QQ: 86-ECB-13

Guidance For Developing the SCP-CDR and SCP Q-Lists

April 1986

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U.S. Department of Energy
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FOREWORD

This document is provided as project guidance for use in developing site specific Q-Lists in a consistent manner for the SCP-CDR and SCP. Early identification of Q-List items is important in order to streamline DOE's QA, design, planning, safety analysis and licensing efforts and ensure to the extent practical that the DOE Q-Lists are technically consistent with NRC regulatory requirements and interpretations as promulgated in NRC Generic Technical Positions.

The methodology presented in this paper, when systematically applied, can provide technically sound and logically traceable Q-List determinations for all repository program aspects. The resulting Q-Lists will be rooted, for the most part, in well defined and documented technical bases, criteria, and assumptions and can be adjusted or modified as the design matures, and as additional data from site characterization efforts, or other data enhancement efforts mature.

Primary considerations affecting the need for immediate implementation of the guidance contained in this paper include:

- Early preliminary identification of potential failure mechanisms and estimated occurrence rates leads to an early understanding of principle risk contributors and development of responsive site characterization plans and activities.

- A low level of design detail does not preclude making a reasonable determination of significant risk contributors. This determination, with appropriate uncertainty, leads to prioritization of data needs, identification of high-sensitivity data requirements, and focusing of design direction.

- The reliance on "sound engineering judgment" for the development of a Q-List does not provide a structured decision framework which can be applied with any measurable consistency. The potentially large cost and schedule impacts associated with such decisions particularly in the Exploratory Shaft phases, mandates a documentable approach which can be validated.

- Factors affecting decisions relating to component parts of the exploratory shaft which are placed on the Q-List should be traceable through to repository design features.

- The Draft NRC Q-List Position[1] paper issued 1/86 indicates that risk assessment methodology should be implemented early in the program.

- The methodology provided in this guidance represents an early phase of a continuing assessment program. The objectives are to develop and refine the list of items important to safety and waste isolation as the design, data bases, and analytical methodologies evolve. The

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[1] Kennedy, J. E., "When, Where, and How Much QA," USNRC Division of Waste Management, Attachment A, presented at ASQC Nuclear Waste Management Quality Assurance Topical Conference on January 20-21, 1986.

SCP submittal will likely be released at approximately the time when the ACD is initiated. Initial SCP Q-List determinations will be revised as site characterization progress reports are submitted as a result of both improved data bases and maturing design. The initial determinations will, however, play an important role in focusing DOE/NRC interactions, establishing consistent DOE/NRC Q-List and safety analysis methodology, helping to direct program resources to the significant risk contributors, and establishing early guidance for QA application.

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1.0 INTRODUCTION

This guidance paper is an amplification of the general Q-List[1] methodology documented in "Methodology for Formulating a Q-List and for Applying Graded Quality Assurance to Mined Geologic Disposal Systems," dated April 1986.

A brief discussion of the purpose and characteristics of SCP Q-Lists is provided in Section 2.0. The relationship between the SCP-CDR Q-List and the SCP Q-List is also addressed in this paper. Repository program aspects requiring Q-List evaluations to determine items/activities[2] important to safety or waste isolation for inclusion in the SCP-CDR are described in Section 3.0 and appropriate methodologies are provided in Section 4.0. Methodologies appropriate for application to ESF evaluations are called out in this section. The paper also provides a methodology for assessing the circumstances under which retrievability equipment may need to be placed on the Q-List.

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[1] A determination of structures, systems, components and activities that are important to safety and waste isolation for the mined geologic disposal system (MGDS) is required per 10 CFR 60 requirements. The resulting list of structures, systems, components and activities which are important to safety and waste isolation is called the "quality list" or "Q-List." The items and activities on the list will be subject to a formal quality assurance (QA) program as required for site characterization and licensing of the geologic repository.

[2] Activity is an effort (operation, task, function, or service) which influences or affects the achievement or verification of objectives stated in the WBS dictionary. The SCP Q-List would need to include, for example, major site-characterization data collection activities such as waste-package testing, excavation of the exploratory shaft, and surface and sub-surface soil and rock testing.

Section 5.0 provides the required Q-List development schedule to enable meeting the SCP preparation schedule commitments.

2.0 BACKGROUND

This section discusses the benefits associated with early submittal of a Q-List to NRC via the SCP from both DOE's and NRC's perspective. Characteristics of the Q-List such as ability to update and/or remove items are also provided in this section.

2.1 PURPOSE OF Q-LIST FOR SCP-CDR AND SCP

2.1.1 DOE Headquarters and Project Offices Perspective

The Q-Lists included in the Site Characterization Plan-Conceptual Design Report (SCP-CDR) and SCP will be used by Department of Energy (DOE) to increase program effectiveness and increase the potential for ACD and LAD closure of open design and licensing related issues with the Nuclear Regulatory Commission (NRC), thereby improving repository licensability. The following benefits of early identification of Q-List items in the SCP are realizable from the DOE HQ and project office perspective:

2.1.1.1 Prioritization of SCP and Design Process

The Q-List indicates that additional attention regarding safety analyses and design criteria must be given the listed items in the design process in developing and carrying out SCP plans. Projects will be requested to provide sufficient technical and licensing-oriented definition of activities regarding systems identified as important to safety and/or waste isolation. Early,

preliminary identification of design features which have a dependence upon site characteristics and which may be important to safety or waste isolation is essential.

2.1.1.2 Enhanced Quality Assurance (QA) Requirements

Retroactive QA has historically been shown to be extremely difficult to defend. Early identification of Q-List items will result in early and appropriate application of graded QA requirements as per 10 CFR 50, Appendix B and conditions of the NRC QA Review Plan to support licensing needs. Computer codes used in Q-List systems design, for example, will be benchmarked and controlled. The design process, including design interfacing, technical reviews, and verification will be appropriately documented.

2.1.1.3 Appropriate Design Criteria

All Q-List items classified as important to safety will be designed according to criteria considered appropriate for meeting 10 CFR 60.131 b general design requirements. Identification of required codes and standards for designing Q-List items is required and may result in standards development efforts. Note that Q-List items classified as important to waste isolation are not required to meet 10 CFR 60.131b general design requirements.

2.1.1.4 Define Safety Analysis Requirements

Identification of an item on the Q-List will require performance of safety analyses to further assess the need to maintain the item on the Q-List. Additionally, early identification of items important to safety or waste isolation is necessary since safety analysis methodologies and

analytical techniques need to be developed and in many cases models need to be verified. Computer codes will need to be benchmarked and approved for specific applications. Q-list testing programs used to develop benchmarked computer codes need development, as do the data bases, in order to support analytical requirements.

2.1.1.5 Streamlined Issue Resolution

The Advanced Conceptual Design (ACD) is being focused on resolution of key design issues as well as minimization of design options carried into the License Application Design. Early identification of Q-List items can be used as a major planning tool for defining studies and their timing for resolving the major issues prior to License Application (LA), as well as the type and extent of pre-license submittal interreaction with NRC necessary in order to come to closure on these major issues. The design will need to evaluate design options which may reclassify a system, component, or structure to non-Q-List status.

2.1.1.6 Focusing of Safety Evaluations

Preliminary definition of Q-List items can be used to guide both initial and follow-on safety evaluations and research efforts while focusing attention on potential safety issues.

2.1.1.7 Support Overall Program Planning

Since the LAD primarily focuses on items important to safety and/or waste isolation, taking these items to near final design, the Q-List is required

before effective planning can be done, e.g., budget planning, schedule 44 development, and LA phase scheduling.

2.1.1.8 Link to Post-Closure Performance

The Q-List items important to waste isolation will have a link to post-closure performance allocation and assessment as well as to pre-closure performance allocation relative to items important to waste isolation. The Q-List needs to be developed early so these links can further be defined.

2.1.1.9 ESF Testing Implications

If permanent features of the Exploratory Shaft Facility (ESF) are required to be on the Q-List, programmatic assessment of the impact on ESF design, construction, and operation is required. In addition, if retrieval equipment or processes are on the Q-List, ESF testing of the equipment may be required and ESF design changes could be necessary.

2.1.1.10 Highlighting Performance Confirmation

Performance confirmation may be the key to successfully licensing the repository. Inclusion of performance confirmation activities on the Q-List, similar to inclusion of SCP activities, will give the performance confirmation program the emphasis required to ensure proper incorporation in the overall licensing strategy.

2.1.2 Nuclear Regulatory Commission (NRC) Perspective

Pre-license application interaction with NRC regarding Q-lists has several benefits to NRC, but ultimately improves the programs understanding of NRC's regulatory concerns. The following items are benefits to the NRC associated with early submittal of Q-List items in the SCP:

2.1.2.1 Focusing of SCP Plans

The Q-List will be an important element of NRC's reviews related to the adequacy of the SCP plans and site characterization progress reports. NRC will use the SCP Q-List to check against the SCP plans to ensure that key issues that could arise and which are amenable to site characterization are addressed in the SCP. Additionally, site characterization progress reports will be reviewed in light of these key systems.

2.1.2.2 Feedback on NRC's Q-List Items

NRC will compare the DOE list with their internally developed list. Items not on the DOE list will likely be identified as areas of NRC concern, and DOE may want to include these items for QA and design purposes.

2.1.2.3 Timely NRC Interaction

By being apprised at an early date of Q-List items, NRC will be more prepared to provide technical positions in response to site characterization test results, ACD studies, DOE safety evaluations, and design maturity-related

alterations to the Q-List. Additionally, QA on studies and testing for design-related items that NRC also feels are important will improve licensability.

2.2 CHARACTERISTICS OF ITEMS ON SCP-CDR AND SCP Q-LISTS

2.2.1 Q-List is Provisional

Determination of Q-List items for the SCP-CDR will be preliminary. The list should tend to be on the conservative side from a regulatory viewpoint, and therefore should include marginal items. Realistic approaches, however, should be used in defining the list, with appropriate margin allowed for technical and regulatory uncertainties.

2.2.2 Q-List is Subject to Update

All Q-List (and non-Q-List) items will be continually undergoing review and update based on data from SCP activities, safety analyses of maturing designs, and regulatory perspectives issued by NRC. Any item on the Q-List may be removed, provided the removal is based upon compliance with project specific procedures that enable a systematic assessment of the factors impacting the item and the programmatic/licensing consequences of changing the items classification. Prior to removal, discussion with NRC may be advisable.

2.2.3 Q-List has Specific QA and Design Needs

Items and activities important to safety or waste isolation which are determined by using methodologies given in Section 4.0 will be on the Q-List and will be included in the SCP-CDR. The items on the Q-List will be subject to 10 CFR 50, Appendix B (Level 1) QA requirements and will be designed to criteria consistent with 10 CFR 60 design requirements. Additionally, Q-list items included in Chapter 6 of the SCP should be a factor in developing SCP Chapter 8 plans for work to be performed.

2.2.4 Potential Q-List Items

Any item which is not included in the Q-List but which has a reasonable potential for being Q-listed as additional project studies and NRC interactions take place shall be considered, at DOEs option, as a "Potential Q-list Item" (refer to Attachment A). These items will be given Level 1 QA and will be designed to criteria consistent with 10 CFR 60 design requirements but would not be considered to be on the Q-list and therefore will not be included in the SCP-CDR. This procedure ensures that the appropriate level of QA is applied to the potential Q-list item such that addition of the item to the Q-list at a later date can be readily accomplished. Although the "Potential Q-list Items" will not be submitted in the SCP, and are not formally subject to regulatory agency review, it is anticipated that items considered as "Potential Q-list Items" would be discussed with the NRC through the pre-license interaction process.

2.2.5 SCP CDR Q-List is Complete

The Q-List for the SCP-CDR should include both preclosure and post-closure identification of items important to safety and/or waste isolation. Repository and ESF systems and major structures and components, as well as natural, engineered and institutional barriers will be considered for assessing items important to safety and/or waste isolation. Major site-characterization data collection activities, such as waste-package testing, excavation of the exploratory shaft, and surface and subsurface soil and rock testing, should also be included. The SCP Q-List will be a subset of the SCP-CDR Q-List and will include only those items which are perceived on a site-specific basis to be pertinent to site characterization plans.

3.0 REPOSITORY PROGRAM ASPECTS REQUIRING Q-LIST EVALUATIONS

Table 3-1 presents a tabulation of repository program aspects which must be evaluated in order to arrive at a complete Q-List for the repository system, including ESF, for the SCP-CDR. A brief description of each program aspect and associated area of impact, as summarized in Table 3-1, is provided below.

3.1 PRECLOSURE EVENTS (OPERATIONAL) IMPACTING PUBLIC SAFETY

Evaluations performed for this category will establish systems, components, and structures important to safety for the repository system and will consider credible internal and external repository events such as flood, fire, airplane crash, and cask drop. NRC is anticipated to have reasonably well defined positions regarding the surface facility portions of the evaluations, but will be more interactive with DOE in evaluating the subsurface portions of this category.

3.2 PRECLOSURE EVENTS (OPERATIONAL/RETRIEVAL) IMPACTING ABILITY TO PERFORM RETRIEVAL

As a result of an abnormal event during the operational phase, retrieval on a local or global basis may be required. Additionally, internal and external abnormal events could occur during the retrieval period. The retrieval equipment must be able to operate under these abnormal conditions. An assessment of these series of events is required, therefore, to determine if the function of any systems, components, or structures is necessary in

order to carry out the retrieval mandate. Any such system, component, or structure including retrieval equipment, could be classed as important to waste isolation and placed on the Q-List.

3.3 PRECLOSURE EVENTS (CONSTRUCTION/OPERATIONAL) IMPACTING POST CLOSURE PERFORMANCE

Normal or accident events during preclosure can feasibly impact natural barrier systems and potentially compromise post-closure performance. Shaft or drift excavation techniques for example, could result in a disturbed zone with extensive micro-fracturing. Additionally, excessively high extraction ratios or under-designed rock support systems could lead to an event which changes the characteristics of the site and compromises its isolation potential. An evaluation of events which may cause impacts on the ability of the natural and engineered barriers to perform their function may lead to items or activities being Q-Listed for the repository, including ESF.

3.4 PRECLOSURE EVENTS (DECOMMISSIONING) IMPACTING POST CLOSURE PERFORMANCE

After the emplacement and caretaker phases, and upon authorization for closure by the NRC, decommissioning operations will commence. During this preclosure phase, construction activities will be taking place which may impact the way DOE will permanently close and seal the repository. These activities need to be evaluated to determine if post closure performance objectives could be impaired due to inadequate or improper decommissioning methods. Any decommissioning procedure, activity, or component contributing to meeting the post-closure performance objectives will need to be included on the Q-List.

3.5 POST CLOSURE EVENTS IMPACTING POST CLOSURE PERFORMANCE

Evaluations performed for this category will define natural and engineered barriers important to waste isolation, for the repository, including ESF, and will consider anticipated and unanticipated postclosure events such as seismic events or human intrusion. The probable impact of these events on the ability of the natural and engineered barrier systems to meet the post closure performance objectives will help define which structures, systems, components, and activities are necessary to comply, or demonstrate compliance with, the NRC/EPA performance objectives and criteria and therefore need to be placed on the Q-List as important to waste isolation.

NRC's "defense-in-depth" philosophy is aimed at reducing residual uncertainties to a satisfactory level by redundancy and diversity of design. Therefore overlapping barrier design features are required, and the degree of regulatory assessment "credit" for each of the barriers toward meeting the performance objectives will likely need NRC interaction to be determined. Early in the program, an assessment of which post-closure items are important to waste isolation and which include these considerations should be made. Additionally, the performance confirmation program activities largely form the basis for the NRC's decision to permanently close the repository and will likely require Level 1 QA.

Table 3-1 Repository Program Aspects Requiring Q-List Evaluations to Determine Items Important to Safety or Waste Isolation

Methodology Key	Item Classed Important To:	Program Aspect	Area of Impact	Comments/Examples
A	Safety	Preclosure Events - Operational	Public safety	Cask drop event having radiological consequences.
B	Waste Isolation	Preclosure Events - Operational/Retrieval	Ability to perform retrieval	Flood event impacting ability to carry out retrieval.
C	Waste Isolation	Preclosure Events - Construction/Operational	Postclosure performance	Coupled effects or shaft excavation affecting performance of natural and engineered barriers. Performance confirmation program activities as used to confirm natural system properties.
C	Waste Isolation	Preclosure Events - Decommissioning	Postclosure performance	Seal construction techniques are critical to seal performance.
C	Waste Isolation	Postclosure Events	Postclosure performance	Tectonic activity or flood event may alter the natural systems performance capability. Waste package is part of "defense-in-depth" philosophy at NRC.

Note: 1. Major data collection SCP activities are included on the Q-List per a 12/85 agreement between NRC and DOE. However, other SCP activities which are not included in the Q-List but which, by the manner in which they are performed, could potentially impact pre- or post-closure performance adversely, should be assessed.

2. Preclosure events include naturally occurring events such as floods and earthquakes.

4.0 METHODOLOGIES FOR DEFINING ITEMS IMPORTANT TO SAFETY OR WASTE ISOLATION

Determination of systems and major structures and components important to safety or items important to waste isolation for the SCP-CDR will be based on the general methodology guidance presented in the January 1986 Office of Civilian Radioactive Waste Management (OCRWM) guidance document entitled; "Methodology for Formulating a Q-List and the Application of Graded Quality Assurance to Mined Geologic Disposal Systems." The methodologies outlined below are consistent with the SCP oriented general methodology described in that document.

4.1 METHODOLOGY A - PRECLOSURE EVENTS (OPERATIONAL) IMPACTING PUBLIC SAFETY

Figure 4-1 schematically represents the SCP-CDR methodology for preclosure events during repository operations which may impact public safety. This methodology is based on the application of risk assessment techniques and represents an early phase of a continuing assessment program. The program's objectives are to develop and refine the list of items important to safety or waste isolation. At this early stage of design, it is recognized that only a conceptual level of design detail is available, and that the sub-surface design is purposefully more advanced than the surface design in order to support SCP and ESF requirements.

The methodology, therefore, concentrates on identification of credible initiating events, applies use of event trees to determine response of the repository systems to initiating events, and applies use of preliminary

consequence modeling to determine projected radiological consequences in terms of dose at or beyond the boundary of the unrestricted area. The modeling does not require application of fault tree analyses, failure mode and effect analyses (FMEA), human factors evaluations, common cause failure analyses, or systems interaction evaluations, which are more appropriate at later design stages. Additionally, application of importance ranking for components is not required at this time since fault tree analysis is not being performed at this stage of design.

Frequency of occurrence estimates for initiating events are required for both surface and sub-surface analyses. Quantitative system failure rates for sub-surface systems shall be estimated and, where data base is lacking, conservative bounding assumptions shall be made and justified. Quantitative system failure rates for surface systems are not required. Qualitative discussion of surface event scenarios and projected event consequences is acceptable for SCP purposes.

All evaluations performed will be preliminary and based on best available data as augmented by engineering judgment, where required. The methodology and results shall be documented appropriately for reference in the SCP-CDR. The following steps describe in more detail the methodology depicted in Figure 4-1, and provide examples, where appropriate. Note that the relationship between preclosure performance allocation and Q-list requirements has not been established yet. Additional guidance in this regard requires DOE specification of a preclosure accident safety criterion and detailed discussions with the NRC. Interim guidance in this regard will be issued to supplement the SCP-CDR methodology for identifying systems and major structures and components important to safety.

4.1.1 Establish Design (Step 1)

Reference the repository SCP-CDR design configuration. Document design data and applicable assumptions required for performing this evaluation, such as, exhaust ventilation flow rates and configurations, waste emplacement mode(s) included in the evaluation, waste package design utilized, anticipated specifications for water control systems, etc.

4.1.2 Scenario Identification and Screening (Step 2a)

Potential surface and sub-surface facility initiating events have been reviewed and are presented in Tables 4-1 and 4-2, respectively. These events are considered a minimum set of events for each project to apply an initial screening process to for elimination of insignificant contributors. Additional site specific events may be considered, as appropriate. A screening criterion of 10^{-6}/yr shall be used as a lower bound credible occurrence frequency. This screening criterion is recognized to be highly conservative and is intended to be used as a screening criterion for Q-list purposes and not to be used for design purpose. Initiating events surviving this initial screening process are considered credible on a preliminary basis and will then be developed into accident scenarios.

4.1.3 Performance Information Data Base (Step 2b)

The data required for logic model quantification relative to system performance will be documented in the performance information data base. Event trees are used to simulate the interactions of various systems that could influence the outcomes of a credible initiating event. System operational assumptions and system equipment reliability data must be established for sub-surface operations.

4.1.4 Define Consequence Approach (Step 3a)

The identification and evaluation of radiological consequences resulting from accident processes or events are major elements in the risk assessment of the preclosure operational phase of the repository. Some postulated surface and sub-surface events can lead to the breach of containment barriers and subsequent release of radionuclides or can provide a mechanism for transport of radioactive contamination to the environment. The release may be airborne, transported via dewatering systems, or transported via groundwater movement.

A consequence assessment approach should be defined based on several factors including waste form (spent fuel or HLW), radionuclide inventory, level of design maturity, transport mechanisms (including meteorology assumptions), and the preliminary nature of this evaluation. Qualitative characterization of radiological consequences based on technical judgment is acceptable where quantitative assessment is impractical due to design or model immaturity reasons. Where quantitative assessment is performed, the spent fuel inventory of radionuclides shall be based on ORIGIN-2 analyses contained in Tape 12796 for 60,000 MWD/MTU burnup and a 5 year cooling period.

4.1.5 Approximate Events Progression (Step 3b)

Events identified in Step 2a as credible initiating events are developed into accident scenarios by coupling the interaction of all plant systems/operator actions (intermediate events) potentially capable of influencing the outcome of the initiating event (consequence). Event tree logic models are to be used to represent these accident scenarios in a numerically quantifiable form. An accident scenario is a subset of a particular event tree, consisting of the initiating event and a unique path of assumed intermediate event successes and/or failures leading to a consequence of interest or accident mitigation. Reduction in the number of event trees is possible if similar initiating events with similar projected consequences are grouped into a single (or enveloping) initiating event for development into a single event tree. Figure 4-2 is presented as an example event tree for a flood based initiating event.

4.1.6 Technical Judgment on Event Consequences (Step 4a)

Based on the consequence approach established in Step 3a, and the accident event progression provided via the event trees, an assessment of radiological consequence is made. Technical judgment should be used to define the consequence. Characterization of the site-boundary dose relative to 0.5 rem is necessary. This characterization may be "significantly-less-than 0.5 rem", "on the-order-of 0.5 rem", or "significantly larger than 0.5 rem," for example.

4.1.7 Technical Judgment on Sequence Probability (Step 4b)

For the sub-surface facility evaluations, system failure rate probabilities shall be estimated based on performance data base information. For identified systems not described in sufficient detail at this stage of design, a failure probability based on performance of similar systems or based on conservative bounding assumptions must be assigned.

For the surface facility evaluations qualitative assessment of accident scenario credibility is acceptable.

4.1.8 Is Consequence Greater Than or Equal to 0.5 Rem? (Step 5)

Based on the results of step 4a the scenario consequence is compared to the 10 CFR 60 numerical criterion and a judgment is made as to the projected site-boundary dose being greater than or equal to the criterion. If the consequence is clearly less than the criterion, the scenario is eliminated. If the consequence is greater than or equal to the criterion, go to step 6.

4.1.9 Is Probability Significant? (Step 6)

For the sub-surface facility evaluation, the accident scenario branch probability is compared to the 10^{-5}/yr criterion, including a possible additional factor to account for technical and regulatory uncertainties. If the total branch probability is numerically less than the criterion, the

scenario is not considered credible and should be eliminated from consideration. Otherwise, the scenario is considered credible and forms a basis for placing the causal and/or resulting mitigative items on the Q-List (see Step 7).

For the surface facility evaluation, the scenario credibility assessment is qualitatively performed. If the scenario is judged credible then it forms a basis for placing the causal and/or resulting mitigative items on the Q-List (see Step 7). Otherwise the scenario should be eliminated from consideration.

4.1.10 Identify Q-List Items (Step 7)

In order to place an item on the Q-List based on Methodology A, an assessment must be made of which systems, components, or structures have failed to perform their functions during a credible event and led to the release being greater than 0.5 rem at or beyond the site boundary. Once this preliminary determination has been made, based on technical judgment the causal item(s) and/or resulting mitigative features, are placed on the provisional Q-List.

4.2 METHODOLOGIES FOR DEFINING ITEMS IMPORTANT TO WASTE ISOLATION

The following subsections describe methodologies which can be used to define items important to waste isolation for inclusion in the SCP-CDR and SCP Q-Lists. The program aspects and their associated areas of impact as indicated in Table 3-1 are keyed to these methodologies.

4.2.1 Methodology B - Preclosure Events (Operational/Retrieval) Impacting Ability to Perform Retrieval

Figure 4-3 presents a schematic diagram relating to Methodology B. During normal repository operation, various abnormal initiating events may occur which can feasibly lead to the requirement to retrieve. First, an accident may occur which causes the NRC to order retrieval. Second, a systematic failure can occur which would probably be detected via the performance confirmation program and could lead the NRC to require retrieval. Thirdly, Congress could mandate retrieval for economic or political reasons. Regardless of the cause, once retrieval is set in motion, the Act and 10 CFR 60 mandate that the action be successfully carried out. Time allowance for retrieval operations is flexible, and no restrictions are specifically imposed regarding retrieval costs. NRC does indicate, however, that retrieval must not be impossible or impractical.

It is incumbent upon DOE to evaluate initiating events which may credibly lead to a local or global retrieval mandate by the NRC and determine which retrieval equipment, if any, need be Q-Listed and which systems, components, or structures need to properly function in order for DOE to show capability to retrieve.

Identification of an event which could result in the failure of a system, component, or structure such that the ability to retrieve is made impossible or impractical, would require the casual system, component, or structure (and/or the resulting mitigative item) to be classified as important to waste

isolation and placed on the Q-List. Note that NRC mandated retrieval of waste packages on a localized or specific basis, as a result of an abnormal event or accident, is not considered to be under the umbrella of 10 CFR 60.143 (monitoring and testing waste packages of Subpart F-Performance Confirmation Program). Therefore, retrieval equipment need not be constructed prior to establishment of the retrieval mandate and Q-List requirements on retrieval equipment would be limited to the application of Level 1 QA to the design and prototype testing programs.

In assessing whether retrieval equipment must be Q-Listed in the SCP-CDR, or whether repository or ESF subsurface systems, components, or structures must be Q-Listed and their design criteria modified, a risk assessment methodology similar to Methodology A is applied.

All evaluations performed will be preliminary and based on best available data as augmented by engineering judgment where required. The methodology and results shall be documented appropriately for reference in the SCP-CDR. The following sub-sections describe in more detail the methodology depicted in Figure 4-3, and provide examples, where appropriate.

4.2.1.1 Repository Design Data Base

Reference the repository SCP-CDR design configuration. Document design data and applicable assumptions required for performing this evaluation, such as, exhaust ventilation flow rates and configurations, waste emplacement mode(s) included in the evaluation, waste package design utilized, anticipated specifications for water control systems, etc.

4.2.1.2 Abnormal Initiating Events

The abnormal initiating events for retrieval listed in Table 4-3 are selected as a minimum set for signifying that a retrieval mandate is likely. Associated with each event on the list is an indication of whether local or global retrieval is most likely, i.e., differentiating between retrieval of waste packages in a single drift section versus mass-scale retrieval.

4.2.1.3 Initiating Event Identification and Screening

The abnormal initiating events identified in sub-section 4.2.1.2 may need expansion on a site-specific basis. An assessment of each candidate event must be made as to its frequency of occurrence probability. A screening criterion of 10^{-5}/yr shall be used as a lower bound credible occurrence frequency rate. Initiating events surviving this initial screening process are considered credible on a preliminary basis and will then be developed into accident scenarios.

4.2.1.4 Approximate Event Progression

For the events where retrieval is local, normal retrieval operations are likely, and no abnormal events need be assumed due to the limited time frame. Event progressions for the accident scenarios are then developed similar to Methodology A (See Subsection 4.1.5) and event tree logic models are utilized.

For the Table 4-3 events where retrieval is global, the assumption should be made that an abnormal internal or external event affecting the subsurface may occur during retrieval operations. Therefore, the events presented in Table 4-2 should be assumed to occur during retrieval operations and should be included in the evaluation. Event progessions for the initiating events and accidents are then developed as above.

4.2.1.5 Technical Judgement on Sequence Probability

For all event trees, system failure rate probabilities shall be estimated based on performance data base information developed for Methodology A. For identified systems not described in sufficient detail at this stage of design, a failure probability based on performance of similar systems or based on conservative bounding assumptions must be assigned.

4.2.1.6 Accident Scenario Screening

The accident scenarios are screened against the 10^{-5}/yr screening criterion plus a potential additional factor to account for technical and regulatory uncertainty. Scenarios with probabilities lower than the criterion are considered incredible and should be eliminated from further consideration.

4.2.1.7 Determination of Q-List Requirements

An assessment should then be made, using Table 4-4 for guidance, as to retrieval equipment Q-List status. In this table, the severity of event impact on the waste package and underground environment is related in a matrix to potential Q-List status for retrieval equipment. Consideration of Q-Listing specific pieces of retrieval equipment requires event and

site-specific technical judgment. The matrix specified in the table is based on projected accident radiological releases from a single waste package, as analyzed in the WESTON Preliminary Repository Underground Design Safety Assessment Report, November 1985, as well as on engineering judgment regarding potential event impacts on the underground environment. When, based on technical judgment, the retrieval equipment Q-List status determination is made it must be determined whether there is reasonable assurance that the retrieval equipment will be able to properly operate in the underground environment and perform the retrieval function. If retrieval is considered possible then the design meets preclosure performance requirements specified in 10 CFR 60.111 without requiring Q-Listing of any systems, components, or structures, except possibly specific pieces of retrieval equipment.

If retrieval is considered impossible or impractical, then the causal and/or resulting mitigative system or major component or structure is placed on the Q-List and the appropriate design criteria are adjusted to either reduce the probability of scenario occurrence or to mitigate the consequences. The scenario is then reassessed to ensure that the retrieval option is preserved.

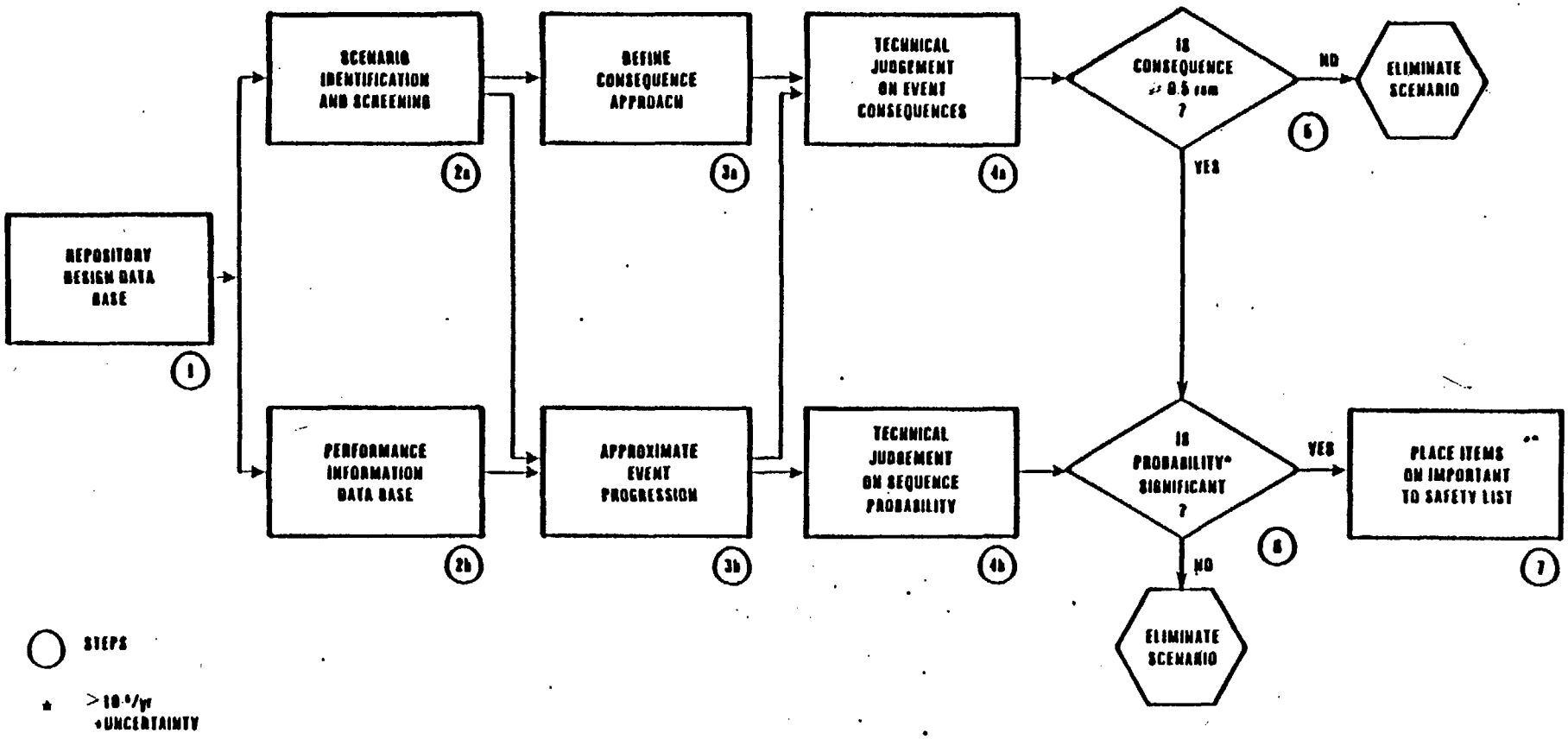
4.2.2 Methodology C - Postclosure (and Preclosure) Events and Considerations Impacting Postclosure Performance

In determining which barriers may be important to waste isolation, a conservative assessment comparing barrier performance requirements to postclosure performance objectives and goals is required. The designation of structure, system, and components to be placed on the Q-List at the SCP design stage, and all site characterization activities that are essential to adequately evaluate these items, will be based on technical judgment. Allocation of performance (in demonstrating compliance with 40 CFR 191) to a

post-closure barrier, including natural site, engineered, or institutional, based on its contribution to meeting post-closure performance objectives requires inclusion of the item on the Q-List. Examples of barriers which may be allocated performance are fuel cladding, waste package canister, waste package container, packing, borehole seals, engineered backfill, and permanent shaft-seals.

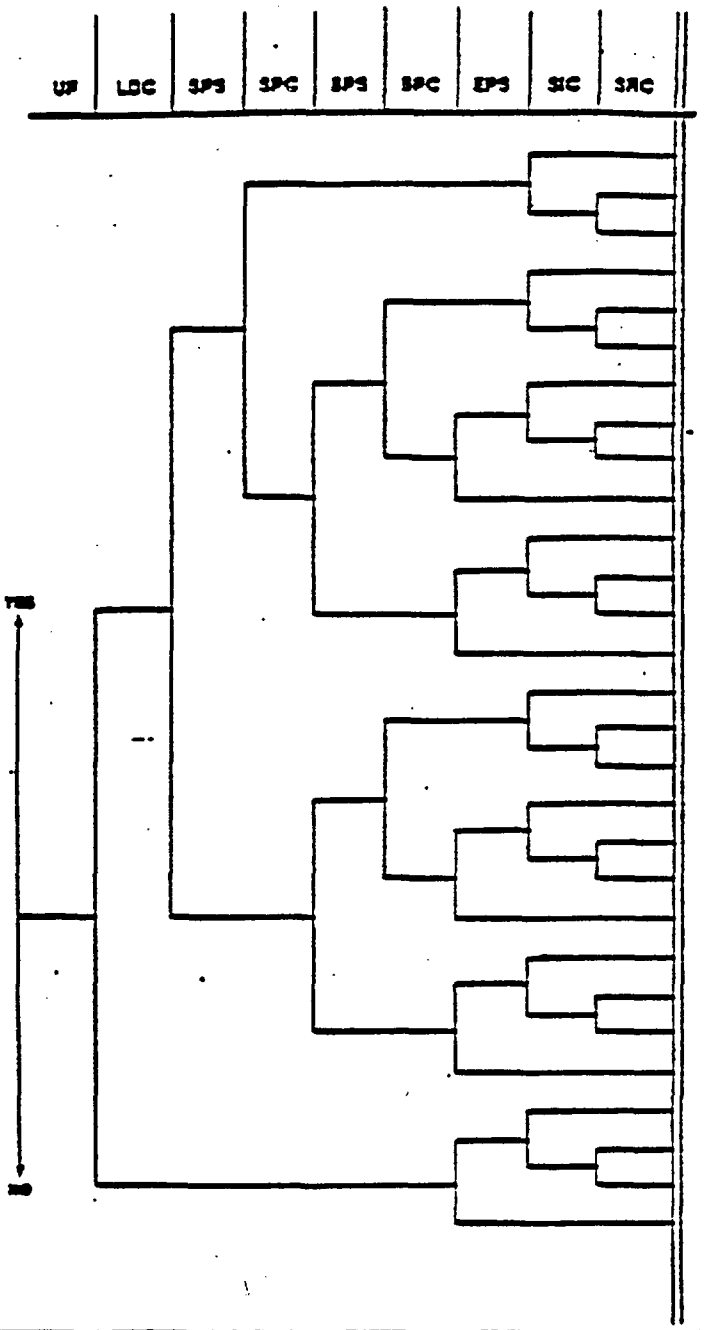
Additionally, the potential exists for a preclosure event, either normal (i.e., construction) or unexpected (i.e., coupled effects, partial retrieval) to have an impact on postclosure performance. For each project, a review of those site specific characteristics (such as fracture spacing and orientation, or rock discontinuities) which come to bear in this evaluation should be made. Local (partial) retrieval is considered to be an unexpected preclosure operation which must be carried out without adversely impacting the ability of the remaining waste packages, or the site, to meet the post closure performance objectives. A review of the local retrieval event is required therefore to evaluate how the retrieval operation might feasibly impact the underground facility including items such as emplaced waste packages, seals, engineered barriers, and rock characteristics. Assessments can then be performed to determine which systems, components, structures, or activities during the preclosure period for the repository or ESF may need to be Q-Listed in order to reduce their potential for impact on postclosure performance requirements. Allocation of performance to a preclosure system, component or structure based on contributing to meeting post-closure performance objectives requires inclusion of the item on the Q-List.

During preclosure, the NRC will be reviewing repository performance confirmation monitoring and testing data for verification of design and performance assumptions. Also, the NRC will be ensuring that decommissioning actions do not increase uncertainty and will be comparing analytical projections for preclosure performance to actual occurrences and trends. An assessment must be made, therefore, as to what equipment or activities support the ability of NRC to grant authorization to proceed with closure, such as performance confirmation program activities, and include these items on the Q-list.



** MITIGATIVE SYSTEMS ARE REQUIRED, AND MUST BE Q-LIST IF THE DOSE IS ≥0.5 rem. THE MITIGATIVE SYSTEM MUST THEREFORE REDUCE THE DOSE CONSEQUENCE TO <0.5 rem.

Figure 4-1. Methodology A - SCP-CDR identification of items important to safety.



UF UNDERGROUND FLOODING; LDC FLOODING LESS THAN THE DESIGN PUMPING CAPACITY;
SPS STARTUP OF SUMP—PUMP SYSTEM; SPC SUMP-PUMP SYSTEM CONTINUES TO OPERATE;
BPS STARTUP OF BACKUP-PUMP SYTEM; BPC BACKUP-PUMP SYSTEM CONTINUES TO OPERATE;
EPS OPERATION OF EXTERNAL PUMPING SYSTEM; SIC STRUCTURAL INTEGRITY COMPROMISED;
SRC SEVERE RADIATION CONTAMINATION

FIGURE 4-2
BASE EVENT TREE FOR UNDERGROUND FLOODING
BASALT, SALT, AND TUFF.

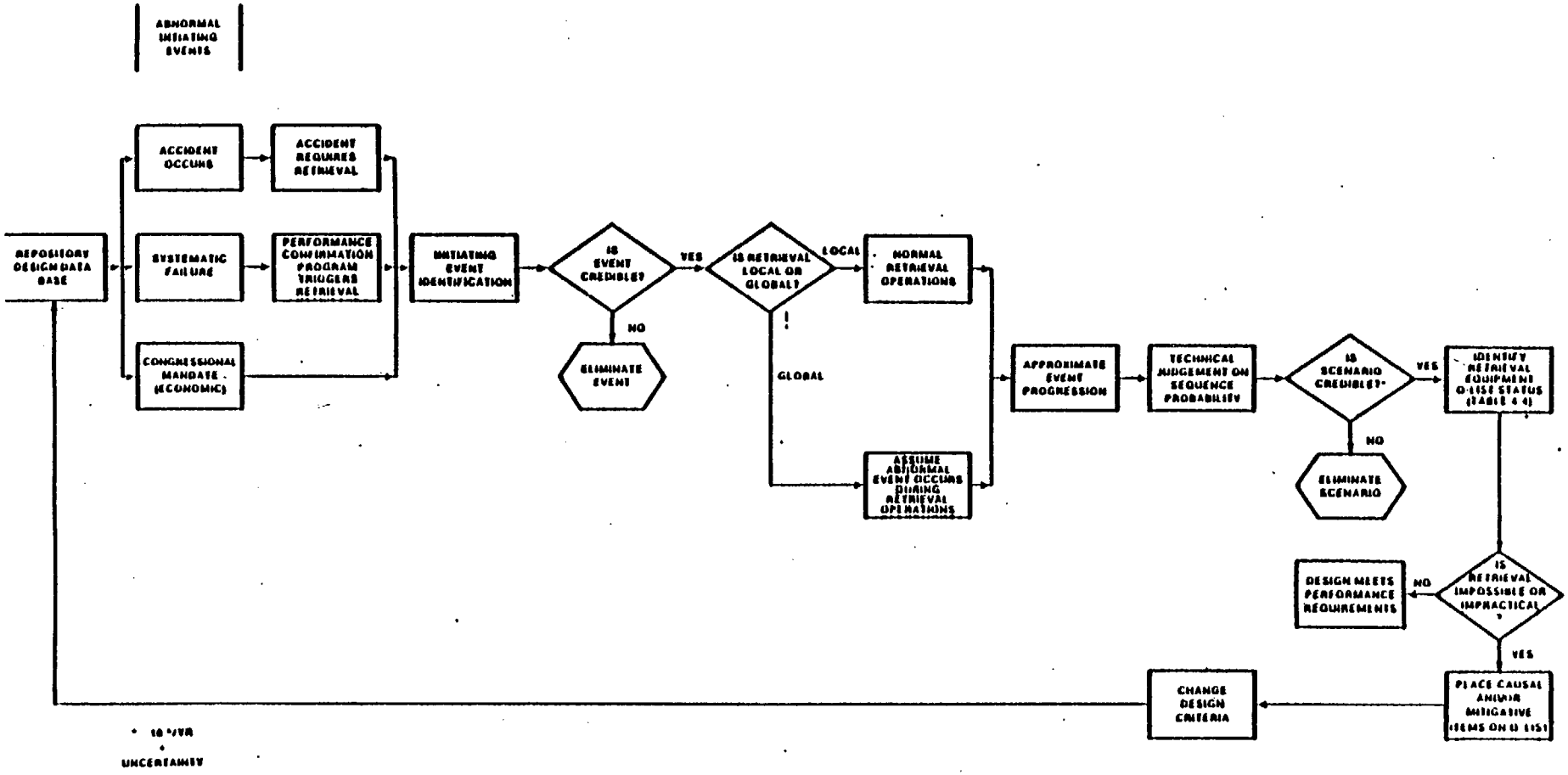


Figure 4-3. Methodology B schematic for preclosure events (operational/retrieval) impacting ability to perform retrieval.

TABLE 4-1

PRECLOSURE SURFACE FACILITY INITIATING EVENTS

- MINIMUM SET -

	Basalt	Salt	Tuff
I. Internal Events			
1. Fire	X	X	X
2. Explosion	X	X	X
3. Waste Handling Events (Drops, Tip Over, Etc.)	X	X	X
4. Breach of Fuel Pin Clad (Welding/Laser Disassembly/ Consolidation Caused)	X	X	X
5. HVAC System Failure	X	X	X
II. External Events			
1. Aircraft Crash	-	-	X
2. Seismic Event	X	X	X
3. Hurricane/Tornado	X	X	X

TABLE 4-2

PRECLOSURE SUBSURFACE FACILITY
INITIATING EVENTS
- MINIMUM SET -

	Basalt	Salt	Tuff
1. Hoist cage drop of waste package	X	X	-
2. Hoist cage overtravel at headframe during retrieval of waste package	X	X	-
3. Transporter crash on ramp, with fire	-	-	X
4. Underground explosion via commercial explosives	X	X	X
5. Underground explosion via methane	X	X	-
6. Seismic event	X	-	X
7. Underground flood (or groundwater intrusion)	X	X	X
8. Fire	X	X	X
9. Areal power density overload	X	X	X
10. Improper construction techniques	X	X	X
11. Operator error— installation/ pre-closure operations	X	X	X
12. Shaft failure—			
common mode - Max.	X	X	-
single - Min.	X	X	-
13. Drift collapse	X	X	X
14. Coupled effects	X	X	X
15. Retrieval (failed waste package related)	X	X	X

TABLE 4-3

ABNORMAL INITIATING EVENTS FOR RETRIEVAL

- MINIMUM SET -

Abnormal Initiating Event for Retrieval	Local Retrieval	Global Retrieval
Underground explosion via commercial explosives	X	
Underground explosion via methane[1]	X	
Seismic event[2]	X (Moderate)	X (Major)
Underground flood[1]		X
Areal power density overload	X	
Operator error	X	
Drift collapse	X	
Coupled effects		X
Systematic failure		X
Congressional mandate (economic)		X

[1] Not applicable to tuff site.
[2] Not applicable to salt sites.

TABLE 4-4
Potential Retrieval Equipment Classification Matrix

Event Severity		Retrieval Equipment Q-List Status*		
Waste Package Integrity	Underground Environment	Consider Not Q-Listing	Consider Treating as if Q-Listed	Consider Q-Listing
Slight[1]	Slight[4]	X		
Slight	Moderate[5]	X		
Slight	Severe[6]		X	
Moderate[2]	Slight	X		
Moderate	Moderate		X	
Moderate	Severe			X
Severe[3]	Slight			X
Severe	Moderate			X
Severe	Severe			X

[1] Waste package is slightly damaged, e.g., deformed, but breach of package is not likely during removal and transport and no special equipment is required.

[2] Waste package is moderately damaged, e.g., punctured, but radionuclide contamination during removal and transport is confinable using specialty equipment.

[3] Waste package is severely damaged and control of radionuclide contamination during removal and transport will require extensive procedures and extensive specialty equipment and control measures to protect operational personnel and minimize releases to the environment to under 0.5 rem.

[4] Underground environment enables use of standard design retrieval equipment.

[5] Underground environment has been moderately changed such that some excavation and opening stabilizing may be required in order to utilize the standard retrieval equipment.

[6] The underground environment has been impacted to such a large extent that extensive reexcavation and opening stabilization is required, and specially designed retrieval equipment may be required to enable retrieval of the waste packages.

* 10 CFR 60.131b design requirements should be imposed on retrievability equipment placed on the Q-List.

5.0 SCHEDULE FOR DEVELOPING Q-LISTS

According to the attached SCP Preparation Schedule BWIP and NNWSI will be completing their SCP's in December 1986 with SRPO following in April 1987. The following schedules for developing Q-Lists are consistent with the SCP preparation schedules.

5.1 BWIP

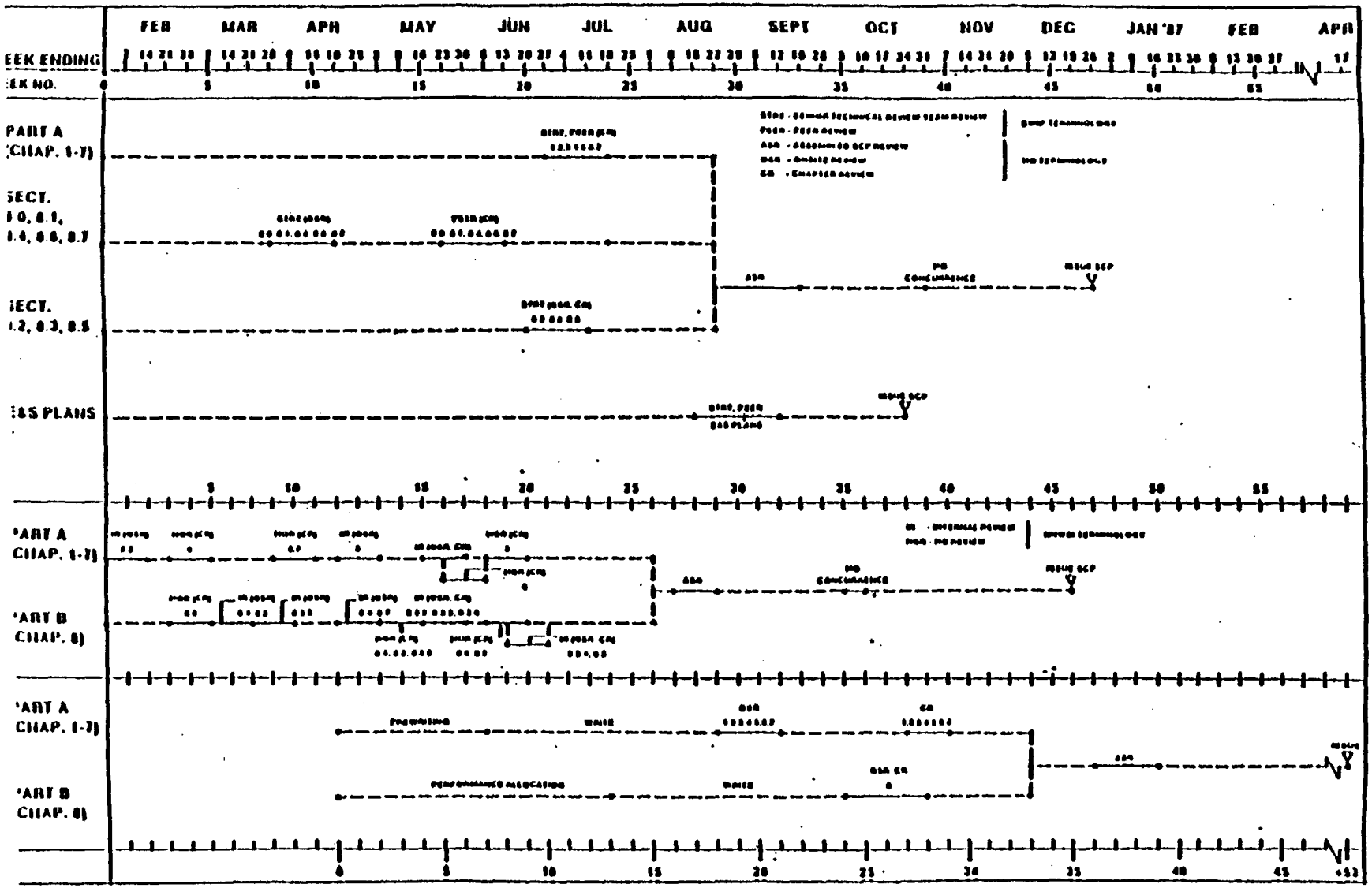
BWIP should have their SCP Q-List complete by mid-May 1986 in order to support the SCP preparation schedule.

5.2 NNWSI

NNWSI should have their SCP Q-List complete by Mid-May 1986 in order to support the SCP preparation schedule.

5.3 SRP

SRP should have their SCP Q-List complete by late July 1986 in order to support the SCP preparation schedule.



Schedules for SCP preparation (1/28/86)

Extracted from "Methodology for Formulating a Q-List and Application of Graded Quality Assurance to Mined Geologic Disposal Systems," DOE, 4/86

ATTACHMENT A

DECISION CRITERIA FOR DETERMINING QUALITY LEVELS OF ITEMS AND ACTIVITIES

CATEGORIES OF STATEMENTS OF WORK (SOW)	QUALITY LEVEL 1	2	3
1. ITEMS (HARDWARE)			
A. PUBLIC HEALTH AND SAFETY CONSIDERATIONS			
o Is the item on the Q-List?	X		
o Does the item have a reasonable potential for being upgraded to the Q-list at a later date.	X		
B. DOE PROGRAMMATIC OBJECTIVES CONSIDERATIONS			
o Failure or malfunction of the item could cause the following potential impact on DOE mission objectives:			
- Critical impact on cost (≥$1000k) or schedule (≥6 months)	X		
- Major impact on cost (≥$500K but <$1000K) or schedular delay (≥3 months but <6 months)		X	
- Minor impact on cost (<$500 K) or schedular delay (<3 months)			X
C. WORKER HEALTH AND SAFETY CONSIDERATIONS			
o Failure or malfunction of the item could have potential impact on the radiological or non-radiological health and safety of the workers		X	

F 1325.8
(12-84)

United States Government | Department of Energy

memorandum

DATE: March 26, 1987

REPLY TO ATTN OF: RW-23

SUBJECT: Responses to July 1986 SCP Q-list Methodology Workshops

TO: J. Neff, SRPO
J. Anttonen, BWIP
D. Vieth, NNWSI

SCP Q-list Methodology Workshops were held at each of the project offices in July 1986. The workshops provided an excellent opportunity to discuss the methodology and each Project's specific concerns and ideas. As a result of the workshops, DOE-HQ was requested to clarify parts of the methodology. The workshop responses are identified in sections 3 (NNWSI), 4 (BWIP), and 5 (SRP) of the attached document.

During the workshops there was much discussion on the present structure of the Q-list and its intent. A basic clarification thought necessary was to make clear the benefits of having hardware and activities placed in different categories. Therefore, also attached is a proposed restructuring of the Q-list and its contents and a Design Classification System (section 2 of the attached document). The Design Classification System is identified merely to illustrate the need to separate, for design purposes, hardware from activities and levels of design criteria for non-Q-list hardware. The major points of the clarification are:

1) The Q-list would be reserved for hardware items only including systems, structures, and components important to safety and engineered barriers important to waste isolation. Natural barriers (including any host rock included as part of the engineered barrier system) important to waste isolation are not Q-listed.

2) A Quality Activities List is created to capture all activities performed on natural barriers which could adversely affect the waste isolation capabilities of the site and for which the application of design criteria would have no meaning. This activities list is not intended to identify and portray all activities normally associated with the design, construction and operation of structures, systems and components on the Q-list. As is normal practice, activities associated with Q-listed structures and hardware will be conducted via QA Level 1 procedures. Activities on the Quality Activities List would also need to be performed in accordance with QA Level 1 procedures.

3) Items important to waste isolation are defined as those engineered and natural barriers allocated performance to meet the 10 CFR 60 subpart E postclosure performance objectives. The hardware portions of these barriers should be Q-Listed. Activities performed on the natural portions of these barriers should be placed on the Quality Activities List.

4) Systems deemed important to preservation of the retrieval option would not be on the Q-list, unless also important to safety or waste isolation. Equipment used for retrieval operations could be Q-listed if they are found to be important to safety, or important to waste isolation (from a performance allocation standpoint). Otherwise, retrieval equipment will have specific design criteria (rather than Q-list design criteria) and an appropriate level of QA.

5) A Design Classification System (DCS) is proposed. This approach is consistent with the DOE-WIPP program and the nuclear industry in general. The system enables the repository designers the flexibility to meet system reliability requirements. This DCS is identified to clarify the need for separating design requirements from QA requirements while developing a system which satifies the needs of both design and QA. If the projects agree with a DCS approach and the structure of the DCS, we plan to implement it during ACD development.

The last section (6) of the attached document identifies how this proposed Q-list reformatting would affect the SCP. It is anticipated that no additional information in the SCP will be required due to this reformatting other than what was already identified in the SCP AO. Rather, it will more clearly focus the requirements (both design and QA) for structures, systems, and components important to safety and barriers important to waste isolation and activities related to these categories.

The material included in this package was presented to you during the September 1986 Project Manager's meeting. It is also consistent with the DOE responses to NRC on NRC's GTP concerning the Q-List.

Please identify to me by April 13, 1987, any comments on this proposed revision to the Q-list approach. If you have any questions about the attached information, please call me or Mark Frei of my staff at FTS 896-5355.

Ralph Stein, Director
Engineering and Geotechnology
Office of Civilian Radioactive
Waste Management

Attachment

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