan Review Report that identifies all comments received and all deficiencies identified in the review. The report shall provide a plan for corrective action, a timetable for the resolution of the review comments and the personnel responsible for this resolution. When all corrective actions mandated in the report are closed, the report will be logged in SCML. Entry into the SCML allows software verification and validation activities to commence.

3.4.12 Media Control and Security

Before any software proceeds beyond this phase of its life cycle, the physical media containing the images of software shall be physically protected to prevent their inadvertent damage or degradation. The CCTO shall establish the physical and administrative controlled environment under which media will be stored. Actions related to this activity shall be logged in the SCML.

3.4.13 Software Design and Testing Final Review

This review shall be conducted in accordance with FSN procedure DC-09 by the RDE against all software, regardless of source, prior to the Installation and Checkout phase of the life cycle. The purpose of this review is to assure that all aspects of software Quality Assurance and software configuration management, as delineated in this plan have been accomplished up to, and including, this phase. The review will also establish the acceptance or rejection of acquired or existing software.

The software Design, Implementation and Testing Final Review is an evaluation of the completed requirements, design, and implementation process prior to independent verification and validation.

3.4.14 Software Design and Testing Final Review Report

The RDE shall document the results of the Software Design and Testing Final Review in a Report that identifies all comments received and all deficiencies identified in the review. The report shall provide a plan for corrective action (if necessary), a timetable for the resolution of the review comments and the personnel responsible for this resolution. The Software Life Cycle cannot proceed until an approved Software Design and Testing Final Review Report has been logged into the SCML.

The format of the report, the reviewers, and the approvers shall be as specified by the LDE.

The Software Design and Testing Final Review Report shall be produced for all acquired or existing software.

3.5 INSTALLATION AND CHECKOUT PHASE

Prior to the completion of this phase, the media must be controlled, the user documentation must be prepared and the Software Verification and Validation Plan must be complete. These activities must be documented, reviewed and reported in the SCML. (See PP-80-07)

Documentation and review activities listed in this phase shall apply to all software whether acquired or existing.

During this phase, the software becomes part of a system incorporating other software components, the hardware, and production data. The process of integrating the software with other components may consist of installing hardware, installing the program, reformatting or creating databases, and verifying that all components have been included.

Checkout activities during this phase shall consist of the execution of test cases for installation and integration. Test cases from earlier phases shall be enhanced and used for installation and integration testing.

After the installation is complete, the Verification and Validation activities shall be performed according to the SVVP for the target software.

3.5.1 Installation Test

The CCTO shall certify the installation of the program on the FSN certified computer environment in accordance with PP-80-07. The CCTO shall be responsible

for proper installation of the software on the target hardware. Sufficient testing should be done to provide reasonable confidence that the software can be loaded and operated correctly without causing problems for other programs or any data that is maintained on the system. The results of installation activities shall be documented in a conversion report describing the results of test problems and changes necessary for final installation and integration. Once these activities are completed, it shall be logged in the SCML.

3.5.2 Software Verification and Validation Activities

Software verification activities shall be performed to an extent proportional to the critical importance of the software. Software verification shall be performed by an independent reviewer or organization to assure that the software requirements are implemented in the software design, and the software design is implemented in code. Appropriate methods such as inspection, analysis, test, or demonstration shall be applied to accomplish verification objectives.

Software validation activities are performed to demonstrate that the model as embodied in the computer software is a correct representation of the process or system for which it is intended. This is accomplished by comparing software results against verified and traceable data obtained from laboratory experiments, field experiments or observations, or in situ testing. Specific sets of data used in the validation process shall be identified and justification shall be made for their use.

When data are not available from the sources mentioned above, alternative approaches used shall be documented. Alternative approaches may include peer review and comparisons with the results of similar analysis performed with verified software.

3.5.3 Software Verification and Validation Report

The results of software verification and validation activities shall be documented in a Software Verification and Validation Report or as specified in the Software Verification and Validation Plan. The documentation shall describe activities performed to verify:

- The correctness of the mathematical approach taken and the formulae applied;
- Input/output assumptions are accurate and reasonable for the intended applications;
- Scope of the verification sufficiently defined;
- Completeness of test data, and test results and consistency of test results with those expected.

3.5.4 Software Verification and Validation Review

The Software Verification and Validation Review (SVVR) shall be performed in accordance with FSN procedure DC-09. The SVVR summarizes the observed status of the software as a result of the execution of the SVVP. It outlines any major deficiencies found; provides the results of reviews, audits, and tests; indicates the status of planned corrective actions (if necessary); and shall recommend whether the software is, or is not, ready for operational use. This independent, interdisciplinary review shall be coordinated by the RDE.

3.5.5 Software Verification and Validation Review Report

The RDE shall document the results of the SVVR in a Software Verification and Validation Review Report that identifies all comments received and all deficiencies identified in the review. The report shall provide a plan for corrective action, a timetable for the resolution of the review comments and the personnel responsible for this resolution.

Prior to the CCTO releasing the software for use in the Operation phase, all corrective actions required to satisfy the Software Verification and Validation Review Report shall be accomplished and the report logged in the SCML and approved by the PM and the QA department. Entry into the SCML releases the software for use in the Operation phase.

3.6 OPERATION AND MAINTENANCE (ERROR CONTROL) PHASE

During this phase, the software has been approved for operational use. To ensure that only verified and validated software is available for use, the following steps shall be taken:

- The CCTO will verify that only officially released software will be made available to the user(s).
- Software usage will be recorded on the Transfer Recipient Log and on the Access Authorization form supplied by the user.
- Access Control Activities are performed as described in Section 3.7 below.

Should software discrepancies occur, the RDE shall document the discrepancies, make a recommendation of maintenance, prepare a technical impact statement with the evaluation of the impacts of discrepancies on previous calculations, and submit the documentation to the Configuration Control Board for disposition. Software shall be maintained in accordance with procedure PP-80-10 and PP-80-01 to remove latent errors (corrective maintenance), to respond to new or revised requirements (perfective maintenance), or to adapt the software to changes in the software environment (adaptive maintenance). These shall be done following

directions in this plan and according to the Software Configuration Management described in Section 3.2.

Perfective maintenance shall be performed by the software supplier when identified by the responsible LDE on a Software Authorization form. Normal procedures shall be followed starting with the Requirements/Authorization Phase.

Adaptive maintenance shall be performed by the CCTO and logged in the SCML. These changes may or may not require revalidation of software. (See also Section 3.2)

Corrective maintenance activities are described below. Corrective maintenance shall be performed by the software supplier when identified by the responsible LDE on a deficiency report. Normal procedures shall be followed starting with the Requirements/Authorization phase through the acquisition, evaluation and test of software changed to correct suspected errors. When errors are identified, the following shall be performed:

- The CCRS shall document the error.
- The CCRS shall notify the in-house Responsible Party and the CCTO.
- The CCRS shall place a hold on software usage as directed by the CCTO, until discrepancy is resolved.
- If software is acquired, the producer and/or transfer party shall be notified in writing.
- The Transfer Recipient Log shall be reviewed and recipients notified in writing.
- Once the discrepancy is resolved, the software shall be subjected to the requirements in the Installation and Checkout phase.
- Other activities as required by the Access Control Activities Section (3.7) and the Reference to Runs Section (4.0).

3.7 ACCESS CONTROL PHASE

The CCTO through the CCRS shall maintain a log of every certified run of software in accordance with procedure PP-80-06. The following information, as a minimum, shall be entered into this Access Control Log prior to each certified run use:

- Unique identifying Access Control Log Number
- Date of access
- Software Environmental Configuration identification number

- o Software Configuration Item reference number, (name and version number)
- o Data Configuration Items to be used
- o Users name(s)
- o Access Authorization form number
- o Parameters (supplied by engineer on Access Authorization form)
- o Engineer's name
- o Validation/Verification status

After use, the following information must be added:

- o Output Identification number (See Certified Run Output Section)
- o Run completed properly
- o Output review results
- o Indication as to whether a computer error occurred or not
- o Acceptance or Rejection based on Computer Certification Run

After a run, a Certified Run Review shall be conducted in accordance with PP-80-06.

3.7.1 Access Authorization Form

An Access Authorization Form is required before a user can produce a certified run. The form must identify the software package to be used, the data items involved, parameters to be used, and have a brief explanation of purpose and signature of the appropriate LDE(s) according to the signature list and official authorization instructions. The LDE shall establish a procedure that defines this process and file it with the CCRS, who will submit it to the CCTO for approval.

3.7.2 Certified Run Operation

The certified run operation shall be performed by the CCTO in accordance with PP-80-11. The CCTO shall ensure that the Access Authorization Form, Hardware Certification Form, Software Certification Form and run operations instructions are complete and in accordance with the SCML and SECML. The CCTO shall initiate the software application computer operation and certify that the certified computer run operations were completed properly with output results or shall record computer operation discrepancies for review in accordance with PP-80-06.

The CCTO shall accept or reject the Computer Certification Run based on the Certified Run Operation. The CCTO shall ensure that all supporting documentation is available for review. Supporting documentation includes computer output (results), code input data including data bases and original sources/references of and assumptions used to obtain such data, code design, user's and/or operation manuals, verification/validation test results and/or hand calculations.

3.7.3 Certified Run Reviews

Certified Run Reviews shall be performed in accordance with PP-80-06. Procedures shall be established by appropriate LDEs with coordination by the CCTO for documenting and reviewing software use to assure that all results are accurate, traceable, and reproducible. Requirements shall be established for identifying or making copies of all analyses and supporting documentation. Supporting documentation includes computer output (results), ACL information, assumptions used, parameters used, reproduction instructions, traceability information, and any other review information. Any auxiliary software used to do technical calculation shall be included in the documentation.

All authorized software used for certification shall be independently reviewed and approved to assure that the software selected is applicable to the problem being solved and that all input data and assumptions are valid and traceable. As part of any independent review any auxiliary software used shall be included.

3.7.4 Access Control Log Folder

After each certified run, a folder shall be created by the CCRS containing the ACL information, the user's parameters, the output, review information, and a complete description of how to reproduce the run so that an auditor could reproduce the result. The CCTO, the QAR, and appropriate LDEs shall certify that the information is sufficient to provide traceability, reproducibility, and a statement of benefit.

If after the review process the run is deemed of no value, an entry shall be made in the ACL, no further work is required, and the folder is labeled "INVALID". However, if the run is deemed acceptable and after determination by the QAR, the appropriate LDE, and the CCTO that the information is complete, the folder shall be labeled "COMPLETED".

Only "COMPLETED" folders are QA documents and all information related to the completed run shall be maintained as such. Copies of the completed folder contents will be sent to the FSN Records Center (FSNRC). Other folders may be maintained for internal purposes.

3.7.5 Certified Run Output

All output generated shall be stamped with time/date and ACL reference number by manual or electronic means.

3.8 REPORTING

The CCRS shall submit information related to "COMPLETED" certified runs to the DOE in accordance with written procedures.

4.0 REFERENCES TO RUNS

Use of results of certified runs may be accomplished only if the runs are declared "COMPLETE".

Any references made to results in official documents must be accompanied by the ACL number. Prior to use in a document, a Reference form must be filed with the CCTO through the CCRS. If there is a hold placed on the run, the requestor will be notified whether or not permission for use is granted. The CCTO, through the CCRS, will maintain a log of references. In the event a run is decertified for invalid data, incorrect use, or other reason, all references logged as having used the subject information shall be notified with receipt acknowledgement. Further use of the results will not be granted unless the decertification is reversed. Evaluation for impact of the decertification on prior usage will be handled in accordance with the FSN Configuration Management System.

5.0 CONTROL OF SOFTWARE CONFIGURATION MANAGEMENT DOCUMENTATION

Software baseline documentation identified in Figure 3 are QA Records and shall be handled in accordance with PP-50-01 and shall be maintained in the controlled area established by the CCTO until transferred to the FSNRC.

6.0 REFERENCES

NNWSI Project Quality Assurance Plan, NNWSI/88-9

FSN Quality Assurance Plan, QAPP-002

NUREG-0856, Final Technical Position on Documentation of Computer Codes for High-Level Waste Management

DC-09, Interdiscipline Review

PP-50-01, YMP Records Management

PP-60-02, YMP Purchasing

PP-80-01, Software Configuration Management

PP-80-03, Data Management

6.0 REFERENCES (Continued)

PP-80-04, Software Classification and Authorization

PP-80-05, Software Acquisition, Evaluation and Test

PP-80-06, Software Access Control

PP-80-07, Software Installation and Checkout

PP-80-10, Software Operation and Maintenance

PP-80-11, Certified Run Operation

GLOSSARY OF

TERMS AND DEFINITIONS

ACTIVITY: Any time consuming effort (operation, task, function, or service) which influences or affects the achievement or verification of the objectives of the YMP as depicted in the Work Breakdown Structure (WBS) Dictionary.

APPLICATION: The use of computer software, programs, models or other computer components to perform engineering design analysis, calculations, and scientific analysis.

AUXILIARY SOFTWARE: (1) Software that may be easily and exactly verified, and that performs a simple function such as conversion of units, change in data format, or plotting of data in support of primary analysis software. (2) A stream of commands or sequence of streams of commands executed to utilize a system maintained software in which the system maintained software generates reportable results. Auxiliary software does not generate primary data.

BASELINE: As used for computer software: (1) The stage of computer software at a completed and reviewed phase of the software life cycle; (2) Approved documentation generated within or as a result of completing a phase of the software life cycle.

CERTIFICATION: The act of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or components in accordance with specified requirements.

CERTIFIED RUN OR RUN: Use of certified software to produce a deliverable item.

CHARACTERISTIC: Any property or attribute of an item, process, or service that is distinct, describable, and measurable.

COMPUTER CODE: A sequence of instructions suitable for processing by a computer. This may include the use of an assembler, a compiler, an interpreter, or a translator to prepare the program for execution as well as to execute it.

COMPUTER HARDWARE: Those tangible items that are not software.

COMPUTER SOFTWARE: A set of computer codes, procedures, rules and associated documentation and data pertaining to the operation of computer systems. This includes user-provided instructions and data that implement pre-programmed algorithm control systems; computer codes and data that will reside in firmware; and, when specified, user-provided instructions and data used by commercial software such as spread sheet and database packages.

CONFIGURATION MANAGEMENT: As used for computer software: (1) A system for orderly control of software, including methods used for labeling, changing, and storing software and its associated documentation. (2) The systematic evaluation, coordination, approval or disapproval, and implementation of all approved changes in an item of software after establishment of its baseline.

CONTROLLED AREA: The facility location where the access, use, storage and retrievability of software and software documentation is limited to that of authorized individuals. Controlled areas for software, data, and output may also exist.

CONTROLLED COMPUTER SYSTEM: An isolated arrangement (system) of computer hardware and software maintained in a access controlled area. This controlled system is for the sole purpose of producing a certified independent repetition of the entire computation of technical calculations.

CORRECTIVE ACTION: Measures taken to rectify conditions that are adverse to quality and, where necessary, to preclude repetition.

DATA: A general term used to signify all the basic information elements that can be produced or processed by a computer. (See also Authorized Input Data and Official Data)

DESIGN: The act of developing designs for construction or of analyzing the performance of repository engineered structures, systems, components, and natural barriers. Design documentation includes, but is not limited to, drawings, specifications, test plans, design reports, test reports, system design descriptions, configuration status listing, design manuals, and manuals describing computer programs used for design or performance analysis.

DEVELOPMENT: The technical and management processes that commence with the identification of functional requirements and that lead to new or modified products and associated documentation.

DOCUMENT: Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A document is not considered to be a QA Record until it satisfies the definition of a QA Record as defined below.

INSPECTION: Examination or measurement to verify whether an item or activity conforms to specified requirements.

ITEM: An all-inclusive term that is used in place of any of the following: appurtenance, assembly, component, equipment, material, module, part, structure, subassembly, subsystem, system, unit and prototype hardware. This term includes magnetic media, and other materials that retain or support data.

OBJECTIVE EVIDENCE: Any documented statement of fact, other information, or record, either quantitative or qualitative, that pertains to the quality of an item or activity, based on observations, measurements or tests that can be verified.

OVERVIEW: An analysis and assessment by management of the scope, status, adequacy and effectiveness of Program quality achievement and assurance activities. Overview encompasses effectiveness assessments, technical reviews, readiness reviews, audits, and surveillances, as appropriate.

PEER: A peer is a person having technical expertise in the subject matter to be reviewed (or a critical subset of the subject matter to be reviewed) to a degree at least equivalent to that needed for the original work.

PEER REVIEW: A documented critical review performed by personnel who are independent of those who performed the work but who have technical expertise at least equivalent to those who performed the original work. Peer reviews are in-depth, critical reviews and evaluations of documents, material or data that require interpretation or judgment to verify or validate assumptions, plans, results or conclusions or when the conclusions, material or data contained in a report go beyond the existing state of the art.

A peer review is an in-depth critique of assumptions, calculations, extrapolations, alternate interpretations, methodology, and acceptance criteria employed, and of conclusions drawn in the original work. Peer reviews confirm the adequacy of work. In contrast to peer review, the term "technical review" refers to a review to verify compliance to predetermined requirements, industry standards, or common scientific, engineering and industry practice.

PROCEDURE: A document that specifies a precise step-by-step method for effecting a solution to a problem.

QUALIFICATION (PERSONNEL): The characteristics or abilities that are gained through education, training, or experience, which are measured against established requirements, such as standards or tests, that qualify an individual to perform a required function.

QUALITY ASSURANCE: All those planned and systematic actions that are necessary to provide adequate confidence that the geologic repository and its subsystems or subcomponents will perform satisfactorily in service.

QUALITY ASSURANCE RECORD: An individual document or other record/report that has been executed, completed, and approved and that furnishes evidence of (1) the quality and completeness of data (including raw data), items, and activities affecting quality; (2) documents prepared and maintained to demonstrate implementation of QA programs (e.g., audit, surveillance, and inspection reports); (3) procurement documents; (4) other documents such as plans, correspondence, documentation of telecons, specifications, technical data, books, maps, papers, photographs, and data sheets; (5) items such as magnetic media; and (6) other materials that provide data and document quality regardless of the

physical form or characteristic. A completed record is a document or item (and documentation) that will receive no more entries, whose revisions would normally consist of a reissue of the document (or documentation), and that is signed and dated by the originator and, as applicable, by approval personnel.

QUALITY ASSURANCE LEVEL I: Those radiological health and safety related items and activities that are important to either safety or waste isolation and that are associated with the ability of a geologic nuclear waste repository to function in a manner that prevents or mitigates the consequences of a process or event that could cause undue risk to the radiological health and safety of the public. Items and activities important to safety are those engineered structures, systems, components, and related activities essential to the prevention or mitigation of an accident that could result in a radiation dose either to the whole body or to any organ of 0.5 rem or greater either at or beyond the nearest boundary of the unrestricted area at any time until the completion of the permanent closure of the repository. Items and activities important to waste isolation are those barriers and related activities which must meet the criteria that address post-closure performance of the engineered and natural barriers to inhibit the release of radionuclides. The criteria for items or activities important to safety and waste isolation are found in 10CFR60 and 40CFR191.

QUALITY ASSURANCE LEVEL II: Those activities and items related to the systems, structures, and components which require a level of quality assurance sufficient to provide for reliability, maintainability, public and repository worker nonradiological health and safety, repository worker radiological health and safety, and the other operational factors that would have an impact on DOE and YMPO concerns, and the environment.

QUALITY ASSURANCE LEVEL III: Those activities and items not classified as QA Levels I or II.

REPAIR: The process of restoring a nonconforming characteristic to a condition such that the capability of an item to function reliably and safely is unimpaired, even though that item still does not conform to the original requirement.

RESPONSIBLE LDE: The Lead Design Engineer who has jurisdiction over a particular software entity.

SOFTWARE VALIDATION: The act of demonstrating that the model, as embodied in the computer software, is a correct representation of the process or system for which it is intended. Software validation is accomplished by comparing software results against verified and traceable data obtained from laboratory experiments, field experiments or observations, or in situ testing.

SOFTWARE VERIFICATION: The act of assuring that the software requirements are implemented in the software design, and the software design is implemented in code. Verification may be accomplished by appropriate methods such as inspection, analysis, test or demonstration.

SURVEILLANCE: The act of monitoring or observing to verify whether or not an item or activity conforms to specified requirements.

TESTING: An element of verification that is used to determine the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental, or operating conditions.

TRACEABILITY: The ability to trace the history, application, or location of an item and like items or activities by means of recorded identification.

TRIVIAL CALCULATIONS: Computations which could be done on paper or with an unprogrammed calculator.

USER'S INSTRUCTIONS/MANUAL: The documentation that supplies the user with enough information to prepare input, run, and to interpret output from a computer software application.

VERIFICATION: The act of reviewing, inspecting, testing, checking, auditing or otherwise determining and documenting whether or not items, processes, services, or documents conform to specified requirements.

VALIDATION (QA RECORDS): Validation is the act of reviewing a document or document package to ensure it is complete, authenticated, reproducible, and microfilmable.

LIST OF ACRONYMS

AAF - Access Authorization Form
ACL - Access Control Log
CCRS - Computer Certification Records Specialist
CCTO - Computer Certification Technical Officer
CFR - Code of Federal Regulations
CRO - Certified Run Output
CRR - Certified Run Review
DOE - Department of Energy
FR - Final Review
FSN - Fenix and Scisson of Nevada
FSNRC - Fenix and Scisson of Nevada Records Center
IT - Installation Test
LDE - Lead Discipline Engineer
MC&S - Media Control and Security
NRC - Nuclear Regulatory Commission
NUREG - Nuclear Regulations
PM - Project Manager
QAR - Quality Assurance Representative
QAPP - Quality Assurance Program Plan
RDE - Responsible Discipline Engineer
SA&E - Software Acquisition and Evaluation Phase
SCML - Software Configuration Management Log
SDD - Software Design Description
SDDR - Software Design Description Review
SDDRR - Software Design Description Review Report
SDTFR - Software Design and Testing Final Review
SDTFRR - Software Design and Testing Final Review Report
SEC - Software Environment Configuration
SECML - Software Environment Configuration Management Log
SES - Scientific and Engineering Software
SQA - Software Quality Assurance
SQAP - Software Quality Assurance Plan
SRR - Software Requirements Review
SRRP - Software Requirements Review Plan
SRRR - Software Requirements Review Report
SRS - Software Requirements Specification
SVVA - Software Verification and Validation Activities
SVVAR - Software Verification and Validation Activities Report
SVVP - Software Verification and Validation Plan
SVVPR - Software Verification and Validation Plan Review
SVVR - Software Verification and Validation Review
SVVRR - Software Verification and Validation Review Report
TD - Test Documentation
TDR - Test Documentation Report
UD - User Documentation
UDR - User Documentation Review
UDRR - User Documentation Review Report
YMPO - Yucca Moutain Project Office

ATTACHMENT 1

Standard Form 185, Software Summary

FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

01. Summary date (Yr. / Mo. / Day)	02. Summary prepared by *(Name and Phone)*	03. Summary action: New ☐ Replacement ☐ Deletion ☐ Previous Internal Software ID)
04. Software date (Yr. / Mo. / Day)	05. Software title	07. Internal Software ID
06. Short title		

08. Software type	09. Processing mode	10. Application area — General		Specific
☐ Automated Data System	☐ Interactive	☐ Computer Systems Support/Utility	☐ Management/ Business	
☐ Computer Program	☐ Batch	☐ Scientific/Engineering	☐ Process Control	
☐ Subroutine/Module	☐ Combination	☐ Bibliographic/Textual	☐ Other	

11. Submitting organization and address	12. Technical contact(s) and phone

13. Narrative

14. Keywords

15. Computer manuf'r and model	16. Computer operating system	17. Programming language(s)	18. Number of source program statements
19. Computer memory requirements	**20. Tape drives**	**21. Disk/Drum units**	**22. Terminals**

23. Other operational requirements

24. Software availability			25. Documentation availability		
Available ☐	Limited ☐	In-house only ☐	Available ☐	Inadequate ☐	In-house only ☐

26. FOR SUBMITTING ORGANIZATION USE

STANDARD FORM 185
JULY 1974
U.S. DEPT. COMMERCE-NBS
(FIBS. PUB. 30)

ATTACHMENT 2

EXAMPLE OF
SOFTWARE PRODUCER FORM

Date:

To: _____ / _____
Company Software Product/Version

SUBJECT: SOFTWARE QUALITY ASSURANCE REQUIREMENTS AND REQUEST

Please answer each of the following by encircling your response to each question. Upon completion, please certify correctness by having the Quality Assurance/Control individual responsible for the product sign and date this form.

1. Do you have Software Development and Quality Assurance Plans? Yes No
   If yes, does your Plan contain the following:

   a. Review and Approval of requirements? Yes No
      Please describe._____
      _____
      _____
      _____
      _____
      _____

   b. Review and Approvals of Design? Yes No
      Please describe._____
      _____
      _____
      _____
      _____
      _____

   c. Review and Approvals of Implementation? Yes No
      Please describe._____
      _____
      _____
      _____
      _____
      _____

   d. Review and Approvals of Testing and Checkout? Yes No
      Please describe._____
      _____
      _____
      _____
      _____
      _____

e. Review and Approvals of Maintenance? Yes No
Please describe._____

f. Review and Approvals of Verification? Yes No
Please describe._____

g. Review and Approvals of Validation? Yes No
Please describe._____

OTHERWISE, please describe your quality control procedures.

2. Do you have a Configuration Management version control? Yes No
If Yes, please describe. _____

3. Do you have a complete software User's Manual? Yes No
4. Do you have a complete software Installation Manual? Yes No
5. Do you have a complete benchmark, test case, and instructions? Yes No

ATTACHMENT 2

EXAMPLE OF
SOFTWARE PRODUCER FORM

6.	Do you have a complete Source Code Listing available?	Yes	No
7.	Do you have a complete Error Processing/Recovery manual?	Yes	No
8.	Do you have a complete Systems Interface Manual showing:		
	a. System dependent features, utilities, libraries?	Yes	No
	b. Compiler requirements, if any?	Yes	No
	c. Hardware requirements and limitations, if any?	Yes	No
	d. Controls or command files required, if any?	Yes	No
	e. Program interface;interactions affecting logic?	Yes	No
9.	If an on-site inspection was conducted, could these items be readily verified?	Yes	No
10.	May we conduct an on-site inspection at any time, if we choose to do so?	Yes	No
11.	Please provide licensing descriptions.		
12.	Please provide identification of models used and references.		
13.	Do the standards, conventions, techniques or methodologies which have guided the software development and described methods used to assure compliance with your quality assurance program reside within a company controlled document?	Yes	No

Name _____ Title _____ Date _____

ATTACHMENT 2

EXAMPLE OF
SOFTWARE PRODUCER FORM

PRODUCT ANALYSIS

Fenix & Scisson of Nevada is required to conduct a product analysis of the targeted software packages. Please assist by furnishing the information for these questions.

1. Previous version identifications and their release dates?

2. Present version identification and its release date?

3. Quantity sold for each version?

4. Customer profile for all versions?

FENIX & SCISSON OF NEVADA	YUCCA MOUNTAIN PROJECT (YMP) PROCEDURE		
SUBJECT: SOFTWARE CONFIGURATION MANAGEMENT	PREPARED BY: R. HILSINGER	EFFECTIVE DATE:	NUMBER: PP-80-01
	REVISION: 0 PAGE 1 OF 13	SUPERCEDES: NEW PROCEDURE	

1.0 PURPOSE

This procedure identifies the requirements and methods for configuration management of software and related documents that will be used in support of Nuclear Regulatory Commission (NRC) licensing activities.

2.0 APPLICABILITY

This procedure applies to computer software and related documents used by FSN to produce certified runs for NRC licensing activities. This procedure covers the configuration management of computer software and related documents that are controlled by procedures that implement the FSN Software Quality Assurance Plan.

3.0 REFERENCES

3.1 FSN Software Quality Assurance Plan

3.2 DC-26, Configuration Change Control

3.3 DC-28, Configuration Identification & Documentation

3.4 PP-50-01, YMP Records Management

3.5 PP-80-04, Software Classification and Authorization

3.6 PP-80-05, Software Acquisition, Evaluation and Test

3.7 PP-80-07, Software Installation and Checkout

3.8 PP-80-08, Software Certification

3.9 PP-80-10, Software Operation and Maintenance

3.10 PP-80-13, Purchasing of Computer Hardware and Software

4.0 DEFINITIONS

4.1 Baseline - As used for computer software: (1) The stage of computer software at a completed and reviewed phase of the software life cycle; (2) Approved documentation generated within or as a result of completing a phase of the software life cycle.

APPROVED:	APPROVED:	APPROVED:

4.2 Computer Software - A set of computer codes, procedures, rules and associated documentation and data pertaining to the operation of computer systems. This includes user-provided instructions and data that implement pre-programmed algorithm control systems; computer codes and data that will reside in firmware; and, when specified, user-provided instructions and data used by commercial software such as spread sheet and database packages.

4.3 Software Documents - Documents that are generated by the PP-80 series of procedures that implement the Software Quality Assurance Program. These include the documents for the life cycle phases for a particular computer software.

4.4 Software File - A file that contains all the software documents related to a particular computer software. This file is not intended to contain documentation that is issued for the operation of the software, e.g. Software User Documentation.

4.5 User's Documentation - The documentation that supplies the user with enough information to prepare input, run, and to interpret output from a computer software application.

5.0 RESPONSIBILITY

5.1 Computer Certification Records Specialist (CCRS) - The CCRS is responsible for logging, retention and other actions as required by this procedure.

5.2 Computer Certification Technical Officer (CCTO) - The CCTO is responsible for logging, retaining, and preparing forms and for other actions as required by this procedure.

6.0 PROCEDURE

The activities contained in this procedure are initiated by other controlling procedures (see Attachment 1, Controlling Procedure Matrix) and is not intended to be followed in the order presented except when noted. Users of this procedure are directed to go to the subheading that implements the action required by the controlling procedure, as appropriate.

6.1 Logging and Maintaining Software Configuration Management Log (SCML) Status

CCRS receives software document and makes initial log entries or updates existing entries in the SCML in accordance with Attachment 2 as required by applicable controlling procedures.

6.2 Filing and Retention of Software Documents

CCRS receives software documents and performs the following activities for filing and retention:

6.2.1 Obtains a file folder and labels the folder with the identification number of the respective software document. A separate file folder is prepared for each individually numbered software document.

6.2.2 Places the respective software document in the folder.

6.2.3 Updates the file index for the software file with the new documentation.

6.2.4 Files the folder containing the software document in the applicable software file for retention in the designated controlled area. Software files are identified with the following as a minimum:

A. Software Name (commercial name).

B. Respective SCML Number (FSN-SCML-90-XX).

6.3 Placing Software Products on "HOLD" Status

CCRS or CCTO places software products on "HOLD" status as required by controlling procedures or as directed by management as follows:

6.3.1 Makes "HOLD" entries in the SCML in accordance with Attachment 2 for the respective software product.

6.3.2 Tags the applicable software product with a tag or label that indicates "HOLD" and provides a brief explanation or references a Deficiency Report number.

6.4 Removing Software Products From a "HOLD" Status

CCRS or CCTO removes software products from a "HOLD" status as required by controlling procedures or by management direction as follows:

6.4.1 Makes "HOLD REMOVED" entries in the SCML in accordance with Attachment 2 for the respective software product.

6.4.2 Removes the "HOLD" tags from the applicable software product and discards the tags.

6.5 Issuing Numbers for Software Documents

CCRS issues numbers for software documents when requested by providing an existing or new SCML number, as applicable. (See Attachment 2 to issue new numbers). The numbers issued for software documents are the numerical digits of the SCML number assigned to a particular computer software. For example, 90-01 would be issued for SCML number "FSN-SCML-90-01".

6.6 Performing Limited-Use-Software Activities

CCRS or CCTO performs Limited-Use-Software activities as initiated by Software Design Description Waivers and Software Validation Waivers as follows:

6.6.1 Labels the software and any copies with a label that indicates "LIMITED-USE-SOFTWARE" and provides a reference back to the applicable waiver or waivers that contains the restrictions for use. Labeling is normally provided on the software container or containers and is intended to be visible to a user.

6.6.2 Labels the user documentation and any copies of the user documentation with a label that indicates "LIMITED-USE-SOFTWARE" and provides a reference back to the applicable waiver or waivers that contains the restrictions for use. Labeling is normally provided on the user documentation cover or covers and is intended to be visible to a user.

6.6.3 Retains a copy of the applicable waiver or waivers with the software or user documentation so this information is provided to the users when they receive the software.

6.7 Media Control and Security

CCRS determines whether the controlling procedure requiring this media control action is PP-80-05 or PP-80-13, and proceeds as follows:

6.7.1 If the media control has been initiated by PP-80-13, then retain the newly purchased software in a secure area that is accessible only to assigned personnel. This software is to be provided, in accordance with controlling procedures, to those individuals performing the tasks to release the software to operations.

6.7.2 If the media control has been initiated by PP-80-05, then retains the software as follows:

A. Master software (supplier provided copy) - sealed and vaulted.

B. Working copies - maintained and stored in the software library (secure area) to be checked out to users on request in accordance with controlling procedures.

6.8 Releasing Software for Operations

CCRS or CCTO performs the following activities to release software to operations:

6.8.1 Enter "Released to Operations" status in the SCML in accordance with Attachment 2.

6.8.2 Initiate a Design Base Memorandum (DBM) in accordance with DC-26 to enter the baselined computer software in the Status Reporting System.

6.8.2.1 Enter the assigned DBM number in the SCML in accordance with Attachment 2.

6.8.3 Labels the software and user documentation with the SCML number that was assigned in accordance with Attachment 2. If the commercial software name has not been indicated on the software or user documentation by the supplier, then include the commercial software name on the label with the SCML number.

6.9 Records

All YMP records generated by this procedure shall be handled in accordance with PP-50-01.

7.0 QUALITY ASSURANCE RECORDS

The Software Configuration Management Log (SCML) is a QA Record generated by this procedure and shall be handled in accordance with PP-50-01.

ATTACHMENT 1

Controlling Procedure Matrix

PROCEDURE	DOCUMENT CONTROLLED BY PROCEDURE
PP-80-04	1. Software Producer Form
	2. Software Requirements Specification
	3. Software Requirements Review Plan
	4. Software Requirements Review Report
**********	**********
PP-80-05	1. Software Producer Form (returned from the Supplier).
	2. Software Producer Form cover sheet
	3. Software Design Description
	4. Software Design Description Review Report
	5. Design Description Waiver
	6. User Documentation
	7. User Documentation Review Report
	8. Test Documentation
	9. Test Documentation Review Report
	10. Software Verification and Validation Plan
	11. Software Verification and Validation Plan Review Report
	12. Software Validation Waiver
	13. Software Design and Testing Final Review Checklist
	14. Software Design and Testing Final Review Report
	15. Software Media

ATTACHMENT 1

Controlling Procedure Matrix (Continued)

PROCEDURE	DOCUMENT CONTROLLED BY PROCEDURE
PP-80-07	1. Software Verification and Validation Report
	2. Software Verification and Validation Review Report
PP-80-08	1. Discrepancy Report
	2. Software Certification Form
	3. Conversion Report
PP-80-10	1. Software Discrepancy Report
	2. Software Maintenance Request
PP-80-13	1. Software Media (received from procurement)
	2. Procurement Documentation

ATTACHMENT 2

Software Configuration Management Log (SCML)
Instructions

1.0 Overview

The intent of the SCML is to provide all related information for a particular computer software and related documentation in a central location (the SCML Log). This provides the information to identify a software configuration baseline and related changes. It also provides a chronology of the software versions since all changes to an existing configuration are treated as a new configuration. Changes to baselines are summarized as follows:

1.1 Changes to the computer software and supplier provided documentation that is in process for certification as a baselined item are made by returning the software to the software supplier from whom the software was obtained. Changes to the computer software and supplier provided documentation after they are baselined are handled in accordance with DC-28 as required by their respective controlling procedures.

1.2 Changes to software documents that are in the approval process (i.e., prior to approval) to become a baselined item are covered by their respective controlling procedure and are identified by sequential revision numbers. Changes to software documents that are baselined (i.e., after approval) are handled in accordance with DC-28 as required by their respective controlling procedure.

1.3 Changes to computer certified runs that are baselined are covered by DC-28 as required by controlling procedures. This ensures that the impact of a change is assessed prior to updating the baseline, that required action is documented and appropriate information concerning the change or its impact on previous calculations or results is transmitted to all affected parties.

2.0 Instructions

CCRS or CCTO performs the following as appropriate:

A. Provides an SCML number for each computer software (software configuration) as follows:

1. Enters the SCML number in the space provided. Numbers are assigned consecutively using FSN-SCML and the last two digits of the year as a prefix (e.g., FSN-SCML-90-1, SCML-90-2, etc.).

2. If there is a change to an existing software configuration, then perform the following:

a. Assign a new SCML number and treat the changes as a new software configuration.

b. Provide a brief description of changes that occur between versions of a software in the comment section of the SCML log of the changed software.

3. Sign and date for each number issued in the space provided.

B. Provide the software information for each software configuration as follows:

1. Enter the software and version of the software in the space provided as indicated on the respective Software Authorization Request.

2. Circle the software classification as indicated on the respective Software Authorization Request.

3. Enter the Design Base Memorandum munber as required by the applicable controlling procedure.

C. Enter software status as required by applicable controlling procedures. Include the following information for "HOLD" status:

1. Identification of the document that is the basis for the "HOLD" or management individual that authorizes the "HOLD" status to be made.

2. Brief explanation or reason for the "HOLD" or removing a "HOLD".

3. Date and Initial each entry.

D. Makes SCML entries in the space provided for the applicable software documents as required by the controlling procedures as follows:

Note: Not all spaces will have entries. Entries are dependent on the classification of the software and are dictated by the controlling procedures. Entries that are not required may be marked not applicable "N/A".

1. Enter the software document identification number.

2. Enter the document disposition when applicable (Approved or Disapproved).

3. Date and Initial each entry.

E. Provide comments as appropriate. This space is provided to make comments that provide information not covered by other entries or to augment other entries.

ATTACHMENT 2

EXAMPLE of Software Configuration Management Log (SCML)

A. SCML Number:

FSN-SCML-90-

_____
(Signature/Date)

B. Software Information:

1. Name of Software/Version:

_____

2. Software Classification: (circle one)

SES NONSES NONCALC

3. Design Baseline Memorandum (DBM) Number: _____

C. Software Status:

1. Released to Operations: _____
(Signature/Date)

2. Returned to Supplier: _____
(Signature/Date)

3. "HOLD" Status: (Use extra sheets as necessary)

_____

_____

_____

_____

_____

4. Other: (specify)

_____

_____

_____

_____

D. SCML Log Entries:

The letters in parenthesis following each item number listed below indicate whether it is applicable for that particular classification. The letters apply to the respective classification as follows: a is for SES; b is for NONSES; c is for NONCALC.

1.(a,b,c) Purchase Order Number

2.(a,b,c) Software Summary (Standard Form #185)

3.(a,b) Software Requirements Specification

4.(a,b) Software Requirements Review Plan

5.(a,b) Software Requirements Review Report

6.(a,b) Software Producer Form Cover Sheet

7.(a) Software Design Description

8.(a) Software Design Description Review Report

9.(a) Design Description Waiver

10.(a,b) User Documentation

11.(a,b) User Documentation Review Report

ATTACHMENT 2

EXAMPLE of Software Configuration Management Log (SCML) (Continued)

12.(a,b) Test Documentation

13.(a,b) Test Documentation Review Report

14.(a) Software Verification and Validation Plan

15.(a) Software Verification and Validation Plan Review Report

16.(a) Software Validation Waiver

17.(a,b) Software Design and Testing Final Review Checklist

18.(a,b) Software Design and Testing Final Review Report

19.(a) Software Verification and Validation Report

20.(a) Software Verification and Validation Review Report

21.(a,b,c) Discrepancy Report

22.(a,b,c) Software Certification Form

ATTACHMENT 2

EXAMPLE of Software Configuration Management Log (SCML) (Continued)

23.(a,b,c) Conversion Report

24.(a,b,c) Software Discrepancy Report

25.(a,b,c) Software Maintenance Request

E. Comments: (Use extra sheets as necessary)

ENCLOSURE

Yucca Mountain Project
Waste Package Plan

Table of Contents

LIST OF TABLES 3

LIST OF FIGURES 3

ABBREVIATIONS 4

EXECUTIVE SUMMARY 5

1.0 INTRODUCTION 7

2.0 MISSION NEED AND OBJECTIVES 7

2.1 Source of Mission 7
2.2 Objectives 8
2.2.1 Technical Objectives 8
2.2.2 Schedule Objectives 9
2.2.3 Quality Objectives 9

3.0 TECHNICAL PLAN 10

3.1 Description of Boundaries of the Waste Package Program 10
3.1.1 Definitions 10
3.1.2 Waste Package Program Physical Elements 10
3.2 Work Breakdown Structure 13
3.3 Program Logic and Technical Approach 14
3.3.1 Overall Phasing 17
3.3.1.1 Definition of Requirements 18
3.3.1.2 Preliminary Definition of the Waste Package and Near-Field Environment 19
3.3.1.3 Preliminary Definition of Waste Form Characteristics 20
3.3.1.3.1 Spent Nuclear Fuel 20
3.3.1.3.2 Vitrified High-Level Nuclear Waste (HLW) 21
3.3.1.3.3 Other Nuclear Waste 22
3.3.1.4 Design Concept Development 22
3.3.1.5 Definition of Interfaces 23
3.3.1.6 Development of Material Selection Criteria 23
3.3.1.7 Select Candidate Materials 24
3.3.1.8 Engineering Evaluation of Design Concepts 24
3.3.1.9 Model, Test and Evaluate Material Performance 24
3.3.1.10 ACD Update Near Field Environment Characteristics 25
3.3.1.11 ACD Update on Waste Form Characteristics 25
3.3.1.12 Barrier Materials Selection 26
3.3.1.13 Design, Fabricate and Test Prototypes 26
3.3.1.14 Select and Document Design 26
3.3.1.15 Conduct Performance Assessment of Waste Package Concepts 27
3.3.1.16 Continue Long Term ACD Material Testing 27
3.3.1.17 Continue Long Term LAD Material Testing 28
3.3.1.18 Publish Final Waste Package Design Requirements 28
3.3.1.19 Selection of LAD Design 28
3.3.1.20 LAD Update on Near Field Environment 28

3.3.1.21 LAD Update on Waste Form Characteristics 29
3.3.1.22 Verify Material Requirements Satisfied 29
3.3.1.23 Complete Evaluation and Documentation of Final Design 29
3.3.1.24 Verify Waste Package Requirements Satisfied 30
3.3.1.25 Prepare Input to License Application 30

4.0 RISK ASSESSMENT 31

4.1 Description of Risks 31
4.2 Risk Management 31

5.0 MANAGEMENT APPROACH 31

6.0 ACQUISITION STRATEGY 33

7.0 PROJECT SCHEDULE 33

8.0 RESOURCES PLAN 33

9.0 CONTROLLED ITEMS 33

10.0 SCHEDULED DECISION POINTS 33

11.0 APPROVALS 35

12.0 REVIEW AND CONCURRENCE 35

APPENDIX A 36

LIST OF TABLES

page

Table 1 Waste Package Program Primary WBS Elements 13
Table 2 Items addressed in the WPDR 18
Table A-1 Project Office Waste Package Milestones 36
Table A-2 OCRWM Baseline Milestones 37

LIST OF FIGURES

page

Figure 1 Illustration of conceptual waste package and portions of the EBS 11
Figure 2 Illustration of the relationship of near field environments between individual waste packages in vertical emplacement boreholes 12
Figure 3 Spent Fuel and HLW Containers 13
Figure 4 Flow Diagram for Waste Package Program 15
Figure 5 Illustration of Multi-barrier Approach 16
Figure 6 Diagram illustrating the use of "Bounding Values" 19
Figure 7 Reporting relationships for Waste Package Program 32
Figure 8 Waste Package Program Summary Schedule 34

ABBREVIATIONS

ACD	advanced conceptual design
ATM	approved testing materials
CFR	Code of Federal Regulations
DEIS	draft environmental impact statement
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EBS	engineered barrier system
EIS	environmental impact statement
EPA	U. S. Environmental Protection Agency
ESF	exploratory shaft facility
FEIS	final environmental impact statement
HLW	high-level waste
HWVP	Hanford Waste Vitrification Project
INEL	Idaho National Engineering Laboratory
LAD	license application design
LLNL	Lawrence Livermore National Laboratory
MCC	Materials Characterization Center
MGDS	Mined Geologic Disposal System
MRS	Monitored Retrievable Storage
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
OCRWM	Office of Civilian Radioactive Waste Management
PA	performance assessment
PACS	planning and control system
pre-ACD	pre-advanced conceptual design
QA	quality assurance
QAPP	Quality Assurance Program Plan
QP	Quality Procedure
RIB	Reference Information Base
SAR	Safety Analysis Report
SCP	Site Characterization Plan
SIP	Scientific Investigation Plan
SP	study plan
SQAP	Software Quality Assurance Plan
SR	YMP System Requirements Document
TPO	Technical Project Officer
UZ	unsaturated zone
WAPS	Waste Acceptance Preliminary Specification
WBS	work breakdown structure
WMSR	Waste Management System Requirements Document
WP	waste package
WPDR	Waste Package Design Requirements Document
WVDP	West Valley Demonstration Project
YMP	Yucca Mountain Project
YMPO	Yucca Mountain Project Office

EXECUTIVE SUMMARY

The purpose of this plan is to describe the waste package program of the Yucca Mountain Project and to establish the technical approach against which overall progress can be measured. It provides guidance for execution and describes the essential elements of the program, including the objectives, technical plan, and management approach. The work described in this plan covers the time period up to the submission of a repository license application to the U.S. Nuclear Regulatory Commission (NRC). This plan will be revised as necessary to accommodate changes in the Yucca Mountain Project Office (Project Office) or the Office of Civilian Radioactive Waste Management (OCRWM), and their plans and procedures. This plan is a Project Office-controlled document and changes to it shall be controlled in accordance with applicable Project Office procedures.

The goal of the YMP waste package program is to develop, assess the effectiveness of, and document a design for a waste package and associated engineered barrier system (EBS) for spent fuel and solidified high-level waste (HLW) that meets the applicable regulatory requirements for a geologic repository.

The technical objective of the YMP waste package program is to design a waste container and associated EBS component that can meet the regulatory requirements with sufficient margin for uncertainty. The design will continue to evolve as data from site characterization are obtained and more detailed phases of design are completed. Inputs to the waste package design include regulatory requirements; interpretations of regulatory terms and design goals; and information on site and near-field environment characterizations, waste form characterization, repository design, and near- and far-field scenarios. These inputs, along with waste package materials testing and characterization, and model development activities, are used to develop designs. The performance of the designs is then assessed to determine whether regulatory requirements will be met. This process is intended to result in sufficient evidence so the NRC can determine, during the licensing proceedings, that there is "reasonable assurance" that the requirements will be met.

Major milestones in the current OCRWM baseline schedule and the YMP schedule are provided. The three OCRWM milestones that pertain directly to the work described in this plan are: (1) start of waste package advanced conceptual design (ACD); (2) start of waste package license application design (LAD); and (3) submission of the repository license application to the NRC. The design of the waste package and associated EBS will be developed in three phases, to be consistent with the OCRWM milestones. These phases are: (1) pre-Advanced Conceptual Design (pre-ACD); (2) Advanced Conceptual Design (ACD); and (3) License Application Design (LAD). During each phase, designs will be developed based on the requirements and the documented technical data (waste form characteristics, near-field environment, and container and EBS materials properties). The pre-ACD phase will focus on first defining the requirements and then identifying feasible design options. These design options will be developed more fully and evaluated during the ACD phase, which culminates in the selection of preferred design options. Prototype fabrication and testing of waste package components will also be completed during the ACD phase. The LAD phase will develop a detailed design of the preferred option, and an analysis to verify that all requirements are satisfied. Because the final design analyses of the waste package and associated EBS depend on information that will be obtained from both surface-based testing and the underground Exploratory Shaft Facility (ESF), the milestones associated with these aspects of the YMP are linked to the design of the waste package and EBS. A final documentation package will be prepared as input for the license application.

Subpart G of 10-CFR-60 requires that all information relating to the design, design analysis, testing, and performance assessment of the waste package and EBS that will form a basis of the license application must be acquired or developed under an NQA-1 quality assurance program based on the criteria of Appendix B of 10-CFR-50. To this end, all participants in the YMP have developed or adopted Quality Assurance Program Plans (QAPPs) that reflect all requirements of the YMP Quality Assurance Plan. In the case of the waste package and EBS work, the requirements of the QAPP are being implemented through a system of Quality Procedures (QPs). The QAPP and QPs are

supplemented by a Software Quality Assurance Plan (SQAP) that specifically addresses the implementation of the requirements of the QAPP to computer software. The QAPP, QPs, and SQAP governing the waste package and EBS program are those developed and used by the Lawrence Livermore National Laboratory.

This plan also includes a discussion of the risks associated with the program, the management hierarchy, and other management issues such as resource planning, scheduling, and acquisition strategy.

1.0 INTRODUCTION

The purpose of this plan is to describe the waste package program of the Yucca Mountain Project (YMP) and to establish the technical approach against which overall progress can be measured. It provides guidance for program execution and describes the essential elements of the program, including the objectives, the technical plan, and the management approach. The work described in this plan covers the time period up to the submission of a repository license application to the U.S. Nuclear Regulatory Commission (NRC). This plan will be revised as necessary to accommodate changes in the Yucca Mountain Project Office (Project Office) or the Office of Civilian Radioactive Waste Management (OCRWM), and their plans and procedures. This plan is a Project Office-controlled document and changes to it shall be controlled in accordance with applicable Project Office procedures.

2.0 MISSION NEED AND OBJECTIVES

The goal of the YMP waste package program is to develop, confirm the effectiveness of, and document a design for a waste package and associated engineered barrier system (EBS) for spent nuclear fuel and solidified high-level nuclear waste (HLW) that meets the applicable regulatory requirements for a geologic repository.

2.1 Source of Mission

The Nuclear Waste Policy Act of 1982 (Public Law 97-425) (hereafter referred to as the NWPA) established a national effort to develop a repository for the permanent disposal of spent fuel and HLW. In passing the NWPA, the Congress charged the U.S. Department of Energy (DOE) with the responsibility for the siting, construction, and operation of such a repository. The NWPA charged the U.S. Environmental Protection Agency (EPA) with the promulgation of standards intended to protect the environment from off-site releases of radioactive material from a repository. These standards are specified in Title 40 of the Code of Federal Regulations, Part 191 (40-CFR-191)[1]. The NWPA charged the NRC with promulgating the technical requirements necessary to license all phases of repository operation. These technical requirements are specified in Title 10 of the Code of Federal Regulations, Part 60 (10-CFR-60). In 1987, the NWPA was amended by the Nuclear Waste Policy Amendments Act of 1987 (Public Law 100-203), in which the Congress directed that all efforts toward the characterization of a repository site be focused on a candidate site at Yucca Mountain, Nevada.

The NWPA implicitly recognizes the need for a waste package program by requiring a discussion of the "possible form or packaging" for the HLW and spent fuel in both the Site Characterization Plan and the DOE Secretary's recommendation for site approval to the President. The NWPA does not mandate specific objectives or function to either the waste package or EBS, though it provides the definition of both terms. Specific technical requirements for the waste package and EBS specified by 10-CFR-60 are discussed in the following sections.

---

[1] The First Circuit U.S. Court of Appeals has vacated and remanded subpart B of 40-CFR-191 to the EPA for further consideration and proceedings. Any changes made by the EPA to its standards will be evaluated by the DOE to ensure that its design program will be adequate. Until changes, if any, are implemented in the EPA standards, the DOE is proceeding on the basis of the standards published on September 19, 1985.

2.2 Objectives

2.2.1 Technical Objectives

The technical objective of the YMP waste package program is to develop a waste package and associated EBS that can meet these regulatory requirements in a way that compliance with the regulations can be demonstrated in a repository licensing proceeding before the NRC. The NRC rule 10-CFR-60.113 mandates two specific performance objectives for the waste package and EBS after the closure of the repository, and divides the post-closure period into two time periods, conventionally referred to as the "containment" and "controlled-release" periods. The containment requirement applies primarily to the waste packages, and the controlled-release requirement applies primarily to the EBS:

Containment [10-CFR-60.113 (a) (1) (ii) (A)]

> ". . . the engineered barrier system shall be designed, assuming anticipated processes and events, so that: Containment of HLW within the waste packages will be substantially complete for a period to be determined by the Commission taking into account the factors specified in 60.113(b) provided, that such period shall be not less than 300 years nor more than 1,000 years after the permanent closure of the repository."

Controlled Release [10-CFR-60.113 (a) (1) (ii) (B)]

> ". . . the engineered barrier system shall be designed, assuming anticipated processes and events, so that: . . . The release rate of any radionuclide from the engineered barrier system following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate of less than 0.1% of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay."

The requirements relating to post-closure performance of the total repository system [10-CFR-60.112] place additional requirements on the design and performance of the waste package and EBS as follows.

> "The geologic setting and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events."

A fourth major objective is to perform a "comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation" [10-CFR-60.21 (c) (1) (ii) (D)].

There are a number of other requirements that apply to the waste package and EBS prior to the permanent closure of the repository. These include radiological protection [10-CFR-60.111 (a)], retrievability [10-CFR-60-111 (b)], and geologic repository operations area design criteria [10-CFR-60.131].

Finally, 10-CFR-60.135 sets forth specific design criteria for the waste package and its components that must be met. These criteria include constraints on the general performance of the package, its chemical reactivity, and provisions for its handling and labeling, as well as design criteria for the waste forms.

2.2.2 Schedule Objectives

Major key programmatic milestones for the work described in this plan include:

- obtain repository horizon core from surface-based testing: 1/92
- complete pre-ACD phase: 9/92
- obtain repository horizon materials from ESF drifts: 9/94
- complete ACD phase: 5/96
- complete ESF EBS test set-up and start EBS tests: 10/96
- complete LAD phase: 9/01
- submit repository license application to NRC: 10/01

In addition to these milestones, intermediate lower-level milestones for the waste package program are listed in Section 7 and in Appendix A. Section 3 (Technical Plan) provides additional discussions of all milestones.

2.2.3 Quality Objectives

All information relating to the design, design analysis, testing, and performance assessment of the waste package and EBS that will form a basis of the license application will be acquired or developed under an NQA-1 quality assurance program based on the criteria of Appendix B of 10-CFR-50. To this end, all participants in the YMP have developed or adopted Quality Assurance Program Plans (QAPPs) that reflect all requirements of the Project Office Quality Assurance Plan, which incorporates the provisions of the OCRWM Quality Assurance Requirements (QAR). In the case of the waste package and EBS work, the requirements of the QAPP are being implemented through a system of Quality Procedures (QPs). The QAPP and QPs are supplemented by a Software Quality Assurance Plan (SQAP) that specifically addresses the implementation of the requirements of the QAPP to computer software. The QAPP, QPs, and SQAP governing the waste package program are those developed and used by the Lawrence Livermore National Laboratory (YMP Quality Assurance Program Plan, LLNL; YMP Quality Procedures Manual, LLNL; YMP Software Quality Assurance Plan, LLNL).

The QPs prescribe the methods used to control scientific investigations, testing activities, design activities, and performance assessments that are described in the technical planning sections of this plan. For example, the QPs describe how scientific investigations and design analyses are planned, controlled, and documented. They also describe which types of documents are quality assurance records, and how these records are created, maintained, and stored. They describe how documents are reviewed and how the information in the documents is verified.

3.0 TECHNICAL PLAN

3.1 Description of Boundaries of the Waste Package Program

3.1.1 Definitions

Waste package - the "primary container that holds, and is in contact with, solidified high-level radioactive waste, spent nuclear fuel, or other radioactive materials, and any overpacks that are emplaced at a repository" [NWPA Sec. 2 (10)]. For the purposes of this plan, the 10-CFR-60.2 definition of waste package will be used, which extends this definition of a waste package to include the waste forms: "means the waste form and any containers, shielding, packing and other absorbent materials immediately surrounding an individual waste container".

Engineered barrier system (EBS) - the "manmade components of a disposal system designed to prevent the release of radionuclides into the geologic medium involved. Such a term includes the high-level radioactive waste form, high-level radioactive waste canisters, and other materials placed over and around such containers" [NWPA Sec. 2 (11)]. The NRC rule 10-CFR-60.2 defines the engineered barrier system: "means the waste packages and the underground facility". The latter means the "underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals." The 10-CFR-60.2 definition will be used in this plan with the interpretation that the excluded "boreholes" refers only to the exploratory boreholes from the surface-based testing program. The boundary of the EBS is used in this plan as coinciding with the surfaces of the underground repository drifts and emplacement boreholes.

Near Field - the near field refers to the underground geologic media that immediately surround the emplaced waste containers. An illustration of this definition is given in Section 3.1.2 and Figures 1 and 2.

3.1.2 Waste Package Program Physical Elements

The physical elements addressed by the waste package program are illustrated in Figure 1. This figure shows a waste container emplaced in a vertical borehole with an air gap between the waste container and the wall of the borehole. A partial liner is shown and will be used as a guide to assist in the initial waste container emplacement operations. The shield plug resides above the waste container and within the partial liner. A cover is used to close the borehole at the surface of the underground repository drift floor. This figure illustrates how the waste package program must address portions of the repository EBS and near-field environment.

The near-field environment is critically important to the design and performance of the waste package and the EBS. The near field extends beyond the boundary of the emplacement borehole as illustrated in Figure 1. Figure 1 illustrates a near field that is bounded by an imaginary cylinder having a nominal diameter of 20 meters and a centerline that coincides with the centerline of the waste container. The upper planar surface of this cylindrical boundary coincides with the floor of the drift while the lower bounding planar surface is perpendicular to the centerline of the waste container and 10 meters below the container's lower surface.

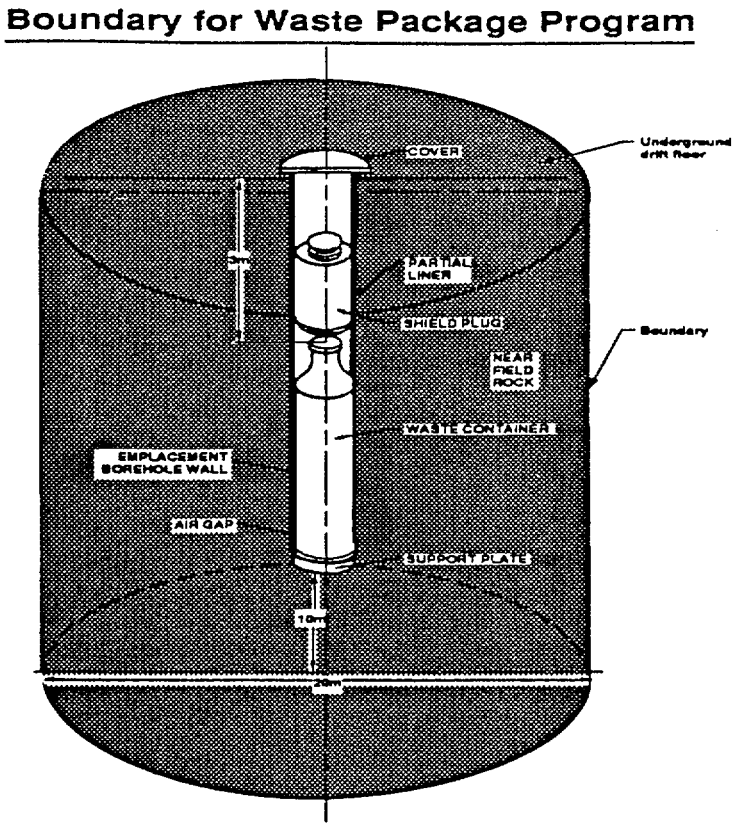


Figure 1 Illustration of conceptual waste package and portions of the EBS

The precise shape of the near-field boundary depends upon the specific process or attribute such as stress, temperature, hydrologic conditions requiring characterization and the time after waste emplacement. For example near-field stresses and radiation fields requiring characterization induced into the geologic media from emplaced waste forms, will extend radially only a meter or so from the borehole wall and only slightly above and below the waste container. In contrast, the hydrologic boundary for saturation requiring characterization may extend up to tens of meters radially and as well as above and below the emplaced waste containers for the first several hundred years after waste emplacement. In general the near-field environment requiring site specific characterization will include major portions of the geologic media between emplaced waste container, between emplacement drifts as well as both below and above the containers and the drifts. Figure 2 illustrates the overlapping of the near-field boundaries. This boundary is subject to further review and change as appropriate, however. It is essential that a boundary be identified for establishing programmatic responsibilities, for insuring that the required tasks are completed, and to insure that interfacing activities are properly coordinated. This plan uses the boundary in Figure 1 to establish programmatic responsibilities.

The near-field properties must include the effects of both the natural and the man-made features (such as the shield plug and any borehole liners used in Figure 1) that impact the behavior of the container and waste forms in the repository. The near-field environment of an individual waste package will be influenced by neighboring packages. Thus, to fully define the conditions to which each waste package will be exposed, emplacement borehole spacings, and other design details of the repository and EBS layouts are needed. Figure 2 illustrates these relationships for several vertically emplaced waste containers.

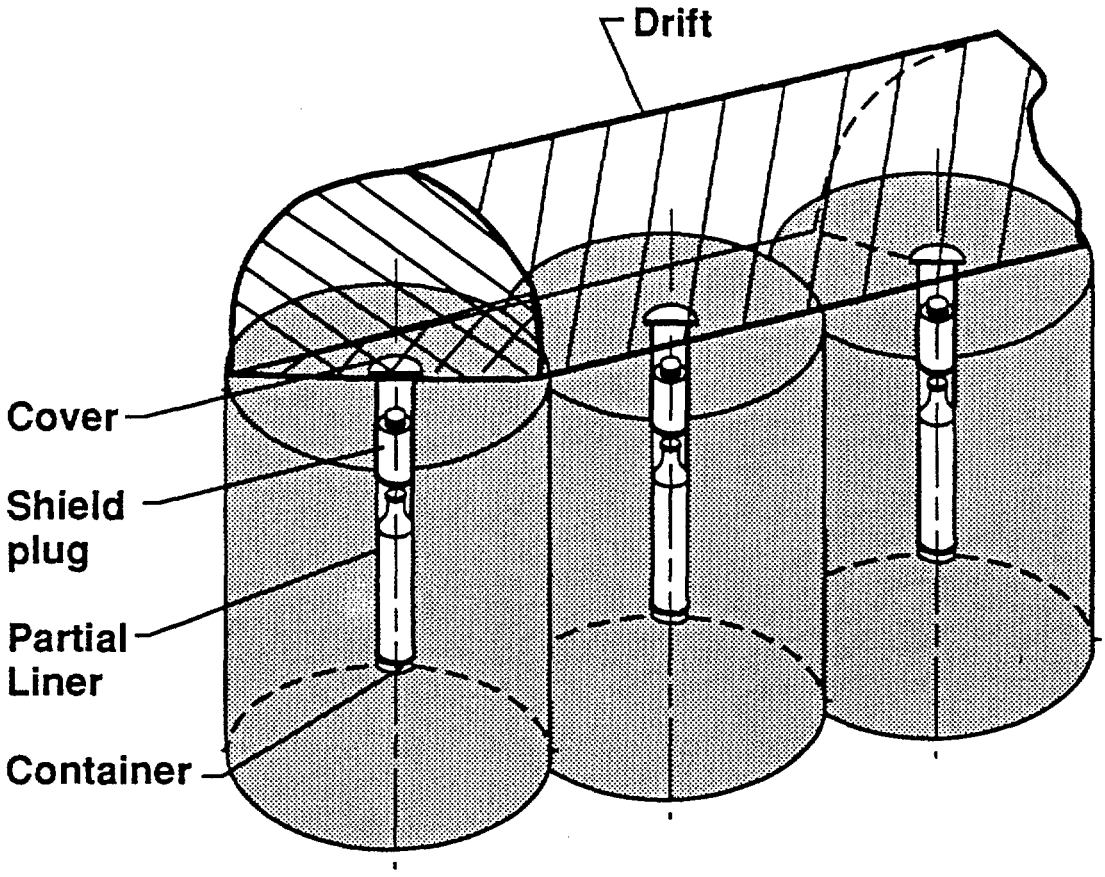


Figure 2 Illustration of the relationship of overlapping near-field environments between individual waste packages in vertical emplacement boreholes

The near-field properties of interest include the mechanical properties of the rock; the pre- and post-emplacement hydrology of the area surrounding the waste packages; the thermal field around the waste packages; the chemical properties of the air, water vapor, and liquid water in the area around the waste packages; and the effects of emplaced waste's radiation field on the near-field properties.

Figure 3 illustrates additional details of the waste containers that contain the spent fuel and the high-level waste. As shown, the waste container for the spent fuel is 187.5 inches (476 cm) long versus 129 inches (328 cm) for the high-level waste. With this one exception, the waste containers are expected to be physically identical and will be fabricated from identical materials using the same manufacturing processes, quality control procedures, and assembly methods. The spent fuel will be present either as intact fuel assemblies or consolidated fuel rods, with or without the hardware resulting from fuel consolidation. In either case, the spent fuel pellets will be contained within the Zircaloy cladding of the individual rods. The HLW will be contained within a 304L stainless steel pour canister, which is sealed and within the disposal container.

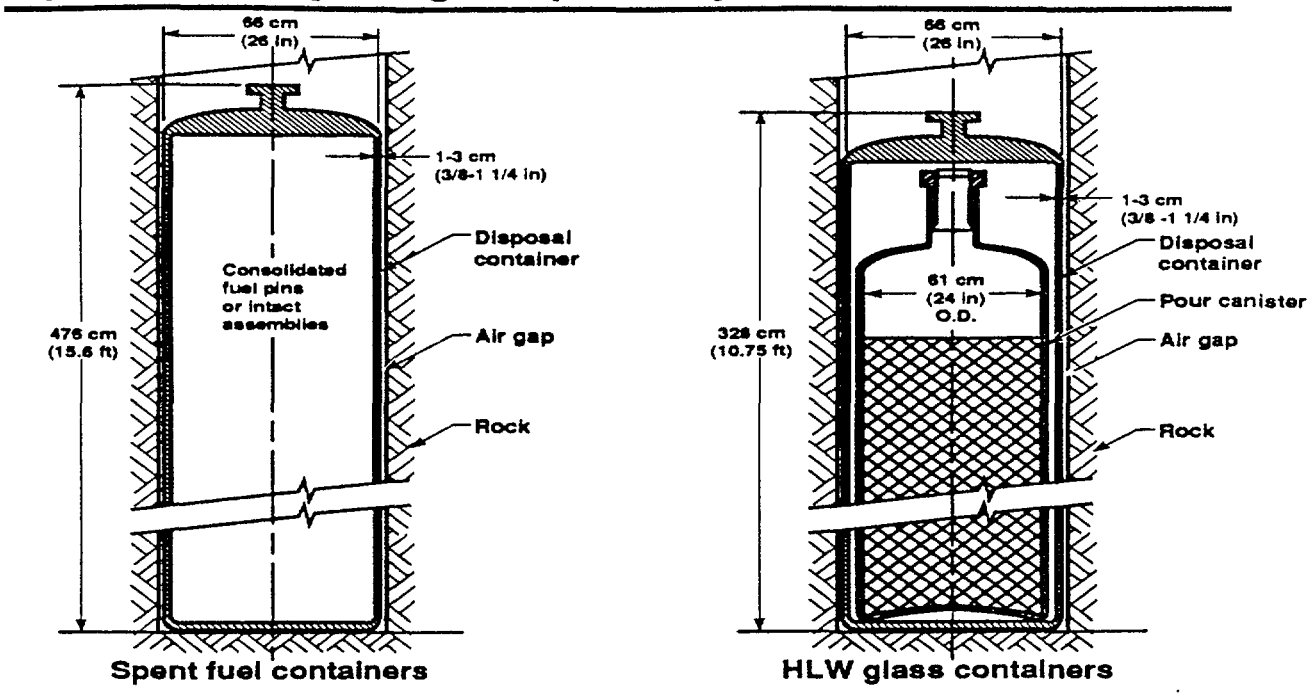


Figure 3 Spent Fuel and HLW Containers

3.2 Work Breakdown Structure

Activities of the YMP are organized into a product oriented Work Breakdown Structure (WBS). The waste package program work scope is contained primarily in WBS Element 1.2.2 as shown in Table 1.

Table 1 Waste Package Program Primary WBS Elements

NUMBER	DESCRIPTION
1.2.2.1	Waste Package Management & Integration
1.2.2.2.1	Chemical & Mineralogical Properties of the Waste Package Environment
1.2.2.2.2	Hydrological Properties of the Waste Package Environment
1.2.2.2.3	Mechanical Attributes of the Waste Package Environment
1.2.2.2.4	Engineered Barrier System (EBS) Field Test
1.2.2.3.1.1	Waste Form Testing - Spent Fuel
1.2.2.3.1.2	Waste Form Testing - Glass
1.2.2.3.2	Metal Barriers
1.2.2.3.3	Other Barriers
1.2.2.3.4.1	Integrated Radionuclide Release Tests & Models
1.2.2.3.4.2	Thermodynamic Data Determination
1.2.2.3.5	Alternate Concepts
1.2.2.4.1	Waste Package Design
1.2.2.4.2	Container Fabrication & Closure Development
1.2.2.4.3	Container/Waste Package Interface Analysis

The waste package program activities also utilize three other WBS elements that are generic and have a broad scope. Funding is derived from Systems (WBS 1.2.1) to cover systems engineering, data base implementation, waste package system performance assessments and near-field geochemical modeling activities. Funding is derived from Regulatory Interactions (WBS 1.2.5) to cover SCP updates and regulatory interactions. In addition, funding is derived from Project Management (WBS 1.2.9) to cover quality assurance, records, project cost and schedule control, and overall project management. More detailed definitions of the WBS work elements are included in the YMP WBS dictionary.

3.3 Program Logic and Technical Approach

The program logic used to develop the waste package design will utilize the classical systems engineering approach. This logic will consist of the following sequence of steps:

a. define waste package design requirements,
b. develop design options to meet requirements,
c. evaluate design options,
d. select preferred design option,
e. develop and engineer the selected preferred design option,
f. verify design requirements have been satisfied.

Due to the lack of confirmed information and data necessary for the establishment of the requirements, especially in the areas of waste form characteristics and the near-field environment surrounding the waste packages, the program will pursue an approach in which the waste package requirements will be established based on the limiting or assumed bounding values using the best information available during each phase of the program. It is expected that some more stringent bounding values will be reduced as additional data are acquired, thereby allowing the design to be refined or to take credit for a more substantial margin of safety.

The steps of the systems engineering approach will be pursued in the manner illustrated by the flow diagram in Figure 4 and discussed in Section 3.3.1.

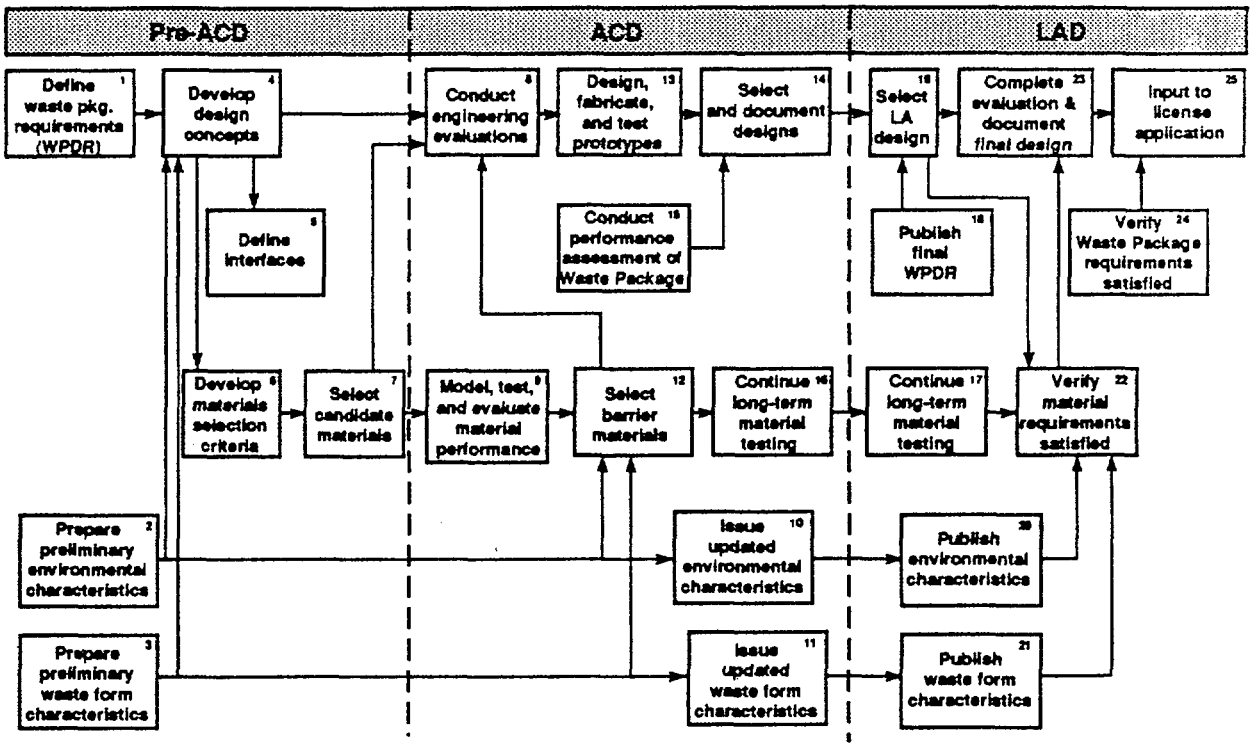


Figure 4 Flow Diagram of Waste Package Program

To be consistent with the repository development program, the waste package program is divided into three phases: pre-advanced conceptual design (pre-ACD), advanced conceptual design (ACD), and license application design (LAD). In each of these phases, the information utilized is progressively better defined and has a more substantial basis. As noted earlier, this program is aimed at the primary objective of achieving a license application design which can be submitted to the NRC for approval through the licensing proceedings.

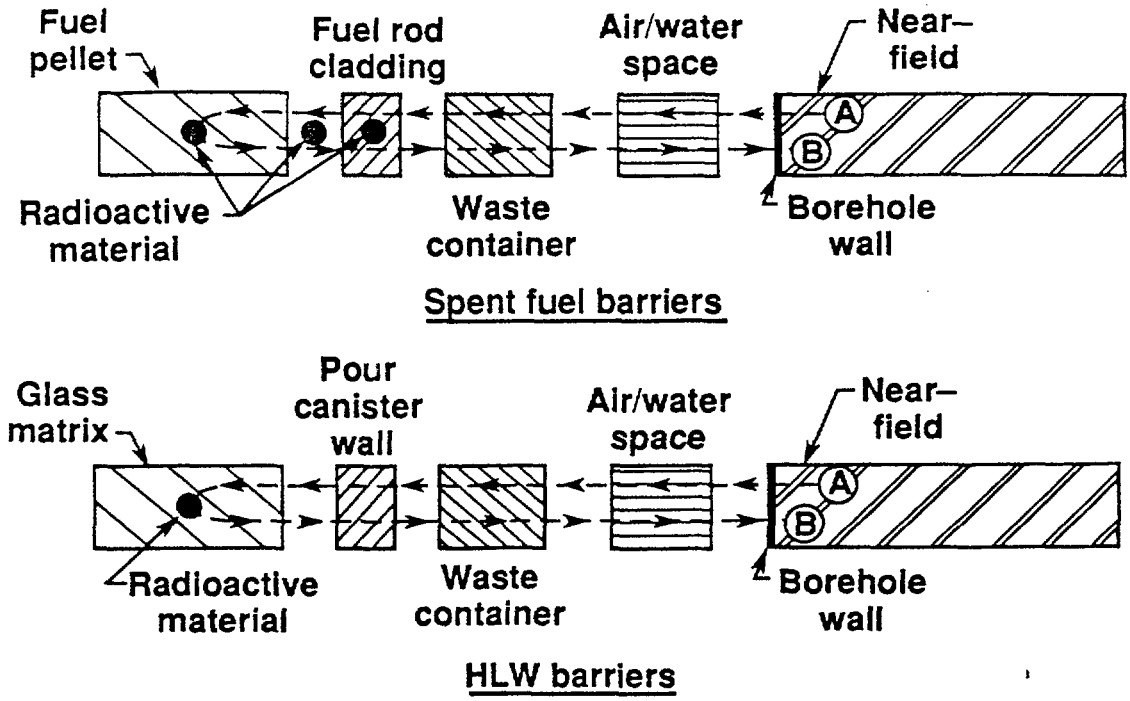


Figure 5 Illustration of Multi-barrier approach

The technical approach that will be used to both contain and control the release of radioactive materials will be based on a multi-barrier approach as conceptually illustrated in Figure 5.

The illustration represents the basic components of the reference designs for the spent fuel waste package and the HLW waste package. As currently envisioned in the conceptual design, the release of non-gaseous radioactive materials from the spent fuel requires the presence of water, and the water must be present to provide a path (A) to (B) through the barriers for radionuclides to be released to the near field as illustrated in Figure 5. That is, the release of radioactive materials from spent fuel pellets requires the following:

1) liquid water must be present in the air gap in sufficient quantities and for a long enough period to establish a mass transport mechanism for the non-gaseous radioactive materials; gaseous radioactive materials can be transported from the container to the near-field environment without the need for water,

2) water or water vapor must be present at the external surface of the waste container for a sufficient time period to cause a breach of the container, say by corrosion through the wall,

3) water or water vapor must continue to be present inside a container for a sufficient time to cause a breach of the fuel rod cladding (a small fraction of the rods will already have cladding penetration),

4) water or water vapor must remain in contact with the fuel pellets for sufficient time to support release of the radioactive material from the pellets, which can then be transported through the failed barriers. Some radioactive materials can also be released from the corrosion and oxidation of the spent fuel cladding and fuel assembly structural hardware.

As illustrated in Figure 5, a similar sequence of events is necessary for the release of HLW from the glass matrix and into the near-field geologic media.

The waste package program is structured to address each of these multiple barriers and to determine the amount of penetration and subsequent radionuclide transport that can be expected during the periods of concern. The program will determine the variability in the penetrations through the individual barriers that may occur. Although during the pre-ACD phase of the program, bounding values will be selected, it is clear that a consideration of the product of the distribution of penetrations of each of these barriers will result in a lower release than the product of the maximum values.

An alternate waste package design concept will be developed and evaluated following the same program logic, technical approach, and activities as planned for the reference concept discussed above. Both concepts will be pursued into the early LAD phase when a single waste package design concept will be selected for final design development. From that decision point in LAD, only a single selected design will be pursued through LAD. Besides fulfilling the 10-CFR-60.20 (c) (i) (ii) (D) requirement on alternative design considerations, this dual path of a reference and an alternative design concept approach is considered essential in view of the high level of uncertainty in three critical programmatic areas.

1) actual waste package service environment characteristics
2) actual waste form characteristics
3) long term prediction capability of container and waste form material behaviors.

For example, with regard to the near-field environmental characteristics, actual data from an underground repository horizon will not be available until it is provided from engineered barrier system field test experiments and from observations made through the use of the exploratory shaft facility (ESF). However, the ESF will not be available for near-field environment characterization tests until the LAD phase. The waste form characteristics required for the waste package program include a substantial degree of uncertainty. Uncertainty is introduced because the spent fuel characterization data will be based on spent fuels available through the LAD dates. These spent fuel inventories are likely to be very different from future spent fuel inventories to be placed in the repository after the year 2010 because future spent fuel will be subjected to much higher burn-up levels and may have different fuel compositions. Finally, the prediction capability of material behaviors for 1000 years or more represents a very substantial extension of the currently best available materials behavior projection capability of approximately 50 to 100 years.

In view of these uncertainties which are not likely to be overcome during the program lifespan through the license application, the pursuit of a single design concept would involve a very high programmatic risk.. If the single design concept were somehow determined to be unsatisfactory because of updated information found late in the program, or during the licensing process, the recovery time for the schedule in terms of developing a new and different design concept would, among other things, require the acquisition of long-term materials testing. Such materials testing would require a minimum of 5 years plus another 5 years, or a total of 10 or more years, to develop a different alternative design and confirm its adequacy through prototype testing and the application of validated models for the waste package environment. Such a programmatic delay is not acceptable. For such reasons, two waste package designs, a reference and an alternative, will be developed through the early LAD phase.

3.3.1 Overall Phasing

As in the repository program, the waste package program consists of the following three phases: pre-advanced conceptual design (pre-ACD), advanced conceptual design (ACD), and license application design (LAD). Activities included in each of these phases are identified and graphically illustrated in Figure 4. Although not always explicitly stated below, the same systems engineering approach is

followed for both reference and alternative designs. These activities are further described in Section 3.3.1 through 3.3.1.25.

3.3.1.1 Definition of Requirements

The first step of the waste package design and development process is to define and document all requirements that the waste package must meet (milestone M01 in Table A-1). The highest-level requirements will be derived directly from the various regulations discussed in Section 2.2. Next, the OCRWM Waste Management System Requirements (WMSR, Volumes I and IV) adds additional legislative and programmatic requirements. Finally, the YMP System Requirements (SR) document defines a top-level allocation of the generic and site-specific requirements among the major subsystems that comprise the MGDS, without unduly constraining design efforts of individual subsystems.

The Waste Package Design Requirements (WPDR) document will be prepared and baselined to establish a common basis for the wide variety of activities within the waste package program and for activities external to the waste package program that have a need for such information. The allocation of requirements to the waste package components will also be defined and documented in the WPDR. These allocations will be based on the preliminary waste form characteristics and near-field environment characteristics described in Sections 3.3.1.2 and 3.3.1.3. Table 2 illustrates the four areas that will be addressed by the WPDR.

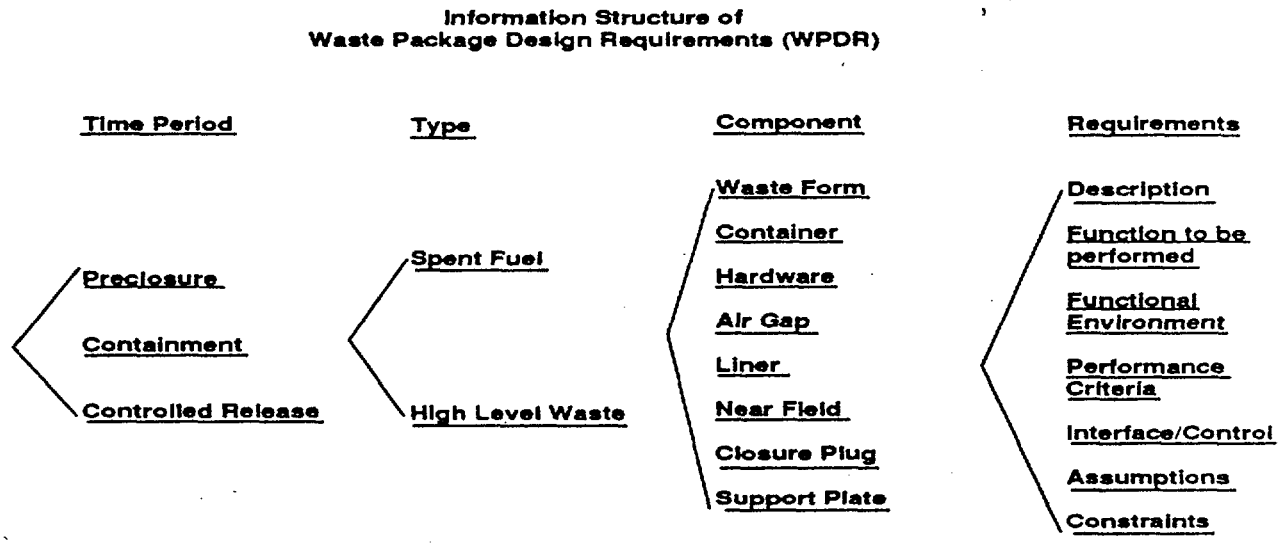


Table 2 Items addressed in the WPDR

Column 1 of Table 2 identifies the different time periods used in the waste package program. Column 2 lists the two primary types of waste forms that must be considered. Column 3 lists the various components associated with each waste package. The types of requirements in the WPDR are shown in Column 4. The WPDR will specify for each time period and for each waste form type and for each component of the waste package, the specific requirements that the design must satisfy. For example, the requirements for the waste package container are substantially different for the "containment period" when its function is to serve as a primary barrier for relatively hot fuel in a relatively dry environment versus the "controlled release period" when the container is allocated a lesser role in restricting the release of radionuclides to the near-field geologic media.

Development of the WPDR document will involve the consideration of waste package design elements, container materials, near-field environment, waste form characteristics, and will necessitate communication and coordination with other Project participants involved in both repository design and site characterization investigations. A WPDR document will be developed (milestone M01 in Table A-1) that is sufficiently detailed to guide pre-ACD activities and to develop design concepts (box 4 in Figure 4). Changes to the baselined WPDR will be subject to configuration management and change control procedures so that provisions are available to update the WPDR as appropriate in later design phases. Two separate WPDR documents will be developed for the reference and for the alternative design configurations in order to delineate and manage the different sets of design requirements and performance allocations.

3.3.1.2 Preliminary Definition of the Waste Package and Near-Field Environment

Based on the best available data for the underground conditions at Yucca Mountain, the near-field environment will be defined and documented (milestone M02 in Table A-1). This document will be baselined and used with the WPDR to develop design options during the pre-ACD phase. The environmental conditions of primary concern that will be addressed in this report are: (a) hydrological (water flow and quantity), (b) geochemical (water quality), (c) thermal, (d) radiation, and (e) mechanical loading conditions associated with the near-field environmental perturbations caused from excavation and construction activities, waste emplacement, and closure operations. Characterization of the environment will be conducted through the use of field and laboratory tests, model development, and analyses. The environmental characterization analyses will be based on currently available laboratory tests and documented data available from all YMP participants and other available sources in addition to WP program studies completed prior to the end of FY 90. Repository horizon samples will not be available from either surface-based testing or from the ESF. Therefore, the document will focus on general tuff environments to provide data to bound the environmental conditions. As new data are developed, they will be incorporated in the document using approved change control procedures. Details of specific activities that will be performed will be described in Study Plans and Scientific Investigation Plans.

This plan assumes anticipated environmental conditions as used in 10 CFR-60 will be defined during the ACD phase. Prior to that time, the near-field environment activities will establish evaluations of bounding conditions of the expected environmental underground conditions present. The values of the parameters in the preliminary document, will be selected to include the bounding values that quantify the near-field environment as illustrated by arrow (A) in Figure 6. It is assumed that bounding values include the anticipated conditions to be developed in ACD, and they will be used in all design and WP performance evaluations.

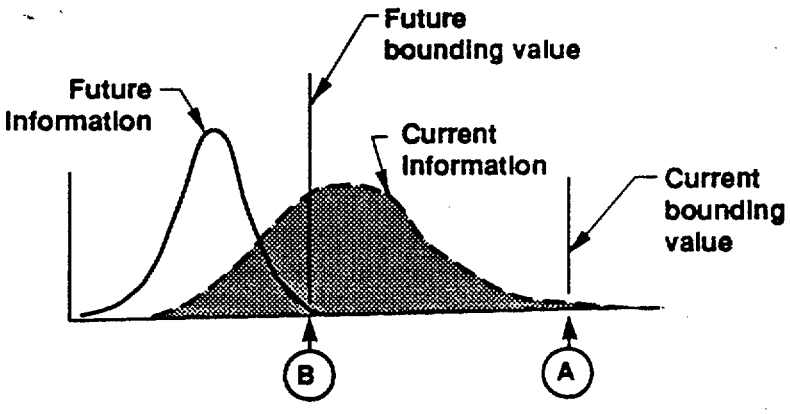


Figure 6 Diagram illustrating the use of "Bounding Values"

It is well understood that there is a spatial variation of the environmental parameters when considering the overall repository site. It is expected that the acquisition of additional near-field site characterization data under more realistic conditions in subsequent program phases after pre-ACD will establish, for some parameters, narrower distributions and possibly shifts in the mean distribution values. When this occurs, the bounding values may be reduced to a level as indicated by (B) in Figure 6. Such a shift could enable the designer to modify the design for less severe conditions, or to document and take additional credit for greater design margins.

3.3.1.3 Preliminary Definition of Waste Form Characteristics

During pre-ACD, resources will be directed to the documentation of the waste form characteristics that impact the design, development and evaluation of the waste package and the engineered barrier system. This preliminary documentation will be based on the best information available (milestone M03 in Table A-1). This document will insure consistency within all the various subsystem elements. Special emphasis will be placed on the identification of characteristics parameters that will be required by the designers and evaluators of the components of the waste package and the EBS. Such characteristics include the quantities of various waste forms, and the ranges of waste form ages, decay heat contents per mass or volume unit, the specific radionuclide inventories per mass or volume unit, the initial uranium 235 enrichments in spent fuel, different types of PWR and BWR spent fuel assemblies and associated physical properties. Additional characteristics are required for performance evaluations and performances assessments.

There are two primary types of waste forms, i.e., spent nuclear fuel and high level nuclear waste. It is recognized that there may be "other" radioactive wastes that may be emplaced in the repository; however, unless these materials are better defined, no effort will be expended, as part of the waste package program activities, toward projecting their characteristics until the ACD phase. Details of specific activities that will be performed on all waste forms will be described in Scientific Investigation Plans.

3.3.1.3.1 Spent Nuclear Fuel

The characteristics used by the designers and performance evaluators must be representative of the total inventory of spent fuel to be emplaced in the repository. The distributions of the preliminary characteristics will be estimated in pre-ACD in a quantitative form using the best information available. So that the representativeness can be established, bounding values (as discussed in the section 3.3.1.2), will be established for developing designs while subsequent in-depth investigations and analyses in later design phases will further refine the data, to better develop the distributions of the variations, and to establish more definitive bounding values. These initial distribution estimates will require significant refinements throughout all phases of design. Efforts will be focused on the characteristics of the spent fuel essential to the design and evaluation of the waste package and engineered barrier systems. Special attention will be given to quantifying parameters where there are near-term applications.

An evaluation will be made of how performance evaluations can deal with the fact that only a small fraction of the total spent fuel to be contained has been generated. For example, only approximately 20,000 MTU of spent fuel exists today and approximately 40,000 MTU spent fuel is yet to be generated by the utilities for the first repository.

The fuels used in the testing programs will be identified as to where they fall within the distributions developed for the ranges of typical spent fuel before detailed characterization tests are initiated. The distributions developed for projected fuel characteristics (i.e., burnup, age, etc.), will be used to define the bounding values selected as the design basis for the waste package concepts. The waste form characteristics report will document these distributions and other characteristics (milestone M03 in Table A-1).

Referring to Figure 5, other spent fuel characteristics that will be determined in the pre-ACD phase for representative spent fuel based on these distributions, include:

- the dissolution and solubility behavior of spent fuel pellets, including the effect of air and water vapor oxidation of the UO_2 pellets and of the groundwater chemistry,
- the fraction of soluble radionuclides existing in the fuel-cladding gap and spent fuel grain boundaries prior to any cladding breach and thereby available for rapid aqueous release to the near field should the barriers illustrated in Figure 5, be breached,
- the release of gaseous radionuclides from the spent fuel waste forms (i.e. spent fuel or cladding), and

These latter characterizations will be performed within the bounds established and documented for the near-field environment conditions (milestone M02 in Table A-1) and within the distributions developed for the spent fuel characteristics.

3.3.1.3.2 Vitrified High-Level Nuclear Waste (HLW)

The characteristics of the HLW that will be used by the designers and evaluators will be representative of the total HLW inventory to be placed in the repository. The establishment of these preliminary characteristics in a quantitative form will be accomplished using the best information available. During pre-ACD, distributions of the quantities and ranges of variations of characteristics such as radionuclide content, decay heat content, radiolytic properties, chemical composition, etc., will be established. Efforts will be made to reduce these to a form required to design waste package concepts and to conduct evaluations. As discussed in section 3.3.1.2, bounding values will initially be established while subsequent in-depth investigations and analyses will be performed to further refine the data and to develop distributions of the characteristics that establish more definitive values. Early attention will be focused on the characteristics of the HLW that will be essential to the design and evaluation of the waste package and engineered barrier system. The preliminary HLW characteristics will include HLW data from the Defense Waste Processing Facility (DWPF) and the Savannah River Laboratory and from the West Valley Demonstration Project (WVDP). Other HLW producers [(Hanford Waste Vitrification Project (HWVP) and Idaho National Engineering Laboratory (INEL)] will quantify the chemical, physical and radiological properties and compositions of the waste forms that they will produce as well as projections for HLW quantities. Such data will be used to update the waste form characteristics report (milestone M03 in Table A-1) to the extent these data are available.

Waste acceptance preliminary specifications (WAPS) for DWPF and WVDP HLW glasses have been established by OCRWM. Representative prototypic samples of HLW glass based on these acceptance criteria will be used for testing. The waste producers will assure a high degree of compliance with the final acceptance criteria via HLW production process control and some limited product sampling and analysis, as described in their respective waste compliance reports. Furthermore, representative sets of Approved Testing Materials (ATMs) for HLW glass will be made and an assessment of the variability introduced into test results due to test method and investigator techniques will be developed.

To some extent, the HLW glass characterization testing program will be limited by the availability of representative samples of glasses. To ensure that glasses assumed in waste package design concepts and used in the testing programs are representative of the expected HLW glass inventory, distributions of parameters will be established. Based on these distributions, bounding HLW glass characteristics (e.g. glass composition, and radionuclide species) will be used to define the design basis for the waste

package. The waste form characteristics report (milestone M03 in Table A-1) will document these distributions, the inventory projections and other characteristics.

The representative characteristics of the projected HLW glass waste form inventory that will be determined include:

- physical,
- chemical,
- radiological, and
- radionuclide properties that are representative ,

- the dissolution behavior of HLW glass, including the effect of groundwater chemistry on dissolution rates and solubility limits,

- the alteration of HLW glass by a water vapor atmosphere and the subsequent dissolution behavior due to the water vapor induced alterations.

The characterization of HLW will utilize the bounding values established in the near-field environment conditions report (milestone 02 in Table A-1). Preliminary models that describe the process controlling the releases of radionuclides from HLW glass waste form will be developed for use in design evaluations and waste package materials performance predictions.

3.3.1.3.3 Other Nuclear Waste

Other than spent nuclear fuel from commercial reactors and vitrified HLW, there are two other general categories of nuclear waste that may be disposed of in the repository. The first category includes relatively minor amounts of spent fuel from specialty and research reactors, commercial spent fuel fragments that have been used in test programs, intact and/or damaged spent fuel rods from various research programs, as well as limited amounts of separated cesium-137 and strontium-90 in sealed capsules. All of the wastes in this first category qualify as high-level wastes and may be considered for disposal in a repository on a case-by-case basis. Some wastes may need further processing before being packaged for disposal. No efforts will be expended during pre-ACD at developing detailed plans for accommodating this minor category of high-level waste in the first repository.

The other category of waste that may be disposed of in a geologic repository includes all "greater than Class-C" nuclear waste. This category represents a relatively large volume of moderately radioactive waste that cannot be disposed of in shallow-land burial sites as "low-level waste." Regulations do not require that this waste be disposed of in a deep geologic repository. No efforts will be expended in pre-ACD for developing detailed plans for accommodating this waste in the first repository.

3.3.1.4 Design Concept Development

Based on the documented baselined design requirements, including functional allocations, preliminary near-field environment characteristics, and preliminary waste form characteristics, a series of waste package design concepts will be developed and documented (box 4 of Figure 4). The development of the design concepts will include initial assessments of the feasibility of appropriate container manufacturing and closure processes, with particular attention to aspects that may require development beyond existing industrial practices. A report documenting the design concepts, together with a preliminary prioritization will be generated (milestone M04 in Table A-1). These design concepts will be used as the basis for detailed engineering evaluations during the ACD phase.

The design concepts report will include drawings and descriptions of the physical configurations, including the container and possible material options; waste form configurations; internal and external

stanchions, supports, and other emplacement configuration EBS appurtenances including liners and shield plugs.

The design concepts will include conceptual designs for a reference thin-walled metallic container and associated EBS components as described in Section 3.1.2 and Figure 3 and other designs. The designs will be evaluated to identify variations (such as diameter changes, waste form capacities, alternative materials, etc) that may be appropriate for further evaluation during ACD.

A preliminary assessment of the performance of the various concepts will be conducted, utilizing the existing container materials characterization, near-field environment and waste form characteristics information. The purpose of these assessments is to assist in establishing a screening and prioritization of the concepts. Other aspects of the design concepts will be considered in the prioritization process, including relative manufacturing feasibility, costs, and operational implications.

3.3.1.5 Definition of Interfaces

The waste package program requires the early identification and continuous management of physical and informational interfaces with other elements of the OCRWM Program. Major waste package interfaces occur between the site characterization activities, repository design, system performance assessment, and regulatory activities. At the Program level, interfaces also exist with the waste production (HLW producers, reactor operators, spent fuel storage) and transportation activities. These interfaces define the information flow that waste package program activities either require from or provide to other program elements in support of the design, evaluation, and licensing. The boundary illustrated in Figure 1 will be used in conjunction with approved interface control procedures to identify and manage the interfaces between the waste package program and other OCRWM program elements.

Interfaces, data transfers, data, and information needs will be identified and documented in an interface report (milestone M05 in Table A-1). Because a continuous assessment of interfaces is essential to the successful development of a waste package design, this initial interface documentation will be baselined and updated as appropriate during all subsequent design phases using approved procedures. Waste package program interfaces will be identified and managed in accordance with guidance provided in the Project Office Management Plan (YMP/88-2), Systems Engineering Management Plan (NNWSI/88-3), and Configuration Management Plan (YMP/88-4), and in compliance with appropriate YMPO change control and other procedures.

3.3.1.6 Development of Material Selection Criteria

Criteria for selection of the container and EBS materials to be used in the ACD will be developed and documented (milestone M06 in Table A-1). As indicated in Figure 4 (box 6), these criteria will follow from the requirements and the allocation of functional requirements in the WPDR to the barrier components of the waste package for various design concepts. To meet the performance requirements assigned to the barrier, the container material is likely to have the greatest impact on performance. Establishment of criteria is separated from material selection because the criteria must address the functional requirements in a material-independent manner.

The selection criteria translate the functional requirements allocated to the various waste package barrier components in the WPDR into material properties and performance attributes that can be both assessed and quantified to compare candidate materials. The criteria will permit a candidate material to be judged for adequacy in meeting the allocated performance goals, and will provide a basis for a quantitative comparison to allow ranking of the candidate materials. The selection criteria will provide for comparisons of attributes of a widely varying nature. For example, issues such as mechanical properties and corrosion resistance must be compared to issues such as cost and prior engineering fabrication experience. Subjective issues such as the expected relative acceptance of the material in a licensing process must be considered. The selection criteria must address the uncertainties

in the barrier performance goals. Because translating functional requirements into quantitative criteria requires subjective opinion regarding the type, form, and importance of each criterion, the selection criteria will be subjected to a formal peer review. The results of the peer review will be documented (milestone M07 in Table A-1).

3.3.1.7 Select Candidate Materials

The selection of candidate container and associated barrier materials (box 7 in Figure 4) will be accomplished by the application of the selection criteria discussed in Section 3.1.1.6. Prior to the material selection, supporting information will be gathered, including existing data on material performance, and on barrier fabrication and container closure processes. The selection process will be conducted and documented (milestone M08 in Table A-1) according to the approved QA program plan to ensure suitability for use in NRC licensing.

For the reference design, the candidate container materials list generated prior to FY90 will be upgraded to be consistent with the approved QA program plan, and to reflect current program knowledge. This upgrade will include a confirmation or modification of the current candidate list of six alloys, starting with the list of alloy systems established in FY81. This confirmation will be performed by screening the alloy systems and applying the approved selection criteria. Following an initial screening process, detailed engineering studies will be conducted on a smaller list of alloys, to permit a more detailed application of the criteria for selection of those alloys for the ACD phase. This selection process will be supported by conduct of degradation mode surveys and laboratory testing. Failure mode models will be developed and preliminary analyses performed to support the selection. These models will be developed to address the bounding near-field environmental conditions expected at Yucca Mountain as discussed in Section 3.3.1.2. An independent peer review of the material selections process will be performed by a panel of experts from technical fields relevant to the selections (milestone M09 in Table A-1).

3.3.1.8 Engineering Evaluation of Design Concepts

Engineering evaluations will be conducted of selected container and associated EBS design concepts to establish their ability to satisfy design requirements and material performance requirements based on the reference sets of near-field environment and waste form characteristics. Consideration will also be given to the container and EBS manufacturing processes likely to be specified for fabrication, as well as repository processes for closure and inspection of the waste container prior to emplacement. A variety of processes will be evaluated and the preferred design concepts will be selected and documented (milestone M10 in Table A-1) for further design development. Preliminary structural, thermal and nuclear criticality design evaluations will be made of the design concepts for the container and other engineered components of the waste package subsystem based on the design requirements. The results of these evaluations and the fabrication and closures processes will be summarized in a report (milestone M10 in Table A-1). This report will include evaluations of the waste container design concepts, as well as other engineered components of the waste package (such as a borehole liners, container supports, and shielding plug) that affect the performance of the design options. The report will recommend the preferred design concepts for further development.

3.3.1.9 Model, Test and Evaluate Material Performance

Laboratory testing of the proposed container and associated EBS materials (box 9 in Figure 4) will continue to provide data to demonstrate that the material performance is adequate and also to support the development of predictive failure models. Materials tests to be performed include aqueous corrosion, oxidation, localized corrosion (crevice or pitting), environmentally assisted cracking (stress corrosion cracking, hydrogen effects), full-scale electrochemical corrosion and stress effects, and long-term phase transformations.

In parallel with the material testing studies, mechanistic models will be developed to describe the barrier material performance. Predictive models for the 300 to 1000 years design lifetime must be developed, assessed, verified, and validated to the extent possible.

3.3.1.10 ACD Update Near-Field Environment Characteristics

In the initial ACD phase, approximately one year of laboratory testing will be completed on rock and water samples obtained from surface-based drilling activities at Yucca Mountain to further develop hydrological, thermal, and geochemical models of the repository horizon. The preliminary near-field environment characteristics report will be modified to assist in the development of the ACD through a change control process to include this information.

During ACD, laboratory testing of samples from the on-going surface-based testing will continue. In addition, larger samples from the underground repository horizon will be available in the later ACD phase. This will allow near-field characterization testing that was not possible with the smaller sized core from the surface-based drilling program. As the information from these tests becomes available, the baselined near-field environment report will be updated in accordance with approved change control procedures. This will ensure information is available for models being developed in conjunction with near-field characterization tests, representative of repository conditions. Models will be developed and used to make preliminary evaluations of the near-field environmental response to waste emplacement and the impact of that response on waste package performance. Verification of codes for models will be completed prior to the application of these codes to any performance assessments. Results from underground prototype field tests will be used to begin validation of these codes for "generic" tuff, and laboratory test results will be used to begin validation of the codes for repository horizon rock.

The near-field environment report will be revised late in ACD to allow inclusion of surface-based core study results and limited information generated by large block testing (milestone M11 in Table A-1). The ACD-phase update will be used as input for the final WPDR document.

The validation of near-field environment characterization models applicable to repository conditions will need to await the availability of in situ data from EBS testing during the LAD phase. Emphasis during the ACD phase will be on evaluating the sensitivity of the design concepts performance to various near-field environmental parameters. A study plan for the field test in the ESF will be developed for the design options under consideration. The tests will include all engineered components of the waste package system, including liners, shield plugs and associated near-field EBS components. Possible design changes to ameliorate adverse aspects of the near-field environment on performance, or to enhance beneficial aspects of the environment, will be evaluated and incorporated into the designs during this phase (box 14 in Figure 4).

3.3.1.11 ACD Update on Waste Form Characteristics

The ACD phase of the waste form characterization will focus on the continued acquisition of waste form characteristics distributions and projected inventory data needed for design analysis and waste package performance predictions and refinement of the models developed earlier. As the development of the ranges of variations of waste form characteristics required for design is established further, the testing program will be focused less on bounding values and more on measured distributions. Only those aspects of waste form behavior that are allocated performance in the WP designs or that are necessary to predict waste package performance will be studied. The waste form testing program will also be re-evaluated to verify that updated information about the near-field environment is being utilized in all waste form characterizations.

The waste form characteristics will be revised during the ACD phase using approved change control procedures as new data become available. In the later stages of ACD, it is expected that the data and

models will be known with more confidence. An ACD-phase update will be issued (milestone M12 in Table A-1) near the end of ACD and will serve as input for the final WPDR document.

During ACD, integrated models to describe the release of radionuclides from the waste packages and all of the multiple barriers illustrated in Figure 5 will be further refined. Characterizations will be conducted of the extent to which reliance can be placed on cladding as a barrier to release and the extent that UO_2 will oxidize under repository near-field conditions. In addition, preliminary models that predict the interactions between the near-field environment, container materials, waste forms, and other man-made components of the MGDS initiated during the pre-ACD phase, will be further refined. A full and complete description of the complex interactions will be based upon the detailed process models that describe the behavior of the individual components as illustrated in Figure 5.

3.3.1.12 Barrier Materials Selection

The objective of the selection process (box 12 in Figure 4), is to choose container and EBS materials that will meet the requirements. The sets of materials selection criteria established for the selection of the material for ACD studies will be used, with any modifications resulting from improvements in the definition of requirements; changes in performance allocations; and data obtained during pre-ACD regarding the service environment, material performance, and operational issues. Any changes to the criteria will be justified and documented using approved change control procedures. The materials selection process and results will be documented (milestone M13 in Table A-1) and used to conduct engineering evaluations.

3.3.1.13 Design, Fabricate and Test Prototypes

During ACD, prototypes of up to three design options will be fabricated, tested and documented (milestone M14 in Table A-1). The purpose of this activity is to evaluate those design details that are key to establishing the engineering feasibility of the design. The scale of the prototypes will be appropriate to the design features to be evaluated. The features will include materials properties, fabrication, mechanical handling, and inspection processes. Testing will include mechanical tests such as impact tests; nondestructive and destructive examination of the of the material, fabrication features; closure and inspection processes; and other tests as needed. The test data will be used to support the selection of designs to be carried on into LAD.

3.3.1.14 Select and Document Design

Based on the engineering evaluations of design concepts (box 8 in Figure 4) and the prototype test activity (box 13 in Figure 4), two designs (one reference and one alternative) will be selected to be pursued in the early LAD phase. This initial selection process is expected to result in the recommendation of up to two reference and two alternative designs for further development until the final two designs can be selected.

The selection process will be documented in the waste package ACD report (milestone M15 in Table A-1). The ACD report will: (1) describe the recommended waste package designs at a level of detail appropriate to the ACD phase; (2) document the other designs considered and the rationale for the selection of the designs; and (3) provide the basis for proceeding with the design process into the subsequent design LAD phase. The waste package ACD report will include drawings, outline specifications, a discussion of fabrication and closure processes, and estimated cost of each of the developed options; performance of each option in regard to the functional requirements; references to the supporting data, engineering performance evaluation models, and model applications; description of the design selection criteria and process; and identification of the selected design options for the reference and the alternative.

3.3.1.15 Conduct Performance Assessment of Waste Package Concepts

One of the primary criteria for selection of designs to be carried forward to LAD and beyond, is the relative performance response during the post-closure period. The method for establishing the predicted performances will be to use waste package performance assessment codes that incorporate appropriate models of the anticipated natural near-field conditions as altered by the presence of the emplaced waste, degradation modes of container materials, and radionuclide release rates from the waste forms. During the late stages of ACD, the relationship between the bounding values being used for design and the anticipated conditions required by 10 CFR-60 will be established.

The assessments performed (box 15 in Figure 4) will be utilized in the selection of the ACD designs to be carried into LAD (box 14 in Figure 4), and will be documented in the ACD report (milestone M15 in Table A-1). For the developed designs, radioactive source terms will be developed for use by the total system performance assessments performed outside the scope of the waste package program. These initial waste package performance assessments will document the models and codes to be used during ACD (milestone M16 in Table A-1). The performance assessment activities will be described in a SIP and will be coordinated with existing integrated OCRWM and Project Office performance assessment plans. The waste package environment and waste form characteristics reports (milestones M02 and M03 in Table A-1) will be used as inputs to both the PA models and codes. The design concepts and container material characteristics will also be used as inputs to PA models and assessments (milestones M04 and M06 in Table A-1).

In addition to the engineering evaluations (box 8 in Figure 4), the evaluation of the design options will use performance assessment codes. Code development, which was initiated and applied during the pre-ACD phase, will be continued during the ACD evaluation process. At a minimum, these codes consist of: (1) single waste package performance code(s) and, (2) source term or ensemble waste package code(s).

There is a continuous flow of information across the interfaces between these code development activities and the materials, waste form, and near-field environmental characterization and modeling activities during design development. The identification, quantification, and delineation of scenarios is a performance assessment activity that will be used to assist the development of waste package designs. The models, the codes, and the applications of the codes will be reviewed independently in accordance with appropriate procedures. The performance assessments will use baselined documents for the waste form and near-field characteristics. This review process helps ensure an accepted body of information from which a design option can be selected.

Uncertainties in performance become increasingly significant as evaluations of design alternatives progress. To distinguish among alternatives, increasingly detailed assessments are required. Continued and early model development, physical testing, and other data collection will help reduce the uncertainties with respect to the design selection process. At a minimum, an understanding of the impact of the uncertainties on the evaluation and selection process is required.

3.3.1.16 Continue Long-Term ACD Material Testing

The modeling and testing activities described in Section 3.3.1.3.9 (box 9 in Figure 4), will be continued to provide the long-term materials testing data required for development, verification and validation of the predictive failure mode models. It is anticipated that at least five years of material performance test data are needed to provide defensible models for the licensing process, and to predict performance over the unprecedented lifetimes required by the NRC regulations. Preparations for an instrumented in situ prototype container with associated barriers for long-term testing in the ESF facility will also be conducted.

3.3.1.17 Continue Long Term LAD Material Testing

This activity is identical to that described in Section 3.3.1.3.16, except that once a final barrier design is selected early in LAD, only those tests and modeling analyses associated with the single selected design for LAD development will continue.

3.3.1.18 Publish Final Waste Package Design Requirements

During all design phases, a review will continue of the impacts on waste package requirements due to NRC rulemaking, quantitative interpretations of qualitative regulatory terms and requirements, and the issuance of NRC generic technical position papers and regulatory guides. Any ensuing changes to the waste package requirements will be incorporated into the WPDR document using approved change control and configuration management procedures. At the start of the LAD phase, the final WPDR will be published for use in selecting the single design concept for the LA design (milestone M17 in Table A-1).

3.3.1.19 Selection of LAD Design

After the start of the LAD phase, a selection will be made between the reference and alternative waste package design configurations for further development. The selection will be based on (1) the final published WPDR, (2) the existing near-field environment characterizations obtained from both large repository horizon block tests and from limited underground ESF EBS field test data of waste package configurations, (3) existing waste form characterization data and, (4) existing long-term container and associated barrier materials testing data. An initial step of the LAD phase is to review and reconfirm the design requirements are satisfied by the two design concepts developed during the ACD phase.

The verification of material requirements will occur in LAD after the selection of a single design configuration for LAD due to the need to await development of additional underground repository horizon ESF EBS field test data, completion of additional long-term barrier materials test data and development of additional long-term waste form characterization data. The earlier a single design concept selection decision is made in LAD, the more the risk that the container material requirements cannot be verified. There is less risk the later in the LAD phase the selection of a single waste package configuration is made. However, the later in the LAD the single selection is made, the longer is the time period that two waste package configurations (i.e. reference and alternative) must be developed as part of the LAD phase. The actual date (milestone M18 in Table A-1) that the selection of a single design will be made, will be established at the completion of the ACD phase.

3.3.1.20 LAD Update on Near-Field Environment

During the LAD phase, laboratory testing using samples of repository horizon rock will be performed to further determine the hydrological, thermal, and geochemical near-field environment properties of Yucca Mountain. Large-scale field tests of the waste package configurations will be conducted in situ in concert with analytical/numerical modeling to determine the performance in the repository environment. Various methods, including peer reviews where appropriate, will be used to evaluate the applicability of previous laboratory and field tests using repository horizon rock. The results will be documented in the report on the near-field environment (milestone M19 in Table A-1).

Model validation will be conducted at different scales ranging from core-scale to large-scale laboratory tests to field-scale tests. Laboratory-scale tests will be used to validate detailed process models. These validated process models, along with data from core-scale tests, will be used in constructing field-scale models of the near-field environment that will then be validated using in situ field-scale tests. The validated field-scale models will be used to provide inputs to near-field performance assessment models and to confirm the adequacy of the LAD.

Many tests performed prior to the LAD phase and prior to access to the in situ repository environment will be, of necessity, strongly thermally overdriven and short in duration. They will therefore perturb a relatively small volume of the emplacement environment. Because key hydrothermal and geochemical processes are very sensitive to thermal loading rates and waste package geometry, thermally overdriven, subscale tests will distort important aspects of the near-field environmental response. With access to the underground environment, in situ confirmation testing can commence at reference thermal loading rates using full-scale heaters over durations that will perturb a near-field volume extending over the scale of the significant heterogeneities. These long-term confirmation tests will be defined in study plans, and will continue beyond LAD. Performance confirmation testing will evaluate the effectiveness of designs and the performance prediction activities. These validations will provide a limited number of points for validation of the predictive models. The confirmation testing will extend the data available to validate the predictive models used to evaluate WP performance during the ACD and LAD phases.

3.3.1.21 LAD Update on Waste Form Characteristics

The distribution models and data developed and used for design and performance evaluations will be re-examined in light of updated information on the distribution of spent fuel and HLW characteristics in the inventories of projected waste quantities. The waste form characteristics work will also begin validation of the detailed process models and test data that were developed during earlier phases for the behavior of the waste forms. A key input to the validation process will be the results of long-term confirmation tests begun during the pre-ACD phase. Additional testing will be conducted as necessary to ensure that the data used to support a license application are based on testing of representative fuel samples. The revised waste form characteristics data will be documented (milestone M20 in Table A-1) and used to support the development of the LAD.

3.3.1.22 Verify Material Requirements Satisfied

The verification of material requirements (box 22 in Figure 4,) will use inputs from the final WPDR (box 18 in Figure 4), the near-field environmental characteristics (box 20 in Figure 4), and the waste form characteristics (box 21 in Figure 4). The verification will be fully documented (milestone M21 in Table A-1). Additional near-field environmental data generated after selection, will be reviewed to ensure the materials selected remain verified as satisfying the requirements used in the license application.

3.3.1.23 Complete Evaluation and Documentation of Final Design

Development of the two designs from the ACD phase will continue into the early stages of LAD. Following the selection of a single waste package design (box 19 of Figure 4), that design will be fully developed, evaluated, and documented. The detailed design will focus on those aspects that will allow the final repository design to be completed and the waste package and repository performance evaluations to proceed. Once these features have been developed, a design configuration freeze will be placed on those elements.

Design details will be specified in drawings and specifications. Detailed component and assembly drawings will be prepared to describe fully all of the waste package configurations that are anticipated. The drawings will specify fabrications and closure details and all component interface dimensions and tolerances. Specifications will define material composition and properties; forming, joining, and inspection processes; and component storage and handling procedures.

Detailed supporting engineering analyses will be performed and verified for incorporation into the Waste Package LAD Report (milestone M22 in Table A-1). The level of detail associated with these analyses will be significantly more than that required in the earlier design phases. The engineering analyses will include, but are not limited to: structural analyses of the engineered components, thermal analyses of the design for the range of variability of waste form and near-field environment

characteristics, nuclear analyses to determine the radiation effects on package materials and other EBS components, and nuclear criticality analyses for as-assembled and degraded configurations. Cost estimates will be refined to reflect the additional design details and material or process specifications that are imposed at this stage of design development.

3.3.1.24 Verify Waste Package Requirements Satisfied

During the LAD phase, the selected design will be verified and documented (milestone M23 in Table A-1), to assure conformance with all of the waste package design requirements, as specified in the WPDR. This verification process consists of three separate, but inter-related, activities that address: (1) design verification, (2) performance assessment, and (3) confirmation testing.

In addition to the verification of the design analyses by qualified individuals who did not perform the analyses, other methods will be employed as appropriate. These will include formal design reviews, independent peer reviews, or performance of verification tests.

Performance assessments will be conducted to verify those aspects of the design requirements that are mandated by the regulations for time periods beyond the scope of conventional engineering analyses, including substantially complete containment for 300 to 1000 years and subsequent control of release of radionuclides from the EBS for 10,000 years following closure of the repository. These assessments will also provide the source term (i.e. the time-dependent, radionuclide-specific prediction of releases from the EBS) for use in the total-system performance assessment activity. Compliance will be verified for the design-basis anticipated processes and events. In addition, assessments of the consequences of unanticipated processes and events will be provided as required for the total system assessments. The methodologies, scenarios, analysis models, and computational codes employed for these assessments will be documented (milestone M24 in Table A-1). The documentation will include the methods used to identify and quantify the scenarios, and the basis for discriminating between anticipated and unanticipated processes and events.

The third component of the verification process is the execution of a performance confirmation testing program, as required by 10 CFR-60, subpart F. The confirmation testing program, as specified, is comprehensive and extends over the operational life of the repository until closure. Obviously, only a limited portion of this program can be implemented prior to the submission of a license application and the balance of the effort is beyond the scope of this plan. Confirmation tests prior to the license application will include manufacture of prototype components to verify the specified processes for fabrication, assembly, and inspection of the engineered waste package assemblies and some in situ field tests constructed in the ESF as soon as that facility is available. Data from these tests will be utilized in the license application. After repository operations are initiated, in situ monitoring of the the performance of representative emplaced waste packages in designated test areas of the facility will continue the performance confirmation testing program.

3.3.1.25 Prepare Input to License Application

The final output of the LAD phase will be the Waste Package LAD report (milestone M22 in Table A-1). This report will contain the information required for the license application SAR as specified in 10-CFR-60.21(c), including: (1) design criteria, (2) design bases, (3) materials of construction, and (4) codes and standards used. The LAD report documentation will contain drawings, specifications for the waste package, and other engineered components, data and models used to establish the near-field environmental conditions under which the package is to perform, data and models used to establish the behavior and radionuclide release characteristics of the waste forms, and data and models used to establish the behavior of the materials used in the container and other waste package components. The documentation package will also include the results of the performance assessments carried out to determine the performance of the design and to verify that the design requirements have been

satisfied. The Waste Package LAD Report (milestone M22 in Table A-1) will be the primary waste package source document for input to the License Application Safety Analysis Report.

4.0 RISK ASSESSMENT

The waste package program contains elements of programmatic, technical, cost, and schedule risks that have the potential for hindering the successful completion of the program.

4.1 Description of Risks

Programmatic risks are generally associated with actions external to the waste package program and include changes in priorities assigned to elements of the waste management system, changes in enabling legislation, changes in regulatory requirements or their interpretations, and actions by other entities that delay access to facilities or underground site data needed for testing or design development activities.

The principal technical risks arise from the unprecedented engineering service life requirements for the waste package. The requirement to predict the performance of an engineered system for hundreds to thousands of years with a high degree of confidence demands that a quantitative mechanistic understanding of degradation processes be obtained and formulated into predictive, extrapolatable service life models. As required by regulations, these degradation processes must include the effects of all anticipated (as used in 10 CFR-60) environmental conditions on all components of the packages, including the waste forms, containment barriers, and other engineered components in proximity to the packages. The development of these mechanistic predictive models incurs significant technical risk because advances in the existing state-of-the-art predictive capabilities in materials sciences and related engineering disciplines are needed to achieve a sufficient defensible understanding. Risks are also introduced due to the current schedule requirements that require the final design to be developed prior to the collection of significant underground ESF test data.

Cost and schedule risks, which are usually related, exist as a result of the uncertainty in the ability to estimate the level of effort or the time required to accomplish necessary scheduled activities. The sequencing of required scientific investigations engenders additional cost and schedule risks resulting from the availability of sufficient technically qualified staff, test facilities, or equipment.

4.2 Risk Management

To deal with the uncertainties generated by these categories of risk, management will develop funding estimates and schedules that contain contingencies designed to mitigate the unavoidable risks, resulting in attainable performance, cost, and schedule goals. The waste package program uses a system of study plans, scientific investigation plans, and lower-level planning documents in conjunction with a project control system to assist in the management and control of cost and schedule risks.

5.0 MANAGEMENT APPROACH

Within the DOE, the Office of Civilian Radioactive Waste Management (OCRWM) provides planning, guidance, budget, and control of the programs established by the NWPA. The Director of the OCRWM is responsible for carrying out the functions of the Secretary of Energy under the NWPA, as amended, and reports directly to the Secretary. The waste package program is authorized by OCRWM with the program execution delegated to the Yucca Mountain Project Office located in Nevada. The Project Office delegates appropriate authority to the LLNL Technical Project Officer (TPO) for management and for providing technical and scientific direction to the waste package program. The TPO has responsibility for detailed planning and implementation of all waste package program technical activities.

Figure 7 illustrates the reporting relationships for those organizations implementing the OCRWM waste package program. As shown, Lawrence Livermore National Laboratory (LLNL) reports through a TPO to the Project Office Engineering and Development Division, Field Engineering Branch and in turn, to the OCRWM Office of Facilities and Siting Development, Siting and Facilities Division, Surface Facilities and Waste Package Branch.

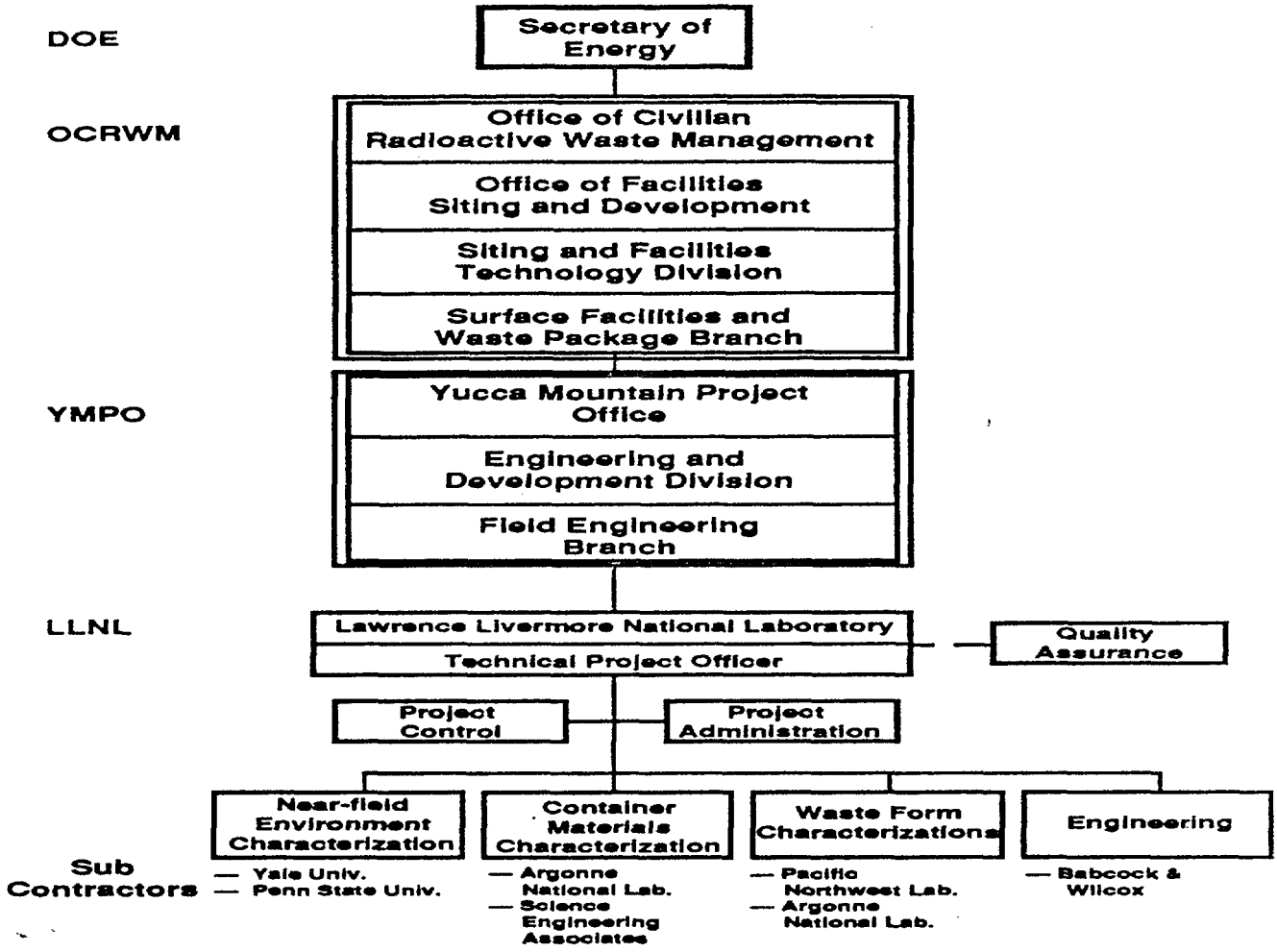


Figure 7 Reporting relationships for Waste Package Program

The LLNL project management structure to carry out the technical objective includes quality assurance, project control, project administration and four technical engineering and scientific groups. The use of four LLNL technical groups is consistent with the waste package program WBS and the technical approach illustrated in Figure 4. The four technical groups include near-field environment characterizations, container materials characterizations , waste form characterizations, and engineering activities. Subcontractors to LLNL are used to conduct specialized aspects of the waste package program under the appropriate quality assurance program administered by LLNL and monitored by DOE.

6.0 ACQUISITION STRATEGY

The Project Office has delegated the prime responsibility for implementing the waste package program to LLNL. LLNL is managed through an agreement with the DOE/San Francisco Operations Office. LLNL is responsible for conducting all waste package program design, development, and associated testing activities. LLNL, as necessary, will subcontract with other national laboratories, universities, or industries to procure the necessary technical and administrative manpower, services and goods required to achieve the objectives of the waste package program.

7.0 PROJECT SCHEDULE

Project management systems at YMPO and LLNL consistent with DOE Order 4700.1 shall use an integrated system for the planning of program activities and control of cost, schedule, and technical performance through the use of a Project WBS. Planning shall be conducted in accordance with DOE Order 5700.7B, shall be based on OCRWM schedules, and shall ensure that all requirements are identified, defined, and satisfied. A summary bar chart for the waste package program is presented in Figure 8. The schedule includes significant milestones from the OCRWM or Project Office Repository Program elements for the period of 1990 through the repository license application submission in October 2001. Major milestones over the same period are shown for the four LLNL technical groups. The bar chart format is also consistent with the WBS structure and the waste package program approach illustrated in Figure 4. Table A-1 contains a tabulation of these waste package program milestones as summarized in Figure 8. The schedule will be submitted for baseline control. Study plans, SIPs and other technical planning documents developed by LLNL define specific detailed technical work tasks to be performed. Schedules and logic networks for the completion of this technical work and the associated resource requirements are developed and controlled using a planning and control system consistent with Project Office requirements.

8.0 RESOURCES PLAN

Based on the schedules and technical planning discussed in Section 7, activities are being initiated immediately to identify resources and estimate costs required to achieve the schedule. Special attention will be directed at FY91 and FY92 with estimates for the out years to be developed in lesser detail. LLNL will prepare budget estimate requests to conduct the work in this plan and submit the requests to the Project Office in FY90 for baseline control.

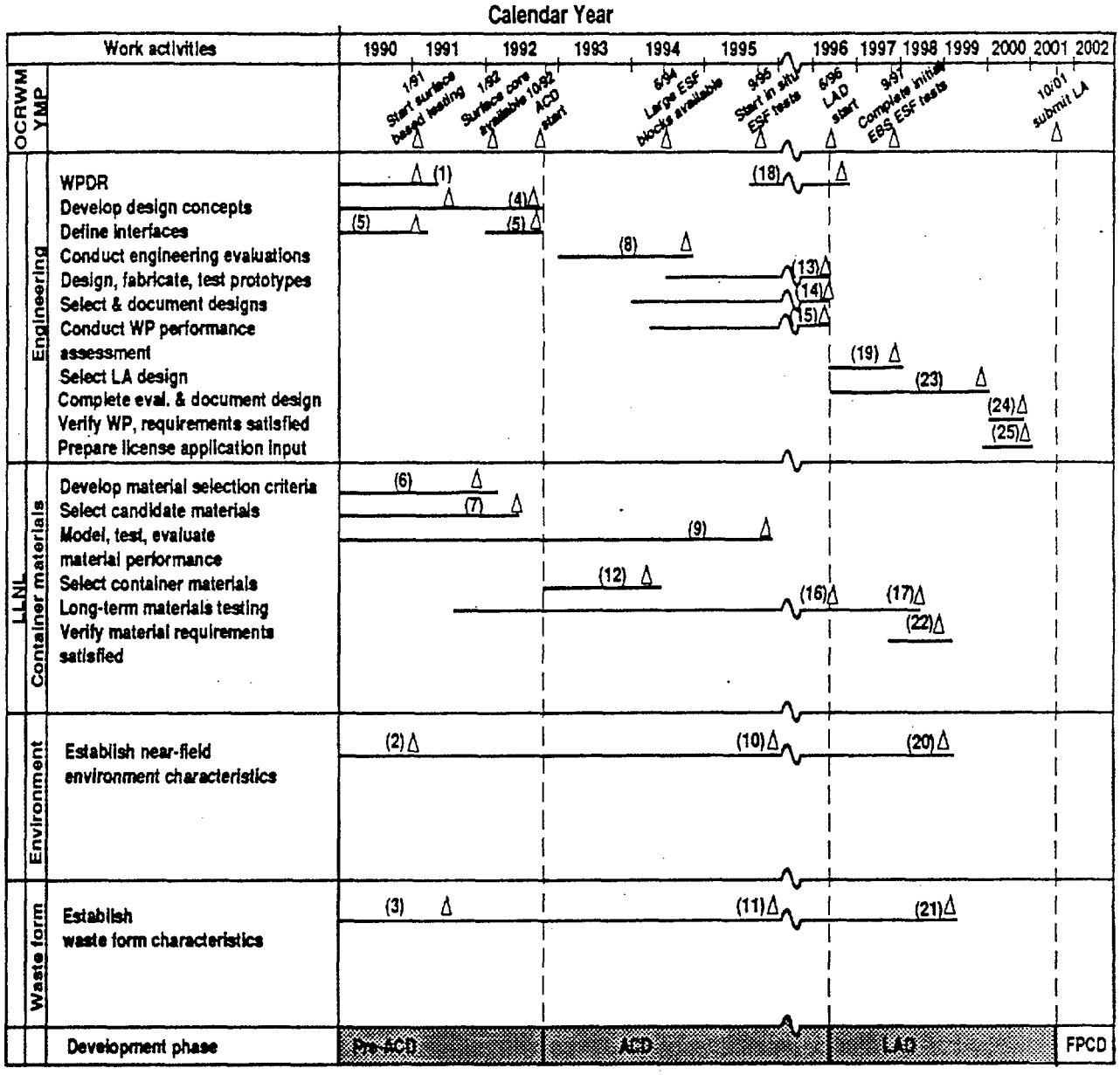
9.0 CONTROLLED ITEMS

The major elements to be controlled by the Project Office for DOE management reporting purposes are cost, schedule, and technical performance. The baselined schedule in Section 7 will be used in conjunction with the WBS as the key control item during each of the three repository development phases: Pre-ACD, ACD and LAD. Changes in baselined cost estimates will be addressed as variances to the baselined waste package program schedule and cost estimates. The technical work scope will be baselined using the schedule, study plans and SIPs.

10.0 SCHEDULED DECISION POINTS

The schedule objectives defined in Section 2.2.2 and Figure 8 provide the basis for establishing key DOE and Project Office decision points in the Waste Package Program. The program includes three phases (pre-ACD, ACD, and LAD), during which certain key decisions must be made to keep the program focused on the overall objective, i.e., development of an adequate waste package design for submission in the repository license application. The major decision points, given below, are related to specific milestones in Figure 8.

Decision Description	Decision Date
Identify design concepts (milestone M04)	Prior to ACD phase (10/92)
Select Container Materials (milestone M13)	Prior to LAD phase (1/96)
Select LA design (milestone M21)	Early LAD phase (1/98)
Confirm design meets requirements (milestone M23)	End of LAD phase (10/00)



ES-022298-LLW12-01

Figure 8 Waste Package Program Summary Schedule

11.0 APPROVALS

Submitted by: _____
L. Jardine, Technical Project Officer,
Lawrence Livermore National Laboratory

Approved by: _____
C. Gertz, Manager
Yucca Mountain Project Office

12.0 REVIEW AND CONCURRENCE

This plan does not require Acquisition Executive approval. Therefore, no further reviews and concurrence other than those in Section 11.0 are required.

APPENDIX AND MILESTONES

Table A-1 Project Office Waste Package Program Milestones.

SITE		
NA	1/92	Core data available from surface based drilling
DESIGN		
M01	12/90	Issue revised WPDR per WMSR (1)
M02	12/90	Issue prelim. near-field environment characterization report (2)
M03	3/91	Issue prelim. waste form characteristics report (3)
M04	6/92	Issue pre-ACD design concepts document (4)
M05	12/90	Issue WP/EBS interface document (5)
M06	8/91	Issue barrier material selection criteria report (6)
M07	10/91	Initiate peer review of selection criteria (6)
M08	6/92	Select candidate barrier materials (7)
M09	8/92	Initiate peer review of materials selection (7)
NA	**10/92**	**START WASTE PACKAGE ACD**
M10	9/94	Issue engineering evaluations report (8)
M11	3/96	Issue updated waste package environment report (10)
M12	3/96	Issue updated waste form characteristics report (11)
M13	10/93	Issue barrier materials selection report (12)
M14	10/94	Start prototype container testing program (13)
M15	6/96	Issue WP ACD report (14)
M16	9/94	Issue report on PA models and codes for ACD (15)
NA	**6/96**	**START WASTE PACKAGE LAD**
M17	7/96	Issue final WPDR (18)
M18	4/98	Issue preferred design option decision (19)
M19	10/98	Issue waste package environment report (20)
M20	10/98	Issue waste form characteristics report (21)
M21	10/98	Verify material requirements satisfied (22)
M22	10/00	Issue WP LAD report (25)
M23	10/00	Verify WP design meets requirements (24)
M24	6/99	Issue report on PA models and codes for LAD (24)
REGULATORY		
NA	6/98	Provide waste package inputs to DEIS
NA	**10/01**	**SUBMIT REPOSITORY LICENSE APPLICATION TO NRC**
EXPLORATORY SHAFT FACILITY		
NA	6/94	Large rock samples available for near-field tests
NA	10/96	Start EBS ESF tests

Bold entries are OCRWM or Project Office milestones.
Numbers in (parenthesis) refer to corresponding box numbers in Figure 4.
All dates for milestone numbers with letter M are LLNL dates or LLNL dates for submission by LLNL to Project Office.

Table A-2 OCRWM Baseline Milestones

Date	Milestone
SITE	
1/91	Start new surface-based testing
3/94	Complete deep UZ drilling
DESIGN	
10/92	Start waste package and repository ACD
6/96	Start waste package and repository LAD
10/01	Start final procurement and construction design
REGULATORY	
12/90	Obtain site access
6/93	Issue repository EIS notice of intent
6/94	Issue repository EIS implementation plan
10/99	Issue repository DEIS
3/01	Issue repository FEIS
10/01	Submit repository license application to NRC
EXPLORATORY SHAFT FACILITY	
3/91	Resume final ESF design
6/92	Start ESF site preparation
11/92	Start ESF collar construction
9/95	Complete ESF connection
11/97	Complete ESF geologic drifting

Lawrence Livermore National Laboratory

LLYMP9003039
March 5, 1990

WBS 1.2.9
"QA: N/A"

Carl Gertz, Project Manager
Department of Energy
Nevada Operations Office
Yucca Mountain Project Office
P.O. Box 98518
Las Vegas, Nevada 89193-8518

SUBJECT: Yucca Mountain Project Status Report - February 1990

Attached is the February Project Status Report for LLNL's participation in the Yucca Mountain Project.

If further information is required, please contact Deborah A. Kiraly of my staff at FTS 543-4571.

Sincerely,

Leslie Jardine
LLNL Technical Project Officer
for YMP

LJJ/DK/dk

YMPO, M. Cloninger
YMPO, M. Blanchard
YMPO, V. Iorii
YMPO, L. Little
SAIC, B. McKinnon
SAIC, D. Morissette

DISCLAIMER

QA checks on data contained here have only been performed to determine that the data has been obtained and documented properly. The LLNL Waste Management Project cautions that any information is preliminary and subject to change as further analyses are performed or as an enlarged and perhaps more representative data base is accumulated. These data and interpretations should be used accordingly.

LAWRENCE LIVERMORE NATIONAL LABORATORY
(LLNL)
YUCCA MOUNTAIN PROJECT (YMP) STATUS REPORT

February 1990

1.2.1 SYSTEMS

1.2.1.1 MANAGEMENT AND INTEGRATION

No significant activities.

1.2.1.2 SYSTEMS ENGINEERING IMPLEMENTATION

No significant activities.

1.2.1.4 PERFORMANCE ASSESSMENT

Staff participated in a Performance Assessment Implementation Plan Working Group 2 (PAIP WG) meeting at the University of California, Berkeley (UCB) on February 5 and 6. The main technical discussion was how to meet WG2's PAIP assigned deliverable of sending a source term to WGI by 2/28/90. WG1 needs this for its April 30, 1990 deliverable of a total systems PA. The later deliverable and date have been publicly announced by DOE/HQ. According to P. Cloke, Science Applications International Corporation (SAIC) and C. Fidrick, Yucca Mountain Project Office (YMPO), WG1 wants five radionuclides only, for one "expected" scenario. Due to the limited time available to produce any useable output, a coordinated WG2 response was agreed to, with each technical contributor using the same set of input parameters. LLNL will do the lead analysis for the two "wet drip" water contact modes, the bathtub and trickle-through modes. Pacific Northwest Laboratory (PNL) will do the lead analysis for the "wet continuous" mode, i.e., diffusion, UCB (Berkeley-Pigford) will do the lead analysis for carbon-14 (C-14) release in a dry mode. We will pick a set of input parameters, and divide up the write-up of the basis and limitations of the parameter values. SAIC will compile the letter report on behalf of the YMPO. LLNL's contribution to the input parameter set to be used (container design, dimensions, contents, 1,000 year inventory and rapid release fraction) were faxed to PNL and UCB on February 9, 1990.

1.2.1.4 GEOCHEMICAL MODELING AND DATA BASE DEVELOPMENT

Release of EQ3/6 to the Nuclear Regulatory Commission (NRC) is delayed. The release must await completion of the associated database verification. Completion of this verification is rescheduled for April 2, 1990.

1.2.2 WASTE PACKAGE

1.2.2.1 MANAGEMENT AND INTEGRATION

No significant activities.

1.2.2.2 NEAR FIELD ENVIRONMENT MODELING AND TESTING

The review process for "Packing Material" report was completed.

Plans for scheduled activities were revised to accommodate new budget constraints for FY90.

Staff participated in the Los Alamos Program Review for Colloid Transport effort.

Modeling work continued on developing scaling relationships (using dimensionless parameter groups) for near field hydrothermal flow. An important outcome of this work is that new drying is superlinearly dependent on the heat generation rate of the waste package. Modeling work was initiated on looking at the effect of having zones of altered permeability (either increased or decreased) along the face of fractures. We have begun by investigation, one-dimensional imbibition in composite matrix blocks of finite thickness.

Work continued on verifying (through the use of numerical models) the applicability of theoretical relationships which determine whether fracture or matrix-dominated flow is likely.

Work continued to model the effect of altered permeability zones in the matrix (either increased or decreased) along the face of fractures. We have been investigating one-dimensional imbibition in composite matrix blocks of finite thickness.

Work continued on modeling analysis of the G-Tunnel experiment with an emphasis on looking at sub-boiling evaporation along fractures. In our previous studies, we only considered fractures which intersect the heater borehole. We are now considering the effect which fractures (not intersecting the heater borehole) have on evaporation behavior. Depending on the proximity of these fractures to the heater borehole, we find accelerated drying behavior (at a given radial distance) relative to fractures which intersect the heater borehole. We are attempting to understand the observed drying behavior at sub-boiling temperatures at G-Tunnel.

Work continued on verifying (through the use of numerical models) the applicability of theoretical relationships which determine whether fracture or matrix-dominated flow is likely.

Staff met with Brenda Langkopf and Mert Fewell of Sandia National Laboratory's performance assessment group to discuss our near field modeling work. They are planning to model hydrothermal flow within the

disturbed zone and wanted to gain insight from our near field hydrothermal and fracture-matrix flow modeling work.

Staff began writing and continued working on activity plans for the mechanical attributes task.

Investigated work on the effort of radiation on mechanical properties of rock in the near field environment.

A review was completed on the paper "Temperature Measurements from Engineered Barrier System Field Test."

D. Wilder participated in the Surface Based Testing Prioritization meeting held in Albuquerque on January 24.

A. Ramirez continued working on stand alone reports for horizontal prototype test and neutron logging data report.

1.2.2.3 WASTE FORM MODELING AND TESTING

Spent Fuel, Zircaloy Cladding Degradation, Glass Waste Form
A draft report on "UO_2 Dissolution Rates: A Review" was completed in preparation for the planned LLNL visit of Dr. C. Wilson, PNL.

Discussions continued on the costs of completing test plans that were supported and in progress at PNL and Argonne National Laboratory (ANL) during the first quarter of FY90, but these test plan activities became unsupportable due to budget restraints.

Innovative Technology, was awarded the contract for the purchase of a glove box for UO_2 dissolution testing being done at LLNL.

Spent fuel dissolution data and status of spent fuel dissolution activities at PNL were reviewed during Dr. C. Wilson's visit to LLNL. The coordination of future spent fuel dissolution model development and dissolution testing for PNL and LLNL activities was discussed. Both the plans and needs for obtaining dissolution data from the very limited number of oxidized spent fuel samples (Einziger's low temperature samples) were also discussed; high current cost estimates and the long duration of hot cell dissolution testing in conjunction with the existing low and uncertain budget reduction expected during the next few years dictate that only planning activities for new oxidized spent fuel dissolution testing occur in FY90.

Staff completed its review of the PANDORA document for the Performance Assessment technical area.

Staff re-evaluated plans to initiate long term dissolution testing of the oxidized spent fuel specimens during FY90 at PNL due to the expected funding in FY91 which would be insufficient to continue testing after October 1990. This indicates that the present funding at PNL may be re-allocated to other test plan activities.

Comments from two additional reviews of the SIP for Glass Testing were incorporated into the manuscript.

1.2.2.3 METAL BARRIER SELECTION & TESTING

Staff participated in a planning session for future work in the Exploratory Shaft Facility at Yucca Mountain.

Preliminary PACS training was completed.

A letter proposal was received from ANL outlining their response from LLNL to provide a plan for continuing the long-term SCC tests that are underway for candidate container materials under a lower level of effort.

Staff began training and informational gatherings for the 1990-1996 WAS submission.

Work continued on re-writing of the Waste Package Program Plan (WPPP) along DOE-HQ guidelines. W. Clarke participated in a working session in Washington, D.C. to re-write the WPPP in cooperation with DOE/HQ.

A part-time replacement has been secured from LLNL who has expertise in mechanical metallurgy and modeling. This individual will assist in supervising the laboratories, and will begin predictive model development in conjunction with the environmental modeling studies.

1.2.2.3 THERMODYNAMIC DATA DEVELOPMENT

No significant activities.

1.2.2.3.4 INTEGRATED RADIONUCLIDE RELEASE

Staff continued work on writing a Scientific Investigation Plan (SIP) for integrated testing activities.

A draft Technical Implementing Procedure (TIP) entitled "Using the DECTAK Surface Profiling System" was completed. Received notification that Sloan technologies will not provide QA required documentation for DECTAK profilometer calibration and began making arrangements for NIST to provide calibration and documentation.

Software was developed that generates a plot-form so that the CAMECA data reduction software can be tested without having the ion microscope on line.

Staff attended AGU/ASLO Ocean Sciences meeting and attended sessions in radiochemistry, solid-aqueous phase interaction, and trace metal mobility in the environment.

As part of the planning for the diffusion experiments, a water bath was tested and found to maintain a very constant temperature over a week.

1.2.2.4 WASTE PACKAGE DESIGN

No significant activities.

1.2.5 REGULATORY INTERACTIONS

1.2.5.2.1 NRC INTERACTION SUPPORT

Planning of technical presentations was initiated by LLNL staff for the Nuclear Waste Technical Review Board Meeting to be held March 19-20, 1990, Denver, Colorado.

1.2.9 PROJECT MANAGEMENT

1.2.9.1 MANAGEMENT

Work continued on preparation of the final Waste Package Program Plan document.

1.2.9.2 PROJECT CONTROL

Staff attended guidance briefing on WAS development in Las Vegas on February 8. Currently developing WAS input.

LLNL FY90 Cost Plan was completed and submitted to the YMPO

LLNL FY90 Capital Plan was completed and submitted to the YMPO

Continuing to generate PACS packages for submittal to the YMPO.

1.2.9.3 QUALITY ASSURANCE

The Trend Analysis Report for January 1990 was issued.

QARS-003 (Quality Assurance Requirements Specification for Instrument Calibration Services) has been finalized and forwarded to organizations providing instrument calibration services to LLNL-YMP.

LLNL reviewed Draft ICN #1 to Administrative Procedure 5.18Q and also ICN #2 to Administrative Procedure 5.17Q. These were transmitted to the Project Office on February 6-7, 1990.

Quality Procedure 16.2 (Rev. 1), "Trend Analysis" was issued.

QP 2.6 "Readiness Reviews" has been rewritten and distributed informally for comments.

A new procedure, QP 2.12 "Special Studies and Activities" has had minor editorial changes and has been re-submitted for approval.

LLNL-YMP's responses to SDRs 479 and 480 and Surveillance Observations YMP-SR-90-012-001 through YMP-SR-90-012-003 were completed and forwarded on February 16 to the YMP Office.

Controlled copies of the approved LLNL-YMP Software Quality Assurance Plan were forwarded on February 15 to the YMPO and their Quality Assurance Support Contractor Office as requested.

D. Short attended the second meeting of the Interface Control Working Group (ICWG) in Las Vegas on February 15.

The staff performed an internal review of Scientific Notebooks.