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Determination of Importance Evaluation Cover Sheet

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23. Remarks
This Category III Determination of Importance Evaluation (DIE) evaluates activities associated with Phase I of the Exploratory Studies Facility (ESF) Enhanced Characterization of the Repository Block (ECRB) drift (which is also known as the East-West [Cr]oss Drift). This DIE establishes Quality Assurance (QA) controls to prevent or minimize, to the extent practical, the potential [im]pact of these activities on site characterization data, the waste isolation capabilities of potential repository and the Yucca Mountain site, and/or other Q-List items that have been constructed or installed at the Yucca Mountain site. This DIE is required to be used as input to the applicable implementing documents for the activities evaluated herein. 102

This DIE is distributed as a controlled document in accordance with M&O procedure QAP-6-1.

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DETERMINATION OF IMPORTANCE EVALUATION FOR ESF ENHANCED CHARACTERIZATION OF THE REPOSITORY BLOCK DRIFT (PHASE I)

1.0 PURPOSE

This Determination of Importance Evaluation (DIE) applies to Phase I of the Exploratory Studies Facility (ESF) Enhanced Characterization of the Repository Block (ECRB) Drift (also known as the ESF East-West Cross Drift). The ECRB Drift originates on the left rib of the ESF North Ramp and crosses at approximately 15 meters (m) to 20 m above the proposed waste emplacement zone of the potential repository block (in an east-northeast to west-southwest direction) (Section 6.1). The ECRB Drift will end at a terminal face just west of the western most strand of the Solitario Canyon fault. The specific focus of this Phase I ECRB Drift evaluation is the portion of the ECRB Drift from the end of the ECRB Starter Tunnel to the crossover point of the Topopah Spring (TS) Main Drift. This Category III DIE was developed for the ECRB Drift because the waste-isolation-related assumptions and models used in the DIE for the Subsurface ESF (Reference 14.1) do not completely bound ECRB Drift activities.

This evaluation applies to Phase I ECRB Drift construction and operation activities. Activities associated with construction/mobilization of testing accommodations—such as borehole drilling or the installation of test instrumentation—within the Phase I portion of the ECRB Drift are also evaluated herein. A brief description of these activities is provided in Section 6.0. Activities associated with the actual conduct of testing are not evaluated by this DIE. The determination of potential test-to-test interference impacts attributable to the conduct of testing activities is the responsibility of the assigned Principle Investigator(s) (PIs) and is addressed in the supporting evaluation(s) for the applicable Field Work Package(s) (FWPs). Furthermore, the validity and veracity of the test data are also the responsibility of the assigned PIs and are not evaluated in this DIE.

The objective of this DIE is to determine whether Phase I ECRB-Drift-related activities, as identified in Section 6.0, could potentially impact (1) Yucca Mountain Site Characterization Project (YMP) testing or (2) the waste isolation capabilities of a potential repository at the Yucca Mountain site. Any controls necessary to limit such potential impacts are also identified herein.

Revision 00 (i.e., Phase I) of this DIE does not evaluate those activities associated with the portion of the ECRB Drift that passes over the potential waste emplacement zone of the repository block. Revision 01 (i.e., Phase II) of this DIE will evaluate these activities. A potential Revision 03 to this DIE may also be required for incorporation of testing data (which are collected in testing activities as discussed in Section 6.0) into the waste isolation evaluation.

2.0 QUALITY ASSURANCE

This DIE was prepared in accordance with Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O) implementing line procedure Nevada

Line Procedure (NLP) NLP-2-0 Revision 03 (Reference 14.2), subject to the requirements of the United States Department of Energy (DOE) Office of Civilian Radioactive Waste Management Quality Assurance Requirements and Description for the Civilian Radioactive Waste Management Program. The evaluation herein is quality-affecting because it establishes the applicability of the Quality Assurance (QA) program to field activities associated with the Phase I ECRB Drift with specific regard to potential impact on site characterization data, the waste isolation capabilities of a potential geologic repository at the Yucca Mountain site, and other permanent Q-List (Reference 14.3) items (which are classified QA-1, QA-2, and QA-5, including natural barriers) that have been constructed or installed at the Yucca Mountain site. This DIE addresses:

1. Activities associated with permanent items, and

2. Temporary items or activities which are subject to QA control (temporary items are not assigned specific classification numbers).

Pursuant to the requirements of Title 10, Code of Federal Regulations Part 60 (10 CFR 60), Section 15(c)(1) (Reference 14.4), QA controls for minimizing, to the extent practical, any potential for impacts (as identified herein) to permanent, classified items, including potential impacts associated with the use of temporary items, are established by this DIE.

3.0 METHODOLOGY

This evaluation was performed in accordance with procedure NLP-2-0, (Reference 14.2). It is a Category III DIE because it addresses field activities that are potentially significant with respect to their effects on Q-List (Reference 14.3) items and/or site characterization data and that do not have an applicable Category III DIE or analogous precedent. This DIE was prepared by:

1. Reviewing the best available design information related to subsurface construction, operation, and maintenance activities associated with the ECRB Drift;

2. Evaluating the potential of these activities, including the use of associated temporary items, to affect Q-List (Reference 14.3) items and site characterization testing; and

3. Eestablishing controls as required to minimize, to the extent practical, potential impacts on Q-List (Reference 14.3) items (including the natural barrier) and site characterization testing.

The best available information related to ECRB Drift items/facility construction, operation, maintenance, and testing activities includes but is not limited to preliminary/approved M&O design documents and construction drawings and specifications, FWPs, Testing Study Plans, Test Coordination Office (TCO)/PI criteria letters, and applicable Lotus Notes. In cases where inputs from these documents provide critical characteristics that could potentially impact the conclusions and derived requirements of this evaluation, specific reference citations are provided in the text.

After approval of this DIE, implementing documents (e.g., FWPs, design specifications, and design drawings) will be reviewed by the Safety Assurance (SA) Department. These reviews are conducted to:

1. Ensure that the original basis for the evaluation (i.e., best available design information) adequately bounds the final scope of activities to be conducted in the ECRB Drift, and

2. Verify that any applicable DIE requirements have been properly integrated into the implementing documents.

4.0 ASSUMPTIONS

4.1 It is assumed throughout this DIE that Phase I of the ECRB Drift is offset from the closest waste package emplacement area by a minimum distance of 37 (m) (Reference 14.1). This assumption establishes bounding conditions for the Phase I ECRB Drift analysis.

4.2 It is assumed throughout this DIE that ECRB Drift construction activities (e.g., tunnel boring machine [TBM] operation and support, utility installation, testing accommodation support/set up, and dust suppression) are conducted in accordance with approved design documents (i.e., specifications and drawings) and FWPs, which implement the applicable requirements of the ESF Design Requirements (ESFDR) (Reference 14.5). This assumption is based on the preservation of a conservative design basis, and it establishes the boundary conditions for this DIE.

4.3 The tracers, fluids, and materials (TFMs) to be used in the ECRB Drift will be those for which data (e.g., Material Safety Data Sheets [MSDSs]) have been provided and reviewed (Attachment II). TFMs that have not yet been reviewed will be evaluated in accordance with the project TFM procedure (Reference 14.6). It is assumed throughout this DIE that the MSDS-recommended procedures will be followed for use, storage, handling, ventilation, spills and leaks, and personnel safety. Temporary items/materials used for the construction, operation, and maintenance of facilities and equipment in the ECRB Drift, which are not permanently emplaced/committed to the Subsurface ESF environment (based on the detailed Title III as-built documentation), are exempted from the TFM program reporting requirements of Reference 14.6. Similarly, Section 13.2 of this DIE specifically exempts certain temporary items/materials from TFM program reporting requirements because their use is evaluated herein to have negligible potential to impact either site characterization data and/or site waste isolation characteristics. This assumption establishes the scope for this DIE with respect to TFMs and is based on the ESFDR (Reference 14.5) and Yucca Mountain Administrative Procedure (YAP) YAP-2.8Q (Reference 14.6).

4.4 Based on the TFM procedure (Reference 14.6), it is assumed throughout this DIE that water used for fire suppression and control will be treated as a significant spill.

5.0 COMPUTER CALCULATIONS

No analytical computer programs have been used directly in the preparation of this document. However, computer programs have been used in referenced documents, which form the basis for some of the results presented in this document. Detailed discussions of these computer calculations, including their treatment under the QA Program, are provided in the referenced documents.

6.0 DESCRIPTION OF ACTIVITIES

This section provides general descriptions of ECRB Drift items/facility construction, operation, maintenance, and testing activities. These activity descriptions establish the general bounding conditions for this Phase I DIE. Future activities that are not bounded by these activity descriptions will require a separate SA Department evaluation as required by NLP-2-0 (Reference 14.2).

6.1 ECRB DRIFT OVERVIEW AND PHASE I BOUNDARY DEFINITION

References 14.7, 14.8, and 14.9 describe the layout of the overall ECRB Drift. This drift begins with an approximately 26-m ECRB Starter Tunnel, which is located on the left rib of the ESF North Ramp at approximately Station 19+92 m. Activities associated with the ECRB Starter Tunnel have been previously evaluated by a separate DIE (Reference 14.10). From the Starter Tunnel, the ECRB Drift extends generally west-southwest for of approximately 2823 m, where it terminates underground at a point approximately 50 m west of the western-most strand of the Solitario Canyon fault. The path of the ECRB Drift passes approximately 15 m to 20 m above the proposed waste emplacement zone of the potential repository. There is a minimum offset of approximately 53 m between ECRB Drift and the ESF Thermal Testing Facility (TTF), which meets the requirement of a 50-m to 100-m offset as established by the responsible PI (Reference 14.9). The excavated invert of the ECRB Drift has a positive slope relative to the ESF North Ramp (i.e., it slopes upward from its origin) until the drift is completely through the proposed waste emplacement zone. The excavated invert slope then becomes negative (i.e., sloping toward the Solitario Canyon fault) to the west of the proposed waste emplacement zone.

At approximately Station 7+73 m of the ECRB Drift, the drift crosses the TS Main Drift (at about Main Drift Station 30+61 m) approximately 20 m to 25 m above the TS Main Drift centerline. The portion of the ECRB Drift between the Starter Tunnel and the TS Main Drift crossover point is defined as Phase I of the ECRB Drift.

6.2 ECRB DRIFT CONSTRUCTION

6.2.1 TBM Excavation

From approximately Station 0+26 m of the ECRB Drift, excavation is accomplished by TBM. The TBM is an electric-powered continuous mechanical mining or excavation machine which consists primarily of a cutting head, shielding, grippers, and several cars of trailing gear—which may accommodate the TBM operating systems. As discussed in Reference 14.11, the ECRB Drift TBM is sufficiently similar to the TBM used to excavate the ESF TS Loop so as to be bounded by the TBM activity description in Reference 14.1, with two exceptions. First, the ECRB Drift TBM has a 5-m diameter cutterhead. Second, the ECRB Drift TBM is equipped with a water spray system for controlling dust. The water spray system will be operated at different flow rates during Phase I excavation with the intention of determining an optimum flow rate which maximizes water recovery and removal with tunnel muck via the conveyor belt.

6.2.2 Ground Support, Invert, and Rails

Ground support techniques used in the ECRB Drift are sufficiently similar to those used in the ESF TS Loop so as to be completely bounded by the activity description in Reference 14.1. However, the inverts and rail line for the ECRB Drift differ from the ESF TS Loop configuration. As discussed in Reference 14.11, the ECRB Drift rail line is laid on beveled cross ties (with no ballast material) on the excavated invert of the drift.

6.2.3 Dust Suppression

Reference 14.12 identifies various dust control techniques to be implemented behind the TBM cutterhead in Phase I of the ECRB Drift. A dust fogger system will be used throughout the ECRB Drift in areas where dust is typically generated (e.g., conveyor transfer points and rock/borehole drilling stations). A surfactant material will also be used/tested in a limited segment of the ECRB Drift. A binding agent may also be applied to muck that is on the conveyor.

A dust fogger system will inject pressurized water through a configuration of sprayer heads with tiny nozzle orifices. The system will minimize the amount of water used for dust suppression and increase the effectiveness of the water to capture airborne dust particles due to atomization of the water (i.e., it creates a very fine mist with a slight electrical charge).

The surfactant material will be applied via injection into the water of the dust fogger system. The purpose of a surfactant is to increase dust suppression effectiveness while reducing the amount of water required for the control of airborne dust. The ECRB Drift surfactant material is specifically formulated for use in this application (Reference 14.13). The ECRB Drift surfactant has a relatively low organic material content for surfactant materials, and will be injected into the dust fogger system at a low concentration level (Reference 14.14).

As the conveyor belt carries muck out of the ECRB Drift, water that has been applied to the muck evaporates and may increase the potential for dust generation associated with conveyor operation. To minimize the potential for dust generation associated with the conveyor belt, a system for applying a binding agent to the muck may be added to the water system used to control dust on the conveyor belt. The application of a binding agent is restricted to the top of the conveyor belt and only when the conveyor is in operation.

Due to the potential for committed quantities of TFMs—including dust suppressant-related TFMs—to impact site characterization data and waste isolation characteristics, various methods for recovering both water and surfactant may be implemented. The types of recovery methods are similar to the spill recovery and excess water removal activities used in other ESF alcoves described in Reference 14.1.

6.3 ECRB DRIFT UTILITIES

As discussed in Reference 14.15, utilities for Phase I of the ECRB Drift include power distribution, electrical grounding, communications, lighting, ventilation, water supply (i.e., non-potable water traced with Lithium Bromide [LiBr])[1], wastewater, fire protection, compressed air, muck conveyor belt, and material handling/personnel transport systems. While sizes of ECRB Drift pipes, cables, etc., may vary slightly, these utilities are comparable to those of the ESF TS Loop. As such, the individual attributes and activities associated with the ESF TS Loop utilities, as described in Reference 14.1, conservatively bound those of the ECRB Drift utilities. Any constructor-supplied utilities are also bound by all requirements of this DIE and the applicable design specification.

6.4 ECRB DRIFT PHASE I TESTING

As discussed in References 14.16 through 14.22, the following testing activities will be conducted in Phase I of the ECRB Drift. Additional testing activities are scheduled for the remainder of the ECRB Drift and will be described and evaluated in the DIE for Phase II of the ECRB Drift.

Generally, testing activities conducted within the Phase I portion of the ECRB Drift consist of dry drilling (using rock bolt drills), dry coring, air monitoring, and bulk rock sampling techniques. These general testing activities are described in further detail in References 14.16 through 14.22. Other tests associated with Phase I of the ECRB Drift will be conducted in the ECRB Starter Tunnel and in the ESF TS Loop and have been described and evaluated in References 14.1, 14.10, and 14.18. The following sections provide a general description of ECRB Drift Phase I testing activities.

6.4.1 Moisture Flux Studies

The two major emphases of moisture flux studies in Phase I of the ECRB Drift are hydrologic testing and hazardous mineral (i.e., minerals having the potential to adversely impact waste isolation capabilities) assessment. These tests also generate data to be used in confirming the evaluation of water and organic material loss that will be included in Revision 01 (i.e., Phase II) of this DIE. The general activities associated with moisture flux studies are described in

[1]Note: Chlorinated potable water that does not contain LiBr tracer is used for drinking and hand wash stations in the ECRB Drift. Ice made from untraced chlorinated potable water may also be used in drinking water coolers underground.

References 14.17 and 14.18 (Section 6.10). The following specific ECRB Drift Phase I testing activities are subject to the requirements of Reference 14.17.

1. After TBM operation has commenced, a single approximately 1.5-inch diameter by 2-m deep dry-drilled hole using one of the TBM mounted rock drills will be drilled about every 25 m of excavation of the ECRB Drift. These boreholes are drilled into the left rib of the drift at a height accessible from the invert. An instrument package (heat dissipation probe) will be placed into each of these boreholes by the PI as quickly as practical after the cutterhead exposes the rock matrix.

2. After TBM operation has commenced, a single HQ-sized by about 2-m deep dry-drilled/cored borehole will be drilled at approximately 50-m intervals of the drift excavation. These boreholes are drilled/cored into the left rib of the drift at a height accessible from the invert using a core rig mounted in the work area of the TBM. Neutron logging will be conducted in these boreholes at predetermined time intervals.

3. After TBM operation has commenced, a single HQ-sized by about 6-m deep dry-drilled/cored borehole will be drilled at approximately Station 5+00 m of the Phase I ECRB Drift excavation. This borehole is also drilled/cored into the left rib of the drift at a height accessible from the invert using a core rig mounted on the mapping gantry. Neutron logging will be conducted in these boreholes at predetermined time intervals.

4. Beginning at approximately Station 1+26 m, an approximate 50-m test area has been established in which the constructor uses water at an application rate that is calculated based on both machine optimization and dust abatement requirements. In this test area, three HQ-sized boreholes will be dry drilled/cored in an array from a core rig mounted on a flat car. These boreholes are arranged such that one borehole is drilled/cored in each of the following configurations: (1) approximately 2 m deep into the left rib below springline, (2) approximately 6 m deep into the left rib above the invert, and (3) 10 m deep into the bottom of the invert. These boreholes will be drilled/cored immediately after the TBM trailing gear has passed. About one week later, a 15-m HQ-sized dry-drilled/cored borehole will be drilled/cored into the bottom of the invert in the same array. Cores will be collected, and neutron logging will be conducted in these boreholes at predetermined time intervals.

5. Beginning at approximately Station 1+76 m, an approximate 5-m test area has been established in which the constructor uses an approved organic surfactant during TBM operations. In this "test area," three HQ-sized boreholes will be dry drilled/cored in an array from a core rig mounted on a flat car. These boreholes are arranged such that one borehole is drilled/cored in each of the following configurations: (1) approximately 2 m deep into the left rib below springline, (2) approximately 6 m deep into the left rib above the invert, and (3) 10 m deep into the bottom of the invert. These boreholes will be drilled/cored immediately after the TBM trailing gear has passed. About one week later, a single 15-mr HQ-sized dry-drilled/cored borehole will be drilled/cored into the bottom

of the invert in the same array. Cores will be collected, and neutron logging will be conducted in these boreholes at predetermined time intervals.

6. Throughout ECRB Drift construction activities, construction support will be requested by the TCO to install simple hangers for testing instrumentation including temperature, humidity, and air monitoring stations. Periodically, the TCO may request that the conveyor belt be stopped temporarily to collect muck samples.

6.4.2 Perched Water Testing

Should perched water be encountered in the ECRB Drift, it is tested as required by Reference 14.19. The general activities associated with perched water testing are described in Section 6.3 of Reference 14.18.

6.4.3 Consolidated Sampling

Consolidated sampling is a general testing activity that is conducted throughout the subsurface ESF. The typical activities associated with consolidated sampling are described in Section 6.2 of Reference 14.18. ECRB Drift consolidated sampling activities will be conducted as required by Reference 14.20.

6.4.4 Construction Monitoring

Construction monitoring is another group of general testing activities that is implemented throughout the subsurface ESF. These testing activities are controlled by the requirements of Reference 14.21 and are described in Section 6.9 of Reference 14.18.

6.4.5 Geologic Mapping

Geologic mapping is to be performed in Phase I of the ECRB Drift. Typical geologic mapping activities are described in Section 6.1 of Reference 14.18 and are conducted as required by Reference 14.22.

6.5 TFM USAGE

TFM usage has been discussed in the text of Sections 6.1 through 6.4, as appropriate. For TFMs which were not specifically/individually discussed in Sections 6.1 through 6.4 of Reference 14.1 and 14.18 have previously evaluated an extensive list of TFMs that are approved for use in the subsurface ESF. Attachment II contains a comprehensive list of TFMs (i.e., a list of TFMs that have been either previously evaluated by Reference 14.1 or specifically evaluated by subsequent sections of this DIE), which are approved for use in ECRB-Drift-related activities evaluated in this DIE. However, Attachment II TFMs are approved for use in ECRB Drift activities, provided their use and quantities are consistent with the restrictions established in Section 13.3 of this DIE.

As stated in Assumption 4.3, the use of TFMs is controlled by the requirements of the TFM procedure (Reference 14.6). The use of any TFM within the subsurface ESF, which is not listed in Attachment II, is evaluated as required by Reference 14.6 prior to its use. However, only those TFMs that are permanently committed within the subsurface ESF are required to be reported as required by Reference 14.6.

7.0 DESIGN EVENTS

The following events and activities were considered for potential evaluations: earthquake, rockfall, use of and inadvertent spills of oil or other fluids from construction equipment, fires, explosions, ground water inflow, TBM operation, conveyor operation, ground support installation, rail haulage (including use of locomotives), use of water and compressed air, and drill-and-blast operations. These events and activities, which include the use of the temporary items, are evaluated in accordance with NLP-2-0.

Fire and explosions are evaluated with regard to potential impacts. Disruption of other items as a result of earthquakes, fires, and explosions are not specifically evaluated in this DIE; however, deterministic failure of systems and components is used to assess the potential impacts on site characterization activities and waste isolation.

This DIE evaluates potential spills of quantities of fluids of concern (other than water), which could be released in a credible equipment or vehicle accident or failure, and determines their potential to impact site characterization testing activities and waste isolation. An example of such credible accidents or failures is the rupture of an oil tank or fuel tank on a locomotive.

8.0 AFFECTED Q-LIST ITEMS

8.1 REPOSITORY INTERFACES

8.1.1 Proximity to Repository

As discussed in Reference 14.7, the ECRB Drift construction begins with breakout in the left rib at about Station 19+92 m and at approximate elevation 1082 m along the ESF North Ramp (Reference 14.7). The ECRB Starter Tunnel trends southwestward (at an approximate centerline azimuth of 254 degrees) to approximately Station 0+26 m. From Station 0+26 m, the TBM excavates along the same approximate 254-degree centerline azimuth to about Station 1+82 m. The drift then turns to an approximate centerline azimuth of 229 degrees and continues to approximately Station 7+73 m, a point just prior to crossing over the TS Main Drift.

After crossing the TS Main Drift, the ECRB Drift excavation continues at approximately 15 m to 20 m above the potential waste emplacement zone of the repository block (Reference 14.8). At approximately Station 23+20 m of the ECRB Drift, the TBM begins a turn to the right and at approximately Station 26+40 m, it reaches an approximate centerline azimuth of 289 degrees (Reference 14.7). Excavation continues on this heading until the ECRB Drift termination point of approximately Station 28+23 m. The terminus of the ECRB Drift is approximately 50 m west of the western most strand of the Solitario Canyon fault (Reference 14.9). A discussion of the hydrologic and geologic conditions (i.e., of the potential repository's natural barrier) that are encountered by the ECRB Drift is included in Section 9.0 of this DIE, including elevations and locations.

8.1.2 Proximity to Planned and Existing Boreholes

Reference 14.23 lists existing and planned boreholes in the vicinity of the ECRB Drift. Surface-based testing (SBT) site characterization activities range from surface geologic mapping and sampling to the drilling and instrumentation of boreholes at water-table and greater depths. SBT activities with potential sensitivity to the underground construction and/or testing activities conducted in the ECRB Drift are: (1) tests conducted in proximity to the hydrogeologic unit penetrated by the TBM and (2) tests sensitive to mechanical vibration, mechanical stress, and/or the electromagnetic fields created by electrical equipment used in the ECRB Drift. An evaluation of potential impacts on site characterization testing (including SBT) is included in Section 10.0 of this DIE.

8.1.3 Planned and In-Process Tests

Approximately fifty tests are or have been planned for the ECRB Drift. Five FWPs (References 14.17 and 14.19 through 14.22) describe these testing activities in greater detail. However, further tests could be required in the future, such as in response to the requirements of regulatory agencies or to changing programmatic requirements. Thus, a conservative approach, in which reasonable efforts are taken to minimize changing the general characteristics of the ECRB Drift and surrounding rock is advantageous. The M&O TCO has examined the testing requirements for each test in the five FWPs previously discussed and has identified potential construction constraints.

8.2 POTENTIALLY AFFECTED Q-LIST ITEMS

The proposed activities will affect the Topopah Spring welded, lithophysae-rich (TSw1) and Topopah Spring welded, lithophysae-poor (TSw2) hydrogeologic units. Additional underlying hydrogeologic units may also be affected, depending on the quantity and behavior of the applied construction water and TFMs. The Topopah Spring welded (TSw) hydrogeologic units are on the Q-List (Reference 14.3). In addition, the engineered items on the Q-List that may be affected include the Underground Excavations, the Waste Ramp or the Tuff Ramp, and the Seals. The planned excavation activities may affect permanent items including ground support and underground openings.

9.0 EXPECTED CONDITIONS

The ECRB Drift excavation is entirely in the unsaturated zone, beginning from the left rib of the ESF North Ramp at approximately Station 19+92 m at an elevation of about 1082 m, crossing (at an elevation of about 1093 m) approximately above Station 30+61 m of the TS Main Drift, proceeding through the potential repository block (above the potential waste emplacement zone) to an elevation of about 1114 m, and ending at an elevation of about 1103 m at approximately Station 28+23 m of the ECRB Drift (Reference 14.7). The water table under the portion of the ECRB Drift that is east of the TS Main Drift is nearly flat and lies at an elevation of approximately 730 m (References 14.24 and 14.25). To the west of the TS Main Drift, the water table rises from approximately 730 m to about 770 m at the termination point of the ECRB Drift (References 14.24 and 14.25). Therefore, the water table lies approximately 352 m below the ECRB Starter Tunnel and approximately 333 m below the western end of the ECRB Drift.

9.1 SIGNIFICANT GEOLOGIC FEATURES

The ESF TS Loop excavation is discussed in References 14.26 through 14.30 relative to the major geologic strata in terms of both the revised lithostratigraphic nomenclature and the thermal/mechanical (TM) nomenclature for the rock units used in the three-dimensional site model by the United States Geologic Survey (USGS). The lithostratigraphic units along the ECRB Drift will be the same as encountered by the TS Loop and an accurate geologic cross section can be produced using the extensive geologic information obtained during the TS Loop construction. The lithostratigraphic units along the TS Loop include three groups (in descending order): the Timber Mountain Group; the Paintbrush Group, which includes five ash flow tuffs separated by bedded tuffs; and the Crater Flat Group. The ECRB Drift excavation begins within the Topopah Spring Tuff upper lithophysal (Tptpul) of the Paintbrush Group and ends within this same unit (west of the Solitario Canyon fault) after crossing through the crystal-poor, middle nonlithophysal (Tptpmn), crystal-poor, lower lithophysal (Tptpll), and the crystal-poor, lower nonlithophysal (Tptpln).

Yucca Mountain Lithostratigraphy:

The Timber Mountain Group is comprised of the Rainier Mesa Tuff (**Tmr**) and pre-Rainier Mesa Tuff bedded tuff (**Tmbt1**) within the TS Loop.

In order of descending stratigraphy, the Paintbrush Group includes:

Tuff Unit "X" (**Tpki**)

Pre-Tuff Unit "X" bedded tuff (**Tpbt5**)

Tiva Canyon Tuff (which is broken into three units: crystal-rich—**Tpcrv**; undifferentiated, devitrified—**Tpcun**; and crystal-poor, vitric, nonwelded—**Tpcpv**)

Pre-Tiva Canyon Tuff bedded tuff (**Tpbt4**)

Yucca Mountain Tuff (**Tpy**)

Pre-Yucca Mountain Tuff bedded tuff (**Tpbt3**)

Pah Canyon Tuff (**Tpp**)

Pre-Pah Canyon Tuff bedded tuff (**Tpbt2**)

Topopah Spring Tuff (which is broken into eight units: crystal-rich, vitric, non- to moderately welded—**Tptrv**; crystal-rich, devitrified, nonlithophysal—**Tptrn**; crystal-poor, upper lithophysal—**Tptpul**; crystal-poor, middle nonlithophysal—**Tptpmn**; crystal-poor, lower lithophysal—**Tptpll**; crystal-poor, lower nonlithophysal—**Tptpln**; crystal-poor, densely-welded subzone—**Tptpv3**; and crystal-poor, vitric, non- to moderately-welded—**Tptpv1** and **Tptpv2**),

Pre-Topopah Spring Tuff bedded tuff (**Tpbt1**).

In order of descending stratigraphy, the Crater Flat Group consists of the Calico Hills Formation (**Tac**) and the Prow Pass Tuff (**Tcp**), both of which contain basal bedded tuffs.

The lithostratigraphic units are grouped into TM units by the USGS, which are summarized in Reference 14.26. Because the TM units are based on properties which result from processes in addition to petrogenesis, the boundaries of these units do not correspond directly to formational boundaries but do, in general, correspond to rock unit boundaries. In order of descending stratigraphy the TM units are:

Undifferentiated overburden (**UO**) that includes the Tmr, Tmbt1, Tpki, Tpbt5, and Tpcrv;

Tiva Canyon welded unit (**TCw**) that is equivalent to the Tpcun;

Upper Paintbrush nonwelded unit (**PTn**) comprised of the Tpcpv, Tpbt4, Tpy, Tpbt3, Tpp, Tpbt2, and Tptrv;

Topopah Spring welded, lithophysae-rich unit (**TSw1**) that includes the Tptrn and Tptpul;

Topopah Spring welded, lithophysae-poor unit (**TSw2**) that includes the Tptpmn, Tptpll, and Tptpln;

Topopah Spring welded, vitrophyre (**TSw3**) that is equivalent to the Tptpv3; and

Lower Topopah Spring non-welded unit and Calico Hills Tuff non-welded (**CHn**) that is comprised of the Tptpv1, Tptpv2, Tpbt1, Tac, and Tcp.

9.2 SIGNIFICANT HYDROLOGIC FEATURES

The TM units are closely related to the hydrogeologic units and the designators used here to refer to the hydrogeologic units are taken to refer to the corresponding TM units: TCw – Tiva Canyon welded, PTn – Paintbrush nonwelded, TSw (1,2,3) – Topopah Spring welded, and CHn – Calico

Hills nonwelded. Because information concerning the thickness and extent of the basal Tiva Canyon units (Tpcpv and Tpbt4) and the Topopah Spring caprock (Tptrv) zones is not available in all cases, the PTn hydrogeologic unit (for this evaluation) consists of the Yucca Mountain and Pah Canyon members of the Paintbrush Tuff (Tpy, Tpbt3, Tpp, and Tpbt2), at a minimum.

The distances to geologic and hydrologic features along the ECRB Drift (as measured along the tunnel excavation) and the minimum distance from each geologic and hydrologic feature to potential waste emplacement areas (i.e., the minimum offsets from potential waste emplacement areas) are given in Table 9.1 (References 14.31, and 14.25). The spatial relation between the ECRB Drift and the current conceptual design of the potential repository is extrapolated from Reference 14.25 and the latest design drawings available for the locations of potential expansion area emplacement drifts (Reference 14.31). The ECRB Drift will be kept a minimum of 15 m to 20 m from potential waste emplacement zones within the primary emplacement area. Potential expansion areas (References 14.31 and 14.25) that may be used as part of the potential repository lie beneath the Phase I section of the ECRB Drift (0 – 476 m) east of the Ghost Dance fault. The closest potential waste emplacement zone under the Phase I section of the ECRB Drift is assumed to be the contact between the upper lithophysal (Tptpul), and the middle nonlithophysal (Tptpmn) zones of the Topopah Spring Formation, which constitutes the TSw1 - TSw2 contact (Reference 14.25). This contact represents approximately the uppermost boundary of potential waste emplacement expansion areas beneath the Phase I section of the ECRB Drift.

Table 9.1 Geologic and Hydrologic Features along the ECRB Drift

Geologic/Hydrologic (G/H) Feature	Location of G/H Feature along ECRB Drift (m)	Minimum Distance from G/H Feature to Potential Waste Emplacement Area[2] (m)
Phase I ECRB Drift		
TSw1	0 - 773	~37
Drill Hole Wash faults	67 - 146	60
Ghost Dance fault	536 - 542	60
TS Main Drift		
TSw1	773 - 1036	15-20
TSw2	1036 - 2540	15-20
Solitario Canyon fault splays	2540 - 2552	60
TSw1	2552 - 2674	- 62
TSw2	2674 - 2753	- 147
Solitario Canyon fault	2753 - 2758	- 221
TSw1	2758 - 2815	- 226

[2] Note: Approximated by determining "straight-line" distance to closest waste package using a right triangle.

9.3 FRACTURE CONDITIONS

During excavation, a number of geologic faults and fault systems will be encountered in the ECRB Drift (see References 14.27 through 14.30). The following discussion is summarized from the geologic information obtained during the excavation of the TS Loop of the ESF and covers both these encountered conditions and the features of the Solitario Canyon faults which, although not encountered in the TS Loop excavations, are being studied from the site surface.

9.3.1 Drill Hole Wash Fault

The Drill Hole Wash fault is comprised of two distinct faults encountered at Stations 19+01 m and 19+43 m from the North Portal along the TS Loop, with a strike of 316 and 150 degrees, respectively. Both faults dip steeply to the west. Approximately 4 m of normal movement (i.e., vertical offset) has been measured along this fault, with an indeterminate amount of associated lateral movement. The fault system is expected to be encountered during Phase I of the ECRB Drift between 67 m and 146 m from the start of the ECRB Drift.

9.3.2 Ghost Dance Fault

The Ghost Dance fault was encountered at Station 57+30 m along the TS Loop and in Alcove #6. The Ghost Dance fault is a normal fault that crosses the TS Main Drift at Station 57+30 m. It has a strike of approximately 205 degrees and about 1.2 m of offset downward to the west. The fault zone consists of a clast-supported breccia with angular to subangular clasts of Tptpmn and Tptpll ranging from less than 0.5 centimeters (cm) to 15 cm. Both the hanging wall and the footwall are moderately to intensely fractured with the fracture zones extending away from the fault. The fault system is expected to be encountered during Phase I of the ECRB Drift between 536 m to 542 m from the start of the ECRB Drift.

9.3.3 Solitario Canyon Fault System

The Solitario Canyon fault system was not encountered during the TS Loop excavation of the ESF. Information concerning the Solitario Canyon fault and associated splays has been complied by surface geologic mapping and trench studies. The Solitario Canyon fault system is generally a north-south trending westward dipping fault with associated splays. Greater than 10 m of offset is predicted for the main fault within Solitario Canyon. Two splays of the fault system are expected to be encountered during excavation of the ECRB Drift between Stations 25+40 m and 25+52 m and between Stations 27+53 m and 27+58 m of the ECRB Drift. This fault system will be encountered during the excavation of the Phase II section of the ECRB Drift.

9.3.4 Fault Fracture Densities

Fracture densities are generally higher in the vicinity of these faults and fault systems. As such, these fault systems have the potential to act as faster pathways for fluid flow, perhaps providing test access to the water table. Fracture densities expected for the hydrogeologic units discussed previously are given in Reference 14.32 as 10 to 20 fractures/cubic meter (m^3) for the TCw, 1 fracture/m^3 for the PTn, 8 to 40 fractures/m^3 for the TSw, and 2 to 3 fractures/m^3 for the CHn.

9.4 HYDROGEOLOGIC, GEOCHEMICAL, AND GEOMECHANICAL CHARACTERISTICS

Beneath the ECRB Drift excavation, the water table is relatively flat on the east side of the TS Main Drift, with an increase in gradient to the west of the TS Main Drift. It lies primarily in the CHn hydrogeologic unit (References 14.24 and 14.33). The groundwater table lies in the TSw3 formation west of the Bow Ridge fault and in the CHn east of the Bow Ridge fault (Reference 14.33). The saturated groundwater flow in this area is inferred to be in a southeasterly direction from the conceptual repository (Reference 14.33).

Water entering the TSw hydrogeologic units along the ECRB Drift may result in water movement through fractures, matrix, or some combination of the two paths (Reference 14.34). The degree to which water movement in fractures is attenuated by capillary imbibition into the matrix is poorly understood at present. Although it is possible to identify qualitatively the potential impacts from perturbations to the geochemical characteristics of the Yucca Mountain site, in many cases the data to quantify each causal link along the path to radionuclide release are not available. For example, dissolved organic carbon (DOC) may be a food source for microbes which may then cause changes in water chemistry that may enhance corrosion of the waste package or radionuclide solubility/transport. Because the quantitative data are not available for these relational links, it is not currently possible to evaluate the potential TFM impacts at the level of consequence to radionuclide releases. Therefore, surrogate performance measures have been adopted as the criteria for indicating that an item/activity may impact waste isolation.

In general, such surrogate criteria are based on the idea that potential local perturbations to ambient site conditions that are below the level of the natural system variability would be indistinguishable from the ambient system. For cases in which site data are not available to quantify the ambient system variations, the variability of aqueous geochemical parameters across the site is assumed to be at least 10 percent of ambient conditions. One example of such a surrogate criterion is the 10-percent increase in background aqueous nitrate concentrations used as the limit for local perturbations to the nitrogen system. This type of evaluation produces recommended limitations based on the local perturbations to the geochemistry at the closest waste package—if changes were expected across the entire conceptual repository, then these types of surrogate criteria would not be appropriate. As such, these evaluations produce recommended limits to keep local geochemical perturbations within the noise of the ambient geochemistry, with any farther-reaching changes kept commensurately smaller (this would not be applicable if the 10-percent change occurred over a large portion of the site).

The average concentrations, in parts per million (ppm), and standard deviation of measurements (References 14.35 and 14.36) for five constituents of unsaturated zone fluids are shown in Table 9.2.

Table 9.2. Unsaturated Zone Dissolved Ion Concentrations: Sample Average, Sample Standard Deviation, and Percent Uncertainty

Ion	Average Concentration[3] (ppm)	Sample Standard Deviation[3] (ppm)	Standard Deviation (Percent of Average)
$SO_4^{=}$	92	53	58
Cl^-	70	25	36
Ca^{2+}	60	30	50
Mg^{2+}	11	4.7	43
Na^+	45	15	33

Although data are limited for dissolved constituent concentrations in unsaturated zone water, the available data indicate that a 10-percent perturbation of the average ambient value is limited to about one-third to one-sixth of the actual sample standard deviation for the dissolved constituents shown in Table 9.2. The assumption that using a 10-percent perturbation of the average ambient value is, in general, a conservative criterion for being within the noise of the natural system. In addition, as pointed out by Yang et al. (References 14.35 and 14.36), the analytical uncertainties for values of the concentrations in the unsaturated zone waters are ±5 percent in general and ±10 percent for sulfate. Based on these data, the assumption that local perturbations to the ambient geochemistry of 10 percent or less cannot be differentiated from the natural system variation is considered to be very conservative.

10.0 IMPACT ON SITE CHARACTERIZATION TESTING

10.1 INTRODUCTION

The ECRB Drift is designed as an underground facility for conducting tests and collecting scientific and engineering data to be used for:

1. Assessing the suitability of the Yucca Mountain site for the disposal of radioactive waste, and

2. Providing design information for construction of the potential repository.

Site characterization activities are planned along the ECRB Drift and in associated testing alcoves and niches where most of the long-term testing activities will be conducted. The scope of the long-term testing activities has not yet been fully developed, and they will be evaluated in future DIEs. Geologic sampling, hydrologic sampling, and geologic mapping will be conducted in the ECRB Drift behind the TBM. ECRB-Drift-specific design specifications and drawings

[3] Note: Values calculated from data given in Yang, et al. (References 14.36 and 14.37).

describe the systems, subsystems, and components required to meet the needs of the underground site characterization testing program during construction, maintenance, and testing activities. Simultaneously, SBT activities will be on-going in the Conceptual Controlled Area Boundary.

10.2 TESTING ACTIVITIES POTENTIALLY IMPACTED

10.2.1 Thermal Testing Facility Testing

The TTF (Alcove #5) is the current ESF testing facility nearest to the ECRB Drift. As discussed in Reference 14.9, the minimum offset distance between the TTF and the ECRB Drift has been established as 50 m. Reference 14.9 also established a maximum offset distance of 100 m to facilitate possible borehole drilling between the two facilities. Compliance with these restraints will not incur any construction-to-test or test-to-test interference.

10.2.2 Moisture Flux Studies

Within the TS Main Drift, there are several ongoing moisture flux studies. The nearest moisture flux testing sites are located in the TS Main Drift near the crossover point of the ECRB Drift. These testing sites are located at approximately Station 28+30 m (LB50) and Station 35+00 m (LB40) of the TS Main Drift. Within this same interval of the TS Main Drift, located at approximately Station 29+00 m, is an anemometer mounted in the upper quarter of the right rib. No construction-to-test or test-to-test interference with these tests and measurements, associated with the construction of or testing activities in the ECRB Drift, is anticipated due to the distance separating these moisture flux testing locations and the ECRB Drift crossover location.

10.2.3 Surface-Based Testing Boreholes

As discussed in Reference 14.23, SBT boreholes (with their approximate Nevada State Plane coordinates) that are located within 500 m of the entire ECRB Drift track include: hydrologic test borehole, USW H-5 (766634N, 558909E); geologic exploratory borehole, UE-25 a#4 (767972N, 564472E); north ramp geologic borehole, UE-25 NRG-5 (767890N, 564770E); north ramp geologic borehole, USW NRG-7 (768804N, 571172E); north ramp geologic borehole, USW NRG-7a (768768N, 570269E) and geologic borehole, USW SD-9 (767999N, 561818E). Of these, SD-9, NRG-5, NRG-7, NRG-7a, and a#4 have been evaluated for their proximity to the ESF North Ramp and TS Main Drift. Borehole H-5 lies approximately 500 m northwest of the ECRB Drift track. Due to the offset distance between the testing activities being conducted in these boreholes and the ECRB Drift, no construction-to-test interference is anticipated. With respect to test-to-test interference, potential impacts to SBT are taken into consideration in each applicable FWP as tests are planned. Further, the TCO ensures that FWPs—for new testing activities such as those in the ECRB Drift—are reviewed by PIs responsible for concurrent testing activities in SBT boreholes, which could potentially be impacted by these new testing activities. No other interferences with SBT activities in the area have been identified. Future borehole drilling in the vicinity of the ECRB Drift is dependent on funding from DOE and cannot be accurately predicted at this time. Should any future surface drilling be planned, test interference due to the proximity of the ECRB Drift will be addressed in the evaluation for the specific FWP (or equivalent documentation) for those boreholes.

10.3 WATER TABLE

The ECRB Drift varies between approximately 333 m and 352 m above the water table (Section 9). Negligible test interference from construction is expected to SBT tests planned in the saturated zone because of the distance of separation. In addition, existing liquid tracers used during the construction of Phase I of the ECRB Drift could be detected in saturated zone water if it was affected by significant amounts of construction water. While it is considered to be unlikely, the surfactant material used in Phase I of the ECRB Drift could also potentially be detected in the saturated zone water if significant amounts of construction water containing the surfactant material are lost to the geologic environment.

10.4 UNDERGROUND CONSTRUCTION

The excavation of the ECRB Drift by the TBM will occur concurrently with the installation and operation of the required construction utilities and TBM support accommodations. Other underground construction activities in the ECRB Drift area may include drill-and-blast or mechanical excavation of operation and test support areas. Excavation effects on rock properties are taken into consideration by the responsible PI when tests are fielded via integration into FWPs.

Operation of the ECRB Drift TBM provides the means for access for underground testing. The testing concerns with regard to the potential for TBM operational spills and leaks are presented in Section 10.7.2. There is no anticipated interference to testing from TBM operations.

Tests within the TBM envelope are those that occur along the ECRB Drift, generally immediately after the TBM passes. Most of these activities are not sensitive to continued TBM operation, but they require that access be accommodated by the construction operations—within the limits that safety concerns allow. The following planned tests in the ECRB Drift have been prioritized to develop an integrated construction and testing schedule. The TCO should coordinate access needs with the Construction Management Organization (CMO). These tests will utilize a dry-drilling process using rock bolt drills, dry coring, air monitoring, and bulk rock sampling techniques.

<u>Moisture Flux Studies</u>

Moisture flux studies planned for the ECRB Drift are described in Section 6.4. These activities should be conducted as soon as practical after the TBM passes. Instrumentation in support of these tests may be placed inside or outside of boreholes that were specifically drilled for moisture flux studies or boreholes that are not being used for other testing activities (Reference 14.17).

To facilitate the flow of information for moisture flux testing in Phase I of the ECRB Drift, water use information, that is compiled by the Constructor, should be reviewed by the TCO and then submitted to the SA Department. This will ensure that the PIs have access to the most complete set of water use data. Accurate water use data are critical to ensure a valid PI interpretation of ECRB Drift Phase I moisture flux studies data (i.e., data on the amount of water actually committed to the site during excavation activities). These data will ultimately be used to validate assumptions in Phase II (i.e., Revision 01) of this DIE, which is required prior to TBM advance beyond ECRB Drift Station 7+73 m.

Perched Water Testing in the ECRB Drift

Should perched water be encountered, it should be sampled and examined as soon as practical after being encountered. The CMO should notify the TCO when perched water is encountered to facilitate sampling. When perched water is detected (as indicated by flowing water), the TCO, in conjunction with the PI and the CMO, will decide whether excavation operations should be suspended to facilitate more complete testing and sampling. Small-flow perched water zones may only require that water samples be collected along with an estimate of the flow rate and total volume of water produced. Access may be needed for long-term sampling and monitoring of perched water zones, which will continue until the nature of a perched water zone is determined and all test-related quality-affecting activities are completed (Reference 14.19).

Consolidated Sampling

Access is needed to locations identified as deferred sample collection areas during geologic mapping or other testing activities. Some samples, such as gels, may need to be collected as soon as practical after they are detected in a new exposure. Such sample collections should occur prior to installation of ground support and wall washing. No water or tracer, other than the traced construction water and air-misted water used for cleaning the tunnel wall, should be used in the immediate vicinity of a sampling location without the approval of the PI. At the present time, LiBr is the only approved tracer to be used in construction and cleaning water in subsurface ESF activities. The use of TFMs, especially during construction, in the proximity of the sampling location should be documented (Reference 14.20).

Construction Monitoring

Access is required to allow for the drilling of boreholes and installation of instrumentation to accommodate construction monitoring. The field activities and the requirements for borehole locations, drilling and coring, instrument installation, data collection, and reporting are described in Reference 14.21. No test interference impacts attributable to construction monitoring activities have been identified. The use of TFMs, especially TFM use associated with construction activities, in the proximity of a sampling location should be documented (Reference 14.21).

Geologic Mapping Associated with TBM Operations

Geologic mapping is a subsurface ESF site characterization activity that may conflict with the installation of required ground support. The ECRB Drift crown and ribs require the installation of rockbolts for stability. Where necessary, straps, ring beams, steel lagging, steel sets, wire mesh, interlocking wire mesh, shotcrete, and/or full concrete lining may also be installed. Because geologic mapping is a photographic and observational activity, which is best performed as soon as practical following excavation, immediate installation of ground support could obscure geological details. As such, ground support installation should be performed, to the extent practical, after geologic mapping has been completed (Reference 14.22). Thus, for normal mapping operations, nothing more than pattern bolting and, if necessary for safety concerns, approximately 15.2-cm square or greater wire mesh should be used. If additional ground control (such as steel rings, lagging, mesh less than 15.2-cm square, and/or shotcrete) is necessary due to poor ground conditions, the TCO and the mapping PI will confer with the CMO to identify if the needed ground support can be installed in a manner that allows the collection of geologic data to the extent practicable (Reference 14.37).

Water used to clean the tunnel and alcove walls for geologic mapping should be traced with a LiBr tracer and an air/water mixture should be used to minimize water loss. Only an air/water spray will be used for cleaning excavated ECRB-Drift-related tunnel walls.

10.5 OPERATION AND TEST SUPPORT AREA EXCAVATION

The ECRB Drift is a test support area (with respect to the overall ESF). No other alcoves and niches are to be excavated during Phase I of the ECRB Drift (Reference 14.38). Any alcoves or niches planned within the ECRB Drift will require evaluation by the SA Department in Phase II of this DIE.

10.5.1 Mucking of Broken Rock

Diesel-fueled equipment may be used to remove muck from the excavated areas of the ECRB Starter Tunnel or other locations within the ECRB Drift, as required (see Section 10.6.6 and Section 6.9 of Reference 14.1). Use of hydrocarbons, such as lubricants, engine oil, and coolants for this equipment should be controlled to the extent practical to prevent and mitigate releases to the subsurface environment. No test interference potential is expected from the use of operating fluids as long as they are not spilled or spills are cleaned up to the extent practical. Refueling, routine maintenance that involves lubricants, engine oil or coolants, and repair should be performed carefully to minimize the potential for spills. Spills should be reported in accordance with the TFM procedure (Reference 14.6).

10.5.2 Excavation Techniques

The ECRB Drift and the ECRB Starter Tunnel may be excavated by using a TBM, by using controlled drill-and-blast techniques (which are developed and modified as work progresses), or by using a road-header type, mechanical excavator. Blast monitoring, blast damage assessment, and blast residue require monitoring as part of the construction monitoring testing activities (Reference 14.21). For any drill-and-blast activities conducted as a part of ECRB Drift excavation, accurate records should be maintained of the time, location, type of explosive used, and size of each blast, and the records submitted to the appropriate project records system. These data may be of interest to PI(s) who may need to address the blasting in the tunnel in the analyses of their data. The blast records in conjunction with post-blast observations, if necessary, by the responsible PI(s), are sufficient to ensure that controlled drill-and-blast methods do not impact subsequent or in-process testing in an undetected or unpredictable way.

10.5.3 Ground Support Concerns

The installation of grouted rockbolts and the application of shotcrete have the potential to alter gas sample and hydrologic data and to obscure lithology and structures of interest to mapping activities. Therefore, grouted rockbolts and shotcrete should not be used in the ECRB Drift to avoid potential test interference, except as necessary to meet safety standards and/or as approved by the TCO. Split sets, other mechanical bolts, wire mesh, steel sets, or other materials (if approved in accordance with the TFM procedure) are acceptable for ground support. Prior to placing any shotcrete or other cementitious material in the alcoves for personnel safety, ground support, or other purposes, the field operator should coordinate through the TCO. The TCO will provide PI concurrence and special instructions (if any) to minimize testing impacts.

10.6 OTHER TEST INTERFERENCE CONCERNS

It is judged that the coordination between the CMO and the TCO will be sufficient to address access needs such as those identified in the following sections:

10.6.1 Fire Protection System

The use of fire suppressing agents (including water) should be treated as a spill and dealt with accordingly. Fire suppressing dry chemicals proposed for the fire extinguishing system are considered in terms of TFM parameters by this evaluation (see Attachment II). Quantities of all materials used should be reported in accordance with the TFM procedure (Reference 14.6). If additional fire suppression agents are selected for use, their potential impact on site characterization activities should be evaluated in accordance with Reference 14.6.

10.6.2 Subsurface Conveyor System

As discussed in Section 6.0, the conveyor system is equipped with a dust control and suppression system to contain the dust generated by the handling and conveying of muck. As part of this system, atomized water spray headers are installed at loading and transfer points. LiBr is added as a tracer to water used for dust control, as well as for other underground construction. Water volumes used for dust control should be measured (e.g., cumulating flow meters) and records should be maintained and recorded routinely, identifying the quantities. In addition, a surfactant material will be added to the dust suppression water between approximate Stations 1+76 m and

2+25 m of the Phase I portion of the ECRB Drift. A binding agent may also be added to water that is applied directly to the muck on the conveyor.

It is expected that the water used for conveyor system dust control will be applied directly to the muck on the conveyor belt and will be removed with the muck. The system designed for general dust control uses atomizing spray heads that minimize the amount of water introduced into the subsurface environment—thereby avoiding excessive water use. However, larger spray nozzles may be used to apply the water/binding agent mixture to the muck on the belt. Since most of the water used for dust control is expected to be removed with the muck, no construction-to-test or operation-to-test interference is anticipated as a result of this activity. Similarly, since nearly 100 percent of the binding agent is expected to be removed with the muck, no construction-to-test or operation-to-test interference is anticipated. Since the surfactant material is to be applied by an atomized spray system, an indeterminate amount of the surfactant material will not be captured in the muck and hence will not removed by the conveyor system. Some portion of the surfactant is expected to be captured and removed by the ventilation system. Some small, yet indeterminate, amount of the surfactant material is expected to remain after construction activities—with this residual amount of surfactant material being the focus of an ECRB Drift Phase I testing activity. Since the quantity of residual surfactant material and surfactant-testing data validity are dependent upon amount of surfactant material that is applied, a record of the amount of surfactant material used should be maintained. No other construction-to-test or operation-to-test interference associated with surfactant material use is anticipated.

10.6.3 Power Distribution System and Lighting

As discussed in Section 6.0 of Reference 14.1, conveyor and ventilation system components are electrically grounded at designed intervals. Potential test interference impacts may be created if the ground enhancing material contains chloride. The grounding enhancing material to be used should not contain chlorides, such as the coal-derivative GEM®.

Transformers, cabling, and other electrical equipment installed underground have the potential to influence test equipment as a result of electromagnetic interference (EMI). Therefore, the TCO ensures that, during the development of each FWP (as applicable), the responsible PIs coordinate with the Architect/Engineer (A/E) to survey the specific location where test equipment is located (as necessary) and determine whether additional electromagnetic protection is required. Due to this coordination effort, no test interference is expected to occur from installation and operation of the power distribution and lighting systems. The constructor may be required to install EMI shielding or other mitigation measures as part of the implementation of the FWP.

Uninterruptible power supply and emergency lighting systems may be used as long as spills (e.g., battery acid) are avoided. If spills occur, they must be cleaned up as soon as practical. The volumes and locations of any spills must be documented and reported in accordance with the TFM procedure (Reference 14.6).

10.6.4 Subsurface Water Distribution System

As discussed in Section 6.0, the water distribution system supplies traced, nonpotable water to the ECRB Drift. Spill and leak control measures are incorporated into the design to minimize or avoid the potential for test interference. No test interference due to the operation of the underground water distribution system is anticipated as long as leaks and spills are (1) avoided to the extent practical and (2) identified, mitigated, and cleaned up as soon as practical.

10.6.5 Ground Support and Rockbolt Grouting

As described in Sections 6.0 and 10.6.10 of Reference 14.1, steel sets, lagging, grout, shotcrete, mesh, steel straps, and/or rockbolts may be used for ground support. Boreholes for rockbolts, anchor-bolts, and other ground support bolts are drilled into the tunnel walls. Compressed air utilized for general construction drilling and construction does not contain tracer (Reference 14.39). It is preferred that these boreholes be drilled dry, although it is not required. If water usage is necessary for drilling, the amount of water should be kept to a minimum; water allowed to be lost to the subsurface environment should be minimized, and the water should be traced.

Rockbolts may be cement grouted in the ECRB Drift, however, this was not the general practice throughout the TS Loop (Reference 14.1). Cement grout poses a potential test interference due to possible alteration of the *in situ* pH of water/moisture in contact with the grout. Additionally, large volumes of grout could potentially migrate significant distances away from the ECRB Drift alignment if the grout is emplaced under pressure. Cement grouting pressures and quantities should be limited to the extent practical for that grouting associated with rockbolt installation. The potential distances, to which cement grout will penetrate into and through rock fractures and fault systems, is directly related to the grouting pressures and grout quantities used. Accordingly, rockbolts should not be grouted in the ECRB Drift, to the extent that safety concerns allow, without TCO approval. Because testing activities can potentially be moved to a location further away from an area where grout is required to be injected, if necessary, no test interference is anticipated as long as the TCO is consulted.

Mixing water for grout and pre-mixed (wet) shotcrete is not required to contain tracer for test interference purposes (Reference 14.39). Grout additives should not contain chloride to the extent practical to minimize the potential of affecting chlorine-sensitive site characterization testing.

Ground support should be installed after geologic mapping and sampling activities are completed, to the extent practical. If the encountered ground conditions require ground support in excess of the existing design (Section 6.5 of Reference 14.1), the impact of suggested remedial activities (i.e., chemical grout injection) should be addressed in a separate evaluation.

ECRB Drift testing includes monitoring of the installed ground support systems. Access to selected rockbolts should be provided for installation of load cells. This activity is coordinated between the TCO and the CMO and is controlled in the applicable FWP.

10.6.6 Use of Diesel-Powered Equipment

Diesel-powered equipment is used underground—including the ECRB Drift—alcove excavation, and material and personnel transportation; it may also be used for muck haulage. Diesel exhaust mixes with outside air, which circulates through the tunnel, due to a negative pressure at the tunnel face that is created by exhaust fans. The gaseous oxides of carbon and diesel particulate matter (DPM) in the diesel exhaust could potentially impact site characterization testing that (1) is sensitive to microorganisms that feed on carbon compounds, or (2) is based on chemical analyses of carbon compounds where the diesel products may have penetrated into the wall rock and contaminated the *in situ* gases collected for site characterization. The potential enhancement of microorganism growth (due to the introduction of DPM) will not have a test interference impact on some proposed tests, and may actually enhance the conduct of other planned tests, due to the effects of introduced materials that can be measured more quickly. No test interference due to the generation of DPM was identified for the planned site characterization tests in the ECRB Drift.

Because the ventilation system maintains the tunnel atmosphere at slightly less than atmospheric pressure, it is hypothesized that the diesel-contaminated tunnel atmosphere will be exhausted from the tunnel, without advective inflow into the fractures and rock matrix, for much of the time while the ventilation system is operating. However, since expected variability of atmospheric pressure is an order of magnitude greater than the ventilation induced pressure difference, there could be advective air flow from the tunnel into fractures and the rock matrix as barometric pressure rises after an interval of low pressure (e.g., a winter storm).

Presently, there may be enough data on the permeability of the rock mass, fracture flow, the interconnectivity of fractures, and the magnitude of this pneumatic pressure difference to assess this impact, but such an analysis has not been carried out. Diesel usage in the ESF—including the ECRB Drift—can provide an opportunity to collect test and monitoring data to better define these parameters. A testing program was implemented by the scientific testing participants to utilize this opportunity to collect data in parallel with the use of diesel-powered equipment in the excavation of the TS North Ramp. Monitoring and testing of diesel emissions should consider emissions of carbon gases. The diesel testing (which had to occur prior to use of diesel in the affected areas of the potential waste emplacement zone (i.e., in the track of the ECRB Drift) [as defined in Reference 14.7]) provided data that, in conjunction with continued diesel emission monitoring, diesel use records, and other planned site characterization testing data, will allow testers to assess any potential impact on site characterization testing activities. In addition, the diesel use records should record the type of engine or equipment that consumed the diesel fuel, the volume of fuel used, and the number of hours the equipment was operated.

The potential use of A-55 clean fuel as a substitute for diesel fuel has been proposed for the ECRB Drift. As discussed in Section 11.3.3, A-55 clean fuel should reduce DPM. However, A-55 clean fuel use should be subject to the same emission monitoring and use records requirements as noted for diesel fuel above.

10.6.7 Materials and Personnel Transportation

Rolling stock is described in Section 6.9 of Reference 14.1. The electric hydraulic scissor lift cars, along with the maintenance/lube car, have the potential for leaks or spills from the car mechanisms. No interference due to rail car use is anticipated as long as leakage and spillage is avoided to the extent practical; and leaks and spills are identified, mitigated, and cleaned up as soon as practical. The volumes and locations of any spills should be documented and reported in accordance with the TFM procedure (Reference 14.6).

10.6.8 Subsurface Sanitary Facilities

Portable self-contained chemical toilets may be provided at appropriate locations in the ECRB Drift. As long as spills are avoided and cleaned up to the extent practical, should they occur, no test interference is anticipated. The volumes and locations of any spills should be documented and reported in accordance with the TFM procedure (Reference 14.6).

10.6.9 Communications Systems

No test interference concerns have been identified with regard to communication systems at the present time. Should the PIs determine that the communications systems may be causing test interference to any ECRB Drift data acquisition system (after these systems are in place), further electromagnetic shielding may be installed to one or both of these systems. It is the responsibility of the PIs to identify additional shielding requirements in the preparation of the applicable FWP (see Section 10.6.3).

10.6.10 Compressed Air Distribution System

Provision will be made in the applicable FWP to prevent the introduction of water from the compressed air supply into tests that are sensitive to water, such as radial borehole tests. No other test interference concerns are expected since the accumulated oil and water from the air treatment process will not be used underground and are required to be disposed of in accordance with environmental regulations. It is the responsibility of PIs to ascertain whether compressed air treatment is adequate. Compressed air used in the collection of core and in the conduct of experiments and testing for site characterization may be tagged with a chemical tracer. Since this is not a construction-to-test interference requirement but a potential prerequisite for specific site characterization testing activities, any tagging requirements will be addressed by the applicable FWP for the specific test.

10.7 TRACERS, FLUIDS, AND MATERIALS

A variety of TFMs will be used during TBM operations, installation and operation of utilities, and support for TBM operation. All construction materials or substances used underground should first be reviewed for potential effects on the Engineered Barrier System (EBS), waste isolation, and on-site characterization activities. The TFM procedure (Reference 14.6) adequately provides for this evaluation through DIEs. The presence of combustible materials in the ECRB Drift should be controlled and limited such that testing is not adversely affected. Attachment II lists those TFMs that were reviewed for this evaluation and indicates identified special handling or storage requirements from a test interference perspective. Potential causes of test interference due to TFMs are discussed in the following section.

Use of TFMs should be documented in detail and reported in accordance with Reference 14.6. Samples of TFMs used in ECRB Drift construction and testing construction are available for examination by PI(s) upon request.

10.7.1 Tracers

The addition of a universal tracer (LiBr is currently the preferred tracer used in water) is required for water used underground in dust suppression, wall cleaning prior to mapping, and other construction applications. It is not required in water used in concrete, grout, or shotcrete mixtures, except when grout may be used in the vicinity of any perched water location as identified by the TCO (Reference 14.39). The LiBr concentration tracer in construction and mapping water should be within a maximum range of 10 ppm to 20 ppm, not to exceed 30 ppm are controlled by the requirements in Reference 14.1.

Compressed air used in borehole drilling does not require tracing with a chemical tracer. If required for testing purposes, the compressed air may be traced. The common tracer used in air is sulfur hexafluoride (SF_6). Attachment II also identifies SUVA-COLD MP® and the noble gases helium (He), neon (Ne), argon (Ar), krypton (Kr), and xenon (Xe) as acceptable tracer gases. Since the use of tracers and concentrations thereof can have an impact on nearby testing activities, the use of any additional tracer, as needed for ECRB Drift testing, will be identified and evaluated in the specific FWP.

10.7.2 Fluids Used in Operation of the TBM

No test interference from TBM operational fluids is anticipated as long as leaks and spills are avoided to the extent practical. Periodic checks are made to detect leaks and spills, and spills are cleaned up as soon as possible. The volumes, locations, and results of mitigation of any spills should be documented and reported in accordance with the TFM procedure (Reference 14.6).

10.7.3 Chloride-Based Materials

The use of chloride-based materials (e.g., sodium chloride, potassium chloride, magnesium chloride) should be minimized to the extent practicable because of the potential impact on chlorine-sensitive site characterization testing such as Chloride-36 studies. The use of chloride-based additives to cementitious materials such as shotcrete or grout should be minimized to the extent practical.

10.8 SUBSURFACE ESF TESTING INTERACTIONS

In developing controls specific to the ECRB Drift, this evaluation incorporates design and/or construction constraints identified in the ESFDR (Reference 14.5) with regard to the interface between testing and various excavation activities. Thus, this evaluation does not specifically include testing-related activities in the ECRB Drift after it is constructed and its testing accommodations have been installed. However, specific construction constraints applicable to the fielding of the tests, such as whether tracer gas is required in the drilling of boreholes, will be addressed in the individual FWPs for those activities. ECRB Drift testing sites are selected by the PI(s) in coordination with the TCO. The selection process takes into account potential interference from and with other test activities. As such minimal test-to-test interferences associated with subsurface ESF testing activities are anticipated. FWPs ensure that potential interference from and with other test activities are minimized. FWPs are developed by the TCO. The TCO is the field coordinating agency for ECRB Drift test implementation and represents the interests of both the DOE and the PIs with respect to site characterization testing activities and potential test interference issues.

Ideally, the goal of ECRB Drift testing activities is to expedite (1) the operation of the TBM in order to complete construction the ECRB Drift as soon as practical and (2) the acquisition of scientific data through testing and monitoring activities. Maximizing the potential of these goals requires close coordination between all affected organizations. The coordination between construction, and ESF testing and SBT resides with the CMO and TCO. The CMO and TCO jointly derive a working construction schedule that defines construction/test sequence for test support during the TBM excavation. Test specific construction support requests from the TCO are communicated to the CMO and implemented through FWPs.

Although the ECRB Drift provides the opportunity to test in more representative conditions than can be provided by surface outcrops, the tunnel opening itself introduces surface atmospheric conditions to a volume of rock where *in situ* data are desired. For example, an anticipated temporal lag between the time of tunnel excavation and when the tunnel effect may be transmitted into the rock mass is the window of opportunity in which certain planned ESF tests should be staged. In these cases, the deferral of testing until construction is complete could result in biasing the test results in an undetectable and unpredictable way.

11.0 IMPACT TO WASTE ISOLATION CHARACTERISTICS

The ECRB Drift is a northeast–southwest trending tunnel beginning from the ESF North Ramp proceeding to the TS Main Drift and above the proposed location of the potential repository block. This tunnel excavation will be directly over waste emplacement areas within the potential repository block and expansion areas. Due to the likely sensitivity of the proposed waste emplacement areas to the addition of TFMs and/or alterations to the rock units, a revision to this DIE will address the potential waste isolation and testing concerns for tunnel construction and testing beginning from the intersection with the TS Main Drift and continuing over the potential waste emplacement area. Thus, the Phase I DIE for the ECRB Drift covers the excavation and testing from the ECRB Starter Tunnel to the intersection of the ECRB Drift and TS Main Drift.

Waste isolation effects from construction and testing during Phase I of the ECRB Drift can be generally addressed using the assumptions and analyses developed for the Subsurface ESF DIE (Reference 14.1). Because the Phase I DIE addresses the construction/testing activities only until the excavation has proceeded as far as its intersection with the TS Main Drift (without exceeding a minimum offset of approximately 37 m from the potential waste emplacement areas), the assumptions used for the Reference 14.1 analyses are used here to conservatively bound the waste isolation effects of Phase I of the ECRB Drift.

Phase I of the ECRB Drift provides a unique opportunity to test and evaluate the potential waste isolation effects of construction methods before the excavation proceeds through the repository block. Previous methods used to quantify committed TFMs during ESF construction resulted in limited information, which in most cases was insufficient to determine the actual TFM loss. As a result, TFM usage during ESF construction was limited to the maximum committable quantities that could be lost with negligible waste isolation effects. In previous DIEs, this maximum quantity was generally well below the amount necessary for the construction or testing activity. For example, water use and organic input were strictly limited during the ESF tunnel construction due to the sensitivity of the site to these parameters. As a result, dust suppression within the tunnel has proven to be a problem. Better quantification of uncertainties like water use and recovery during tunnel excavation and construction could drastically change the controls developed for the construction of the potential repository. With the large offset of Phase I of the ECRB Drift from the potential repository block and expansion areas, new construction and testing methods will be developed and tested during this interval to help quantify the amount of committed TFMs during construction. It is not likely that a better quantification of the amount of committed materials from construction activities will affect the waste isolation analyses contained herein, rather, it could potentially provide the basis to validate new construction activities. These activities may include more water use and the use of organically-based surfactants (if it can be shown that the recovery of these TFMs results in a committed amount below the maximum limits for negligible waste isolation effects).

In the following sections, the evaluations of potential hydrologic, geochemical, and thermal/ mechanical perturbations that could affect impacts to waste isolation are discussed. In the specific geochemical evaluations discussed in Section 11.3 of this DIE, the conclusions were based on scenarios that should conservatively bound potential perturbations to ambient conditions. If such conservative calculations indicate that the items/activities are not likely to impact the ambient conditions above the level of the chosen surrogate criterion (as discussed in Section 9.4), it can be reasonably concluded that the items/activities can be used/performed with negligible risk for potential impact to waste isolation from any reasonable scenario (with only those controls that are applied in this evaluation). Because the specific evaluations discussed in Section 11.3 of this DIE are conservative bounding scenarios based on surrogate criteria, it cannot be concluded that impacts to waste isolation are assured for cases where results exceed the surrogate criterion for negligible perturbations to ambient conditions. However, it can be reasonably assumed that the potential impacts to the surrogate performance parameters resulting from the geochemical changes in these scenarios represent upper bounds for impact for any plausible scenario.

To provide a consistent approach to evaluating the potential impacts in all cases, an effort is made to choose a reasonable bounding scenario. The bounding scenario is not taken from a subjective consideration of the most probable case, nor is it assigned from identification of the worst case. In many cases, the most probable scenario cannot be identified quantitatively because lack of appropriate information precludes quantifying such probabilities. In addition, uncertainties in identification of the worst case, and quantification of resulting effects, preclude using the worst case to constrain these evaluations in most cases. The bounding case is chosen, in part, because it can be quantified in a straightforward manner and includes conservative assumptions to ensure that it encompasses the potential impacts from virtually all reasonable scenarios. In all cases, it will be necessary for a future evaluation of the consequences to waste isolation resulting from the committed items and actual configuration of any final constructed facility.

11.1 HYDROLOGIC EVALUATIONS

11.1.1 Effects of Irretrievably Lost Water

The performance of a conceptual nuclear waste repository at Yucca Mountain is based on the strategy of waste containment, isolation, and attenuated exposure. Containment refers to keeping the waste inside waste packages (e.g., steel canisters), while isolation refers more generally to keeping the waste from reaching the accessible environment. Attenuation of exposure is a result of delay in the release and transport of radionuclides to the accessible environment and dilution of the radionuclides in the water. The accessible environment is where the public is potentially exposed to the waste. These three elements of the nuclear waste disposal strategy (i.e., containment, isolation, and attenuated exposure) are intimately related to the occurrence and behavior of water in the subsurface environment. Containment of waste is affected by water through the role water plays in corrosion and failure of waste packages, dissolution of radionuclides, and migration of dissolved radionuclides from inside waste packages to the surrounding geologic environment. The principle avenue for migration of the radionuclides from the rock at the potential repository to the accessible environment is by advective transport in water. Similarly, the travel times for radionuclides to reach the accessible environment are affected by advective transport in water. Finally, the dilution of released radionuclides that reach the accessible environment depends on the flow and mixing of water (Reference 14.1).

One of the important characteristics of Yucca Mountain as a potential nuclear waste repository is that it has a relatively large zone of partially saturated rock (about 600 m of vertical thickness in the primary waste emplacement block [Reference 14.32]). This zone lies between the surface and the water table, and is found to have a wide variety of water saturations (ranging on average from about 30 percent to 90 percent of the pore space [Reference 14.32]). For unsaturated conditions, most of the ambient water is confined to the smaller interstices of the rock matrix, limiting its ability to interact with the waste container and waste forms. Water, being the wetting phase against air, tends to first occupy the smaller interstices of the rock matrix and fill larger ones as the water saturation increases. As a result, lower water saturations may result in lower rates for corrosion, dissolution, and transport processes. Therefore, unsaturated conditions are considered an important attribute for repository performance, and lower water saturations are expected to provide better performance.

Water in the potential repository environment is expected to be redistributed by the effects of heat produced by the radioactive waste. The heat enhances vaporization of water and gas-phase movement, which tend to create either global or local zones of lower water saturation in the potential repository depending on the density and configuration of waste emplacement, background infiltration rate, and other factors. The thermo-hydrologic behavior of the potential repository system is currently the subject of detailed process-level calculations. At present, these calculations do not incorporate the potential effects of water lost during construction activities as part of the ambient conditions. In addition, these calculations have a large degree of uncertainty due to the complex processes involved, such as vaporization/condensation phenomena; transient, unsaturated, nonequilibrium flow in fractured rock; and uncertainties regarding specifics of the potential repository design. Therefore, such detailed calculations are not yet considered appropriate for the present evaluation. However, Revision 01 of this DIE will address these issues more thoroughly as the ECRB Drift passes through the repository block and directly over potential waste emplacement areas.

Depending on a variety of factors, the water lost in the ECRB Drift may be redistributed within the geologic environment by the effects of repository heating. Under certain conditions, the heating may tend to redistribute and combine the water lost in Phase I of the ECRB Drift with a much larger mass of water in a zone of condensation outside the dry-out region with water lost from the ESF excavation. In this case, the effects of the water lost from both the ECRB Drift and the other ESF excavations are expected to be negligible in comparison with the much larger volumes of natural ambient water redistributed around the potential repository. However, other conditions may result in less disturbance of the water lost from the tunnels by the waste heat. Under these circumstances, one possible scenario is that the saturation around the waste packages returns to near-ambient conditions and that the tunnel excavation and testing water remains relatively localized and migrates to the nearest waste packages. This near-ambient condition repository coupled with the flow of lost ECRB Drift water directly toward potential waste emplacement locations is used to bound the effects of lost water on the potential near-field repository performance.

Water is used for a variety of purposes to facilitate underground construction. The primary use is for dust control during rock excavation and removal. Water is also used to drill holes for emplacement of rockbolts and testing apparatuses. The underground use of water has no effect on the potential performance of a nuclear waste repository unless that water is irretrievably lost to the environment. An evaluation of this lost water on the potential repository performance is presented in the following sections. Uncertainty exists in these evaluations because of the precision and accuracy of measuring natural variability and the application of various modeling techniques. However, uncertainty of no greater than 10 percent would not substantively affect the conclusions of this evaluation.

11.1.2 Waste Package Corrosion

The waste package, waste form, backfill (or packing), invert, ground support, emplacement drift, drip shield, and other engineered items in the potential repository constitute the EBS. Corrosion of the waste package is a process that affects waste containment and is currently modeled as a function of relative humidity and temperature (Reference 14.40). The corrosion model is split into two regimes: humid air corrosion for a relative humidity of less than 85 percent, and aqueous corrosion for a relative humidity of greater than or equal to 85 percent (Reference 14.40).

The relative humidity at ambient conditions is reported in Attachment III of Reference 14.1, showing that at ambient conditions, the relative humidity is about 99 percent. Additional water in the rock matrix surrounding the emplacement drifts would only cause a variation in the relative humidity between 99 percent and 100 percent. Because aqueous corrosion is insensitive to the relative humidity, the increase in water saturation due to additional water lost in the ECRB Drift would have a negligible affect on corrosion of waste packages.

11.1.3 Spent Nuclear Fuel Dissolution and Engineered Barrier System Transport

Spent nuclear fuel dissolution rates, in some cases, affect the rates of radionuclide release from the EBS. The spent nuclear fuel dissolution rate model used in Reference 14.40 is not dependent on water saturation or humidity, although if this rate is high enough, the mobilization rate will be a function of the radionuclide flux through the waste canister. This flux is dependent on diffusive and advective transport processes, which may be sensitive to local hydrologic conditions. Specific information on these transport processes within EBS materials is very limited. Diffusive radionuclide transport in the local rock matrix may be considered an analog for diffusive EBS radionuclide transport processes (see Section 11.1.4), and is used to evaluate potential changes in performance due to increased local water saturations. Advective transport processes in the EBS are expected to be driven by advective flux occurring in the local rock fractures and matrix (Reference 14.40). A discussion of this sensitivity is given in Section 11.1.4. Therefore, the sensitivity of EBS radionuclide transport to water saturation is assumed to be captured through analysis of radionuclide transport in the local rock mass surrounding the EBS.

11.1.4 Aqueous Radionuclide Transport in the Near-Field

As in Reference 14.1, the definition of near-field used in this evaluation is the transport pathway through the rock matrix to fractures. This near-field movement may be critical if the bulk of the radionuclide transport through the unsaturated zone occurs in fractures and is limited by radionuclide access to fracture pathways. If not, then the analysis of far-field transport (see Section 11.1.5) becomes critical.

The effects of water on the near-field are conservatively restricted to a 5-m wide enhanced saturation zone. The use of a 5-m wide zone is a nominal, but conservative, width of the enhanced saturation region corresponding to the diameter of the ECRB Drift excavation. This is conservative because smaller quantities of water will have a larger effect on saturation if restricted to this zone rather than more widespread dispersal in the geologic environment. Discharged water may propagate from its discharge point in the ECRB Drift to the nearest potential waste emplacement zones. The tunnel diameter is used as the length scale appropriate to the introduction of water discharged in the tunnel to the geologic environment.

Although both advection and diffusion mechanisms are likely to be involved in radionuclide transport, these mechanisms are not necessarily contributing equally to the overall radionuclide transport rate. A comparison of advective and diffusive transport rates at different levels of water saturation is given in Attachment IV of Reference 14.1. Transport rates are probably diffusion dominated at lower saturations, but at elevated saturations advection and diffusion transport rates are expected to be similar. Therefore, the effects of added water in the ECRB Drift on near-field advection and diffusion must be considered.

The general approach is to consider the estimated natural variability in processes related to near-field radionuclide transport and then compare with the change in average behavior due to an increase in water saturation from the average undisturbed ambient water saturation. If the increase in average transport rate lies within the natural variability of the existing condition, then the saturation increase is not expected to noticeably affect near-field radionuclide transport. The analysis of the natural variations in ambient diffusive transport compared with average diffusive transport behavior under elevated water saturations is given in Attachment V of Reference 14.1. The results of this analysis indicate that diffusive transport is not sensitive, relative to natural variations in diffusive transport at ambient conditions, to increases in water saturation from the average ambient water saturation to saturated conditions.

A similar analysis for advective transport is presented in Attachment VI of Reference 14.1, and finds that advective transport is not sensitive, relative to natural variations in advective transport at ambient conditions, to an increase of water saturation from the average ambient water saturation to an average water saturation of 0.99, but marginally sensitive to saturated conditions. Because the transport process will disperse the saturation levels due to added water, the limiting quantity of added water in the ECRB Drift is assumed to be the amount required to saturate the rock lying between the nearest potential waste emplacement location and the ECRB Drift excavation. This quantity of water lost per unit length of excavation, Q_L, is $(1-S_I)*\phi*W*D_o$, where S_I is the initial (undisturbed) water saturation, ϕ is the porosity, D_o is the minimum offset between the ECRB Drift excavation and potential waste emplacement locations, and W is the width of the saturated zone. Given W=5 m (see Section 6.2), ϕ =0.13, S_I=0.74 (Reference 14.32), and D_o=37 m (Table 9.1), the limiting quantity of water discharged per unit length Q_L= 6.25 cubic meters per meter (m^3/m).

11.1.5 Aqueous Radionuclide Transport in the Far-Field

The definition of far-field used in this evaluation is the transport pathway through the unsaturated zone to the water table. Although added ECRB Drift construction and testing water may move through fractures, this water is not expected to remain in fractures for future potential interaction with radionuclides. The water entering fractures will either drain (relatively quickly) to the saturated zone or be absorbed into the ambient unsaturated rock matrix. Water that drains through fractures to the saturated zone will have a negligible effect on radionuclide transport to the saturated zone. Water that is held in the unsaturated rock matrix may affect far-field transport. A bounding calculation for far-field transport effects of the ESF tunnel construction water is given in Attachment VII of Reference 14.1, that considers the effects of an initially saturated zone 37 m thick with a tracer added to the leading edge of the saturated zone. The travel times for the tracer with and without the disturbance to the flow field are calculated, giving a reduction in travel time of about 15 percent for the disturbed flow case. This reduction as a result of additional water from the ESF tunnel was determined to be negligible in comparison with the travel time variations that are expected. For example, the variation in travel time through matrix in the unsaturated zone may be computed from velocity and distance data given in Tables 7.2-4 and 7.4-1 in Reference 14.40. The ratio of maximum to minimum travel times of non-retarded species in the six stratigraphic columns used for the high-thermal-load case is a factor of 13 to 39. Likewise, the ECRB Drift is expected to have a negligible effect on the far field travel times.

11.1.6 Aqueous Radionuclide Transport in the Saturated Zone

The quantities of water found to potentially affect aqueous radionuclide transport in the unsaturated zone are far smaller than the quantities of water that would be expected to have a non-negligible effect on aqueous radionuclide transport in the saturated zone. An analysis of perched water flowing down a borehole to the saturated zone was evaluated in terms of its effects on the saturated zone hydraulic gradient, which is proportional to the flow velocity and inversely proportional to the aqueous radionuclide travel time (Reference 14.23). This analysis found that a groundwater mound resulting from the loss of 36,500 m^3 over one year in a single borehole that penetrated the saturated zone would dissipate to negligible levels in less than four years. This may be compared with the limiting quantity of water spread throughout the entire 773 m of Phase I of the ECRB Drift, based on a limiting rate of 6.25 m^3/m, giving a total of 4,831 m^3. Therefore if the quantity of water lost in the Phase I ECRB Drift is limited to 6.25 m^3/m of tunnel excavation, any effects of this water on potential aqueous radionuclide transport in the saturated zone is expected to be negligible.

11.1.7 Gaseous Radionuclide Transport in the Unsaturated Zone

The addition of water will affect gaseous radionuclide transport in the unsaturated zone. An increase in water saturation will always reduce the diffusive transport rate in the gas phase (Reference 14.41), or increase the diffusive travel times of gaseous radionuclides. Therefore, the addition of water is not expected to adversely affect potential repository performance.

11.1.8 Dust Control Water

The following discussion concerning the fate of dust control water was taken from Reference 14.1. As part of the ECRB Drift Phase I construction operations, water may be sprayed via water misting systems to reduce the concentration of dust in the tunnel atmosphere. The proposed amount of water use is unknown. An analysis of water applied to the inverts during ESF tunnel construction was conducted in Attachment VIII of Reference 14.1 and indicated that the ability of the ventilation system to remove water due to evaporation in the ECRB Drift exceeds the rate of water use (for dust suppression) over a distance of about 1100 m—if the application rate is less than 0.20 gallons/meter per day (gal/m-day) (or 0.76 liters/m-day), which is a function of the distance along the tunnel (i.e., [x] in Equation 11-1). This same analysis can be used to evaluate the evaporation rate within the ECRB Drift. Substituting in the appropriate parameters for the ECRB Drift (Table 11.1) into the previous Reference 14.1 analysis (Equation 11-1) and solving the variables (using the same assumptions for humidity, temperature, viscosity, and densities) yields a distribution of water removal (Q_v) that is very close to the distribution for the TS Loop (i.e., the evaporation rate for a 700-m to 1000-m (x) interval of the Phase I portion of the ECRB Drift is approximately the same as for the TS Loop, at the same water application rate [see Figure 11.1]). Therefore, in accordance with the Reference 14.1, dust control water applied in a fine mist within Phase I of the ECRB Drift at a rate of 0.76 l/m-day over a distance of no longer than 1100 m is expected to evaporate and would not need to be counted as water lost to the geologic environment.

$$Qv = \frac{A}{B}(\rho_{vs} - \overline{\rho_{v0}})\exp\left\{\frac{-x}{BV}\right\}$$

(Equation 11-1)

Table 11.1 Parameters Used to Calculate Q_v

Parameter	**ECRB Drift**	**ESF Drift (Reference 14.1)**
Tunnel Radius (R)	2.5 m	3.81 m
Air Flow Rate (V)	1.34 m/s	1 m/s
Reynolds Number ($R\acute{e}$)[4] (Equation VIII-34, Reference 14.1)	4.36×10^5	4.96×10^5
Friction Factor (f)[4] (Equation VIII-35, Reference 14.1)	0.065	0.054
Cross Sectional Area of the Tunnel (A)	19.6 m^2	45.6 m^2
B (Equation VIII-30, Reference 14.1)	183.23 s	319.6 s
y_1 (Equation VIII-20, Reference 14.1)[4]	2.500485 m	3.810532 m
y_2 (Equation VIII-21, Reference 14.1)[4]	-4.8526×10^{-4}m	-5.3243×10^{-4}m
ρ_{vs} (Reference 14.1)	0.02097 kilograms (kg)/m^3	0.02097 kg/m^3
ρ_{v0} (Reference 14.1)	0.003975 kg/m^3	0.003975 kg/m^3

[4] Note: These parameters were used to develop parameters specifically associated with Equation 11-1.

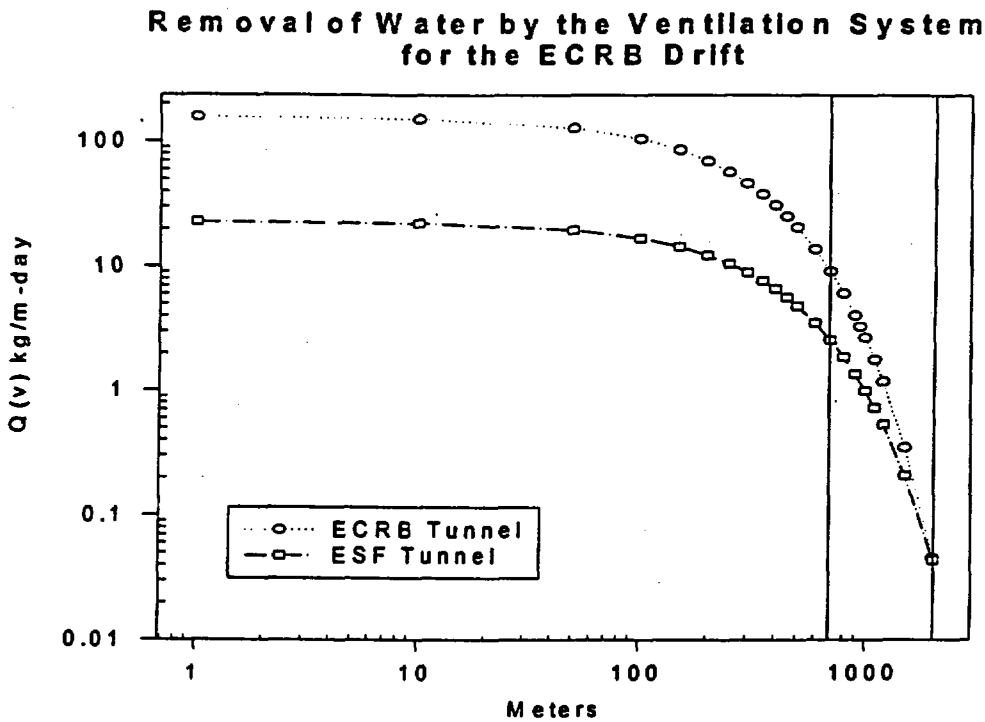

Figure 11.1 Distribution of Potential Removal of Water by the Ventilation System

11.2 TRACERS, FLUIDS, AND MATERIALS

The following discussion of potentially-retained constituents from various fluids and materials was taken largely from the Package 2C evaluation covering the ESF North Ramp (Reference 14.42), portions of the Package 1A evaluation covering the Starter Tunnel and Alcove #1 (Reference 14.43) and the DIE for the Subsurface ESF (Reference 14.1) because of the similarity of substances to be considered for the entire ECRB Drift. Additional discussion and detailed references can be found in the corresponding sections of those documents. Tracers are viewed entirely as retained substances and so are not discussed further here but are evaluated in Section 11.3 of this DIE. The specific TFMs listed in Attachment II have been reviewed to ensure that they fall into the groups defined in the following section and are therefore covered by any applicable controls.

11.2.1 Fluids and Materials

The only ECRB Drift items that are planned to be incorporated into the potential repository (i.e., planned permanent items) are (Reference 14.3) underground openings and ground support. Items that are left (intentionally or unintentionally) at the site post-closure (above and below ground) are defined as committed items in an evaluation of surface-based fluids and materials usage (Reference 14.44). Non-committed substances are only those fluids and materials that are not being emplaced into the environment in such a way as to become a committed part of that environment. Such non-committed substances are those that are planned to be removed from the site at or before the time of closure, and are not expected to leave behind noticeable, non-removable residues. Because of the condition of removal prior to closure, some solid materials are excluded from this evaluation designation of non-committed (e.g., salt) because they are soluble to the extent that they have the potential to dissolve into the environment over a relatively short time period (i.e., days to a few months). Based on the reasoning given in the evaluations of the Package 1A TFMs (Reference 14.43), the surface-based non-committed fluids and materials (Reference 14.44), and the Package 2C TFMs (Reference 14.42), non-committed items are assumed to have negligible impact on waste isolation and are not evaluated further.

Substances considered committed items and evaluated here for the ECRB Drift are steel sets, lagging (wood and steel), wood blocking, lubricating oil retained (from cutting) on steel sets, rockbolts, wire mesh, shotcrete and/or fibercrete, cementitious grout, oil mist from compressed-air system, steel, concrete, concrete admixtures, and galvanized steel. In addition, because diesel equipment will be employed during construction of the Starter Tunnel (and perhaps several proposed niches), and some of the exhaust constituents (both inorganic and organic) may become committed to the underground, the potential impacts of these constituents were explicitly analyzed for use in the TS Loop in the Package 2C evaluation (Reference 14.42) and this same analysis is used for the ECRB Drift to develop controls on the quantities of materials committed as discussed in Section 11.3 of this DIE. Furthermore, in the event of a fire, combustion products and fire-suppression substances may become committed items. Therefore, the potential impacts to waste isolation from the proposed fire-suppression substances were also explicitly evaluated using a bounding scenario in the Package 2C evaluation (Reference 14.42). In the event of an actual fire, the specific materials that burn should be evaluated for potential impacts to waste isolation. In the Package 2C evaluation, substances produced from fires were assumed to be close enough to the constituents produced in diesel exhaust that evaluation of exhaust constituents bounds the potential impacts to waste isolation of fire products. Because fire products are not planned to be incorporated into a potential repository, a more general waste isolation evaluation should be performed if there is a need to further evaluate such potential impacts.

As discussed in detail in the Package 2C evaluation, explosives are not considered committed items because most of their residues are expected to be removed either as volatiles or within the excavated materials.

It was concluded in the Package 2C evaluation (Reference 14.42) that fluids which are not planned to be dispersed into the environment (e.g., diesel fuel, lubricants, coolants, battery acid, and cleaning solvents) are expected to have negligible impact, provided that a plan for spill containment and clean-up exists. In accordance with the YMP QA procedures for recording TFM use at the site, any planned non-committed fluids or materials that become retained intentionally or unintentionally as part of the committed environment require documentation of the amounts of substance retained in the environment and evaluation of the potential waste isolation impacts of that specific retention. The evaluation of specific materials that become part of the committed environment will be part of the Total System Performance Assessment (TSPA) evaluations.

11.2.2 Committed Inorganic Substances

Items such as steel sets, rebar, lagging (steel), rockbolts, wire mesh, shotcrete and/or fibercrete, cementitious grout, and galvanized steel (in general, steel, concrete, and shotcrete) are expected to have negligible impact on waste isolation resulting from perturbations to the near-field geochemistry because their use near potential waste emplacement sites (i.e., within potential repository drifts) is expected to overshadow any effects resulting from their use in the ECRB Drift. These near-field effects include raising the pH from 11 to 13 and the potential for generation of colloids from the cementitious material. The former may enhance some dissolved radionuclide concentrations, whereas the latter may provide an additional mobile component for some radionuclides. In addition, potential effects on far-field geochemistry caused by dissolved a calcium ion introduced from cementitious material are expected to be negligible because mineralogic controls exerted through fluid-rock reaction should constrain large deviations in the calcium ion concentrations to close proximity to cementitious materials via calcite precipitation. In general, water used in cementitious materials isn't expected to migrate, however, zones affected by thermal dryout due to repository heating may result in substantial movement of the cementitious water to the surrounding rock. Therefore, water used in cementitious materials within the region of thermal dryout should be counted as water lost to the environment. The thermal dryout zone depends on potential repository design, however, the dryout isn't expected above the PTn hydrogeologic unit (References 14.54 and 14.55). A more detailed analysis of these qualitative issues would be required if there was to be a large increase in the amount of committed cementitious materials in the ECRB Drift (i.e., more than an order-of-magnitude increase over the current plans for shotcrete and grouting), as discussed in Section 6 of Reference 14.1.

11.2.3 Committed Organic Substances

Because of the numerous qualitative issues regarding committed organic materials (e.g., dissolved organic enhanced solubility and transport of radionuclides and microbial effects), use of such materials in potential repository drifts is unknown. Therefore, the previously stated reasoning on committed inorganic substances does not apply to any organic materials that might be contained within cementitious materials as a result of the addition of admixtures. In addition, this discussion covers the previous specific evaluations of discrete sources of aqueous nitrates (NO_3^-), sulfates ($SO_4^{=}$), and phosphates ($H_2PO_4^-$) addressed in the Package 2C evaluation (Reference 14.42) of diesel exhaust constituents and fire-suppression materials. These materials are potential sources of nutrients for microbes and $H_2PO_4^-$ has the potential for readily complexing radionuclides (specifically actinide elements). If retained in large quantities, these constituents may also be a concern for generating low pH (i.e., acid) conditions. Constraints based upon the other concerns, however, should conservatively bound any potential pH perturbations because of the large pH-buffering capacity of the geologic system.

As pointed out in the Package 2C evaluation, organic compounds may accelerate waste package corrosion through enhanced microbial activity and/or facilitate radionuclide transport in the geosphere via complexing of cations (Reference 14.42). This previous evaluation indicated these effects are constrained by the ability of deposited organic materials to migrate to either waste package locations or radionuclide pathways in sufficient concentration to have a significant impact.

A previous bounding calculation was performed in Reference 14.1. This calculation determined the potential influence of retained organic substances in the ESF Starter Tunnel and in Alcove #1 (Reference 14.43). In that general analysis, the retained organic materials were assumed to be a point source that completely dissolved as organic carbon and migrated toward potential waste package emplacement sites. All committed organic fluids and materials were considered as indistinguishable.

A second previous bounding calculation was also performed in Reference 14.1. This calculation determined the potential influence of retained organic substances within the ESF North Ramp (Reference 14.42). In that analysis, the retained organic materials were assumed to convert completely to DOC and to migrate toward potential waste package emplacement sites within the TSw2 horizon. All committed organic fluids and materials were considered as behaving identically.

These previous analyses presented in Reference 14.1 will be the basis for the analysis and controls developed for the use of organic substances within Phase I of the ECRB Drift for excavation and testing. The total organic budget includes all sources of committed organics in the ECRB Drift. Examples of such sources are wood blocking/lagging for steel sets, oil mist from the compressed air system, lubricating oil (for cutting) retained on steel sets, organic diesel exhaust components, and concrete admixtures used in shotcrete. In addition to these introduced sources of organics, opening the mountain to the external environment allows the introduction of potentially committed organic materials in the form of airborne particles in the ventilation air and in the form of organisms that may inhabit, and deposit organic residue in, portions of the tunnel.

Accidental loss of any organic fluid such as fuels, lubricants, or coolants used in equipment necessitates documentation and evaluation of the specific unintentional releases, and incorporation of the retained amounts of committed organic fluids into the evaluation of the final configuration of the potential repository.

11.3 GEOCHEMICAL EVALUATIONS

11.3.1 Tracers

As discussed in References 14.42 and 14.43, LiBr, proposed as a tracer for construction water, will be added at a maximum concentration of 30 ppm (minimum 10 ppm), with a target concentration of 20 ppm (±2 ppm). In addition, SF_6 will be added at concentrations not to exceed 20 ppm to air used for drilling test boreholes if requested by the TCO. It was concluded in both these previous evaluations that because of the low concentrations and limited quantities used, these tracers are expected to have only negligible effects on the geochemistry near potential waste emplacement sites, or along potential gaseous and aqueous radionuclide pathways. No other tracers have been proposed for used within Phase I of the ECRB Drift.

Tetra fluoroethane (SUVA-COLD MP®) has been evaluated for use in conducting tracer tests to estimate the tortuosity and effective porosity of faults and their associated fault zones. Given a borehole diameter of 2 inches, the total volume of gas per 20-m segment of borehole depth is 4.0536×10^{-4} m^3 ($V = \pi r^2 h$). The molecular volume of an ideal gas at standard pressure and temperature (V_m) is 0.0224414 m^3/mol; thus, the total number of gas moles per 20-m segment is equal to 0.008085. With the concentration of this gaseous organic tracer not exceeding more than 30 ppm (see Section 11.3.1 of Reference 14.18) the total number of moles of tetra fluoroethane is equal to 2.4255×10^{-7} moles. Because of the low quantities used, tracers are not expected to have significant effects on the geochemistry near potential waste emplacement sites, nor along potential gaseous and aqueous radionuclide pathways.

In addition, noble gases (i.e., He, Ne, Ar, Kr, and Xe), have been proposed for use as tracer gases to support ESF subsurface testing activities—potentially including the ECRB Drift. These gases have a lesser potential to cause waste isolation impacts than either SF_6 or tetra fluorethane due to their extremely stable chemical state. The evaluation of SF_6 as a tracer gas is conservatively considered to be a bounding evaluation for the use of He, Ne, Ar, Kr, and Xe as tracer gases within the ECRB Drift. Therefore, these tracers are expected to have negligible effects on the geochemistry near potential waste emplacement areas or along aqueous or gaseous radionuclide pathways.

11.3.2 Committed Organics

The negligible impact level for DOC was defined as local perturbations of 0.1 ppm (References 14.1 and 14.43). In those evaluations, it was assumed that:

1. The retained organic material represents a point source,

2. The dissolution of the organic point source is complete and instantaneous,

3. Dispersion of the organic source occurs via saturated flow toward potential waste emplacement zones, and

4. No reactions to degrade the concentration of total DOC occur.

These evaluations concluded that, for the TS Loop (References 14.1 and 14.43):

1. If the total retained organic materials in the Starter Tunnel and Alcove #1 is less than 420 kg, it is expected that there should be negligible impact to the geochemistry of groundwater within the Potential Expansion Areas Boundary (i.e., perturbations to fluid compositions should be less than 0.1 ppm DOC).

2. If the total retained organic materials in the ESF Starter Tunnel and Alcove #1 is less than 2500 kg, it is expected that the impact to the geochemistry of groundwater within the Proposed Repository Outline should be negligible, although there is some potential for impact to the groundwater geochemistry within the Potential Expansion Areas 2, 3, and 6.

3. If the total committed DOC was kept at or below the following for the TS Loop: 95 grams per meter (g/m) from Station 0+00 m to 13+11 m , 28 g/m from Station 13+11 m to 18+59 m, 13 g/m from Station 18+59 m to Station 24+08 m, and 10 g/m for the remainder of the tunnel, it is expected that there should be negligible impact to the waste isolation capabilities of the potential repository.

Phase I of the ECRB Drift is approximately 773 m long, beginning from the left rib of the ESF North Ramp at approximately Station 19+92 m and ending at the cross over with the TS Main Drift. When differences in the tunnel size are taken into account, the analyses within Attachment II of Reference 14.42 for the TS Loop can be applied to Phase I of the ECRB Drift to develop controls for the use of organic substances for testing and construction to avoid potential impacts to the waste isolation capabilities of the potential repository.

Scaling the Reference 14.42 analysis for the smaller diameter ECRB Drift yields an organic limit of 6.51 g/m at a 37 m offset (at the closest distance to potential waste emplacement expansion areas for Phase I of the ECRB Drift) as a conservative organic limit for the entire length of Phase I of the ECRB Drift. There should be no significant waste isolation effects (1) due to the large offset between Phase I of the ECRB Drift and any waste emplacement areas, and (2) since organic use during Phase I construction is not expected to exceed these limits except during a 50-m testing interval (see Sections 6.4 and 11.3.5 of this DIE).

It should be reiterated here that this evaluation does not indicate that an impact to waste isolation will occur if these limits are exceeded, but only that the potential for impacts to waste isolation exist. However, controls developed from constraints on potential impacts from this case are expected to minimize impacts from any reasonable flow scenario (this excludes the worst-case of disequilibrium fracture-flow).

11.3.3 Diesel Exhaust

In a previous evaluation of committed components from diesel exhaust (i.e., sulfur oxide gases, nitrogen oxide gases, and DPM) in the ESF North Ramp (References 14.1 and 14.42), it was indicated that potential impacts were bounded by an analysis showing that retention of these materials within the ESF North Ramp for the planned usage of diesel equipment will not impact potential radionuclide release and transport over a 10,000-year time period, provided that the local perturbations to the near-field water compositions at the closest waste package were kept at or below a value of 10 percent of ambient concentrations of their corresponding dissolved constituents ($SO_4^{=}$, NO_3^-, and DOC, respectively). This evaluation was based on the estimated distribution of diesel usage throughout the ESF North Ramp and assumed that relatively insoluble constituents that remain in the gas phase would be removed via the planned ventilation system. The previous evaluation concluded that although carbon monoxide and carbon dioxide may be retained, the natural aqueous and gas phases have concentrations of carbon dioxide that are high enough that these constituents would produce negligible perturbation to the natural system. In the Package 2C evaluation (Reference 14.42), negligible-impact-limit constraints on the exhaust emission rates of the explicitly evaluated components were derived and are provided in Table 11.2 below.

Table 11.2 Diesel Exhaust Emission Components Negligible-Impact-Limits

Aqueous Constituent	Total Exhaust Constituents As	Limiting Emission Rates of Exhaust Constituent (g/hr)
DOC	DPM	24
NO_3^-	NO	120
$SO_4^=$	SO_2	590

The conclusions of the Package 2C analysis can be applied to Phase I of the ECRB Drift without compromising the validity of the analysis. Diesel fuel is expected to be used during Phase I of the tunnel construction at a reduced rate when compared to the ESF North Ramp of the TS Loop. Constraining the diesel emissions within the ECRB Drift to values below the TS Loop limits defined previously should not result in any significant waste isolation effects due to the large offset between Phase I of the ECRB Drift and any waste emplacement areas. In addition, the proposed use of A-55 clean fuel in place of diesel, should further reduce the emissions of NO and DPM within the ECRB Drift.

Because these constraints were derived for a specific distribution of diesel usage throughout the North Ramp, these emission rates for diesel exhaust constituents cannot be applied in a general way. However, general constraints for each of these constituents for the Phase I ECRB Drift can be derived from the more general analysis of perturbations to these components from all sources, as performed in the Package 2C evaluation (Reference 14.42) and as discussed in the following section.

11.3.4 Other Source Constraints

The same approach used for diesel exhaust constituents was applied to evaluate the limits on NO_3^- and $SO_4^=$ from all sources in the ESF North Ramp (Reference 14.42), where it was indicated that potential impacts were bounded by an analysis showing that retention of these materials within the ESF North Ramp from all sources will not impact potential radionuclide release and transport over a 10,000 year time period, provided that the local perturbations to the near-field water compositions at the closest waste package were kept at or below a value of 10 percent of ambient concentrations of these dissolved constituents (see Attachment II of Reference 14.42 and Equation 11-2 of this DIE). Because other materials may be used in different distributions (i.e., not necessarily in the proportions assumed for diesel emissions in the previous Reference 14.42 evaluation). The previous analysis assumed that the major impact for peak concentration perturbation at any point is due to the source density (parameter *d* in Equation 11-2) associated with the closest portion of the tunnel (parameter *h* in Equation 11-2). Based on this previous analysis (Equation 11-2), substituting in minimum offset distance and tunnel radius (R) for the ECRB Drift provided general constraints for the total source constraints on NO_3^- and $SO_4^=$. These limits are spatially dependent, so the limits for which potential waste emplacement zones are at the minimum 37-m offset from the TS Loop were used to constrain the potential waste isolation impacts from the ECRB Drift. Therefore, the conservative limits for negligible impacts on committed quantities for these constituents in Phase I of the ECRB Drift are provided in Table 11.2 below.

Table 11.3 Phase I ECRB Drift Recommended Limits (g/m)

DOC	NO_3^-	$SO_4^=$
6.51	65	241

11.3.5 Use of Organic Surfactants

Two approximately 50-m testing intervals have been proposed as part of Phase I of the ECRB Drift. Within the second testing interval (i.e., from approximately Station 1+76 m to Station 2+25 m), organic surfactants have been proposed to be tested as a means of dust control within the tunnel. The committal of the organic material will also be measured to quantify the amounts committed by the use of these materials. Over this interval the maximum source density (*d*) of organic applied within the ECRB Drift can be calculated using the analysis in Equation 17 of Attachment II in Reference 14.42 and substituting the appropriate parameters for the ECRB Drift, as shown in Equation 11-2. Thus, when differences in the tunnel size are taken into account, the Reference 14.1 analyses for the TS Loop can be applied to Phase I of the ECRB Drift, and controls for the use of organic substances associated with testing and construction activities can be developed, which minimize the potential for impacts to the waste isolation capabilities of the potential repository.

(Equation 11-2)[5]

$$C_p(d,h,\phi) = \left[\frac{d}{\phi(4\pi h a_x)^{\frac{1}{2}}} \right]$$

where,

l = $d * 2\pi R$
Cp = the peak concentration at the closest waste package (≅ 0.1 ppm)
d = the mass density (grams per square meter)
ϕ = the porosity (≅ 0.1)
h = linear distance to the closest waste package (m)
a_x = dispersion in the x direction (1/10 of linear distance) (m)
l = linear organic limit (g/m)
R = ECRB Drift Radius (m)

[5] Note: The source of Equation 11-2 is Reference 14.42, Attachment II, Equation 17.

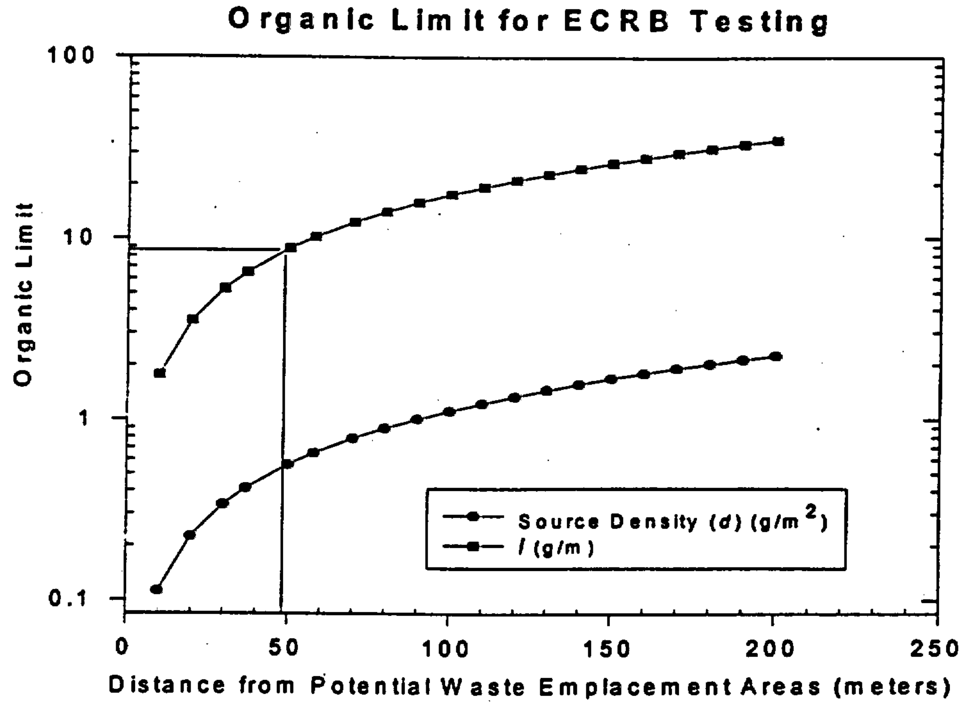

Figure 11.2 Organic Limit per Distance from Closest Waste Emplacement Area

At 49-m minimum offset from potential waste expansion areas (over the second testing interval), the organic limit for negligible impacts to waste isolation would be 8.8 g/m of tunnel excavation.

The length of the testing interval is approximately 50 m and occurs over potential expansion areas for waste emplacement. It is expected that the organic usage during this interval will exceed the recommended limit of 8.8 g/m. Because of the conservative nature of the analysis, and uncertainties with the exact location of the potential expansion areas, organic use in excess of this limit does not indicate that an adverse impact to waste isolation will occur, only that the potential for impacts to waste isolation may exist. In addition, due to the relatively small interval over which this organic surfactant will be used (approximately 50 m) it is expected that only the expansion areas directly beneath the test interval have the potential to be affected. Due to the relatively small area of the potential expansion zone that could be affected and the large offset of this test interval from the potential repository waste emplacement areas (i.e., greater than 540 m), it is expected that the testing of organic surfactants over this interval will have negligible effects on the waste isolation capabilities of the potential repository and may only affect a small portion of the potential expansion area.

11.3.6 Fire-Suppression Materials

The specific material designed for use as the primary fire-suppressant material is the dry chemical trade named *Ansul Foray*, which represents a potential source of aqueous NO_3^-, $SO_4^=$, and $H_2PO_4^-$, was specifically analyzed in the previous Package 2C evaluation (Reference 14.42). In this previous evaluation, it was indicated that potential impacts were bounded by an analysis showing that retention of fire-suppression materials within the ESF North Ramp will not impact potential radionuclide release and transport over a 10,000-year time period. Release of $H_2PO_4^-$, NO_3^-, and $SO_4^=$ will not impact radionuclide release and transport, provided a reasonable clean-up of the material can be achieved following a fire that necessitated the simultaneous discharge of the automated systems (i.e., the systems that protect the hydraulic oil tank and the lubrication system on the TBM). In the previous analysis (Reference 14.42), it was estimated that the 90 percent of the dry chemical can be removed by simple vacuuming and that half of the remainder of the material will be adhered to equipment and could be removed in the cleanup of that equipment. Therefore, it was noted that if water is used in conjunction with the dry-chemical, clean-up may be much reduced as the water could wash the dry chemical into fractures, and most of the material would therefore become potentially committed to the environment. It was recommended, therefore, that water be used in conjunction with this fire-suppression material only if necessary for safety.

Because the previous evaluation of the fire-suppression material analyzed its impacts throughout the ESF North Ramp based on the minimum 37 m offset to the closest potential waste package (Assumption 4.1) and the bounding fire scenario is a TBM fire, the previous recommendations for negligible impact from this material in the ESF North Ramp and the entire TS Loop can be applied throughout Phase I of the ECRB Drift.

If the evaluated committed fluids and materials are constrained according to the recommendations given in this section, they are expected to have only negligible effects on the geochemistry near potential waste emplacement sites, or along potential gaseous and aqueous radionuclide pathways. Therefore, the use of committed fluids and materials, subject to these constraints, for construction and operations conducted throughout the entire Phase I section of the ECRB Drift, are expected to have negligible impact to waste isolation capabilities of the site.

11.4 THERMAL/MECHANICAL EVALUATIONS

The previous evaluation of potential impacts to waste isolation caused by thermal-mechanical perturbations resulting from retained TFM and from excavation methods in the TS Loop (References 14.1 and 14.42) indicated that:

1. The potential effects of committed substances on TM characteristics of natural barriers or engineered items in the ESF North Ramp are expected to be negligible if the substances do not interfere with the emplacement and performance of ESF North Ramp seals (at the time when sealing plans for the tunnel are prepared, further analysis of potential impacts to waste isolation should be performed).

2. There is a negligible impact on the overall waste isolation capability of the entire potential repository due to the generation of preferential aqueous pathways through the mechanically disturbed zone.

3. Movement of underground fluids along the sealed ramp (and its surrounding mechanically disturbed zone) should have a negligible impact on the waste isolation capability of the potential repository.

4. To minimize the potential impact of the mechanically disturbed zone induced by the excavation, the TBM method, which results in a smaller disturbed zone compared to the drill-and-blast method, is recommended for the primary excavation method for ECRB Drift construction.

5. Regardless of the excavation method used for the ECRB Drift, no potential impacts to waste isolation resulting from the lack of a specified standoff distance for boreholes were identified, because boreholes will be sealed above and below the potential repository horizon.

Because sealing issues are identical for the TS Loop and the ECRB Drift and the previous evaluation analyzed the potential impacts from excavation methods in a general and spatially independent manner, the recommendations for negligible impact limits from References 14.1 and 14.42, can be applied directly to the Phase I of the ECRB Drift. If these recommendations are followed, then it is expected that there will be negligible impact to waste isolation capabilities of the site due to construction and operations conducted throughout Phase I of the ECRB Drift.

12.0 IMPACT TO OTHER Q-LIST ITEMS

Potential impacts to other Q-List items (e.g., ground support and underground openings) are bounded by controls applied:

1. In the applicable classification analyses,

2. To limit potential adverse impacts to site characterization testing (see Section 10.0 of this DIE), and/or

3. To limit potential impact to the waste isolation capabilities of the site (see Section 11.0 of this DIE).

As such, additional requirements are not necessary.

13.0 ESTABLISHMENT OF CONTROLS

13.1 SUMMARY OF RESULTS

This evaluation concludes that various activities associated with the Phase I of the ECRB Drift require QA controls in order to limit or prevent potential test interference or waste isolation impacts during ECRB Drift construction and testing activities. Controls for these activities are presented in Section 13.3. This DIE is predicated on these items being temporary. Any incorporation of these items or their constituents into the preclosure or permanent repository will require a new evaluation as part of the design of permanent items.

13.2 BASIS FOR CONTROLS

13.2.1 Records

It is judged that the record keeping provisions of 10 CFR 60.72 (Reference 14.4)—as applied to the ESF through ESFDR Sections 3.2.1.1.1.A, 3.2.1.1.4.C, and 3.7.1.2.B (Reference 14.5)—also provide the function of limiting impact in accordance with 10 CFR 60.15(c)(1) (Reference 14.4) (e.g., information on locations and descriptions of temporary structural support components that may be needed for the final ground support design). Therefore, these ECRB Drift records are required as QA records (Requirement 1).

13.2.2 Tracers

Section 10.0 of this DIE indicates that release of untraced water into the tunnel represents a potential test interference. The delivery of properly traced water is the significant consideration to provide assurance of the ability to differentiate such water from naturally occurring sources. The only approved tracer for water is LiBr. Therefore, only nonpotable water that has been traced with LiBr shall be transported into the ECRB Drift (Requirement 2). The concentration of the LiBr tracer must be controlled (i.e., checked to be 20 ppm ±10 ppm) prior to its introduction into the ECRB Drift by Requirement 3 in Reference 14.1 (Requirement 2). Tracer is not required in water outside the TS Loop used in mixing concrete, grout, and shotcrete (Reference 14.39). As a measure applied to support appropriate interpretation of potential site characterization results, this requirement is conservatively judged to be a QA requirement.

13.2.3 TBM Requirement

As discussed in References 14.1 and 14.11, five fluids are used to operate the TBM: hydraulic oil (in onboard reservoirs); lubrication oil (also in onboard reservoirs that are used to lubricate the main bearing, bull gear and speed reducers); seal grease; lubrication grease (at wear points on the TBM); and water (sufficient for dust control at the conveyor dump points and at the face, bearing purge, and recirculated cooling water [also in onboard reservoirs that are used to cool the main drive motors and hydraulic oil and an onboard reservoir]). TBM fluid systems are closed systems, with the exception of the water spray and seal purge discharges, which are expected to be removed with the excavated muck. References 14.1 and 14.11 also indicate that leak mitigation features are incorporated into the design of a TBM.

Such design features are conventional quality features, which should limit potential impacts associated with spills from TBM operations. In order to minimize the potential for underground TBM equipment spills, the following minimum maintenance practices are also imposed as QA requirements (Requirement 3):

- TBM maintenance procedures shall include provisions to contain loss of hydraulic fluid due to the removal of hydraulic lines or components.

- Periodic sampling of hydraulic and lube oils for contaminants shall be performed as part of preventative maintenance. The frequency of the sampling shall be based on manufacturer's recommendations or as approved by the A/E.

- Periodic maintenance shall be performed on components containing, or associated with, fluids of concern. The extent (e.g., type of maintenance and components to be maintained) and frequency of maintenance shall be based on manufacturer's recommendations or as approved by the A/E.

These requirements, along with other requirements discussed elsewhere in this DIE on spill mitigation and cleanup, are judged adequate to limit potential impact to site characterization testing and to waste isolation to the extent practical. The TBM excavation data (as discussed in Reference 14.45) and any other records generated as a result of TBM controls are QA records (Requirement 1). Normal operating practices such as exchange of information on anomalous indications or problems during shift turnover, information on TBM progress, and response to alarms do not require additional QA control, except where this information requires recording as a QA record under 10 CFR 60.72 (Reference 14.4) (Requirement 1).

13.2.4 TBM Excavation

Conventional commercial TBM excavation techniques in the ECRB Drift are not expected to compromise the ability to provide either adequate ground support systems or the roadbed for some yet to be determined function in a potential repository. The minimum QA-2 criteria established for Main Access Openings (Reference 14.45) sufficiently bound DIE concerns with respect to the TBM excavation of the ECRB Drift such that additional QA requirements are not necessary.

13.2.5 Ground Support and Drift Integrity

It is recognized that prior to completion of formal thermal and seismic analyses, and the performance assessment evaluation of the hydrologic effects of these analyses, the impact of these excavations cannot be quantified. A subsequent revision of this DIE will incorporate the results of such an analysis in terms of the possible impacts associated with thermal and seismic effects. The TSPA will also assess such potential impacts. Upon completion of the pending analyses and the TSPA, it may be necessary to revise the design of a potential repository. However, it is not anticipated that the structural/thermal analysis will conclude that even the potential failure (i.e., the collapse) of the ECRB Drift poses any significant impact on the operation or performance of the potential repository.

13.2.6 Damage to Rock from TBM Excavation

Damage to the rock from TBM operation is not expected to be significant enough to create preferential pathways during ECRB Drift construction (Reference 14.42). More specifically, TBM excavation is expected to provide relatively low impact to the site and provides confidence that such techniques, as controlled as discussed previously, are consistent with limiting adverse impacts to the extent practical.

13.2.7 Linings, Roadway, and Seals Impact

Neither seal, lining, nor roadway repository design criteria have been established. No evaluation of the likelihood of disturbing a potential seal mount, lining surface, or roadway can be made at this time. However, it is judged that commercial-grade equipment and standard design and construction practices—such as the controlled use of the TBM for excavation (Reference 14.45)—provide sufficient assurance against such an event (i.e., significant disturbance). Furthermore, future design criteria must consider the as-found conditions in the ECRB Drift. The ECRB Drift design does not include a concrete lining, which eliminates any potential for this type of impact. As discussed in Reference 14.45, the ECRB Drift currently has no function in a potential repository, but its future use should not be precluded should some repository purpose be identified. As such, the ground support to be installed in the ECRB Drift is not subject to QA requirements, but the future installation of QA-1 classification a ground support system should not be precluded. The use of standard, commercially available ground support for stabilization in the ECRB Drift is judged sufficient to limit such impacts to the potential repository to the extent practical. As such, no additional QA requirements are necessary.

13.2.8 Rockbolts and Preferential Pathways

Per Reference 14.1, the potential creation of preferential pathways by use of rockbolts is not considered significant. The length and diameter of the hole required for bolt placement are insignificant relative to the size of the ECRB Drift excavation. The majority of the rockbolts are placed in such a way that any preferential path would drain into the ECRB Drift. Further, the rockbolt, along with accompanying materials, act to significantly block the hole that is created. As noted in Section 13.2.7, the design and placement of a rockbolt ground support system in the ECRB Drift is not expected to preclude the installation of permanent ground support in the future. Therefore, it is judged that rockbolt placement has no significant impact to waste isolation, and no QA requirements are necessary.

13.2.9 Boreholes and Standoff Distances

Sections 10.0 and 11.0 of this DIE indicate that in consideration of existing and planned boreholes, no minimum standoff distance requirement has been identified for the ECRB Drift. Any standoff for future boreholes or associated excavations will be defined by DIEs prepared for those activities.

13.2.10 Geologic Mapping

As discussed in Section 10.4 of this DIE, test interference in the ECRB Drift can occur if obscuring ground support is installed prior to the completion of geologic mapping since the mapping is a photographic and observational activity. As such, the installation of supports that can obscure geologic information should be performed after geologic mapping is complete. As discussed in Reference 14.1, the immediate installation of ground support that significantly obscures geologic information prior to conducting geologic mapping activities only occurs when personnel safety is of concern. Since changes to ground support procedures and materials require A/E review and approval (Reference 14.46), it is judged that no specific QA controls to minimize test interference impact are required.

13.2.11 Schedule of Testing Activities

As discussed in Section 10.8 of this DIE, the schedule for conducting testing activities is equally important to the site characterization program as the schedule for construction activities that provide testing access. The instrumentation planned for ECRB Drift testing activities will collect data—at or near faults or key geologic contacts—that may be irretrievable if testing activities were delayed until the entire ECRB Drift was constructed. Further, certain ECRB Drift instrumentation is required to collect information significant for viability assessment in 1998. Phase I ECRB Drift testing data is also critical to the unimpeded excavation of the Phase II portion of the ECRB Drift (i.e., excavation beyond Station 7+73 m). Continued excavation beyond Station 7+73 m of the ECRB Drift is contingent upon (1) approval of the DIE for Phase II of the ECRB Drift and (2) verification of the Phase II DIE water loss and organic material loss limits (Requirement 16). As a conservative measure applied to limit potential impacts to both waste isolation and site characterization data, this requirement is imposed as a QA control. The verification of the Phase II DIE limits is strictly dependent upon data generated during Phase I testing activities.

In order to (1) assure that critical testing activities are conducted as required and (2) ensure that the excavation of the ECRB Drift proceeds in a timely manner, the field-determined location and schedule of ECRB testing activities (including construction support for testing activities) shall be subject to TCO approval. This requirement is conservatively imposed as a QA control to limit potential impact on site characterization activities (Requirement 15). TBM excavation and testing activities may occur concurrently if the TCO and the CMO ascertain that (1) continued such activities will not endanger the project personnel, the TBM trailing gear, and support systems, and (2) adequate access can be provided to enable the preparation and conduct of testing activities.

13.2.12 Water Controls

As discussed in Section 11.1 of this DIE, unsaturated conditions are considered an important attribute for repository performance, and lower water saturations are expected to provide better performance. The following controls are conservatively judged sufficient to limit to the extent practical any potential waste isolation impacts associated with the lost of water to the ECRB Drift geologic environment.

Accidental spills of water are to be minimized to the extent practical, and any spills that do occur are to be cleaned up as soon as practical to prevent loss to the environment (Requirement 5). Water lost within the ECRB Drift shall not exceed an average of 6.25 m^3 per linear meter of ECRB Drift excavation (Requirement 5). For constant ground conditions (which is a reasonable basis for a given day), water lost at the front the TBM and water used in the installation of ground support should be relatively uniform over the tunnel excavation for that day, which is consistent with discussions in Section 11.0 of this DIE. Based on this mode of operation, coupled with requirements to minimize and cleanup spills, it is judged that checking that the water lost limit has not been exceeded can be performed a minimum of once per day (Requirement 5).

Water loss reporting shall be on a once-per-day basis, for each day that water is used in the ECRB Drift, and shall specify the particular 5-m segment(s) of the ECRB Drift where the water was applied. The reduction to 5-m averaging segments is necessary because of the reduced width of the ECRB Drift compared to the width of the TS Loop. The cumulative total of water lost in each 5-m segment of the ECRB Drift, prior to closure of the potential repository, shall not be allowed to exceed the loss limit, without additional SA Department evaluation. The cumulative (i.e., lifetime) total water loss limit for a 5-m ECRB Drift segment would be 5 m x 6.25 $m^3/m = 31.25 m^3$. This calculated limit is the cumulative total amount of water that could be lost in that 5-m segment of the ECRB Drift, prior to closure of the potential repository (Requirement 5).

The 6.25 m^3/m limit includes water used in the ECRB Drift for cementitious materials, such as concrete, shotcrete or grout[6], because the entire ECRB Drift is below the lower limit of the PTn member (i.e., below the PTn-TSw1 contact) (Section 9). However, the limit only includes water used for such purposes where the cementitious material is considered to be committed (i.e., to remain post-closure) (Requirement 5). This accounting for water that is used in committed cementitious materials below the lower limit of the PTn member is necessary due to the possibility of thermal dryout, which results from repository heating. Thermal dryout could potentially cause substantial movement of the cementitious water from the location of emplacement to the surrounding rock as discussed in Section 11.2.2.

As discussed in Section 11.1.8 of this DIE, water applied in a fine spray on the natural invert surface—for the purpose of ECRB Drift dust suppression—is expected to evaporate and need not

[6]Note: As used here, grout includes rockbolt grout and grout used for ground consolidation purposes, as well as non-cementitious chemical grouts (if used).

be counted as water lost to the geologic environment, provided the water is applied at a rate of no more than 0.20 gal/m-day (0.76 liters/m-day) over sections no longer than 1100 m. One method of dust suppression in the ECRB Drift will be the use of an atomized spray fogger system at various points along the ECRB Drift where dust is typically generated (see Section 6.2.3). The use of the fogger system is expected to greatly reduce the amount of water that is applied for dust control purposes—possibly below the 0.76 liters/m-day over sections no longer than the 1100-m limit. However, based on the discussion in Section 11.1.8 (as supported by Attachment VIII of Reference 14.1), any water daily application to sections in sections longer than 1100 m would have to be reported as water lost to the geologic environment as required by Reference 14.6 (Requirement 5).

Water lost during the wet drilling of test boreholes emanating (laterally or vertically) from the ECRB Drift shall conservatively be considered to have been lost within the footprint of the ECRB Drift. The quantity of water lost shall be reported as required by Reference 14.6 (Requirement 5). Any water that is recovered during wet-drilling activities is not counted against the water loss limit.

As discussed in Reference 14.1, the A/E identified the potential capability to remove water from the Swellex-type rockbolts with a Swellex water recovery system. However, further evaluation of this activity associated with the TS Loop concluded that the amount of water either remaining in the Swellex bolts or recovered by such a system was not significant compared to the overall water loss limits, such that the specific use of the Swellex water recovery system was not warranted as a QA control. The water used for the Swellex-type rockbolts is reported as construction water lost, so any water recovered using a water recovery system can be used to reduce the amount of water lost to the ECRB Drift geologic environment.

13.2.13 Water TFM Report

Nearly 100 percent of the water used for dust control during TBM excavation, road header, type mechanical excavation or drill-and-blast excavation—as well as the wetting down of muck piles—is expected to be removed with the muck. Examples of water removed with muck include: (1) water applied by the nozzles in the cutterhead of the TBM, (2) atomized water applied by a dust fogger system in the area immediate behind the TBM cutterhead, and (3) water applied directly to the subsurface conveyor muck. However, water used for geologic mapping (as well as that used in mixing committed cementitious materials below the lower limit of the PTn unit) is assumed to be lost to the environment. Any water not removed[7] shall be reported as a consumed quantity As discussed in Reference 14.6 (Requirement 5). QA controls applied as previously described are judged sufficient to limit impacts to waste isolation to the extent practical.

[7]Note: As discussed in Section 13.2.12, water sprayed in a fine mist on the natural invert surface of the ECRB Drift, subject to certain, stated limitations, evaporates and therefore may be considered to be removed. In addition, some of the water used in ventilation scrubber units (if installed; see Section 6.13 of Reference 14.1) in the exhaust ducts from alcoves evaporates, and therefore may be considered to be removed.

13.2.14 Compressed Air

Section 10.6.10 of this DIE indicates that compressed air used for testing may need to be free of condensate. Section 6.16 of Reference 14.1 discusses the fact that drying, filtering and tracing may be performed with portable units local to such tests. The conduct of testing activities is not evaluated by this DIE, and no QA controls are required for testing activities. Any compressed air testing requirements are evaluated in the applicable FWP and/or its associated DIE.

ESFDR 3.8.2.8.1.D indicates that compressed air used underground during construction and operation shall be provided with chemical tracer only upon request by the TCO. As discussed in Section 10.7.1 of this DIE, the TCO may request that traced compressed air be used (e.g., to drill core holes and for field experiments and testing in the ECRB Drift). Since the scope of this DIE does not encompass such testing activities, the requests for such tracers are addressed in the applicable FWPs, no additional QA controls are required.

13.2.15 Water Balance

The ESFDR (Reference 14.5) requires the maintenance of the capability to keep a water balance (ESFDR 3.4.5.3.1.O, 3.4.5.6.1.D, 3.8.2.6.1.A, and 3.8.2.7.1.E). Although no specific impacts are identified, total water loss due to underground activities is a potentially important TFM input to understanding the site's performance. The requirement to maintain a balance is therefore conservatively judged to be a QA requirement in order to provide an accurate estimate in the event of water loss (Requirement 5). The accuracy required to provide an appropriate estimate, however, is sufficiently broad such that tracking water into and out of the ECRB Drift and reporting such quantities in accordance with the TFM procedure (Reference 14.6) along with a listing of the ECRB Drift water uses is considered adequate to provide data to fulfill this requirement.

Water directly associated with the conveyor belt use, TBM operations, mechanical excavator (i.e.. a road-header-type excavator) operation, and wetting of muck piles is assumed to be removed (i.e., not reported as lost water). Therefore, the water balance must account for these water uses versus water used for other purposes. Controls applied to minimize and mitigate spills, including spills of muck and/or water, are judged adequate to limit the potential for leakage from the conveyor to significantly impact the accuracy of the TFM reporting.

Conventional quality instruments (accurate to ±10 percent or better) can be used to obtain the flow values. Quantities of wastewater discharged from the ECRB Drift may be based on changes in level of wastewater tanks into which the water flows. Reporting the flow values (especially total water not removed from the tunnel) in accordance with the TFM procedure (Reference 14.6) is also sufficient (Requirement 5). Data generated as a result of planned *in situ* moisture and ventilation tests are judged to be sufficient for providing any additional data to TSPA for modification of total water use or validation of impact assumptions as necessary. (Note: It is not the intent of the water balance requirement to provide information to determine the extent and amount of drying of the rock surrounding the ramps/drifts.

In summary, the water balance shall include as a minimum: water into the ECRB Drift; water going out of the ECRB Drift; water used for conveyor, TBM and road-header type, mechanical excavator dust control operations (i.e., water applied directly on the conveyor belt, water applied by the dust fogger system, and water applied by TBM spray nozzles); water used for wetting of muck piles (if applicable); and an itemized listing of water uses during the recording period. Data obtained from the water balance on recovered water should be used to adjust water lost reports (Requirement 5).

13.2.16 Ponding of Water

Significant ponding of water may lead to further limitation of the amount of water that can be lost within the ECRB Drift and should therefore be prevented. Any ponded water shall be removed to the extent practical with standard pumping equipment (Requirement 5), and any water not removed will be reported as a consumed quantity as required by the TFM procedure (Reference 14.6) (Requirement 8). Constructor spill control procedures must include a requirement to limit unrecovered spills. Any record generated due to the implementation of a spill control procedure, as well as the procedure itself, must be processed as a QA record (Requirements 1 and 8). Use of Reference 14.6 is adequate for the records requirement. These controls are conservatively imposed as QA controls to limit impacts to waste isolation.

13.2.17 Thermal Testing Facility Interactions

As discussed in Section 10.2.1 of this DIE, ECRB Drift activities do not present a particular test interference concern to the TTF, provided the ECRB Drift layout meets the 50-m to 100-m offset distance requirement established by the responsible PI. As discussed in Reference 14.7, the approved layout of the ECRB Drift indicates that the minimum offset between the TTF and the ECRB Drift is approximately 53 m. Therefore, due to the controls imposed by the ECRB Drift layout design, no additional QA requirements are necessary.

13.2.18 Organics

Section 11.3.4 of this DIE indicates that if the total retained organic constituents do not exceed specified limits, it is expected that no more than a 10-percent change in the ambient aqueous organics concentration will occur. Therefore, there should be negligible geochemical impact in the ECRB Drift to waste isolation. It is recognized that the negligible-impact DOC limits given in Section 11.3.4 would be impractical if applied as construction/operation limits. Further, no specific impact from a change in ambient conditions has been identified, and there is no indication that the potential impact from exceeding these conservative limits through normal, controlled operation is not mitigable. As such, organic use in the ECRB Drift shall be minimized.

In order to limit adverse effects on the long-term potential repository to the extent practical, the amount of organic material that is to be permanently retained in these excavations shall be minimized. The following controls are therefore applied to minimize permanently retained organics and thereby limit potential impacts to the extent practical: the use of permanently retained organics during construction and operation of the ECRB Drift shall be avoided when practical alternative materials and methods exist, leakage of organics from construction and/or operational equipment shall be mitigated and repaired as soon as practical, spills of organics in excess of drips (e.g., ruptured hoses and spills from reservoirs) shall be removed to the extent, and as soon as, practical (Requirement 6). Any organics that are spilled or that are permanently retained in ECRB Drift shall be reported in accordance with the TFM procedure (Reference 14.6) (Requirement 8). Any possible effects on waste isolation of the total amount of organics retained in the ECRB Drift will be evaluated following construction as described in the TSPA. These controls are determined to be sufficient to limit impacts to waste isolation and minimize potential test interference impacts.

13.2.19 Invert Spills

Unlike the TS Loop, there is no concrete invert to assist in the mitigation of spills in the ECRB Drift (i.e., spills should be cleaned up to the extent practical). Liquid spills on the host rock invert of the ECRB Drift must be assumed to have penetrated the invert floor if they are not completely recovered. As such, further visual observations may be necessary to fully assess spills in the ECRB Drift. Unrecovered quantities of spills must assumed to be committed to the site. As discussed in Sections 10.0 and 11.0 of this DIE, such committed spills have the potential to impact waste isolation and to cause test interference. Therefore, they must be reported in accordance with Reference 14.6 (Requirement 8). Any possible effects on waste isolation due to spills in the ECRB Drift will be evaluated following construction as described in the TSPA. Any potential test interference will be evaluated by the appropriate PI(s). These controls are determined to be sufficient to limit impacts to waste isolation and minimize potential test interference impacts.

13.2.20 Perched Water

In accordance with Section 10.0 of this DIE and ESFDR (Reference 14.5) requirement B.8.3.A.2, encountering perched water requires TCO notification in order to give the TCO or PI the opportunity to determine if such measures are necessary (Requirement 11). For purposes of TCO notification, whenever flowing water is detected from excavated surfaces, the perched water notification shall be made. Following tests or collection of water as mandated by the PIs/TCO, remaining perched water is to be removed in accordance with requirements in Reference 14.5.

13.2.21 Diesel Usage and Waste Isolation

Reference 14.47, an analysis of existing (surplus Nevada Test Site [NTS]) diesel equipment, indicated that the actual emission rates may exceed the negligible impact limits for dissolved organic, nitrate, and sulfur dioxide. This analysis makes very conservative assumptions on the amount of exhaust material that is retained in the ESF. Furthermore, the overall organic limits discussed in Section 11.3.3 of this DIE are those limits below which negligible impact is expected, not those limits for which an impact is anticipated. Also, opening the mountain to the external environment allows the potential introduction of organic materials to the underground (e.g., rodents, insects, airborne particles, and organic byproducts). As such, as long as diesel emissions are minimized, the amount of diesel emissions actually retained will be bounded by the organic introduction created by the opening itself. Finally, there is no indication that the controlled use of diesel equipment would result in unmitigable impact to the site's ability to isolate waste. Therefore, it is judged that, provided diesel emissions are minimized to the extent practical, diesel equipment is acceptable for use in the TS Loop, subject to checking and reporting as discussed in the following section. This same justification, which was originally prepared for Reference 14.1, is equally applicable to the ECRB Drift.

13.2.22 Diesel Usage and Test Interference

Section 10.6.6 of this DIE also identifies potential test interference impact on *in situ* gas testing activities due to the carbon content of diesel exhaust in the potential repository emplacement areas. As a result, diesel checking is required to evaluate carbon gaseous discharges prior to use in the potential repository emplacement areas (Requirement 7).

13.2.23 Diesel Requirement

As a conservative measure to limit the potential for waste isolation and test interference impacts, the following requirements are indicated: Diesel equipment shall be subject to periodic testing for DPM, sulfur dioxide, and oxides of nitrogen, carbon monoxide, and carbon dioxide. To ensure that sulfur oxides constituents in exhaust emissions are minimized, the above-ground 40 CFR 80.29 (Reference 14.48) requirement for low sulfur ($\leq$ 0.05 percent) diesel fuel shall be used. In general, detrimental components of diesel exhaust (as identified in previous sections) are to be minimized to the extent practical. Controls for ensuring minimization of these emissions include: (1) minimizing diesel idle time while in the tunnel, (2) conducting regularly scheduled maintenance of diesel equipment, (3) ensuring that diesel emissions are maintained below prescribed guidelines (based on manufacturer's recommendations or as approved by the A/E), and (4) measuring and reporting diesel exhaust emissions. Also, as stated in Section 11.3.3, the use of A-55 clean fuel, as a substitute for diesel fuel, should reduce the amount of detrimental components of diesel exhaust that are released in the tunnel. In addition, diesel locomotives used in the ECRB Drift shall have exhaust treatment systems installed on them that are designed to reduce the emissions of DPM into the underground. Diesel use records shall include as a minimum the type of engine or equipment, the volume of fuel used, and the number of hours the equipment was operated (Requirement 7).

These requirements provide for QA control of diesel emission minimization and are judged to be adequate to limit the potential for adverse impact to the extent practical.

13.2.24 TFM Control

As a conservative measure, it has been determined that the recording of consumed quantities of TFMs as QA records shall be implemented. These reports provide additional bases for the TSPA and allow verification of consumed quantities. Therefore, any TFMs that are permanently emplaced/committed (i.e., are expected to remain after closure of the potential repository) in the

ECRB Drift—including water, hydraulic fluid, fuel, and wood—must be reported in accordance with the TFM procedure (Reference 14.6), except as specifically exempted in this section. These reports must be controlled as QA records (Requirement 8). This control is conservatively imposed as a QA requirement to limit potential impacts to waste isolation and site characterization activities.

The use of tracer gases SF_6, SUVA-COLD MP®, and noble gases (i.e., He, Ne, Ar, Kr, and Xe) in the ECRB Drift is exempted from reporting as TFMs. This exemption is based on the expected (1) negligible impact that these gases present to the waste isolation capabilities of a potential repository at Yucca Mountain (as discussed in Section 11.3.1 of this DIE), and (2) alternate availability of SF_6 usage records (e.g., as part of test documentation records) should such records be required in the future for TSPA activities or to help establish initial conditions for site characterization testing.

Incidental losses of chlorinated, potable water/ice used for drinking and hand washing purposes in the subsurface ESF does not present a significant test interference concern (Reference 14.49). Therefore, such losses need not be reported in accordance with Reference 14.6 reporting requirements.

13.2.25 Rolling Stock

The areas of concern with rolling stock (exclusive of locomotives) are the potential for incidental spills (both of fluids included in the rolling stock and of fluids being transported to the surface) and accidental explosions. The rolling stock constructor and/or supplier is required to incorporate in the design and manufacture of rolling stock cars reasonable methods for preventing and mitigating the leakage and spillage of fluids. In addition, the rolling stock constructor and/or supplier is required to describe a program addressing design features, maintenance, operation, and administrative programs for preventing and mitigating leaks and spills, as discussed in Reference 14.1. As discussed in Reference 14.1, the following features are incorporated into A/E-specified rail cars: wheel bearings designed to mitigate hydrocarbon releases, fail safe airbrakes, and tie-downs and/or guards to prevent supplies and equipment from shifting during transit. Rail grippers are provided on both the scissor lift ventilation car and the scissor lift platform car for stability during lifting operations. A spill board encloses the deck of the maintenance/lube car to contain spilled fluids, and drain plugs will be provided at each end for draining spilled fluids. The maintenance/lube car utilizes rings welded onto the deck for transporting the two grease barrels. Tanks on the maintenance/lube car will be fitted with quick disconnect couplers and caps, sight glasses, and ball type shutoff valves for connections (to prevent overflow). Included in the rolling stock is a tank containing water to be used for storage for subsurface operations. This tank is secured on a standard flat car. The constructor will ensure the operational readiness (with respect to leak prevention/mitigation) of rolling stock before using it in the ECRB Drift. It is also a requirement that maintenance be performed on equipment containing or associated with fluids of concern. The extent (e.g., type of maintenance and components to be maintained) and frequency of maintenance shall be based on recommendations from the manufacturer or as approved by the A/E. These controls, along with spill controls discussed previously, are sufficient to limit impacts to test interference and waste isolation (Requirement 13).

13.2.26 Underground Storage Vessels

Consistent with Reference 14.1, it is conservatively judged that additional storage vessels (i.e., beyond the size of on-board vehicle tanks) for fluids must be placed outside the ECRB Drift to limit the potential for underground leakage. This does not include the sump storage tanks or on-board tanks, such as those on the rolling stock, TBM, or the TBM trailing gear (Requirement 9).

13.2.27 Conveyor Operation

Conveyor operation introduces a potential for the release of contaminants that may adversely impact site characterization data, or the capability of the site to isolate waste. Operating fluids of concern are lubricating oils, hydraulic fluid, grease, and dust suppression water. As discussed in Reference 14.1, the design of the conveyor incorporates several features that will limit spills to the extent practical: utilization of labyrinth seals on pulley and idler bearings to limit grease from leaking, emergency stop switches operated by pull cords located along the full length of the conveyor, use of fully enclosed chutes with a dust suppression water spray system available for use at most transfer points, a solenoid shutoff valve interlock to prevent water usage when the conveyor is empty or not running, and a flow meter on each spray header to indicate the amount of water being used. These conventional quality features are adequate when combined with the spill containment/mitigation limits, to limit test interference and waste isolation impacts. No other QA requirements are required. Section 10.5.1 of this DIE discusses the need to clean up muck spills that are excessively wet to the extent practical to limit exposure of *in situ* rock to water or other contaminants. Controls that are in place to limit/mitigate spills of water, hydrocarbons, and other materials, are adequate to provide this control.

13.2.28 Fires

The primary means of extinguishing fires during construction will be a dry chemical fire protection system. As discussed previously, organic materials retained in the ECRB Drift must be limited to prevent effects on a potential repository. It is judged, however, that chemical releases as a result of fires, or the extinguishing of fires, are insignificant relative to this limit (and are therefore not likely to impact waste isolation) since dry chemical residue will be removed following discharge. Section 11.3.5 of this DIE indicates that dry chemicals and water should not be combined for fire protection unless required for safety reasons. As discussed in Reference 14.1, water hose stations are used only as a supplemental system. It is judged that the backup use of water in the amount required to extinguish a fire is not likely to impact waste isolation and that any impact, as a result of this event, can be adequately evaluated when specific details of the event are available. Any actuation of dry chemical fire, protection systems or the backup use of water will be evaluated following removal of the powder and/or water to the extent practical. The requirements associated with mitigation and reporting of spills are adequate to control this activity (Requirements 5 and 6).

13.2.29 Inadvertent Explosions

Inadvertent explosions could occur in the ECRB Drift during construction. However, the potential for such explosions is considered remote enough not to warrant QA controls. Should a significant uncontrolled explosion occur, an evaluation of potential impacts to the surrounding rock mass will have to be conducted at that time based on as-found conditions.

13.2.30 Underground Storage of TFMs

Section 10.7 of this DIE recommends that the storage underground of TFMs that have decomposition and/or combustion products potentially adverse to site characterization be controlled and limited. As discussed previously, conventional practices including compliance with normal industrial hygiene requirements and personnel safety will be used in the construction of the ECRB Drift. Leak and spill mitigation programs are also required by this DIE, and TFMs are controlled As discussed in Reference 14.6. Due to these requirements and practices, the intent of minimizing storage underground is met, because any use or uncontrolled releases of these fluids are reported via the TFM procedure and evaluated appropriately. Therefore, no additional QA controls are required.

13.2.31 Traced Water and Perched Water

Section 10.7.1 of this DIE recommends that grout used in the vicinity of perched water testing be required to contain a tracer. Since the only available supply of nonpotable water in the ECRB Drift is traced water and grout is mixed at or near the use location, it is judged that no additional QA controls are required.

13.2.32 Rock Drills

As discussed in Reference 14.1, rock drill hydraulic system features include a system design pressure that is two times the maximum hydraulic system operating pressure, hydraulic fittings and hoses with operating pressures of twice the hydraulic system operating pressure, and the full-flow filtering of pressure lines between components and in return lines. Filters are located to provide for ease of servicing. Maintenance of rock drills and similar equipment (e.g., road-header type, mechanical excavators; and front end loaders), which involves the use of fluids of concern (as recommended by the manufacturer or as approved by the A/E), will limit potential impacts to waste isolation and site characterization testing (Requirement 13). Pneumatic drills may be necessary, where access with TBM-mounted electro-hydraulic drills or the drill jumbos is restricted, to install ground support for personnel safety. The use of pneumatic drills is bounded by the controls limiting organics and the TFM reporting of fluids lost or consumed such that additional QA controls are not required.

13.2.33 Drinking Water

Drinking water within the ECRB Drift is expected to be provided in small (on the order of a few gallons) temporary coolers or canteens. For health reasons, drinking water (and any associated ice) will not be traced and may be chlorinated. Untraced, chlorinated water may also be provided to hand wash stations. Because of the conservatism associated with hydrological impact evaluations and conclusions, and because of the small quantities involved, incidental spills of drinking water/ice and hand wash station runoff are not considered to require additional QA controls to limit impacts to waste isolation. See Section 13.2.34 for further discussion of drinking water.

13.2.34 Chlorides

The use of chloride-containing chemicals is to be limited to avoid potential test interference impact (see Section 10.7.3) as follows: only non-chloride-based ground enhancing material (e.g., GEM®) is to be used, and the use of chloride-based concrete and grout accelerators is to be limited to the extent practical. TCO concurrence prior to such use is judged sufficient to provide this control. The amount used shall be recorded in accordance with Reference 14.6 reporting requirements (Requirement 12) if permanently emplaced/committed. This control is conservatively applied as a QA requirement to limit test interference impacts.

The use of chlorinated water/ice for drinking and hand washing purposes in the subsurface ESF does not present a significant test interference concern (Reference 14.49) and therefore does not warrant additional QA controls. Incidental losses as a result of such uses need not be reported in accordance with Reference 15.6 reporting requirements.

13.2.35 Construction Water & Sampling

Section 10.4 recommends that no water or tracers, except for the traced water used in construction and in the air-mist used to clean the tunnel walls, are to be used in the vicinity of sampling locations within the ECRB Drift. Since nonpotable water piped or transported into the ECRB Drift is required to be traced (Requirement 2) with the only approved tracer (i.e., with LiBr), no additional QA controls are required.

13.2.36 Cement Grouting

Sections 10.5.3 and 10.6.5 of this DIE indicate that cementitious grouting associated with rockbolt installation be limited to the extent practical in order to limit impacts to the ability to properly characterize the site. Cement grouted rockbolts are not to be used in the ECRB Drift, except as approved by the TCO. It is conservatively judged that this requirement shall be implemented as a QA control in order to avoid altering gas sample and air permeability data (Requirement 4).

13.2.37 Shotcrete

As discussed in Section 10.5.3, the constructor must coordinate with the TCO prior to applying shotcrete in the ECRB Drift, to assure access for testing (Requirement 10). As a conservative measure applied to limit potential unidentified test interference impacts, this requirement is imposed as a QA control.

13.2.38 Stabilization of Poor Ground Conditions

Alternative excavation/ground support methods (i.e., contingency-based methods outside of specification requirements for stabilizing extremely poor ground) are expected to be invoked occasionally during ECRB Drift excavation. (Alternate excavation/ground support methods have been employed in a few instances in the TS Loop, in accordance with Paragragh 3.01X of Reference 14.50.) These contingencies are typically expected to consist of the use of lean cement, steel, and/or wood cribbing to stabilize weak ground where the immediate safety of personnel or equipment is at risk. Such methods are applied only until competent ground is reached. Actions taken are documented in accordance with Reference 14.51, which requires TCO and SA Department concurrence as soon as practical after the determination of the alternate methods to be used (which may, in some cases, follow implementation). Because these alternate methods are required to protect personnel and equipment, these provisions are judged as adequate to limit potential impacts.

Implementation of such alternate methods typically does not include significant quantities of organic materials, although the use of chemical injection grouting has been considered. Because of the fact that certain injected chemical grouts violate waste isolation no-impact organic thresholds, a prohibition is placed on its use unless it is the only practical method for continuing excavation. Recognizing the fact that chemical grouting requires a non-trivial equipment deployment, this method shall not be used prior to conducting an evaluation of potential waste isolation/test interference impacts (Requirement 14). Such evaluations will be based on the as-found ground conditions that require the use of chemical grouting.

13.2.39 ESF TS Loop and Surface ESF Interfaces and Controls

The applicable subsurface or surface DIE (References 14.1 and 14.52, respectively) should be consulted for the controls applicable to the construction and operation of ESF TS Loop and surface ESF equipment that interfaces with the ECRB Drift equipment. Equipment having such interfaces include the subsurface power/grounding distribution system, communication system, lightning protection system, and surface conveyor system. No additional QA controls are required.

One TS North Ramp interface is not specifically evaluated by Reference 14.1, as of the approval date of this DIE (i.e., the use of A-55 clean fuel as a substitute for diesel fuel). As discussed in Sections 11.3.3 and 13.2.23 of this DIE, the use of A-55 clean fuel is expected to reduce the amount of detrimental emission constituents. Therefore, it is concluded that the use of A-55 clean fuel in the TS North Ramp (between the ESF North Portal and the ECRB Starter Tunnel) is completely bounded by the Reference 14.1 evaluation, conclusions, and QA control requirements. As such, neither further evaluation nor additional QA controls are required.

13.2.40 Electromagnetic Interference

As discussed in Section 10.6.3 of this DIE, transformers, cabling, and other electrical equipment associated with ECRB Drift power distribution and lighting systems could potentially influence test equipment due to EMI. The PIs responsible for individual testing activities will coordinate with the A/E to determine if electromagnetic protection is required. As discussed in Section 10.6.3 of this DIE, EMI shielding or other mitigation measures may be implemented, as required, under the control of the applicable FWP. Therefore, no additional QA controls are required.

13.2.41 Construction Utilities

Temporary construction accommodations could potentially be installed to support construction and operations activities prior to the installation of the A/E-designed support systems. Such temporary accommodations could include muck handling, electric power, lighting, compressed air, ventilation, water, wastewater, fire protection, communications, and monitoring systems. Any potential construction-supplied monitoring system is evaluated as a part of the system it supports. All temporary, constructor-supplied accommodations are subject to the same applicable DIE requirements as the A/E-designed systems—as verified by the A/E. No additional QA controls are required.

13.2.42 Surfactant Material and Binding Agent Use

Section 11.3.5 of this DIE derives a special organics loss limit of 8.8 g/m of excavation that is to be applied in the second ECRB testing interval (i.e., between approximate Stations 1+76 m and 2+25 m). This limit was derived based on the unique offset distance between the testing interval and the closest potential waste package. Section 6.4.1 of this DIE describes testing activities designed to verify the amount of the surfactant material that has been committed to the site (i.e., remains after excavation and recovery activities have been completed). To ensure that the surfactant test is not compromised and to ensure that the bounding conditions of the Section 11.3.5 of this DIE surfactant use limit are not exceeded, surfactant material use is restricted to only the approved testing zone—approximately Station 1+76 m to 2+25 m (Requirement 6). As a conservative measure applied to limit potential waste isolation impacts, this requirement is imposed as a QA control..

As with the general organics evaluation in Section 13.2.18 of this DIE, it is recognized that the negligible-impact DOC limit given in Section 11.3.5 of this DIE (i.e., 8.8 g/m of excavation) are impractical if applied as construction/operation limit. Further, no specific impact from a change in ambient conditions has been identified, and there is no indication that the potential impact from exceeding this conservative limit through normal, controlled operation is not mitigable. As such, surfactant use in the approved testing zone of the ECRB Drift shall be minimized to the extent practical. It should also be emphasized that the surfactant limit is a loss limit, not a use limit. Therefore, efforts to recover as much of the surfactant material as practical are expected to result in the actual quantity of committed surfactant being below the 8.8-g/m limit. The results of the surfactant testing are critical because they will be used to validate the evaluation of surfactant material use in Revision 01 (Phase II) of this DIE, which addresses the ECRB Drift beyond Station 7+73 m. Regardless, for the Phase I ECRB Drift, the implementation of Requirement 6 as a QA control is judged to limit surfactant use to the extent practical with respect to waste isolation considerations, and no additional QA requirements are necessary.

Section 10.6.2 discusses the test interference associated with surfactant material use and concludes the quantity of surfactant material used within the ECRB Drift should be documented. The implementation of Requirement 8 is judged to be sufficient to satisfy the potential test interference concern, and no additional QA requirements are necessary.

Nearly 100 percent of a binding agent, if used, is expected to be removed with the muck, as long as it is only applied to the muck within the confines of the conveyor belt. Thus, if binding agent application is confined to the conveyor, no waste test interference or waste isolation impact is anticipated, based on discussions in Sections 10.6.2 and 11.3.5. A QA control is warranted to ensure a binding agent, if used, is restricted to application on the conveyor belt (Requirement 6).

13.2.43 Alternative Excavation Techniques

Reference 14.1 describes the use of road-header type, mechanical excavators and drill-and-blast excavations techniques to construct support areas (e.g., alcoves, niches, or sump excavations). These excavation techniques could potentially be required within the ECRB Drift for similar purposes. Road-header-type, mechanical excavators are bounded by requirements discussed elsewhere in this DIE on use of equipment containing fluids of concern (Requirement 13). Per Section 10.5.2, drill-and-blast excavation techniques are acceptable provided they are controlled. Neither excavation technique is expected to compromise the ability to provide adequate ground support systems.

To provide evidence of the appropriate application of controlled drill-and-blast techniques, work must be performed by trained personnel in accordance with approved A/E specifications with selected witnessing. Constructor blast plans and blast patterns are approved by the A/E as prescribed by A/E specifications. Inspections are documented for compliance with the A/E specifications. Explosives are procured from a qualified supplier as required by 27 CFR 55 (Reference 14.53). Provisions also include training and qualification documentation, receipt verification of materials, and processing of construction records and changes. These provisions are judged sufficient for these purposes. Training records, procedures, and inspection records associated with drill-and-blast operations must be retained as QA records. At a minimum, the time, location, type of explosive and size (i.e., pounds explosive per delay) of each blast shall be reported. To provide assurance that appropriate practices have been employed and are in conformance with 10 CFR 60.72 (Reference 14.4), use and retention of blast records and blast plans as quality records is required (Requirements 17 and 18).

13.3 QA CONTROLS

The following QA requirements have been identified as a result of this evaluation. These requirements are to be applied in addition to other conventional design practices.

Requirement 1: Records required for 10 CFR 60.72 shall be maintained as QA records. [ESFDR 3.2.1.1.1.A, 3.2.1.1.4.C, and 3.7.1.2.B]

Requirement 2: Nonpotable water transported into the ECRB Drift shall be traced (except for water used outside the tunnel for mixing concrete, grout, and shotcrete that is then used in the ECRB Drift). LiBr concentration is to be controlled by Requirement 3 of Reference 14.1. [ESFDR 3.2.1.2.3.B, 3.4.5.3.1.G, 3.4.5.3.1.P, 3.7.2.5.1, 3.8.2.6.1.E]

Requirement 3: The following minimum requirements apply to TBM maintenance in order to minimize the potential for underground spills of fluids of concern:

(3a) Maintenance procedures shall include provisions to contain loss of hydraulic fluids due to the removal of hydraulic lines or components.

(3b) Periodic sampling of hydraulic and lube oils for contaminants shall be performed as part of preventative maintenance. The frequency of the sampling shall be based on manufacturer's recommendations or as approved by the A/E.

(3c) Periodic maintenance shall be performed on components containing or associated with fluids of concern. The extent (e.g., type of maintenance and components to be maintained) and frequency of maintenance shall be based on manufacturer's recommendations or as approved by the A/E.

[ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D]

Requirement 4: Cement grouting in the ECRB Drift is prohibited without TCO concurrence. [ESFDR 3.2.1.2.3.B, 3.2.1.2.3.D]

Requirement 5: Water use and purposeful or accidental loss of water to the environment in the ECRB Drift shall be minimized to the extent practical by imposing the following controls:

(5a) Any spilled or ponded water shall be minimized and removed from the ECRB Drift to the extent practical with standard pumping equipment.

(5b) Any water not removed shall be reported as a consumed quantity as required by the TFM procedure (Reference 14.6).

Note: Water applied by the atomized spray fogger system is expected to be supplied at or below the rate of 0.20 gal/m-day [0.76 liters/m-day] over sections no longer than 1100 m. Water applied in this manner is expected to evaporate (i.e., is considered to be removed) and it need not be counted as water lost to the geologic environment. However, daily water application in this manner over sections longer than 1100 m shall be reported in accordance with Requirement 5b.

(5c) A water balance shall be maintained and reported in accordance with the TFM procedure (Reference 14.6). The water balance may be used to adjust reports of use against limits. The water balance shall include as a minimum: (1) water into the ECRB Drift; (2) water going out of the ECRB Drift; (3) water used for dust control operations associated with the conveyor, TBM, and other mechanical excavators (i.e., water applied directly on the conveyor belt); (4) water applied by the dust fogger system and water applied by TBM spray nozzles; (5) water used for wetting of muck piles (if applicable); and (6) an itemized listing of water uses during the recording period. (Conventional quality instruments, accurate to ±10 percent or better, may be used to obtain this data.)

Note: It is not the intent of this requirement to provide information to determine the extent and amount of drying of the rock surrounding ECRB Drift.

(5d) The amount of construction water lost in the ECRB Drift excavation (not including the ECRB Starter Tunnel) shall not exceed an average of 6.25 m^3 per linear meter of tunnel excavated, as applied over 5-m segments of the ECRB Drift. Water loss shall be checked at a minimum frequency of at once per day, for each day that water is used. Water loss reporting shall specify the particular 5-m segment(s) of the ECRB Drift where the water was applied. The cumulative total of water lost in each 5-m segment of the ECRB Drift, prior to closure of the potential repository, shall not be allowed to exceed the loss limit, without additional SA Department evaluation.

The water loss limit does not include: (1) water applied by TBM spray nozzles, (2) atomized water applied by a dust fogger system in the area immediate behind the TBM cutterhead, nor (3) water applied directly to the subsurface conveyor muck. The total amount of water use in each of these applications are to be reported as used and recovered in the water balance because this water is assumed to be removed with the muck. Any water recovered that is metered or otherwise measured is also not included in the limit.

The 6.25 m^3/m limit include water used in the ECRB Drift for cementitious materials, such as concrete, shotcrete or grout, where the cementitious material is considered to be committed (i.e., to remain during post-closure).

[ESFDR 3.2.1.1.2.4.H, 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.D, 3.2.1.2.3.E, 3.4.5.3.1.O, 3.4.5.6.1.C, 3.4.5.6.1.D, 3.7.1.2.C, 3.7.2.1.2.E, 3.8.2.6.1.A, 3.8.2.6.1.H, 3.8.2.7.1.E, 3.8.2.7.1.F, 3.8.2.7.1.G]

Requirement 6: The amount of organic material that is to be permanently retained in these excavations shall be minimized to the extent practical as follows:

(6a) The use of permanently-retained organics during construction and operation of the ECRB Drift shall be avoided when practical alternative materials and methods exist.

(6b) Leakage of organics from construction/operational equipment shall be mitigated and repaired as soon as practical.

(6c) Spills or releases of organics, powders, solvents, etc., in excess of drips (e.g., from ruptured hoses and spills from reservoirs) shall be removed to the extent, and as soon as, practical.

(6d) Any materials that are spilled (subject to Requirement 6) or that are permanently retained in the ECRB Drift shall be reported in accordance with the TFM procedure (Reference 14.6).

(6e) Surfactant material use in Phase I of the ECRB Drift is restricted to only the approved testing zone of approximately Stations 1+76 m to 2+25 m.

(6f) Should a binding agent be used to control dust associated with ECRB Drift conveyor system operation, application of the binding agent is restricted to only muck that is in the conveyor belt.

Note: There is no concrete invert to collect/absorb spills in the ECRB Drift—unlike the ESF TS Loop. Therefore, some quantity of spilled materials must be assumed to have been consumed if the entire spill amount is not recovered.

[ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.E]

Requirement 7: The following minimum requirements apply to the use of diesel equipment in the ECRB Drift:

(7a) Diesel equipment shall be subject to periodic testing for diesel particulate matter, sulfur dioxide, and oxides of nitrogen, carbon monoxide, and carbon dioxide. Diesel equipment shall be tested prior to initial use in the ECRB Drift, and at a frequency accepted by the A/E thereafter, and checked to be within manufacturer's recommendations for diesel emission constituents of concern (or within standards developed on site in a manner acceptable by the A/E).

(7b) Diesel exhaust shall be minimized to the extent practical. Controls to minimize diesel emissions shall include minimization of diesel idle time in the tunnel and regularly scheduled maintenance (including maintenance of emissions-related systems).

(7c) Diesel locomotives without exhaust treatment systems that are designed to reduce emissions of diesel particulate matter shall not be used in the ECRB.

(7d) Low sulfur (≤ 0.05 percent) diesel fuel shall be used.

(7e) Diesel use records shall include as a minimum the type of engine that consumed the diesel fuel, the volume of fuel used, and the number of hours of diesel operation.

[ESFDR 3.2.1.1.3.2.D, 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C]

Requirement 8: QA records shall be made and provided in accordance with the TFM procedure (Reference 14.6) of all TFMs that are permanently emplaced/committed (i.e., to remain after closure of the potential repository) to the ECRB Drift, including water and wood, and unrecovered spills, except as specifically exempted in a DIE (e.g., see Section 13.2.24 of this DIE).

Note: TFM use and reporting in the TS Loop and the ECRB Starter Tunnel are controlled by the requirements of Reference 14.1.

[ESFDR 3.2.1.1.3.2.D, 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D, 3.2.1.2.3.E]

Requirement 9: Large fluid storage systems shall not be located underground. Large systems are defined as storage tanks or vessels that exceed the volume of normal on-board vehicle fluid reservoirs, not including the sump storage tank, or those volumes within tanks or systems mounted on the TBM, TBM trailing gear, conveyor drives and belt storage units, or rolling stock. [ESFDR 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D, 3.2.1.2.3.E]

Requirement 10: The application of shotcrete in the ECRB Drift shall be coordinated with the TCO prior to its application to assure access for testing. [ESFDR 3.2.1.2.3.B]

Requirement 11: Provisions shall be made for immediate TCO notification if perched water is encountered, as indicated by water flowing from excavated surfaces. [ESFDR 3.2.1.2.3.A, 3.2.1.2.3.D]

Requirement 12: The use of chloride shall be limited as follows:

(12a) Only non-chloride-based ground enhancing material shall be used.

(12b) Use of chlorides (including chloride-based concrete and grout accelerators) shall be limited to the extent practical. Their use (other than to chlorinate water/ice used for drinking and hand wash purposes) shall require TCO concurrence, and shall be recorded as a TFM if permanently emplaced/committed.

[ESFDR 3.2.1.1.3.2.D, 3.2.1.2.3.A, 3.2.1.2.3.B]

Requirement 13: Minimize the potential of leaks from equipment (e.g., rolling stock; road-header type, mechanical excavators; and diesel locomotives) containing fluids of concern in the tunnel (such as hydraulic fluid and oil) by the following minimum requirements:

(13a) Maintenance shall be performed on equipment containing or associated with fluids of concern. The extent (e.g., type of maintenance and components to be maintained) and frequency of maintenance shall be based on recommendations from the manufacturer or as approved by the A/E.

(13b) The constructor shall ensure the operational readiness of equipment containing fluids of concern (with respect to leaks) before using it in the ECRB Drift by checking for leaks.

[ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D, 3.2.1.2.3.E]

Requirement 14: Evaluation of the use of chemical grout injection to stabilize weak ground (including re-evaluation of potential waste isolation and test interference impact) shall be performed by the SA Department prior to its implementation. [ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.D]

Requirement 15: The field-determined location and timing for preparation and conduct of ECRB Drift testing activities shall be subject to TCO approval. [ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D, 3.2.1.2.3.F]

Requirement 16: Excavation beyond Station 7+73 m of the ECRB Drift is contingent upon (1) approval of the DIE for Phase II of the ECRB Drift and (2) verification of the Phase II DIE water loss and organic material loss limits. [ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.D]

Requirement 17: Controlled drilling-and-blasting within the ECRB Drift shall be performed in accordance with the following minimum QA requirements:

(17a) Qualification of those performing the operations,

(17b) Use of material from a qualified supplier as required by 27 CFR 55 (Reference 14.53),

(17c) Receipt inspection and verification of representative samples of materials,

(17d) Performance to required tolerances (post-blast),

(17e) A/E approval of blasting plans, and

(17f) A/E approval of blasting patterns.

[ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.G, 3.2.1.2.3.H, 3.7.2.1.2.F]

Requirement 18: Drill-and-blast work in the ECRB Drift shall be documented in accordance with the applicable A/E specifications. Drill-and-blast records shall document work processes in conformance with 10 CFR 60.72 (Reference 14.4). Records associated with documentation of training and qualifications for drill-and-blast operations shall be treated as QA records. Explosive receipt verification, blast records, blast plans, and blast patterns shall also to be treated as QA records. As a minimum, the type of explosive, size (i.e., pounds explosive per delay), time, and location of the blast shall be reported as a QA record. [ESFDR 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D, 3.2.1.2.3.G, 3.2.1.2.3.H]

13.4 REMOVAL REQUIREMENTS

Non-permanent items shall be removed to the extent practical, prior to the licensed operation phase of a potential repository. Any incorporation of these items or their constituents into the permanent repository will require a new evaluation as part of the design of permanent items.

13.5 RECOMMENDED CHANGES TO REQUIREMENTS DOCUMENTS

Although not directly associated with this DIE, a request to change Section 3.7.2.3 of the ESFDR (Reference 14.5) has been submitted. Specifically, the ECRB Drift should be added to the list of Main Access Openings. This ESFDR change was requested to ensure that the ECRB is designed and constructed consistent with the orientation, depth, and layout of the repository design. As a direct result of this change, requirements will be mandated that preserve the potential use of the ECRB Drift for some yet to be determined function (such as performance confirmation activities) in a potential repository. Based on adding the ECRB Drift to the list of Main Access Openings, a further request was made to acknowledge that all Main Access Openings are not excavated to a 7.62-m diameter opening. The ECRB Drift is only 5 m in diameter.

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14.50 M&O Design Specification, *Subsurface General Construction*, BAB000000-01717-6300-01501 Rev 04 (including ECRs E96-0041, -0060, -0076, and E97-0011), November 17, 1995.

14.51 *Technical Document Preparation Plan for Plans for Continuing TBM Advance*, BAB000000-01717-4600-00024 Rev 00, April 3, 1995.

14.52 *Determination of Importance Evaluation for the Surface Exploratory Studies Facility*, BAB000000-01717-2200-00106 Rev 02, February 14, 1996.

14.53 Title 27, Code of Federal Regulations, Part 55, "Commerce in Explosives," April 1, 1997, Edition.

14.54 "Effect of Fractures on Repository Dryout," Eaton, R. R., *Proceedings of the Fifth Annual International Conference, High Level Radioactive Waste Management*, Vol. 4. pp. 2442 - 2449, 1994.

14.55 "The Analysis of Repository-Heat-Driven Hydrothermal Flow at Yucca Mountain," Buscheck, T. A. and Nitao, J. J., *Proceedings of the Fourth Annual International Conference, High Level Radioactive Waste Management*, Vol. 1. pp. 847 - 867, 1993.

15.0 ATTACHMENTS

Attachment I	List of Acronyms
Attachment II	TFMs Approved for Use in the ECRB Drift

LIST OF ACRONYMS

10 CFR 60	Title 10, Code of Federal Regulations, Part 60
27 CFR 55	Title 27, Code of Federal Regulations, Part 55
40 CFR 80.29	Title 40, Code of Federal Regulations, Part 80, Subpart 29
A/E	Architect/Engineer
Ar	Argon
CHn	Calico Hills nonwelded
cm	Centimeter(s)
CMO	Construction Management Organization
CPVC	Chlorinated Polyvinyl Chloride
CRWMS	Civilian Radioactive Waste Management System
DIE	Determination of Importance Evaluation
DOC	Dissolved Organic Carbon
DOE	United States Department of Energy
DPM	Diesel Particulate Matter
EBS	Engineered Barrier System
ECRB	Enhanced Characterization of the Repository Block
EMI	Electromagnetic Interference
ESF	Exploratory Studies Facility
ESFDR	Exploratory Studies Facility Design Requirements
FWP	Field Work Package
g/m	Grams per Meter

He	Helium
$H_2PO_4^-$	Phosphate(s)
kg	Kilogram(s)
Kr	Krypton
LiBr	Lithium Bromide
m	Meter(s)
m^3	Cubic Meters
M&O	Civilian Radioactive Waste Management System Management and Operating Contractor
MSDS	Material Safety Data Sheet
Ne	Neon
NLP	Nevada Line Procedure
NO_3^-	Nitrate(s)
NTS	Nevada Test Site
PI	Principal Investigator
ppm	Parts per Million
PTn	Paintbrush nonwelded
PVC	Polyvinyl Chloride
QA	Quality Assurance
SA	Safety Assurance
SBT	Surface-Based Testing
SF_6	Sulfur Hexafluoride
$SO_4^{=}$	Sulfate(s)

TBM	Tunnel Boring Machine
TCO	Test Coordination Office
TCw	Tiva Canyon welded
TFM	Tracers, Fluids, and Materials
TM	Thermal/Mechanical
Tptpll	Topopah Spring crystal-poor, lower lithophysal
Tptpln	Topopah Spring crystal-poor, lower nonlithophysal
Tptpmn	Topopah Spring crystal-poor, middle lithophysal
Tptpul	Topopah Spring crystal-poor, upper lithophysal
Tptrv	Topopah Spring crystal-rich, vitric, non- to moderately-welded
TS	Topopah Spring
TSPA	Total System Performance Assessment
TSw	Topopah Spring welded
TSw1	Topopah Spring welded, lithophysae-rich
TSw2	Topopah Spring welded, lithophysae-poor
TSw3	Topopah Spring welded, vitrophyre
TTF	Thermal Testing Facility
USGS	United States Geologic Survey
Xe	Xenon
YAP	Yucca Mountain Administrative Procedure
YMP	Yucca Mountain Site Characterization Project

TFMs APPROVED FOR USE IN THE ECRB DRIFT

General Notes: Any TFMs containing organics that will be permanently retained are subject to DIE Requirement 6. See Page II-5 of II-5 for other applicable notes, as indicated on individual items in the following lists.

Group 1: Approved for use in accordance with the manufacturer's directions and precautions relative to application, storage, disposal, etc.

1. 007 - Chemical Sharpener (torch tip cleaner)
2. Aervoe-Pacific Marking Paint
3. American Polywater SpliceMaster Cable Cleaner Type GX
4. Ansul "Foray" dry chemical fire suppression agent[4]
5. Burke/EDOCO Acrylic Bondcrete CM-0170
6. Burke Non-Ferrous, Non-Shrink Grout[6]
7. Burnell Fibercrete[3]
8. Burrell Shotcrete[3]
9. Carlon Standard Clear PVC Solvent Cement
10. Citra Scrub Cleaner
11. CRC Extreme Duty Silicon
12. Crosslinked Polyethylene Backer Rod
13. DB-Series Oils
14. Delvo Stabilizer, set retarder admixture for concrete
15. DYNO-Nobel IRESPLIT Semi-Gelatin Dynamite
16. DYNO-Nobel UNIGEL Semi-Gelatin Dynamite
17. Ensign-Bickford PRIMADET Non-Electric Delay Detonators (LP) Series
18. Ensign-Bickford PRIMADET Non-Electric Delay Detonators (MS) Series
19. Ensign-Bickford PRIMADET Non-Electric Delay Detonator Noiseless Lead-In-Line (NLIL)
20. Ensign-Bickford Shock Tube
21. Federal Cartridge Company Small Arms Primers
22. Firedam 150 Caulk
23. Flowcable, powder admixture for cement grout[6]
24. FX-250 rapid-setting mortar (powder & liquid)
25. HPS Shotcrete Accelerator[3]
26. ICI Explosives CORDTEX Detonating Cord
27. ICI Explosives EXEL Flexible Plastic Shock Tubes
28. ICI Explosives EXEL MS Short Delay detonator
29. ICI Explosives EXEL Lead-In Line instantaneous detonator
30. ICI Explosives EXEL LP Long Delay Detonator
31. ICI Explosives GELDYNE Semi-Gelatin Dynamite (cartridges)
32. ICI Explosives USA, Inc., PRIMACORD Detonating Cords
33. ICI Explosives USA, Inc., "Magnum 65" Detonator Sensitive Emulsion Explosive
34. ICI Explosives XACTEX Semi-Gelatin Dynamite (cartridges)
35. ITP Standard Backer Rod

36. Kit 82-A1 (Scotchcast 4)
37. Kit 82-A2 (Scotchcast 4)
38. LAMTEC Corporation Brand WMP-F Facing Material
39. LAMTEC Corporation Brand WMP-30 Facing Material
40. LAMTEC Corporation Brand 3035 Facing Material
41. Lithium Bromide (LiBr)
42. M28R metal magnetic particle weld-testing powder (iron)
43. MARKAL Paintstik "B" and "B 3/8" markers
44. MB-QSL 100, liquid shotcrete accelerator[3]
45. MB-SF, accelerator, silica-fume mineral admixture for concrete, shotcrete[3]
46. Meyco Rockbolt and Anchor Grout, cement grout[6]
47. Midwest Fasteners, Inc., Product Code IHSP spindle fastener
48. Monoammonium phosphate dry chemical fire suppression agent[4].
49. Monobath 50-50 (a photographic developer/fixer)
50. Noble Gases (He, Ne, Ar, Kr, and Xe)
51. Non-Ferrous Shrink Grout No. CM-0010 [6]
52. Owens-Corning Fiberglass Duct Wrap
53. Polyheed, cement dispersing agent
54. POWERCORD 60-, 100-, 150-, 200-grain Detonating cords
55. R-12 (Forane), Food Freezant 12
56. Rheobuild 1000, cement dispersing agent
57. Rheobuild 2500, cement dispersing agent
58. S5Z Wil-X Cement Grout (B) [6]
59. Sanford "Mean Streak" Waterproof Marking Sticks
60. Sherwin-Williams Co. KRYLON Interior/Exterior Spray Paint
61. Sigunit L20, liquid shotcrete set accelerator[3]
62. Sigunit NC Liquid, shotcrete set accelerator[3]
63. Sigunit Powder, shotcrete set accelerator[3]
64. Sikacrete 950, silica-fume admixture for concrete
65. Sikacrete 950DP, densified dry powder microsilica admixture for concrete
66. Sikament 300, water-reducing liquid admixture for concrete
67. SikaTard 902/908/914, set retarder admixture for concrete
68. SikaTell 100, liquid shotcrete admixture[3]
69. SikaTell 200, liquid shotcrete admixture[3]
70. Silli-Soda-Crete Grout (including Type I/II cement, sodium silicate, and Pozzolith 100-XR dispersing agent)[6]
71. Stay-Silv 400023 brazing flux
72. Sulfur Hexafluoride (SF_6)
73. Super Filter Coat No. 412
74. SUVA-COLD MP® (tetra fluoroethane)
75. Tremproof waterproofing
76. Weld-Aid Tip Dip - 006 Nozzle Gel
77. White & Wib Hi Perf. Acry. Paint
78. Wil-X Cement
79. Windex glass cleaner - blue

Group 2: **Approved for use subject to special requirements and in accordance with the manufacturer's directions and precautions relative to application, storage, disposal, etc.**

1. 1275 Alkaplex Industrial Lubricants[1]
2. 1607 Contact Cleaner[1,2]
3. 2001 Monolec Wire Rope Lubricant[1]
4. 3752 Almagard Vari-purpose Lubricant[1]
5. 3M 1606 Cable Cleaner and Degreaser[1]
6. 3M SCOTCH-WELD DP-190 Grey Epoxy Adhesive[7]
7. 3M Super 77 Spray Adhesive[1]
8. 605 Almason Vari-purpose Gear Lubricant[1]
9. 607 Almason Vari-purpose Gear Lubricant[1]
10. A-55 Clean Fuel[8]
11. Aqua Resin Clear with dye[1]
12. ATF Dextron (automatic transmission fluid)[1]
13. Bortz Paint Thinner T1[1]
14. Butyl rubber adhesive[7]
15. CC-2 Preparation Kit (Cable Cleaner)[1]
16. Chevron Soluble Oil HD (Machining oil used during vent line fabrication)[1]
17. Chevron Special LS Diesel Fuel[8]
18. Chlorides[5]
19. Citgo C-500 Motor Oil, SAE 30[1]
20. Citra Spray Paint Numbers 2124, 2125, 2133, 2137, 2143, 2148, 2155, 2156, 2163, 2169, 2171, 2175, 2178, 2182, 2183, 2187, 2190, and 2192[1]
21. CITRIKLEEN (parts cleaner/degreaser)[1]
22. Copper Sulfate (must be retained within reference electrodes)
23. Cotronics epoxy resin w/ hardeners[7]
24. Cotronics two component ceramic adhesive w/ thinners and hardeners[7]
25. CRC Molylub[1]
26. CRC Quick Clean[1]
27. Cresset Crete-Lease 727 release agent[7]
28. Devcon Sure Shot Super Epoxy Resin and Hardener[7]
29. Diesel Fuel[8]
30. Dow Corning 4 electrical insulating compound[7]
31. Dow Corning plastic adhesive 739[7]
32. Drive Train Fluid HD SAE 50[1]
33. Drive Train Fluid HD SAE 30[1]
34. Dura-Lith Grease EP NLGI 2[1]
35. Ensign-Bickford PRIMADET non-electric detonators and lead-in lines[5]
36. EPY500 Part A and EPY500 Part B - two part epoxy[7]
37. EZ Mud Shale Stabilizer and Viscosifier (used inside SEAMIST liner)[7]
38. Fiske Brothers Refining Co. Fiske No. 35 Soluble Oil (cutting oil)[1]
39. Foster 36-10, Weatherite Mastic (roof sealant)[1]
40. GE Silocones Silicone Rubber Compounds SILOGLAZE 2800/2900, SILGLAZE-2[7]

41. Gear Compound EP ISO 320[1]
42. Gear Compound EP ISO 220[1]
43. GEM® [4]
44. Greenlee-Textron Blue Gel Cable Pulling Compound[1]
45. Hydraulic Oil AW ISO 46[1]
46. ICI Explosives POWERsplit Detonator Sensitive Slurry Explosive (cartridges)[5]
47. ITW-Philadelphia Resins Corp. Ramset EPCON System Hardener Ceramic 6 formula[1]
48. ITW-Philadelphia Resins Corp. Ramset EPCON System Resin Ceramic 6 formula[1]
49. John Deere & Company Hy-Gard Transmission and Hydraulic Oil[1]
50. Litton/Kester flux-cored solder wire[1]
51. Lubrication Engineers 9200 Almasol Dry Film Lubricant[1]
52. Lubrication Engineers, Inc., 608 Almagard Vari-Purpose Gear Lubricant[1]
53. Macklanburg-Duncan POLYCEL Expanding Foam[7]
54. Master Builder MicroAir - air entraining agent[7]
55. Matheson Gas Products POLY-ETCH Active Sodium Solution[7]
56. Mollub-Alloy 777-2 (grease used in lubrication of locomotives, pickup and utility trucks)[1]
57. National Floor Sweep[7]
58. Option 1 (Relton) (water based metal working fluid)[1]
59. Para-Chem Southern, Inc. Kraloy PVC Pipe Cement[1]
60. Pot-Pouri solution, in portable toilet units[1]
61. Rawlplug Co. Chem-stud Anchor Capsules[1]
62. Rectorseal Corp. HURRICANE HOMER PVC Solvent Cement[5,7]
63. RPM Heavy Duty Motor Oil SAE 15W-40[1]
64. RPM Universal Gear Lube SAE 80W-90[1]
65. RPM Universal Gear Lube SAE 85W-140[1]
66. SAE 90, Chevron RPM Gear Oil (transmission oil for Tractor Trucks)[1]
67. Safety-Kleen Corp. Safety-Kleen #6638 Premium Gold Solvent[1]
68. Scotch Brand 1602 Insulating Sealer (red)[1]
69. Scotchcast Brand Flame Retardant Compound[1]
70. Scotchkote Brand Electrical Coating[1]
71. Seymore Marking Paint, 16-657[1]
72. Shellzone (R) All Season Antifreeze (ethylene and diethylene glycol)[1]
73. Stay-Clean 40028 (Lead Free) soldering flux[1,2]
74. SUNISO 3GS, viscosity=150 (specially refined oil for air conditioning compressors)[1]
75. Thermo Trap[7]
76. Type HP Cleaner/Degreaser[1]
77. United Duct Sealer[1]
78. Water (Non-potable and Chlorinated)[9]
79. WELD-ON P-70 Primer for PVC and CPVC Plastic Pipe[7]

Group 3: Materials; no identified constraints

1. Concrete
2. Rockbolts
3. Rolled channel arches (steel)
4. Steel
5. Steel lagging
6. Steel sets
7. Wire mesh

NOTES:

1. These materials have decomposition or combustion products that have the potential to interfere with site characterization testing (i.e., chlorine and carbon). Limiting storage underground or storing in fireproof cabinets are conventional practices that can be used to address this concern. Refer to DIE Requirement 6 for QA controls.

2. These materials react with water to form products such as hydrochloric acid and acetic acid. Hydrochloric acid could bias chlorine-36 measurements. Limiting storage underground or storing in such a way as to limit contact with water are conventional practices that can be used to address this concern. Refer to DIE Requirement 6 for QA controls.

3. Refer to DIE Requirement 10 of Reference 14.1 for limits or constraints.

4. Refer to DIE Requirement 6 for limits or constraints.

5. The use of any materials containing chloride in the TS Loop shall require TCO concurrence, with the exception of chlorinated water/ice used for drinking and hand wash purposes (see DIE Requirement 12).

6. Refer to DIE Requirement 4 for limits or constraints.

7. Remove these materials to the extent practical upon completion of testing.

8. Refer to DIE Requirements 6, 7, 8, and 9 for limits or constraints.

9. Refer to DIE Requirement 2, 5, and 8 for limits or constraints.