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YMP/90-55

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Q-LIST

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UNITED STATES DEPARTMENT OF ENERGY

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Q-LIST

REVISION 2

NOVEMBER 1993

Prepared by

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

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

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

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CHANGE HISTORY

REV. NO.	ICN NO.	EFFECTIVE DATE	DESCRIPTION OF CHANGE/ICN
0		07/24/90	Initial issue
1		08/04/93	Complete revision in Sections 1 and 2: added Starter Tunnel items; deleted Exploratory Shaft Facility and replaced with Exploratory Studies Facility Optional Access
2		11/23/93	Revised text and Table of Contents to show natural barriers moved from Appendix A to Section 2; added new Appendix A (Rationale for Natural Barriers on the Q-List); added List of Figures (page vii); added items to Appendices B, C and D. Alluvium has been removed from Q-List and placed on the Management Control List.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Q-LIST

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

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INTRODUCTION

This document, the Yucca Mountain Site Characterization Project (YMP) Q-List, tabulates the engineered items and natural barriers within the Mined Geologic Disposal System (MGDS) that the U.S. Department of Energy has identified as being important to radiological safety or to waste isolation. The Q-List is required by the Office of Civilian Radioactive Waste Management (OCRWM) *Quality Assurance Requirements and Description* (QARD), DOE/RW-0333P, to identify those items and natural barriers subject to the quality assurance (QA) program. Therefore, the Q-List contains engineered items listed in YMP/90-68, *System Requirements Documentation for Use in Identification of Items by the Assessment Team Under AP-6.17Q* (SR), and natural barriers which are defined in the Q-List and illustrated in Section 2, Figure 1.

The Q-List contains items which were included through the process of "Direct Inclusion," a conservative approach initiated with its original issue. As the design of the MGDS matures, classification analyses will replace direct inclusion as an assignment process and justify the removal of many items from the Q-List.

Maintenance of the Q-List is assigned to OCRWM. Each participating organization is responsible for selecting and applying the QA controls that shall be applied commensurate with major characteristics of the Q-List items.

The YMP will continue to use the Physical Subsystems List from the SR as the principal basis for definition of engineered items important to safety (IITS) and items important to waste isolation (IITWI). (See Appendix B for definitions of terms.)

DISCLAIMER

This issue of the Q-List retains the format of engineered items and natural barriers in Revision 0 of the Q-List which does not conform exactly to Attachment 6, of AP-6.17Q, *Classification of Items Important to Safety and Waste Isolation*, Revision 1, now in effect.

IDENTIFICATION OF PERMANENT ITEMS

The identification of items in the SR Physical Subsystem List is not limited to "items" as defined in NUREG-1318, *Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements*, or the QARD Glossary, but includes entries under "Site" that are not intended to be permanent repository items. With the exception of Exploratory Studies Facility (ESF) items intended to be incorporated into a potential repository (i.e., permanent items), engineered items in the ESF design shall be treated as tools used to carry out the activities of site characterization. Control of tools will be covered under the responsible organization's QA program.

Section 1.2.6.0.2b of the *Exploratory Studies Facility Design Requirements*, Rev. 7/2/92, YMP/CM-0019, lists four FSF permanent structures, systems, and components that will be incorporated into the repository:

- ramp and shaft linings;
- underground openings;
- ground support;
- operational seals.

These items shall be designed and constructed with the same criteria, standards and QA as required for the repository, to the extent known at the time of ESF design.

IDENTIFICATION OF NATURAL BARRIERS

The identification of natural barriers is based upon information in the *Site Characterization Plan* (SCP), DOE/RW-0199. The choice of hydrogeologic units for describing the natural barriers at the site, parallels the usage in SCP Table 3-22, and in the SCP discussion of groundwater travel time and total system performance (see SCP Tables 8.3.5.12-2 and 8.3.5.13-5). The hydrogeologic stratigraphy is more relevant to the principal waste isolation functions of the natural barriers than other definitions (such as the thermal-mechanical or geochemical stratigraphy). The principal waste isolation functions of the natural barriers are to reduce water flow from the ground surface to the repository and to retard radionuclide transport from the repository to the accessible environment. These functions are strongly dependent on the distinct hydrologic characteristics of each hydrogeologic unit and specific functions have been identified in the Q-List for each unit. The rationale for selection of these functions and their associated characteristics is provided in Appendix A.

INITIAL DETERMINATION OF ITEMS IMPORTANT TO SAFETY AND ITEMS IMPORTANT TO WASTE ISOLATION

The initial determination of IITS did not utilize the detailed evaluations specified in AP-6.17Q, Revision 0. Instead, all initial assignments were made through the Direct Inclusion (DI) and Exemption provisions of AP-6.17Q which describe DI as a conservative course for determination of importance until more detailed evaluations are completed.

SCP Sections 8.3.2, 8.3.3, 8.3.4 and 8.3.5 were used for the initial determination of IITWI with all of the items being Q-Listed through the DI provision.

EXPLANATION OF ITEM ENTRIES

The Q-List format consists of:

- item Name;
- Work Breakdown Structure (WBS) number;
- a Description of the item or tabulation of its sub-items;
- functions - important to safety or waste isolation;
- characteristics - properties, features, and conditions essential for a barrier to perform safety or waste isolation functions;
- the Assignment of the item as IITS or IITWI, and the method of assignment (i.e., DI or Analysis);
- the Bases Information Reference in which the item is identified;
- the Evaluation Package Reference which justifies the Assignment;
- and the Revision History of each individual item.

Revision 0 of the Q-List identified each sub-item comprising a Q-List item with a Generic Physical Subsystem Structure Code of Accounts number transferred from the SR document; this column is headed by "Subsystem Accounts Code" in this revision. New items do not have this identification but are identified in the Bases Information Reference.

The Q-Listing of new items after the issuance of AP-6.17Q, Revision 1, includes the characteristics and boundaries which cause the items to be placed on the Q-List. Revision 0 of AP-6.17Q did not require a description of characteristics.

Q-LIST SECTION 1

ENGINEERED ITEMS IMPORTANT TO SAFETY

Q-LIST SECTION 1

ENGINEERED ITEMS IMPORTANT TO SAFETY

Item: **Waste Package**
WBS: 1.2.2
Description: SR 2.0, includes the following subsystems:

	Subsystem Accounts Code
Spent Fuel	2.1
Waste Form	2.1.1
Canister	2.1.2
Container	2.1.3
Packing	2.1.4
Other	2.1.9
Defense High-Level Waste	2.2
Waste Form	2.2.1
Canister	2.2.2
Container	2.2.3
Packing	2.2.4
Other	2.2.9
West Valley High-Level Waste	2.3
Waste Form	2.3.1
Canister	2.3.2
Container	2.3.3
Packing	2.3.4
Other	2.3.9

Assignment: IITS-DI (Items Important to Safety - Direct Inclusion) (Typical)
Bases Info. Ref: SR (System Requirements Documentation) (Typical)
Evaluation Pkg Ref: IITS-1 (Evaluation of Items Important to Safety) (Typical)
Revision History: Rev. 1, 8/2/93

Item: **Surface Service and Utility Systems**
WBS: 1.2.4.3
Description: SR 3.1, including the following subsystems:

	Subsystem Accounts Code
On-site Service and Utility Systems	3.1.1
Transportation System	3.1.1.1
roads	3.1.1.1.1
railroads	3.1.1.1.2
Utilities	3.1.1.3
power distribution system	3.1.1.3.1
communication system	3.1.1.3.2
lighting	3.1.1.3.3
potable-water distribution system	3.1.1.3.5
storm drainage system	3.1.1.3.7
sanitary sewage collection system	3.1.1.3.10
fire protection system	3.1.1.3.11
fuel supply	3.1.1.3.12
sanitary landfill	3.1.1.3.13
Off-site Service and Utility Systems	3.1.2
Transportation System	3.1.2.1
roads	3.1.2.1.1
railroads	3.1.2.1.2
bridges	3.1.2.1.3
Utilities	3.1.2.2
power supply	3.1.2.2.1
communication system	3.1.2.2.2
water supply	3.1.2.2.3
drainage system	3.1.2.2.5

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: Surface Facilities
WBS: 1.2.4.3
Description: SR 3.2, including the following subsystems:

	Subsystem Accounts Code
Waste-Handling Facilities	3.2.1
Waste Handling Building	3.2.1.1
building and structures	3.2.1.1.1
cask-handling facilities	3.2.1.1.2
hot cells	3.2.1.1.3
utilities	3.2.1.1.4
HVAC equipment	3.2.1.1.5
waste-handling and packaging equipment	3.2.1.1.6
support facilities	3.2.1.1.7
site generated waste collection facilities	3.2.1.1.8
nuclear material control and accountability system	3.2.1.1.9
lag storage	3.2.1.1.10
vehicle wash facility	3.2.1.3.1
performance confirmation building	3.2.1.3.3
waste treatment building	3.2.1.3.4
Support Facilities for Underground Operations	3.2.2
Ventilation Exhaust Shaft Filtration System	3.2.2.1
Primary Fan Installations for Underground Ventilation Systems	3.2.2.5
Explosive Storage	3.2.2.8

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Balance of Plant**
WBS: 1.2.4.3
Description: SR 3.2.3, including the following subsystems:

	Subsystem Accounts Code
Fire Alarm and Control System	3.2.3.2
Emergency and Backup Power Generator System	3.2.3.3
Medical and Mine Rescue Facilities	3.2.3.9
Monitoring and Operations Control Facilities	3.2.3.11
Health Physics Stations	3.2.3.12
Security Facilities	3.2.3.15
Institutional Barriers	3.2.3.19

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Waste Ramp**
WBS: 1.2.4.3
Description: SR 3.3.1, including the following subsystems:

	Subsystem Accounts Code
Communications Systems	3.3.1.1.1.60
Portal	3.3.1.1.2.10
Stations	3.3.1.1.2.20
Sump	3.3.1.1.2.30
Lining (includes operational seals)	3.3.1.1.2.40
Roadway	3.3.1.1.2.50
Utility Lines	3.3.1.1.2.60
Excavation	3.3.1.1.2.80

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Men-and-Materials Shaft**
WBS: 1.2.4.3
Description: SR 3.3.2.0.0.0, including the following subsystems:

	Subsystem Accounts Code
Headframe	3.3.2.1.1.10
Communications System	3.3.2.1.1.50
Collar	3.3.2.1.2.10
Stations	3.3.2.1.2.20
Sump	3.3.2.1.2.30
Lining (includes operational seals)	3.3.2.1.2.40
Utility Lines	3.3.2.1.2.60
Excavation	3.3.2.1.2.80

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Tuff Ramp**
WBS: 1.2.4.3
Description: SR 3.3.3, including the following subsystems:

	Subsystem Accounts Code
Communication Systems	3.3.3.1.1.40
Portal	3.3.3.1.2.10
Stations	3.3.3.1.2.20
Lining (includes operational seals)	3.3.3.1.2.40
Utility Lines	3.3.3.1.2.60
Excavation	3.3.3.1.2.80

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Emplacement Area Exhaust Shaft**
WBS: 1.2.4.3
Description: SR 3.3.7, including the following subsystems:

	Subsystem Accounts Code
Hoist House	3.3.7.1.1.20
Communications System	3.3.7.1.1.40
Collar	3.3.7.1.2.10
Station	3.3.7.1.2.20
Sump	3.3.7.1.2.30
Lining (includes operational seals)	3.3.7.1.2.40
Fixtures	3.3.7.1.2.50
Pump Discharge Pipe Columns	3.3.7.1.2.60
Excavation	3.3.7.1.2.80

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Exploratory Studies (ES) Modifications for Waste Emplacement Area Air Intake**
WBS: 1.2.4.3
Description: SR 3.3.8, including the following subsystems:

	Subsystem Accounts Code
Headframe	3.3.8.1.1.10
Hoist Shelter	3.3.8.1.1.20
Communications System	3.3.8.1.1.50
Collar	3.3.8.1.2.10
Station	3.3.8.1.2.20
Sump	3.3.8.1.2.30
Lining (includes operational seals)	3.3.8.1.2.40

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Underground Excavations (includes operational seals)**
WBS: 1.2.4.3
Description: SR 3.4, including the following subsystems:

	Subsystem Accounts Code
Main Drift and Entry System	3.4.1
Tuff Main	3.4.1.1
Service Main	3.4.1.2
Ventilation Drifts	3.4.1.3
Waste Main	3.4.1.4
Emplacement Panel Openings	3.4.2
Waste Emplacement Boreholes	3.4.3
Borehole Shielding Closure and Closure Installer	3.4.3.2
Borehole Shield Plug and Shield Plug Installer (Shield Plug only)	3.4.3.3
Borehole Shield Plug and Shield Plug Installer (Installer only)	3.4.3.3

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: Underground Service and Utility Systems
WBS: 1.2.4.3
Description: SR 3.5, including the following subsystems:

Subsystem	Accounts Code
Transportation System	3.5.1
Power Distribution System	3.5.2
Communications System	3.5.3
Lighting System	3.5.4
Ventilation System	3.5.5
Development Area Ventilation	3.5.5.1
Emplacement Area Ventilation	3.5.5.2
Water Distribution System	3.5.6
Chilled Water	3.5.6.1
Potable Water	3.5.6.2
Industrial Water	3.5.6.3
Water Collection and Disposal System	3.5.7
Compressed Air Distribution System	3.5.8
Fire Protection and Control System	3.5.9
Fuel Handling, Storage, and Distribution System	3.5.10
Waste Emplacement and Retrieval System	3.5.12
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Positioning System for Standoff and Retrieval in Long Horizontal Boreholes	3.5.12.2.2
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Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: Seals
WBS: 1.2.4.6.1
Description: SR 3.6, including the following subsystems:

	Subsystem Accounts Code
Shaft and Ramp Seals	3.6.1.1
Underground Excavation Seals	3.6.1.2
Exploratory Borehole Seals	3.6.1.3

Assignment: IITS-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITS-1
Revision History: Rev. 1, 8/2/93

Item: **Exploratory Shaft Facility**

DELETED

This item has been replaced by the Exploratory Studies Facility

Item:	**Ground Support System for the Drill-and-Blast Section of the ESF Starter Tunnel**
WBS:	1.2.6.4
Description:	The ground support system consists of: Rock-bolts Concrete and/or shotcrete (as appropriate)
Characteristics:	The Starter Tunnel may become part of the repository system as an access along which waste may be transported into the underground facility. The Starter Tunnel, if part of the repository, will provide access for future ventilation equipment with potential importance for radiological safety. The ground support system is intended to reduce the probability of rockfalls if the above services become reality. A quantitative assessment of this probability and its consequences has not been made.
Assignment:	IITS - By analysis in the Determination of Importance Evaluation (DIE) listed below.
Bases Info. Ref:	Civilian Radioactive Waste Management System Management and Operating Contractor (M&O) DIE for ESF Starter Tunnel Drill-and-Blast Section, Doc. No. B00000000-AA-09-00005, Rev. 2
Evaluation Pkg. Ref:	AT-93-028
Revision History:	Rev. 0, 8/2/93

Q-LIST SECTION 2

ITEMS IMPORTANT TO WASTE ISOLATION

Q-LIST SECTION 2

ITEMS IMPORTANT TO WASTE ISOLATION

ENGINEERED BARRIERS

Item: **Waste Package**
WBS: 1.2.2
Description: SR 2.0, including the following subsystems:

	Subsystem Accounts Code
Spent Fuel	2.1
Waste Form	2.1.1
Canister	2.1.2
Container	2.1.3
Packing	2.1.4
Other	2.1.9
Defense High-Level Waste	2.2
Waste Form	2.2.1
Canister	2.2.2
Container	2.2.3
Packing	2.2.4
Other	2.2.9
West Valley High-Level Waste	2.3
Waste Form	2.3.1
Canister	2.3.2
Container	2.3.3
Packing	2.3.4
Other	2.3.9

Assignment: IITWI-DI (Items Important to Waste Isolation - Direct Inclusion) (Typical)
Bases Info. Ref: SR (System Requirements Documentation) (Typical)
Evaluation Pkg Ref: IITWI-1 (Evaluation of Items Important to Waste Isolation) (Typical)
Revision History: Rev. 1, 8/2/93

Item: **Institutional Barriers**
WBS: 1.2.4.3
Description: SR, 3.2.3.19, (part of Repository (Balance of Plant))

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **Waste Ramp**
WBS: 1.2.4.3
Description: SR 3.3.1, including the following subsystems:

	Subsystem Accounts Code
Portal	3.3.1.1.2.10
Stations	3.3.1.1.2.20
Sump	3.3.1.1.2.30
Lining	3.3.1.1.2.40
Excavation	3.3.1.1.2.80

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **Men-and-Materials Shaft**
WBS: 1.2.4.3
Description: SR 3.3.2.0.0.0, including the following subsystems:

	Subsystem Accounts Code
Collar	3.3.2.1.2.10
Stations	3.3.2.1.2.20
Sump	3.3.2.1.2.30
Lining	3.3.2.1.2.40
Excavation	3.3.2.1.2.80

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **Tuff Ramp**
WBS: 1.2.4.3
Description: SR 3.3.3, including the following subsystems:

	Subsystem Accounts Code
Portal	3.3.3.1.2.10
Stations	3.3.3.1.2.20
Lining	3.3.3.1.2.40
Excavation	3.3.3.1.2.80

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **Emplacement Area Exhaust Shaft**
WBS: 1.2.4.3
Description: SR 3.3.7, including the following subsystems:

	Subsystem Accounts Code
Collar	3.3.7.1.2.10
Station	3.3.7.1.2.20
Sump	3.3.7.1.2.30
Lining	3.3.7.1.2.40
Excavation	3.3.7.1.2.80

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **ES Modifications for Waste Emplacement Area Air Intake**
WBS: 1.2.4.3
Description: SR 3.3.8, including the following subsystems:

	Subsystem Accounts Code
Collar	3.3.8.1.2.10
Station	3.3.8.1.2.20
Sump	3.3.8.1.2.30
Lining	3.3.8.1.2.40

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **Underground Excavations**
WBS: 1.2.4.3
Description: SR 3.4, including the following subsystems:

	Subsystem Accounts Code
Main Drift and Entry System	3.4.1
Tuff Main	3.4.1.1
Service Main	3.4.1.2
Ventilation Drifts	3.4.1.3
Waste Main	3.4.1.4
Emplacement Panel Openings	3.4.2
Waste Emplacement Boreholes	3.4.3
Borehole Shield Plug and Shield Plug Installer (Shield Plug only)	3.4.3.3

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: Seals
WBS: 1.2.4.3
Description: SR 3.6, including the following subsystems:

	Subsystem Accounts Code
Shaft and Ramp Seals	3.6.1.1
Underground Excavation Seals	3.6.1.2
Exploratory Borehole Seals	3.6.1.3

Assignment: IITWI-DI
Bases Info. Ref: SR
Evaluation Pkg Ref: IITWI-1
Revision History: Rev. 1, 8/2/93

Item: **Exploratory Shafts**

DELETED

This item has been replaced by the Exploratory Studies Facility

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Item: **ESF Starter Tunnel Drill and Blast Section Concrete Invert, Segment Sloping Downward Toward the Portal**
WBS: 1.2.6.4
Description: The concrete invert at the beginning of the ESF starter tunnel drill and blast section is sloped 2% toward the portal entrance.

Characteristics: The Starter Tunnel may become part of the Repository and be used for waste package transport.

The slope toward the portal of the drill and blast section of the Starter Tunnel floor will minimize the potential for water to flow to the Repository level from outside the tunnel.

Assignment: IITWI - by analysis in the following DIE
Bases Info. Ref: M&O DIE for ESF Starter Tunnel Drill and Blast Section, Doc. No. B00000000-AA-09-00005, Rev. 2.
Evaluation Pkg Ref: AT-93-029
Revision History: Rev. 0, 8/2/93

Q-LIST SECTION 2

ITEMS IMPORTANT TO WASTE ISOLATION

NATURAL BARRIERS

Barrier: **Tiva Canyon Welded Hydrogeologic Unit**

WBS: 1.2

Description: Stratigraphic sequence of compositionally zoned, moderately to densely welded, devitrified ash-flow tuff within the Tiva Canyon Member of the Paintbrush Tuff lithostratigraphic unit.

Lateral Extent: Potential repository and usable expansion areas within the lateral extent of the natural barriers in the unsaturated zone, as defined by YMP GENISES Database Reference: YMP93068 and as shown on Figure 1.

Vertical Extent: Within the Tiva Canyon Member of the Paintbrush Tuff: Vertically downward from the top of the uppermost zone of moderately to densely welded ash-flow tuff to the top of the nonwelded to partially welded basal subzone within the informally named columnar zone of Scott and Bonk (1984), inclusive.

Functions: Impede the vertically downward movement of groundwater from land surface to the repository horizon.

Characteristics:

1. Hydraulic conductivity
2. Saturation
3. Thickness
4. Topographic expression

Assignment: IITWI - by analysis (see Appendix A, Rationale for Natural Barriers on the Q-List)

Bases Info. Ref: SCP Table 3-22

Evaluation Pkg Ref: AT-93-021, Rev. 0

Revision History: Rev. 2, 11/1/93

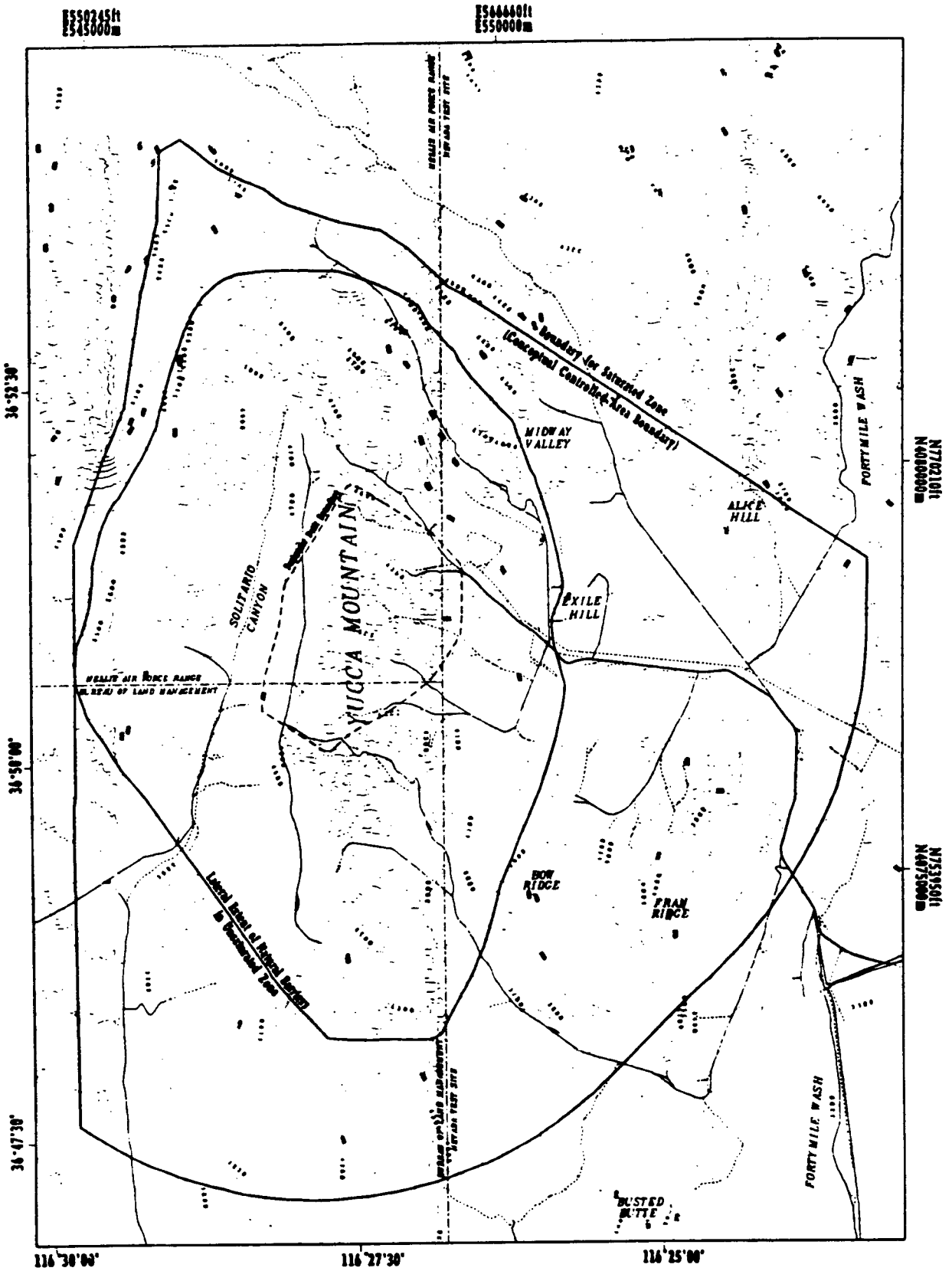

Figure 1 Lateral Extent of Natural Barriers on Q-List (EG&G MAP #YMP-93-197)

SOURCES FOR EG&G MAP # YMP-93-197

1. Boundary for Natural Barriers in Unsaturated Zone was modified from Potentially Usable Areas which were digitized from Sandia Report SAND84-6175, Figure 3. YMP Database Reference is YMP93068. Boundary is approximate.

2. Boundary for Natural Barriers in Saturated Zone obtained from Conceptual Controlled Area Boundary which was digitized from Sandia National Laboratories Product Number CAL0166. YMP Database Reference is CAL0166, topographic contours obtained from U.S. Geological Survey 1:24,000 scale Digital Line Graph. Contour internal 200 feet.

3. Conceptual Perimeter Drift Boundary digitized from Raytheon Services Nevada, Drawing Number YMP-025-2-MING-M101, Revision 1.

4. Road features obtained from 1:6,000 scale orthophoto mission. Photo interpretation completed by EG&G/EM 1991.

5. Projection is Transverse Mercator with grid based on Nevada State Plane Coordinates, Central Zone.

6. Map compiled September, 1993 by EG&G/EM Remote Sensing Laboratory.

7. This map should not be used for quality affecting work.

Figure 1 Lateral Extent of Natural Barriers on Q-List (EG&G Map #YMP-93-197) (continued)

Barrier: **Paintbrush Nonwelded Hydrogeologic Unit**
WBS: 1.2
Description: Vertical stratigraphic sequence of mostly nonwelded and bedded tuffs underlying the Tiva Canyon welded (TCw) unit and overlying the Topopah Spring welded (TSw) unit.

Lateral Extent: Potential repository and usable expansion areas within the lateral extent of the natural barriers in the unsaturated zone, as defined by YMP GENISES Database Reference: YMP93068 and as shown on Figure 1.

Vertical Extent: Downward from the top of the nonwelded to partially welded basal subzone within the informally named columnar zone of Scott and Bonk (1984) in the Tiva Canyon Member of the Paintbrush Tuff, to the top of the vitrophyre subzone within the informally named caprock zone of Scott and Bonk (1984) in the Topopah Spring Member of the Paintbrush Tuff; includes the Yucca Mountain and Pah Canyon Members of the Paintbrush Tuff, where present.

Functions:

1. Impede the vertically downward percolation of groundwater to the potential repository horizon by internal storage and lateral redistribution of water entering the unit from above.
2. Impede the vertically upward transport of gas-phase radionuclides.

Characteristics:

1. Groundwater storage capacity as characterized by porosity, saturation, and thickness
2. Hydraulic conductivity
3. Fracture density
4. Intrinsic permeability contrast with adjacent units

Assignment: IITWI - by analysis
Bases Info ref: SCP Table 3-22
Evaluation Pkg Ref: AT-93-022, Rev. 0
Revision History: Rev. 2, 11/1/93

Barrier: **Topopah Spring Welded Hydrogeologic Unit**

WBS: 1.2

Description: Stratigraphic sequence of compositionally zoned, moderately to densely welded, devitrified ash-flow tuff and vitrophyre within the Topopah Spring Member of the Paintbrush Tuff lithostratigraphic unit.

Lateral Extent: Potential repository and usable expansion areas within the lateral extent of the natural barriers in the unsaturated zone, as defined by YMP GENISES Database Reference: YMP93068 and as shown on Figure 1.

Vertical Extent: Within the Topopah Spring Member of the Paintbrush Tuff: Vertically downward from the top of the vitrophyre subzone within the informally named caprock zone of Scott and Bonk (1984) to the base of the informally named vitrophyre zone of Scott and Bonk (1984), inclusive.

Functions:

1. Promote and sustain near-field environmental conditions compatible with achieving the long-term performance objectives for the engineered barrier system.
2. Accommodate and mitigate potentially adverse far-field effects of repository heat release on adjacent natural barriers important to waste isolation.
3. Impede the vertically downward movement of groundwater toward the potential repository.
4. Impede the vertically downward transport of radioactive materials from the potential repository to the underlying Calico Hills nonwelded hydrogeologic unit.

Characteristics:

1. Saturation
2. Thermal properties
3. Thickness
4. Fracture density

Assignment: IITWI - by analysis

Bases Info. Ref: SCP Table 3-22

Evaluation Pkg Ref: AT-93-023, Rev. 0

Revision History: Rev. 2, 11/1/93

Barrier: **Calico Hills Nonwelded Hydrogeologic Unit**
WBS: 1.2
Description: Vertical stratigraphic sequence consisting of bedded, nonwelded, partially and moderately welded, altered tuff and, locally, rhyolitic lava flows and breccias within the Topopah Spring Member of the Paintbrush Tuff, the Tuffaceous Beds of Calico Hills, and the Crater Flat Tuff lithostratigraphic units.

Lateral Extent: Potential repository and useable expansion areas within the lateral extent of the natural barriers in the unsaturated zone, as defined by YMP GENISES Database Reference: YMP93068 and as shown on Figure 1.

Vertical Extent: From the top of the informally named partially welded zone of Scott and Bonk (1984) at the base of the Topopah Spring Member of the Paintbrush Tuff to the water table, inclusive.

Functions:

1. Impede vertically downward transport of radionuclides from the potential repository to the underlying saturated zone.

Characteristics:

1. Hydraulic conductivity
2. Saturation
3. Geochemical properties
4. Thickness

Assignment: IITWI - by analysis
Bases Info. Ref: SCP Table 3-22
Evaluation Pkg Ref: AT-93-024, Rev. 0
Revision History: Rev. 2, 11/1/93

Barrier:	**Saturated Zone**
WBS:	1.2
Description:	Saturated rock mass present below the water table.

Lateral Extent: The lateral extent of the natural barriers in the saturated zone as defined by YMP GENISES Database Reference: CAL0166 and as shown on Figure 1.

Vertical Extent: Vertically downward from the top of water table to the base of the Tertiary volcanic-rock section, inclusive.

Functions:

1. Impede transport to the accessible environment of radioactive materials released from the repository and transported through the unsaturated zone to the water table.

Characteristics:

1. Hydraulic conductivity
2. Hydraulic gradient
3. Effective porosity
4. Geochemical properties

Assignment:	IITWI - by analysis
Bases Info. Ref:	SCP Table 3-22
Evaluation Pkg Ref:	AT-93-025, Rev. 0
Revision History:	Rev. 2, 11/1/93

APPENDIX A

RATIONALE FOR NATURAL BARRIERS ON THE Q-LIST

APPENDIX A

RATIONALE FOR NATURAL BARRIERS ON THE Q-LIST

1.0 Tiva Canyon Welded (TCw) Hydrogeologic Unit

1.1 Description: The TCw unit, as delimited and described herein, is correlative with the TCw hydrogeologic unit as defined in the SCP, Table 3-22, page 3-139.

1.2 Lateral Extent: The lateral boundaries encompass the area in which hydrologic conditions within the TCw unit could affect the hydrologic state and conditions at the potential repository horizon, including potentially usable expansion areas.

1.3 Vertical Extent: Because the principal waste isolation functions of the natural barriers in the unsaturated zone depend on hydrologic conditions and processes, these barriers are identified and delimited herein as hydrogeologic units. The boundaries of each distinguishable hydrogeologic unit are defined by surfaces across which abrupt, large-magnitude changes of hydrologic properties occur (e.g., hydraulic conductivity). In general, these hydrologic property boundaries will not coincide with lithostratigraphic contacts. However, in order to facilitate the determination of natural barrier boundaries in outcrops, boreholes, and underground openings, these boundaries for the natural barriers are referenced herein to the lithostratigraphic units of Scott and Bonk (1984) and to the lithologic log of Spengler and Chornack (1984) for borehole USW G-4.

Within the Tiva Canyon Member of the Paintbrush Tuff lithostratigraphic unit, the TCw unit extends downward from the top of the upper vitrophyre subzone within the informally named caprock zone of Scott and Bonk (1984) to the top of the nonwelded to partially welded basal subzone within the columnar zone of Scott and Bonk (1984) and includes all or part of the informally named caprock, upper cliff, upper lithophysal, clinkstone, lower lithophysal, hackly, and columnar zones of Scott and Bonk (1984), where present. The TCw unit spans the depth interval from 9.1 to 36 meters, inclusive, in borehole USW G4.

1.4 Waste Isolation Function: The ability of the TCw unit to impede vertically downward groundwater flow results from the combination of low rock-matrix hydraulic conductivity (mean saturated hydraulic conductivity value of 2.3×10^{-11} m/s, Montazer and Wilson, 1984), which impedes the movement of groundwater into and through the unit, and dip-slope topographic expression which promotes surface-water runoff on TCw unit outcrops. High mean fracture density (10-20 fractures/m^3) for the TCw unit (Montazer and Wilson, 1984), implies the possibility for rapid groundwater movement into or through the TCw unit via interconnected fracture pathways under equilibrium or transient nonequilibrium flow conditions, which could compromise the natural barrier function of the TCw unit. Because gas-circulation studies in boreholes at Yucca Mountain (Weeks, 1987; Thorstenson, et al., 1989) indicate the presence of pneumatically connected fracture pathways that could provide conduits for gas-phase radionuclide transport, the TCw unit is not assigned a waste isolation function as a barrier to possible upward transport of gas-phase radionuclides from the repository to the accessible environment (i.e., the atmosphere above the site).

1.5 Hydrologic Properties: Under unsaturated conditions such that the groundwater flux into or through the TCw unit is less than the saturated hydraulic conductivity of the unit, which is approximately equivalent to a flux of 0.7 mm/yr (Montazer and Wilson, 1984), groundwater storage and flow will tend to be confined to the rock matrix (Wang and Narasimhan, 1985). Higher fluxes will tend to saturate the rock matrix and induce equilibrium or transient nonequilibrium groundwater flow in fractures. The natural barrier function of the TCw unit, therefore, is critically dependent on the low rock-matrix hydraulic conductivity and the maintenance of unsaturated conditions within the unit. Consequently, applications of water directly to the TCw unit that could increase rock-matrix saturation or induce transient nonequilibrium water flow in fractures (such as surface-water impoundments on TCw outcrops) could potentially compromise the effectiveness of the TCw unit as a barrier to vertically downward groundwater movement.

1.6 Thickness: The thickness of the TCw unit, which ranges from 0 to as much as 150 meters (Montazer and Wilson, 1984), contributes to its effectiveness as a natural barrier to the extent that groundwater residence time in and travel time vertically through the unit increase with increasing thickness.

1.7 Topographic Expression: The preponderant dip-slope topography developed on erosionally resistant TCw unit outcrops (Scott and Bonk, 1984) promotes surface-water runoff, thereby decreasing the amount of water from precipitation that could be available for direct infiltration into the TCw unit.

2.0 Paintbrush Nonwelded (PTn) Hydrogeologic Unit

2.1 Description: The PTn unit, as delimited and described herein, is correlative with the PTn hydrogeologic unit as defined in the SCP, Table 3-22, page 3-139.

2.2 Lateral Extent: The lateral boundaries encompass the area in which hydrologic conditions within the PTn unit that is present above the potential repository horizon could be affected by land-surface net infiltration, including the possibly usable repository expansion areas.

2.3 Vertical Extent: Because the principal waste isolation functions of the natural barriers in the unsaturated zone depend on hydrologic conditions and processes, these barriers are identified and delimited herein as hydrogeologic units. The boundaries of each distinguishable hydrogeologic unit are defined by surfaces across which abrupt, large-magnitude changes of hydrologic properties occur (e.g., hydraulic conductivity). In general, these hydrologic-property boundaries will not coincide with lithostratigraphic contacts. However, in order to facilitate the determination of natural barrier boundaries in outcrops, boreholes, and underground openings, these boundaries for the natural barriers are referenced herein to the lithostratigraphic units of Scott and Bonk (1984) and to the lithologic log of Spengler and Chornack (1984) for borehole USW G-4.

The PTn, as delimited herein, extends vertically downward from and including the nonwelded to partially welded basal subzone within the informally named columnar zone of Scott and Bonk (1984) in the Tiva Canyon Member of the Paintbrush Tuff to the top of the vitrophyre subzone within the informally named caprock zone of Scott and Bonk (1984) in the Topopah Spring Member of the Paintbrush Tuff, includes the Yucca Mountain and Pah Canyon Members of the Paintbrush Tuff, where present. The PTn unit, as delimited herein, spans the depth interval from 36 to 72.8 meters, in borehole USW G-4.

2.4 Waste Isolation Functions: A principal waste isolation function of the PTn unit is to impede the downward percolation of groundwater that enters the unsaturated zone as net infiltration at land surface. This function results from a combination of the unit's thickness, eastward dip, and hydrologic properties that contribute to the unit's expected ability to store water internally and transmit and redistribute water laterally. Because the unit is relatively unfractured, throughgoing hydrologically connected fracture pathways are not expected to be present (see 2.6 and 2.7).

The PTn unit is expected to be a barrier to the vertically upward transport of gas-phase radionuclides because of effectively low rock-matrix air permeability at ambient rock-matrix saturations and the absence of pneumatically connected fracture pathways (see 2.7).

2.5 Storage Capacity: The storage capacity of the PTn unit depends on the unit's porosity, thickness, and ambient saturation. The porosity of the unit ranges from about 0.3 to 0.5 (Flint and Flint, 1990), the thickness ranges from about 20 to 100 meters (Montazer and Wilson, 1984), and the ambient saturation within the unit ranges from about 0.3 to nearly 1.0 based on sample data from boreholes USW UZ-7 (Kume and Hammermeister, 1991), USW UZ-13 (Kume and Hammermeister, 1990), and USW UZN-55 (Flint, Flint, and Hevesi, 1993). Preliminary groundwater flow-modeling results by Fewell, Sobolik, and Gauthier (1992) indicate that the PTn unit must reach effectively complete saturation before water will move vertically downward from the unit into the underlying TSw unit.

2.6 Hydraulic Conductivity: Because the saturated hydraulic conductivity of the PTn unit is of the order of 10^{-7} m/s (Montazer and Wilson, 1984; Flint and Flint, 1990), compared to a mean value of about 10^{-11} m/s for the rock matrix of the underlying TSw unit (Montazer and Wilson, 1984), the PTn unit is expected to be capable of supporting appreciably greater groundwater fluxes than could occur within the rock matrix of the TSw unit under unsaturated conditions and low hydraulic gradients. Consequently, the PTn unit is expected to promote preferential, lateral, gravity driven down-dip flow of groundwater under conditions of high incident vertically downward groundwater flux from above that would be sufficient to lead to high ($\geq$0.9) saturations within the unit. As the PTn unit saturates due to incident flux from above, the vertically downward moving groundwater will tend to be diverted laterally rather than continuing downward into the TSw unit, thus impeding groundwater movement to the potential repository horizon (Wang and Narasimhan, 1988).

2.7 Fracture Density: Fracture density in the PTn unit averages about 1 fracture/m^3 compared to mean fracture densities of 10-20 fractures/m^3 in the overlying TCw unit and 8-40 fractures/m^3 in the underlying TSw unit (Montazer and Wilson, 1984). Consequently, the likelihood is small for significant liquid-phase or gas-phase fluid movement through interconnected fracture networks within the PTn unit.

3.0 Topopah Spring Welded (TSw) Hydrogeologic Unit

3.1 Description: The TSw unit, as delimited and described herein, is correlative with the TSw hydrogeologic unit as defined in the SCP, Table 3-22, page 3-139, and the combined TSw1 and TSw2 thermal/mechanical units of Ortiz, et al., (1985).

3.2 Lateral Extent: The lateral boundaries encompass the area (1) in which hydrologic conditions within the TSw unit could affect the hydrologic state and conditions at the potential repository horizon, and (2) within which the TSw unit may provide hydrologic flow and transport pathways from the potential repository horizon to the underlying saturated zone.

3.3 Vertical Extent: Because the principal waste isolation functions of the natural barriers in the unsaturated zone depend on hydrologic conditions and processes, these barriers are identified and delimited herein as hydrologic units. The boundaries of each distinguishable hydrogeologic unit are defined by surfaces across which abrupt, large-magnitude changes of hydrologic properties occur (e.g., hydraulic conductivity). In general, these hydrologic-property boundaries will not coincide with lithostratigraphic contacts. However, in order to facilitate the determination of natural barrier boundaries in outcrops, boreholes, and underground openings, these boundaries for the natural barriers are referenced herein to the lithostratigraphic units of Scott and Bonk (1984) and to the lithologic log of Spengler and Chornack (1984) for borehole USW G-4.

Within the Topopah Spring Member of the Paintbrush Tuff lithostratigraphic unit, the TSw unit extends downward from the top of the densely welded vitrophyre subzone within the informally named caprock zone of Scott and Bonk (1984) to the vitrophyre zone of Scott and Bonk (1984) and includes all or part of the informally named rounded, red lithophysal, nonlithophysal, grayish-red lithophysal, mottled, and vitrophyre zones of Scott and Bonk (1984), where present. In borehole USW G-4 the TSw unit spans the depth interval between 72.8 and 410.1 meters.

3.4 Waste Isolation Functions: As the designated host rock for the potential repository, the TSw unit would provide the interface between the engineered barrier system (EBS) and the natural barriers. For example, the storage and movement of water as both liquid and vapor in the host rock in the immediate vicinity of the repository will determine environmental conditions within the EBS as well as the availability of liquid water to transport radioactive material that may be released from the EBS. The thermal and hydrologic response of the TSw unit to repository heating will determine the far-field thermal field (Buscheck and Nitao, 1993) and the extent to which the TSw unit will be able to accommodate and mitigate potentially adverse effects of repository heating on adjacent natural barriers important to waste isolation. In addition, because of its low mean rock-matrix saturated hydraulic conductivity (3.5×10^{-11} m/s, Montazer and Wilson, 1984), the TSw unit can be expected to impede fluid movement toward or away from the potential repository under conditions in which flow is restricted to the rock matrix. Interconnected fracture networks within the TSw unit, however, may provide preferential pathways for both liquid-phase and gas-phase flow. To the extent that they allow for free drainage within the host rock, fractures in the TSw unit may be beneficial to waste isolation. However, fractures may also be conduits for liquid-water flow toward the repository and for water-borne radionuclide transport away from the repository toward the accessible environment. In addition, numerical-modeling results indicate that upward advective gas-phase transport of carbon-14 (as carbon dioxide) through interconnected fractures within the TSw could lead to releases of this radionuclide from the potential repository to the accessible environment (atmosphere) that exceed currently established allowable limits (Ross, et al., 1992). The ability of the TSw unit to perform a waste isolation function will depend complexly on its intrinsic hydrologic and thermal properties and on external and internal conditions (e.g., the vertically downward component of

groundwater flux across the upper boundary between the TSw and PTn units and the repository thermal load).

3.5 Saturation: The maintenance of unsaturated conditions, under which groundwater flow is expected to be restricted to the interconnected pore space within the rock matrix (Wang and Narasimhan, 1985), is critical to the ability of the TSw unit to impede groundwater flow. Under saturated conditions associated, for example, with perched-water bodies or thermally induced condensate (Buscheck and Nitao, 1993), equilibrium and/or transient nonequilibrium flow could be induced in fractures (Wang and Narasimhan, 1985; Klavetter and Peters, 1986), which, if hydraulically connected, could provide pathways for rapid groundwater movement into and through the TSw unit (see 3.7). Unsaturated conditions within the rock matrix of the TSw unit will inhibit groundwater flow through fractures, and associated low hydraulic-conductivity values will promote long groundwater travel times through the unit.

3.6 Thermal Properties: Thermal properties (e.g., thermal conductivity and heat capacity), together with the thickness of the TSw unit, will determine the ability of the TSw unit to accommodate heat release from the repository and to mitigate potentially adverse effects of heating on the overlying PTn and underlying CHn natural barriers.

3.7 Thickness: The thickness of the TSw unit, which ranges from 290 to 360 meters (Montazer and Wilson, 1984), allows for potentially long groundwater flow pathways and travel times through the TSw unit. The thickness of the TSw unit, in particular the vertical distance from the repository horizon to the overlying PTn and underlying CHn units, is expected to contribute to accommodating and mitigating the effects of repository heat release on the overlying and underlying PTn and CHn units (Buscheck and Nitao, 1993).

3.8 Fracture Density: Because of the degree of fracturing within the TSw unit, 8 to 40 fractures/m^3 as reported by Montazer and Wilson (1984), the potential for significant fluid movement through interconnected fracture networks within the TSw unit may compromise its ability to impede groundwater flow (Klavetter and Peters, 1986), and may enhance possible gas-phase radionuclide transport (Ross, et al., 1992). Consequently, the presence or absence of interconnected fracture pathways is critical to the waste isolation function of the TSw unit.

4.0 Calico Hills Nonwelded (CHn) Hydrogeologic Unit

4.1 Description: The CHn unit, as delimited and described herein, is correlative with the CHn hydrogeologic unit as defined in the SCP, Table 3-22, page 3-139, to consist of vitric (CHnv) and zeolitic (CHnz) subunits within the basal Topopah Springs member of the Paintbrush Tuff, the Tuffaceous Beds of Calico Hills, and the upper part of the Crater Flat Tuff lithostratigraphic units.

4.2 Lateral Extent: The lateral extent encompasses the area in which groundwater flow paths may extend from the potential repository and useable expansion areas through the underlying unsaturated zone into the saturated zone.

4.3 Vertical Extent: Because the principal waste isolation functions of the natural barriers in the unsaturated zone depend on hydrologic conditions and processes, these barriers are identified and delimited herein as hydrologic units. The boundaries of each distinguishable hydrogeologic unit are defined by surfaces across which abrupt, large-magnitude changes of hydrologic properties occur (e.g., hydraulic conductivity). In general, these hydrologic-

property boundaries will not coincide with lithostratigraphic contacts. However, in order to facilitate the determination of natural barrier boundaries in outcrops, boreholes, and underground openings, these boundaries for the natural barriers are referenced herein to the lithostratigraphic units of Scott and Bonk (1984) and to the lithologic log of Spengler and Chornack (1984) for borehole USW G-4.

Vertically, the CHn unit as delimited herein, extends downward from the top of the informally named partially welded zone of Scott and Bonk (1984) at the base of the Topopah Spring Member of the Paintbrush Tuff to the top of the water table, here considered to be the upper bounding surface of the saturated zone on which the pore pressure of water is equal to atmospheric pressure. (The altitude of the water table is approximated by the height to which water rises in tightly cased boreholes penetrating and open to the saturated zone.) The CHn unit includes the partially welded zone of Scott and Bonk (1984) at the base of the Topopah Spring Member of the Paintbrush Tuff; the tuffaceous beds of Calico Hills where present above the water table; and the upper part of the Crater Flat Tuff where present above the water table. In borehole USW G-4 the CHn unit, as delimited herein, extends vertically downward from the top of the moderately welded, vitric tuff interval in the basal part of the Topopah Spring Member of the Paintbrush Tuff at a depth of 410.1 meters to the water table at a depth of about 541 meters in the Prow Pass Member of the Crater Flat Tuff (Bentley, 1984).

4.4 Waste Isolation Function: The U.S. Department of Energy in the SCP, Section 6.1.5, page 6-80, allocates primary performance to the unsaturated CHn unit for meeting the overall repository system performance objective in 10 CFR 60.112 for allowable releases of radioactive materials from the geologic repository to the accessible environment, and for meeting the groundwater travel time requirement in 10 CFR 60.113. These objectives and requirements are to be met through combined contributions from the hydrologic and geochemical properties and thickness of the CHn unit (see 4.5, 4.6, 4.7).

4.5 Hydraulic Conductivity: Representative values of saturated hydraulic conductivity for the rock matrix within the CHn unit range from about 10^{-12} m/s to about 10^{-7} m/s, depending on the degrees of welding, devitrification, and alteration (Peters, et al., 1984; Montazer and Wilson, 1984; Flint and Flint, 1990; Loeven, 1993). Low fracture density (less than or about 5 fractures/m^3 based on data from borehole USW G-4 by Spengler and Chornack, 1984) and a high percentage of healed fractures within the CHn unit (19 to 35 percent in core samples from borehole USW G-4 according to Spengler and Chornack, 1984) imply that fracture pathways for groundwater flow in and through the CHn unit are unlikely to be present. Given this range of saturated hydraulic conductivities for the rock matrix and the absence of potentially rapid flow pathways, the CHn unit is expected to be associated hydrologically with groundwater residence and travel times that may contribute significantly to meet the groundwater travel time requirement of 10 CFR 60.113 (Sinnock, et al. (1986); Sinnock and Lin, 1989; Kaplan, 1993).

4.6 Saturation: Because hydraulic conductivity in unsaturated porous media is a function of saturation, the ability of the CHn unit to impede groundwater flow will depend on the spatial distribution of saturation within the unit. Presently available data summarized by Montazer and Wilson (1984) and Loeven (1993) indicate that the ambient saturation within the CHn unit ranges from 0.5 to 1.0. Based on relative permeability data from Peters, et al. (1984) and Flint and Flint (1990), the hydraulic conductivity of the tuffaceous materials composing the CHn unit will be lower by factors ranging from 10 to 1000 at 0.5 saturation relative to

the saturated hydraulic-conductivity values. Activities that could lead to long-term increases of saturation therefore have the potential to increase hydraulic conductivity locally and, thereby, to create preferential flow and transport pathways within the unit.

4.7 Geochemical Properties: Augmenting the hydrologic barrier function of long groundwater residence and travel times, exposed mineral surfaces in rock-matrix pores and extensive zonal and disseminated distributions of zeolites (chiefly clinoptilolite and mordenite) within the CHn unit (Bish and Chipera, 1989) are expected to provide a sorptive capacity to geochemically retard the transport of radionuclides through the unit (Bish, et al., 1984; Meijer, 1992).

4.8 Thickness: The thickness of the CHn unit, which ranges from about 100 to 400 meters (Montazer and Wilson, 1984) combined with the thickness of the TSw unit below the potential repository, is expected to be a principal contributing factor to long residence and travel times for groundwater moving vertically downward from the potential repository into the saturated zone.

5.0 Saturated Zone (SZ) Barrier

5.1 Description: The SZ barrier, as herein delimited, includes all or parts of the welded tuff aquifer and the bedded tuff aquitard of Winograd and Thordarson (1985) beneath the conceptual controlled area. At borehole UE-25p#1 the SZ barrier consists of welded, nonwelded, and bedded tuff within the Tuffaceous Beds of Calico Hills, the Crater Flat Tuff, the Lithic Ridge Tuff, and underlying older tuffs of Tertiary age (Craig and Robison, 1984).

5.2 Lateral Extent: The lateral extent is restricted to the conceptual controlled area where downward projected perimeter demarcates the accessible environment in the subsurface.

5.3 Vertical Extent: Vertically, the SZ barrier extends downward from the top of the water table to the base of the Tertiary volcanic-rock section. The lower boundary is taken to be effectively, the contact between the volcanic rocks of Tertiary age and the underlying carbonate rocks of Paleozoic age. In borehole UE-25p#1 the hydraulic head in the upper part of the Paleozoic carbonate rock section is about 20 meters higher than the composite head in the Tertiary volcanic rock section, which indicates the presence of a confining layer that impedes vertical groundwater flow between the two sections (Craig and Robison, 1984). Consequently, radionuclide transport within the saturated zone is expected to occur principally as lateral transport in the volcanic rock section, here designated as the SZ barrier.

5.4 Waste Isolation Function: Because the current conceptual model for water-borne transport of radionuclides that may be released from the repository considers that transport will occur along flow paths through the unsaturated zone to the water table and laterally through the SZ barrier to the accessible environment, the hydrologic and geochemical conditions and processes within the SZ barrier will be essential for impeding the release to the accessible environment of radioactive materials reaching the water table (Barnard, et al., 1992). In this context the U.S. Department of Energy in the SCP (Section 6.1.5, page 6-80) allocates primary reliance on the unsaturated zone and secondary reliance on the saturated zone to meet the objectives for total repository-system performance in 10 CFR 60.112, and groundwater travel time in 10 CFR 60.113.

5.5 Hydrologic Properties: Under the assumption that groundwater flow within the SZ barrier is Darcian, the groundwater flux and velocity field for advective transport of radionuclides will be determined by the hydraulic gradient, hydraulic conductivity, and effective porosity within the SZ barrier (Barnard, et al., 1992), which are therefore identified as critical characteristics.

5.6 Geochemical Properties: The principal ability of the SZ barrier to geochemically impede radionuclide transport will depend on the mineralogy of fracture surfaces and rock-matrix pore walls and the resultant geochemical properties (e.g., sorption coefficients) along the flow and transport pathways (Meijer, 1992).

6.0 Appendix A References

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APPENDIX B

DEFINITIONS

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DEFINITIONS

Account Code Numbers: A generic physical subsystem structure code of accounts to be used for each physical system of the MGDS. (YMP/90-68)

Assignment: The decision to identify items as either IITS or IITWI and by either DI or Analysis.

Bases Information Reference: Documents which identify items and describe their relation to the potential future repository.

Direct Inclusion (DI): The process of selecting items for the Q-List without conduct of a performance analysis. (AP-6.17Q)

Evaluation Package Reference: Documents which classify items as either Q-List or Management Controls MC-List items by evaluating items against criteria listed in AP-6.17Q.

Items Important to Safety (IITS): Those engineered structures, systems, and components essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of the unrestricted area at any time until the completion of permanent closure. (NUREG 1318)

Items Important to Waste Isolation (IITWI): Natural and engineered barriers that are relied on for achieving the postclosure performance objectives in 10 CFR 60, Subpart E. (NUREG 1318)

Natural Barrier: A geologic entity where physical, mechanical, chemical and hydrologic characteristics individually and collectively act to inhibit, minimize or preclude radionuclide transport. (AP-6.17Q)

Q-List: In the geologic repository program, a list of structures, systems, and components important to safety, and engineered barriers important to waste isolation, that must be covered under the QA requirements of 10 CFR 60, Subpart G. (NUREG 1318)

Revision History: The revision status of individual items in the Q-List.

APPENDIX C

REFERENCES

APPENDIX C

REFERENCES

Unless otherwise stated, refer to the latest revision or interim change of the referenced document.

10 CFR 60	Disposal of High-Level Radioactive Wastes in Geologic Repositories
DOE/RW-0199	Site Characterization Plan
DOE/RW-0333P	Office of Civilian Radioactive Waste Management Quality Assurance Requirements and Description
YMP/CC-0001	Work Breakdown Structure Index and Dictionary - Annex II to the Project Management Plan
YMP/CM-0019	Exploratory Studies Facility Design Requirements, Rev. 7/2/92
YMP/90-58	Supporting Documentation for Evaluation of Items Important to Safety (Appendix 2, Evaluation Package #IITS-1, Evaluation of Items Important to Safety)
YMP/90-59	Supporting Documentation for Evaluation of Items Important to Waste Isolation (Appendix 2, Evaluation Package #IITWI-1, Evaluation of Items Important to Waste Isolation)
YMP/90-68	System Requirements Documentation for Use in Identification of Items by the Assessment Team Under AP-6.17Q
NUREG-1318	Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements.
AT-93-021	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - Tiva Canyon Welded Hydrogeologic Unit
AT-93-022	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - Paintbrush Nonwelded Hydrogeologic Unit
AT-93-023	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - Topopah Spring Welded Hydrogeologic Unit
AT-93-024	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - Calico Hills Nonwelded Hydrogeologic Unit
AT-93-025	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - Saturated Zone
AT-93-028	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - ESF Starter Tunnel Drill-and-Blast Section, Ground Support System
AT-93-029	Yucca Mountain Site Characterization Project Analysis/Evaluation Package - ESF Starter Tunnel Drill-and-Blast Section, Concrete Invert.
AP-6.17Q	Classification of Items Important to Safety and to Waste Isolation

Doc. No. B00000000-AA-09-00005, Rev. 2 — Civilian Radioactive Waste Management and Operating Contractor Determination of Importance Evaluation for ESF Starter Tunnel Drill-and-Blast Section

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APPENDIX D

ACRONYMS AND ABBREVIATIONS

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ACRONYMS AND ABBREVIATIONS

CHn	Calico Hills Nonwelded
CHnv	Calico Hills Nonwelded Vitric
CHnz	Calico Hills Nonwelded Zeolitic
DI	Direct Inclusion
DIE	Determination of Importance Evaluation
EBS	Engineered Barrier System
ES	Exploratory Studies
ESF	Exploratory Studies Facility
IITS	Items Important to Safety
IITWI	Items Important to Waste Isolation
M&O	Management and Operating Contractor
MGDS	Mined Geologic Disposal System
OCRWM	Office of Civilian Radioactive Waste Management
PTn	Paintbrush Nonwelded Unit
QA	Quality Assurance
QARD	Quality Assurance Requirements and Description
SCP	Site Characterization Plan
SR	System Requirements Documentation for Use in Identification of Items by the Assessment Team under AP-6.17Q
SZ	Saturated Zone
TBD	To be determined
TCw	Tiva Canyon Welded Unit
TSw	Topopah Spring Welded Unit
WBS	Work Breakdown Structure
YMP	Yucca Mountain Sité Characterization Project