

U.S. GEOLOGICAL SURVEY
SOFTWARE QUALITY ASSURANCE PLAN
FOR THE
YUCCA MOUNTAIN PROJECT

Effective Date _____

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. ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
CCC	Configuration Control Committee
CF	Configuration
CIRF	Configuration Identification Request Form
CFR	Code of Federal Regulations
CI	Contributing Investigator
CSA	Configuration Status Accounting
CSL	Configuration Status Log
DAS	Data Acquisition Software
DBMS	Database Management System
DOE	U.S. Department of Energy
DRS	Data Reduction Software
ESS	Expert Systems Software
GD	Geologic Division, U.S. Geological Survey
GDRG	Geologic Division Office of Regional Geology
IEEE	Institute of Electrical and Electronics Engineers
MVR	Model Validation Report
NHP	Nuclear Hydrology Program, U.S. Geological Survey
PC	Project Chief
PI	Principal Investigator
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QMP	Quality Management Procedure
SCM	Software Configuration Management
SCI	Software Configuration Item
SDD	Software Design Description

SES Scientific and Engineering Software
SPS Standard Procedures Software
SQA Software Quality Assurance
SRP Software Review Plan
SRR Software Review Report
SRS Software Requirements Specification
SSF Software Summary Form
STS Software Test Summary
SVR Software Verification Report
TC Technical Contact
TPO Technical Project Officer
USGS U.S. Geological Survey
WRD Water Resources Division, U.S. Geological Survey
YMP Yucca Mountain Project
YMPO Yucca Mountain Project Office of the U.S. DOE

1. PURPOSE AND SCOPE

1.1 Introduction

This Software Quality Assurance (SQA) Plan describes the overall methodology by which the U.S. Geological Survey, hereinafter designated YMP-USGS, shall implement the software quality assurance requirements specified in Section 3.3 and Appendix H of the U.S. Geological Survey Quality Assurance Program Plan (YMP-USGS-QAPP-01, R5) for the Yucca Mountain Project (YMP) of the U.S. Department of Energy (DOE). This SQA Plan applies to all software developed, acquired, and maintained by YMP-USGS for application to scientific investigations, studies, or activities subject to the quality assurance (QA) requirements of 10 CFR Part 60, Subpart G (Quality Level I and II). This SQA Plan intends to ensure that the quality of software products developed, acquired, and applied by the USGS is adequately controlled through a structured and ordered sequence of software design, verification, validation, documentation, and software configuration management (SCM) procedures. YMP-USGS will implement these procedures formally by issuing YMP-USGS Quality Management Procedures (QMPs) 3.03, Software Quality Assurance, and 3.14, Software Configuration Management System. The assignment of quality measures to specific software products will be graded by YMP-USGS in accordance with the guidance provide by NUREG-1318 by means of a software classification system based on the nature, complexity, importance, and intended application of the software. The YMP-USGS Software Classification System is described in Section 2 of this SQA Plan.

1.2 Requirement to Prepare an SQA Plan

This SQA Plan is being prepared to satisfy the requirements of Subsection 3.3, Para. 3.3.1.1, of YMP-USGS-QAPP-01, R5, which states: "The YMP-USGS shall prepare a software quality assurance plan that describes the software, development, test, and [software] configuration management system and submit it to the YMPO [Yucca Mountain Project Office] for review and approval."

1.3 Preparation and Content of the SQA Plan

The preparation and content of this SQA plan is adapted from the guidelines and format provided by ANSI/IEEE Std 730-1984, IEEE Standard for Software Quality Assurance Plans. Because ANSI/IEEE Std 730-1984 is intended to apply strictly to Critical Software as defined in Subsection 2.3.1 below, the formal approach established by ANSI/IEEE 730-1984 will be modified, as necessary and appropriate, in order to adapt this SQA Plan to the software products defined in the USGS Software Classification System, Section 2 of this SQA Plan.

Only those functions and responsibilities that pertain directly to SQA will be described in this SQA Plan. These functions and responsibilities are part of the mandate and operation of the USGS Quality Assurance Program for the YMP. This SQA Plan will be reviewed, updated, and revised as needed.

2. YMP-USGS SOFTWARE CLASSIFICATION SYSTEM

YMP-USGS classifies software products according to their nature, complexity, importance, and intended application as follows:

2.1 Nature of a Software Product

2.1.1 DEVELOPED SOFTWARE - New software products that are developed by or under the direction of YMP-USGS subsequent to the effective date of YMP-USGS-QAPP-01, R5, including major modifications to previously existing or acquired software products.

2.1.2 ACQUIRED SOFTWARE - Software products that are to be obtained from sources external to YMP-USGS following the effective date of YMP-USGS-QAPP-01, R5, where such acquisitions include

- a) direct transfers of software products to YMP-USGS from external organizations;
- b) purchase or lease of software products by YMP-USGS;
- c) software products included as part of a service provided to YMP-USGS by an agent or organization external to YMP-USGS;
or
- d) software embedded within instrumentation procured by the YMP-USGS.

Software-product acquisitions, regardless of the source, are subject to the same QA controls and requirements that apply to YMP-USGS procurement of goods and services as set forth in YMP-USGS-QAPP-01, R5, Sections 4 and 7, and their implementing QMPs.

2.1.3 EXISTING SOFTWARE - Software products that were developed or acquired by YMP-USGS prior to the effective date of YMP-USGS-QAPP-01, R5.

2.2 Complexity of a Software Product

The complexity of a software product can be assessed, in part, by the following criteria:

- a. Total number of lines of executable code;
- b. Number of independently developed units or modules within the code;
- c. Number of subprograms accessed within the units or modules;
- d. Number of external interfaces with other codes or systems;
- e. Amount of input data required or the amount of output data generated by the code; and
- f. Number of personnel involved in planning, developing, and programming the code.

2.3 Importance of a Software Product

2.3.1 CRITICAL SOFTWARE - Those software products that process data or perform analyses that directly support repository-system design, construction, and verification, and, therefore, must be subject to the highest degree of quality control. Critical software, for example, would include software products that process data for inclusion in the YMP Reference Information Base.

2.3.2 ANCILLARY SOFTWARE - Software products that are not intended to be used directly to support repository design but provide site-characterization data or analyses and must be subject to sufficient quality control and documentation to permit the performance and reliability of the software to be evaluated,

verified, and validated, for example, by independent technical review.

2.3.3 SUPPLEMENTAL SOFTWARE - Software products that are not to be applied to repository-design or performance issues but that are intended to contribute to an improved understanding of the site geosphere system and processes; to facilitate testing of alternative conceptual hypotheses and models and, otherwise, to contribute indirectly to site-characterization studies and activities. Although these software products are subject to the software lifecycle documentation and controls as described in Section 4 of this SQA Plan, they do not require the degree of testing and review appropriate to either Ancillary or Critical Software.

2.4 Intended Application of a Software Product

2.4.1 SCIENTIFIC AND ENGINEERING SOFTWARE (SES) - Software that uses analytic or numerical methods to compute the solution of one or more equations derived from a discrete set of physical or mathematical principles in order to analyze or to simulate the state, dynamics, or response of a physical system or subsystem. SES that embodies the mathematical formulation of a physical model of a system is designated as model-based SES.

2.4.2 DATA ACQUISITION SOFTWARE (DAS) - Software products whose principal function is to encode, transmit, and store data received from an array of one or more physical sensors.

2.4.3 DATA REDUCTION SOFTWARE (DRS) - Software whose principal function is to transform encoded input data into output digital or analog measures of physical parameters or variables. The DAS and DRS functions may be combined into a single software product. In addition, DRS may embody a physical model and may rely on the mathematical formulation of physical principles to the extent that it more appropriately should be regarded as SES.

- 2.4.4 EXPERT-SYSTEM SOFTWARE (ESS) - Software products based on symbolic programming, artificial intelligence, logical search-tree, and heuristic methodologies.
- 2.4.5 DATABASE MANAGEMENT SYSTEMS (DBMS) - Software products whose principal function is to store, retrieve, and manipulate large collections of data.
- 2.4.6 STANDARD PROCEDURES SOFTWARE (SPS) - Software that includes computer-system operating systems and utility routines; standard commercial software packages; word processors; standard graphics packages; data reformatting operations; or trivial arithmetical operations that can be verified, for example, by hand calculation. SPS is divided into embedded SPS, wherein the SPS is incorporated within a larger code, and stand-alone SPS that operates independently of any other software product. In general, SPS will be exempt from YMP-USGS SQA procedures but will be required to adhere to the QA measures applied to a code in which SPS is embedded or to a study or activity in which stand-alone SPS is invoked.

2.5 Software Classification System Implementation for Specific Software Products

The implementation of the YMP-USGS Software Classification System with respect to specific software products will be performed as part of the function of the Software Configuration Management System in cooperation with the TCs responsible for the software products. The Software Classification System is intended to ensure that software products are subject to an appropriate degree of control, documentation, review, and testing prior to the application of these software products to YMP-USGS scientific investigations, studies, and activities.

3. MANAGEMENT

3.1 U.S. Geological Survey (USGS)

YMP-USGS shall be responsible for the preparation of this SQA Plan and for ensuring its proper implementation to all scientific investigations, studies, and activities conducted by YMP-USGS in support of the YMP. The general organizational structure and QA responsibilities of the YMP-USGS are described in the Introduction and Section 1 of YMP-USGS-QAPP-01. R5.

3.2 YMP Technical Project Officer (TPO)

The TPO has programmatic responsibility for the implementation of SQA requirements within YMP-USGS.

3.3 Chief, Office of Regional Geology (GDRG Chief)

The GDRG Chief provides coordination between the TPO and those personnel within the USGS Geologic Division (GD) who are participating within the YMP. In addition, the GDRG Chief is responsible for ensuring the implementation of YMP SQA requirements and procedures by GD personnel engaged in YMP-related scientific investigations, studies, and activities.

3.4 Chief, Nuclear Hydrology Program Chief (NHP Chief)

The NHP Chief provides coordination between the TPO and those USGS Water Resources Division (WRD) personnel participating in the YMP. The NHP Chief is responsible for ensuring that all appropriate SQA requirements and procedures are properly implemented by WRD personnel conducting scientific investigations, studies, and activities in support of the YMP.

3.5 Principal Investigators, Project Chiefs, and Contributing Investigators

Principal Investigators (PIs), Project Chiefs (PCs), and Contributing Investigators (CIs) have the immediate responsibility for managing and conducting specific scientific investigations, studies and activities in support of the YMP. In addition the PIs, PCs, and CIs are responsible for satisfying all technical and SQA requirements specified in implementing procedures, contracts, purchase documents, or management meetings. In particular, CIs, who are scientists with part or full-time YMP-USGS responsibilities under the supervision of a USGS PI or PC, are responsible for complying with all YMP-USGS SQA requirements and procedures that are applicable to the work being performed in support of the YMP by the CI.

3.6 Technical Contact (TC)

A TC will be designated to be responsible for each version of a YMP-USGS software product. The TC may be a PI, a PC, or a CI or other such technical personnel and, specifically, will be responsible for the development or acquisition and maintenance of a software product or version of a software product. The designation of a TC for a specific version of a software product will be subject, as necessary, to review and approval by the TPO, the GDRG Chief, or the NHP Chief, as appropriate, in order to ensure that the TC has the appropriate technical qualifications. The TC is responsible for the implementation of all technical and SQA requirements that are applicable to any software product or products controlled by the TC.

3.7 YMP-USGS Quality Assurance Manager (QA Manager)

The QA Manager directs the overall YMP-USGS QA Program, which has the fundamental task to ensure that all YMP-USGS software related activities are conducted in accordance with QA requirements specified in the DOE Nevada Operations/YMP QA Plan (YMP/88-9). The QA Manager is supported by a staff of specialists and administrative personnel that, for the purposes of this SQA Plan, will be designated the "QA Office."

3.8 Software Configuration Management (SCM) System

The SCM System has the principal responsibilities to (1) uniquely identify and track software products and their associated documentation, (2) review and approve software-product documentation, (3) control changes to software products and documents, and (4) perform internal YMP-USGS reviews and audits of software products and documentation.

3.9 Software Quality Assurance Specialist

The SQA Specialist has the principal responsibilities to (1) prepare and implement SQA procedures in accordance with the SQA requirements of YMP-USGS-QAPP-01, R5; (2) direct the operation of the SCM System; and (3) assist TCs, PIs, PCs, CIs, and software users to implement the SQA procedures.

3.10 Configuration Control Committee (CCC)

The CCC functions as part of the SCM System within the YMP-USGS QA Office. The principal responsibilities of the CCC are to verify and validate the proper and appropriate implementation of the SQA requirements within YMP-USGS; review and approve SQA-generated documents; review and approve changes or modifications of software products; conduct Configuration (CF) Reviews and CF Audits; arrange for Software Technical/Peer Reviews; and evaluate and classify software products with respect to the YMP-USGS Software Classification System described in Section 2 of this SQA Plan.

3.11 SCM Librarian

The SCM Librarian is responsible for managing the routine operations of the SCM System, SCM baselining approved SQA documents; performing the duties associated with the software Configuration Status Accounting (CSA) function; and recording and distributing the minutes of CCC meetings.

4. SOFTWARE LIFECYCLE METHODOLOGY

4.1 Introduction

YMP-USGS shall adhere to a software lifecycle methodology in order to ensure the systematic, orderly, and structured development or acquisition, operation and maintenance of all software products used by YMP-USGS to support scientific investigations, studies, and activities within the YMP. The extent and degree to which specific software lifecycle requirements shall apply to a YMP-USGS software product will depend on the nature, complexity, importance, and intended application of the software as categorized with the YMP-USGS Software Classification System described in Section 2 of this SQA Plan. All phases of the software lifecycle will be conducted in accordance with the QA measure appropriate to the studies and activities supported by the final software product. No software product will be applied to support any YMP-USGS study or activity until all phases of the software lifecycle appropriate to that software product have been completed and a Software Summary Form (see Section 5.4 of this SQA Plan) for the software has been submitted to the QA Office for review and approval.

4.2 Software Lifecycle Phases

4.2.1 CONCEPTS EXPLORATION PHASE

The Concepts Exploration Phase is a preliminary phase whose purpose is to (1) define the problem to be addressed by the software product, (2) investigate the feasibility of developing the software product, and (3) evaluate the resources required for developing and maintaining the software product. More specifically, this phase applies to SES, DAS, DRS, DBMS, and ESS as follows:

- a. SES: The physical principles, concepts, hypotheses, assumptions, and approximations are identified and formulated mathematically; analytic or numerical solution

techniques and algorithms are evaluated; input-data, physical-property, and input-parameter needs are identified; and needed hardware and other software resources or interfaces are evaluated.

- b. DAS, DRS, and DBMS: Possible and appropriate approaches to data collection, transfers, storage, transformations, reduction, output, and retrievals, as well as database and file structures together with hardware and other software resources and interfaces are identified and evaluated.
- c. ESS: The problem is identified and preliminary approaches to addressing the problem are assessed in order to evaluate the feasibility of developing an appropriate ESS methodology.

Preliminary coding, including pseudocode development, and testing of designs for software units or modules may be performed during the Concepts Exploration Phase; however, no final software product will be developed or applied during this phase. The Concepts Exploration Phase leads directly to the formal software lifecycle Requirements and Design Phases. Documentation required during this phase will consist of a scientific notebook together with any appropriate supporting documents.

4.2.2 REQUIREMENT PHASE

During the Requirements Phase, the purpose and the functional requirements of the software product are formally established; the limits, constraints, and restrictions on the applicability of the software product are determined; the input and output datasets and database requirements and the internal and external file structures are defined; the programming language and protocols are specified; and the anticipated hardware needs are identified.

4.2.3 DESIGN PHASE

During the Design Phase, the specific software architecture, units, modules, interfaces, and data that are necessary and sufficient to satisfy the overall purpose and the functional requirements specified in the Requirements Phase are identified and incorporated into a logical and operational design for the final software product.

4.2.4 IMPLEMENTATION PHASE

The Implementation Phase entails coding, testing, and debugging of software units or modules to produce the source code for the software product. Sufficient comments and annotations should be incorporated within the source code to enable an independent technical reviewer to trace the logic and operations back to the functional requirements specified during the Requirements Phase. In addition, this phase should include the design of tests and test plans whereby the correct performance of units and modules as well as the total software product can be evaluated within the limits of applicability of the software.

4.2.5 TESTING PHASE

The testing phase applies to SES, DAS, DRS, DBMS, and ESS software products. During this phase the software product is subjected to lifecycle verification and validation testing either by the developer or by technically qualified personnel independent of the development of the software product; software verification testing; and, as appropriate, model-validation testing as follows:

- a. Lifecycle Verification testing to demonstrate that:
 - i) The functional requirements established during the Requirements Phase are correctly implemented in the design of the software product.

- ii) The design of the software product is correctly implemented in the code.
- b. Lifecycle Validation testing to demonstrate that execution of the software product yields results that satisfy the purpose and functional requirements established during the Requirements Phase.
- c. Software Verification testing to demonstrate that the software product as embodied in code performs all logical and mathematical operations correctly and does not perform any unintended function or functions that could degrade the performance of the software product.
- d. Model Validation activities to demonstrate that the physical and mathematical models embodied in model-based SES are appropriate and adequate for the intended application of the software product.

Software Verification and Model Validation generally are ongoing activities that are conducted continually throughout the life of the software product. Software Verification testing includes comparing the output produced by a code against known analytic, numerical, or logical solutions or by benchmarking the code with respect to previously verified codes. Direct Model Validation can be performed by comparing model predictions against the results of laboratory or field experiments designed to test the model. Indirect Model Validation entails techniques to build confidence and enhance model credibility and usually relies ultimately on technical peer review to evaluate and assess the adequacy of model performance.

4.2.6 INSTALLATION AND CHECKOUT PHASE

During the Installation and Checkout Phase, the software product is incorporated into its operating environment and tested to ensure, for example, that all external interfaces are provided and that all input and output datasets are properly structured and formatted. The software product will become operational during this phase and will be SCM baselined in accordance with the Software Configuration Management System procedures implemented in YMP-USGS-QMP-3.14.

4.2.7 OPERATION AND MAINTENANCE PHASE

During the Operation and Maintenance Phase, the software product is released to users to support YMP-USGS scientific investigations, studies, and activities within the YMP. The operations aspect of this phase consists of the following:

- a. Managed or controlled distribution to users by the responsible TC in accordance with established SCM System procedures and documentation requirements;
- b. Continued Software Verification testing; and
- c. Continued Model Validation activities for model-based SES.

The maintenance aspects of this phase consists of the following:

- a. Corrective maintenance in which latent defects within a software product are discovered, the effects of these defects on the software-product are assessed, and the software product is changed or modified to correct these defects;

- b. Perfective maintenance in which the software product is changed or modified to satisfy new or revised functional requirements; and
- c. Adaptive maintenance in which the software product is adapted to a new operating environment without change of expected software product performance.

All modifications to software products to which this SQA plan applies that are made in response to corrective, perfective, or adaptive maintenance will be performed in accordance with the software lifecycle methodology. In particular, sufficient testing of the modified software product will be performed in order to demonstrate and ensure that all changes or modifications are made correctly and that none degrade the overall performance of the software product. Testing shall include, as appropriate, Lifecycle Verification and Validation testing as well as Software Verification testing and Model Validation activities as described in Subsection 4.2.5 of this SQA Plan. All changes or modifications to SCM baselined software products will be controlled by the SCM System described in Section 9 of this SQA Plan.

5. DOCUMENTATION

The following documentation, as appropriate to the nature, complexity, importance and intended application of a specific software product, will be provided to the QA Office prior to the application of the software to support any YMP-USGS scientific investigation, study, or activity:

5.1 Software Requirements Specifications (SRS)

The SRS consists of one or more forms to be completed by the TC responsible for the software product and submitted by the TC to the QA Office together with any other supporting documentation. The SRS describes the functional requirements: performance criteria: design constraints; and attributes (e.g., completeness, consistency, accuracy, simplicity, modularity, efficiency, and reliability) and will allow classification of the software product with respect to its nature, complexity, importance, and intended application in accordance with the USGS Software Classification System, Section 2 of this SQA Plan.

5.2 Software Design Description (SDD)

The SDD consists of one or more forms to be completed by the TC responsible for the software product and submitted by the TC to the QA Office together with any other supporting documentation. The SDD describes the software architecture, including units and modules; the internal logic and interfaces; database and dataset structures and access; and the input and output data amounts, formats, and units of measurement.

5.3 Software Test Summary (STS)

The STS consists of one or more forms to be completed by the TC responsible for the software product and submitted by the TC to the QA Office together with all other supporting documentation. In general, the supporting test documentation will consist of test-problem descriptions, identification of the software modules or units tested,

input and output datasets, evaluation of the test results, a listing of the source code used to perform the tests, and identification of the personnel performing the tests. In particular, the STS will describe the results of Lifecycle Verification and Validation tests performed in accordance with Subsection 4.2.5 of this SQA Plan.

5.4 Software Summary Form (SSF)

The SSF is completed and submitted to the QA Office by the TC responsible for the software product following the Installation and Checkout Phase. The SSF is based on U.S. Government Standard Form 185 and will be consistent with the documentation guidelines provided in NUREG-0856. The SSF identifies the software product, the responsible TC, the classification of the software product with respect to the USGS Software Classification System, and the hardware and other software resources required to implement the software product. The SSF also summarizes the purpose and functional requirements of the software, the software design, the extent of verification and validation testing that has been performed, and the software lifecycle and supporting documentation available for the software. The QA Office shall review and approve the SSF in accordance with procedures established for the SCM System and shall notify the responsible TC of such approval prior to the release of the software for application to any YMP-USGS scientific investigation, study, or activity. Following review and approval of the SSF, the software product will be SCM baselined in accordance with procedures established within the Software Configuration Management System described in Section 9 of this SQA Plan.

5.5 Software Verification Report (SVR)

An SVR is prepared for each Software Verification test activity as described in Section 4.2.5 of this SQA Plan and identifies the personnel performing the verification test, describes the test problem and input and output datasets, and evaluates the results of the verification test. The SVR will be prepared by the personnel performing the verification-

test activity and will be submitted to the responsible TC for subsequent transmittal to the QA Office.

5.6 Model Validation Report (MVR)

An MVR is prepared for each model-validation activity conducted for model-based SES as described in Section 4.2.5 of this SQA Plan. The MVR consists of one or more completed forms together with all relevant supporting documentation. For direct model-validation laboratory or field experiments, the supporting documentation will include a description of the experiment and results, the model input and output data, a listing of the source code, and an evaluation of the degree of success achieved by the model-validation activity. The MVR for indirect model-validation activities will describe the activity (e.g., uncertainty or sensitivity analyses) and evaluate the significance of the activity in terms of enhancing model credibility or building confidence in the model's capabilities and applicability. The MVR will be prepared by the personnel performing the validation activity and will be submitted to the responsible TC for transmittal to the QA Office.

5.7 User's Manual

The preparation of User's Manuals for software-products developed by YMP-USGS or under the direction of YMP-USGS, in general, will comply to the extent appropriate with the guidelines set forth in NUREG-0856. User's Manuals will be prepared or made available for all Critical Software and for all software products intended for use by more than one user. At minimum, the User's Manual will

- (a) Describe all mathematical derivations, arithmetic algorithms, physical models, and data manipulations on which the software product is based;
- (b) Summarize the development; testing, including software verification-testing and model-validation activities, as appropriate; and reviews of the software product; and

- (c) Provide sufficient instructions that the software product can be implemented and its correct operation verified by an independent user.

In some cases, for example, for simple DAS and DRS, the preparation of a Technical Implementing Procedure in accordance with YMP-USGS-QAPP-01, R5. Subsection 3.1.7, will be an appropriate and sufficient substitute for a User's Manual.

6. CRITICAL SOFTWARE

6.1 Introduction

Software products that process data or perform analyses to be used in the design and performance evaluation of the repository system are designated Critical Software in accordance with the YMP-USGS Software Classification System defined in Section 2 of this SQA Plan. Although, in general, YMP-USGS is not directly responsible for repository design and verification, provision is made herein for YMP-USGS to conduct software-based analyses that may contribute to direct support of repository design and performance considerations. The development, acquisition, operation, and maintenance of Critical Software will be controlled to a degree commensurate with that required for repository-system design and operation as derived from 10 CFR Part 50, Appendix B.

6.2 Software Lifecycle Control

Critical Software will be subject to stringent software lifecycle control to the extent both feasible and practical. During the development of Critical Software within YMP-USGS or under the direction of YMP-USGS, each document or set of documents produced at each software lifecycle development and testing phase will be reviewed in accordance with procedures established by the YMP-USGS SCM System prior to proceeding to the next succeeding lifecycle phase. Critical Software will be subject to independent technical or peer review prior to the application of any Critical Software product to a licensing-related study or activity. Independent technical reviews will be performed by technically qualified YMP-USGS personnel who are not or have not been involved in developing the software product to be reviewed. Peer reviews will be performed by technically qualified personnel who are external to the Yucca Mountain Project.

6.3 Acquired Critical Software

Acquired Software intended for designation and use as Critical Software will be subject to a range of Verification and, as appropriate, Model Validation testing prior to any application of the Critical Software to YMP-USGS investigations, studies, or activities. In addition, the supplier of any Critical Software acquired by the YMP-USGS will be required to provide all available documentation pertaining to the development and testing of the software. Appropriate Software Technical/Peer Reviews may be required in order to ensure that an Acquired Software product satisfies the software design-control requirements sufficiently to enable the software to be designated as Acquired Critical Software. The certification of Acquired Software as Critical Software will be performed as part of the SCM System operations.

6.4 Upgrading Ancillary Software to Critical Software

Because repository-design issues cannot be completely foreseen, provision will be made to upgrade on a case-by-case basis YMP-USGS-designated Ancillary Software to Critical Software. The methodology to perform such an upgrade entails essentially the same verification, validation, documentation, and review procedures that apply to Acquired Critical Software as described in Section 6.3 above. As in the case of Acquired Critical Software, the certification of Ancillary Software as Critical Software will be performed as part of the SCM System operations.

7. QUALIFICATION OF EXISTING SOFTWARE

Software products developed or acquired by the YMP-USGS prior to the implementation of YMP-USGS-QAPP-01. R5, can be qualified for application to USGS quality controlled studies and activities. All available documentation pertaining to the development and testing of the Existing Software will be obtained, and, to the extent feasible, the software lifecycle development of the software will be reconstructed, including preparation of an SRS, SDD, STS, SWR, MVR, and SSF, as appropriate to the nature, complexity, importance, and intended application of the software. The associated lifecycle documentation so-generated will be submitted to the QA Office by the TC responsible for the Existing Software prior to acceptance of the software for application to YMP-USGS studies or activities. Software Verification testing and, as appropriate, Model Validation activities also will be undertaken. Internal YMP-USGS CF Reviews and CF Audits, described in Section 9 of this SQA Plan, will be performed as necessary, and such Software Technical/Peer Reviews, as described in Section 8 of this SQA Plan, will be conducted, as necessary, to establish the technical integrity and SQA compliance of the Existing Software. Existing Software can be qualified as Critical Software by performing the verification, validation, documentation, and review procedures that apply to Acquired Critical Software as described in Section 6.3 above. The acceptance of Existing Software and the certification of Existing Software as Critical Software will be performed as part of the SCM System operations described in Section 9 of this SQA Plan. All appropriate and necessary documentation will be submitted to the QA Office for review and approval prior to the application of any Existing Software product to support a YMP-USGS scientific investigation, study, or activity.

8. SOFTWARE TECHNICAL/PEER REVIEWS

8.1 Initiation

A Software Technical/Peer Review can be instituted at any development, acquisition, maintenance, or operation phase of a software product. The review can be initiated by request of the responsible TC; the QA Office; the TPO; the NHP Chief; or the GDRG Chief. A Software Technical Review will be mandatory for any Critical Software prior to its application to any YMP-USGS study or activity performed to support repository design or operation. Software Peer Reviews, generally, will be conducted in conjunction with model-validation activities associated with model-based SES.

8.2 Purpose

The purpose of a Software Technical/Peer Review is to review and evaluate the adequacy and sufficiency with which any one or of any set of technical documents, test results, application results, SQA records, or other documentation pertaining to the software product under review satisfy the SQA requirements summarized in this SQA Plan and as implemented in YMP-USGS-QMPs 3.03, R1, and 3.14, R0.

8.3 Management

A Software Technical/Review will be arranged by the QA Office with the concurrence of the TPO. The review will be conducted by a Review Team of which one member will be designated to be the Review Team Leader. The membership of the team will depend upon the nature of the review and generally will include both technical and QA personnel. The technical personnel participating in a Technical Review can be selected from among USGS personnel participating within the YMP; whereas the members of a Peer Review Team must be selected from USGS or other personnel who are not affiliated with the YMP. In all cases, the technical personnel participating in a Technical/Peer Review must be independent of the work producing the item or items under review.

8.4 Procedure

The Review Team, under the direction of the Review Team Leader, will prepare a Software Review Plan (SRP) and submit it to the QA Office for review. Upon approval of the SRP, the Review Team will conduct the review and upon conclusion of the review will prepare a Software Review Report (SRR). The SRR describes the findings of the Review Team, including identification of any software defects or deficiencies. To the extent possible, the SRR also will recommend appropriate corrective actions with regard to correcting any such defects or deficiencies. In general, the completion of the SRR consists of developing and describing an appropriate strategy and methodology for correcting outstanding software defects or deficiencies; of implementing the appropriate corrective actions; and of verifying satisfactory resolution of these defects or deficiencies. However, if the resolution of a quality-affecting software defect or deficiency cannot be attained, a Nonconformance Report will be issued for subsequent action pursuant to the requirements and implementing procedures of YMP-USGS-QAPP-01, R5, Section 15.

9. SOFTWARE CONFIGURATION MANAGEMENT (SCM) SYSTEM

9.1 Purpose

YMP-USGS will establish an SCM System to be implemented by YMP-USGS-QMP-3.14 and whose function will be to (1) uniquely identify, SCM baseline, and track software configuration items (SCIs); (2) systematically control and record changes and modifications made to software products and revisions made to SCIs associated with a software product or version; (3) institute Configuration Status Accounting (CSA) to record the status of software products and to report changes or modifications of software products and revisions of SCIs; and conduct such CF Reviews and CF Audits as necessary to ensure the completeness and integrity of the SQA and SCM functions. The SCM System will function as an independent entity within the YMP-USGS QA Program.

9.2 Software Product and Software Configuration Item (SCI) Identification

Each version of a software product and each SCI associated with a particular version of a software product will be assigned a unique Configuration Identifier (CID). The CID will have the following format

YMP-USGS xxxxxxxxxxxx. VERS yy. REVzz

where

- a. xxxxxxxxxxxx denotes a 12-character or less, alphanumeric name of the software product;
- b. yy is a two-digit, arabic-numeral version number; and
- c. zz is a two-digit, arabic-numeral revision number.

The version number "yy" commences with the number "01" and attaches uniquely to a specific version of a software product. The version number is to be increased in unit increments only when the software

product is changed or modified and a new version of the software product is released. The revision number is attached to an SCI associated with a specific version of a software product, is initially set equal to "00" for the initial and for each new version of a software product, and is increased in unit increments each time the SCI is revised. For example, the software-lifecycle documents associated with a specific version of a software product constitute a set of SCIs for that version. If any reviewed and approved changes to any one of these SCIs were to be made that did not require modification of the associated version of the software product, then the revision number of the altered SCI would be increased by one unit. Such revisions would apply, for example, to changes made to the SRS, SDD, and STS prior to submittal of a software product to the SCM System for SCM baselining.

9.3 Configuration Control Committee (CCC)

The CCC will be chaired by the SQA specialist and will be composed of at least one but not more than two representatives each from the USGS GD and NHP to be selected, respectively, by the GDRG Chief and the NHP Chief, or their delegates. The CCC may appoint, with the concurrence of the GDRG Chief or the NHP Chief, as appropriate, such nonvoting, ad hoc members as necessary in order for the CCC to perform its function. The CCC will meet at least monthly and special meetings may be requested at any time by any CCC member. The principal function of the CCC will be to review and approve SCIs prior to SCM baselining, to organize Software Technical/Peer Reviews, and to conduct internal YMP-USGS CF Reviews and CF Audits.

9.4 SCM Library

The SCM Library will contain all approved, SCM baselined SCIs. A separate file will be established for each SCM baselined version of a software product, and all approved SCIs pertaining to that version will be SCM baselined within the file in the time-order in which they are received by the SCM Librarian. In addition, copies of all approved and SCM baselined SCIs will be transmitted to the USGS Records Center by the

SCM Librarian in accordance with the requirements and implementing procedures of QAPP-01, R5, Section 17.

9.5 Configuration Status Accounting (CSA)

The SCM Librarian will maintain a separate Configuration Status Log (CSL) for each SCM baselined version of a software product. The CSL will provide a readily accessible accounting of all SQA activities, SCIs submitted, and SQA actions taken with respect to that specific version of a software product to which the CSL is dedicated. In addition, the SCM Librarian will maintain a directory of the users of each SCM baselined version of a software product and will notify these users of any actions, pending or implemented, that may impact the performance of the software products or versions that have been distributed to these users.

9.6 Configuration (CF) Reviews

CF Reviews are conducted by the CCC during any phase of YMP-USGS software development, acquisition, maintenance, or operation. The purpose of a CF Review is to ensure that the SQA documentation related to a software product or version satisfies the SQA requirements and implementing QMPs of QAPP-01, R5. The CCC will execute a CF Review by (1) preparing a CF Review Plan, to be reviewed and approved, as necessary and appropriate, by the QA Manager, the GDRG Chief, or the NHP Chief; (2) conducting the review with the cooperation of the TC responsible for the software product or version under review; and (3) preparing a report describing the review and its findings or observations. Any reported software defects or deficiencies will be resolved and closed by the CCC in consultation with the responsible TC together with any other technical or QA personnel requested by the CCC as part of the CF review process. A CF Review is an internal YMP-USGS review and, therefore, is distinct from independent Software Technical/Peer Reviews described in Section 8 of this SQA Plan.

9.7 Configuration (CF) Audits

CF Audits are conducted by the CCC during any phase of YMP-USGS software development, acquisition, maintenance, or operation. The purpose of a CF Audit is to ensure (1) that the software functional requirements as specified in the SRS are being implemented properly in the software design and resultant code; (2) that testing of software units, modules, products, and versions is sufficient to demonstrate the correct implementation of the functional requirements within the software product; and (3) that testing is sufficient to exercise the software product over its range of applicability. The CCC will prepare a CF Audit Plan to be submitted for review and approval by the QA Manager, the GDRG Chief, or the NHP Chief, as appropriate. In order to conduct the CF Audit, the CCC will organize an Audit Team consisting of the SQA Specialist; other CCC members, as appropriate; and other technical or QA personnel from the USGS or from organizations exterior to the USGS, as the CCC deems necessary. The SQA Specialist will be the CF Audit Team Leader. Following completion of the CF Audit, the Audit Team will prepare a report describing the auditing procedures and the results of the audit. Any software defects or deficiencies reported by the CF Audit will be resolved by consultation with the TC responsible for the software product or version undergoing the CF Audit. The CF Audit is an internal YMP-USGS audit whose findings and observations are to be resolved and closed as part of the auditing process.

10. PROBLEM REPORTING AND CORRECTIVE ACTION

Problem reporting and corrective action combines the Software Lifecycle Operation and Maintenance Phase (Subsection 4.2.7 of this SQA Plan) with the SCM function. Latent defects discovered by the users of a particular version of a software product are to be reported by submitting a Software Defect Report to the QA Office for transmittal to the CCC. The CCC in consultation with the responsible TC will assess the impact of the defect on the performance of the software product and, through the SCM Librarian, will notify all other users of the affected software product of the defect and its possible impact. Minor defects, for example, format errors, may require only trivial changes to the affected software product, which can be made without altering the version number. However, if the defect requires major modification to the internal logic or arithmetic operations of the software, these modifications will be made using the full software lifecycle methodology as described in Section 4 of this SQA Plan, and a new version and version number of the modified software product will be generated. Requests to modify a software product in order to correct a software defect or deficiency, to enhance the functional requirements or capabilities of the software product, or to adapt the software product to a new operating environment can be initiated by submittal of a Software Change Request to the QA Office. Prior to proceeding with a modification, the SCR will be reviewed and approved in accordance with procedures to be established as part of the Software Configuration Management System.

11. SOFTWARE-PRODUCT APPLICATIONS

Each application of a software product, including applications of stand-alone SPS, to support YMP-USGS scientific investigations, studies, or activities will be documented by the software user. For each new application, the user will provide to the QA Office a Software Application Summary. Upon completion of a software-product application that invokes Critical Software to perform analyses or to process data to be used directly to support repository design or licensing, the YMP-USGS investigator will prepare a Software Application Completion Report (SACR) for submittal to the QA Office. The SACR will describe the purpose, the underlying assumptions and approximations, the input and output datasets, and the results and conclusions of the software-product application. For model-based SES, the SACR also will summarize the physical, mathematical, and conceptual model; the initial and boundary conditions; and the system geometry. The information to be supplied in the SACR must be sufficient to permit technically qualified personnel to reproduce the application independently of the user. The SAS and SACR prepared for each software-product application will be submitted to the QA Office for review to ensure that the software product is appropriate for the intended application and that the results of the application are independently reproducible. The application documentation will be SCM baselined in accordance with the appropriate SCM System review and approval procedures.

The completion and submittal of an SACR may be required at the discretion of the GDRG Chief, the NHP Chief, or their respective delegates for other than Critical Software applications, specifically for software-product applications that process site-characterization data or that perform site characterization analyses. An SACR shall be required for any software-product application whose results are intended to be published in or to support the publication of an article, report, or other document.

12. TOOLS, TECHNIQUES, AND METHODOLOGIES

At the present time, YMP-USGS has not developed or acquired any special software tools, techniques, or methodologies to support the SQA function; although standard system-based debugging compilers and utilities are in widespread use. Any special software tools, techniques, or methodologies developed or acquired by YMP-USGS to support the SQA function will be subject to the SQA requirements and guidelines of YMP-USGS-QAPP-01, R5, and this SQA Plan.

13. CODE CONTROL

All computer codes and User's Manuals for Critical Software will be controlled in accordance with the requirements and implementing procedures of YMP-USGS-QAPP-01. R5, Section 6.

14. MEDIA CONTROL

A copy of the source code, if available, for each SCM baselined version of a USGS software product will be recorded on two separate magnetic tapes for storage at two separate locations designed specifically for magnetic-tape storage. A copy of the User's Manual together with other operational or maintenance-related documentation, as available, for each software product also will be stored within the magnetic-tape storage facility.

15. SUPPLIER CONTROL

All suppliers or vendors of Acquired Software or of services involving software products and applications will be required to satisfy the SQA and procurement requirements of YMP-USGS-QAPP-01, R5, Sections 4 and 7, and their implementing QMPs.

16. RECORDS COLLECTION, MAINTENANCE AND RETENTION

All SQA documents produced during the development, acquisition, operation, and maintenance of YMP-USGS software products are QA records that shall be under the immediate control of the SCM System. All approved and SCM baselined SQA documents and records will be transmitted to the YMP-USGS Records Center by the SCM Librarian in accordance with the implementing QMPs and requirements of YMP-USGS-QAPP-01, R5, Section 17.

17. REFERENCE DOCUMENTS

- 16.1 ANSI/IEEE Std 729-1983, IEEE Standard Glossary of Software Engineering Terminology.
- 16.2 ANSI/IEEE Std 730-1984, IEEE Standard for Software Quality Assurance Plans.
- 16.3 Code of Federal Regulations, Title 10, Part 50, Appendix B.
- 16.4 Code of Federal Regulations, Title 10, Part 60, Subpart G.
- 16.5 NUREG-1218, Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements (U.S. Nuclear Regulatory Commission, 1988).
- 16.6 NUREG-0856, Final Technical Position on Documentation of Computer Codes for High-Level Waste Management, (U.S. Nuclear Regulatory Commission, 1983).
- 16.7 U.S. Geological Survey Quality Assurance Program Plan for the Yucca Mountain Project (YMP-USGS-QAPP-01, R5).

18. TERMS AND DEFINITIONS

- 18.1 CODE VERIFICATION: Assurance that a computer code correctly performs the operations specified in a numerical model (NUREG-0856). Usually accomplished by comparing code results to (1) a hand calculation, (2) an analytical solution or approximation, or (3) a verified code designed to perform the same type of analysis (benchmarking).
- 18.2 COMPUTER: A functional unit that is controlled by internally stored codes (programs) and that can perform substantial computation, including numerous arithmetic or logic operations, without human intervention.
- 18.3 COMPUTER CODE: A sequence of instructions suitable for processing by a computer.
- 18.4 CONFIGURATION (CF) AUDIT: Verification that any particular phase of the software lifecycle correctly implements the specified software functional requirements; is both consistent and complete with respect to the preceding software lifecycle phases; and complies with quality assurance and technical requirements based on the nature, complexity, importance, and intended application of the software.
- 18.5 CONFIGURATION (CF) REVIEW: Verification that a software configuration item satisfies all quality assurance and technical requirements prior to baselining the item in the Software Configuration Management Library.
- 18.6 CONFIGURATION STATUS ACCOUNTING (CSA): The recording and reporting of the information that is necessary to manage the development, acquisition, maintenance, and operation of software.
- 18.7 CONFIGURATION STATUS LOG (CSL): A record maintained to track all activities and software configuration items associated with a specific version of a software product.

- 18.8 FUNCTIONAL REQUIREMENTS: The capabilities; performance; design constraints; attributes (e.g. correctness, reliability, efficiency, etc.); and external interfaces of a software product.
- 18.9 MODEL: A representation of a process or system.
- 18.10 MODEL VALIDATION: Assurance that a model as embodied in a computer code is a correct representation of the process or system for which it is intended (NUREG-0856). Usually accomplished by comparing model results to (1) physical data, or (2) a verified or validated model designed to perform the same type of analysis (e.g., benchmarking with a validated model). Peer review may be used for model validation if it is the only available means for validating a model.
- 18.11 MODULE: As used for computer software: A logically separable, independently compilable and executable part of a computer code.
- 18.12 QUALITY ASSURANCE: All those planned and systematic actions that are necessary to provide adequate confidence that an item or product conforms to established technical requirements.
- 18.13 SCM BASELINE: As used for computer software: (1) The state of computer software at a completed and reviewed phase of the software lifecycle; (2) Approved documentation generated within or as a result of completing a phase of the software life cycle.
- 18.14 SCM LIBRARY: A systematically managed collection of all software configuration items that pertain to each baselined version of a software product.
- 18.15 SOFTWARE: Computer programs (codes), procedures, rules, and, possibly, associated documentation and data pertaining to the operation of a computer system.

- 13.16 SOFTWARE CONFIGURATION ITEM (SCI): Any SCM baselined SQA document produced during the development, acquisition, operation, and maintenance of a software product.
- 13.17 SOFTWARE CONFIGURATION MANAGEMENT (SCM) SYSTEM: 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 of an item of software after establishment of its configuration.
- 13.18 SOFTWARE DEFECT: A manifestation of an error in software (synonymous with "bug").
- 18.19 SOFTWARE DEFICIENCY: Failure of a software product to correctly implement the specified functional requirements.
- 18.20 SOFTWARE LIFECYCLE: A set of discrete activities occurring in a given order during the development and use of software and software products.
- 18.21 SOFTWARE PRODUCT: A complete software entity that is judged to be ready for application to support YMP-USGS scientific investigations, studies, or activities.
- 18.22 SOFTWARE TECHNICAL/PEER REVIEW: An independent review of a set of SQA Documents performed by technical personnel selected either from within YMP-USGS (Software Technical Review) or from outside YMP-USGS (Software Peer Review).
- 13.23 SQA DOCUMENTS: Any human or machine readable data that describes, defines, specifies, reports, or certifies activities, requirements, procedures, results, or operations pertaining to the development, acquisition, operation, and maintenance of a software product.
- 13.24 UNIT: As used for computer software: Any independently testable part of a software module.

18.25 VERSION: As used for computer software: A new software product resulting from a change or modification made to an existing SCM baselined software product.