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Ground Support Maintenance Plan

By

Gerald L. Shideler

Prepared for:
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Office of Repository Development
P.O. Box 364629
North Las Vegas, Nevada 89036-8629

Prepared by:
Bechtel SAIC Company, LLC
1180 Town Center Drive
Las Vegas, Nevada 89144

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DISCLAIMER

Originator:

SIGNATURE ON FILE 1/8/04

G. L. Shideler Date

Checker:

SIGNATURE ON FILE 1/8/04

J. B. Cho Date

Approval:

SIGNATURE ON FILE 1/8/04

Fei Duan Date

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ACRONYMS AND ABBREVIATIONS

ALARA	as low as is reasonably achievable
BSC	Bechtel SAIC Company, LLC
c/c	center to center
CFR	Code of Federal Regulations
CRWMS M&O	Civilian Radioactive Waste Management System Management and Operating Contractor
DOE	U.S. Department of Energy
ESF	Exploratory Studies Facility
ECRB	Enhanced Characterization of the Repository Block
GROA	geologic repository operations area
HSLA	high-strength low-alloy
LA	License Application
n	neutron
Non-SC	Non-Safety Category
NRC	U.S. Nuclear Regulatory Commission
OD	outer diameter
OSHA	Occupational Safety and Health Administration
PC	performance confirmation
QARD	Quality Assurance Requirements and Description
RH	relative humidity
RHH	repository host horizon
ROV	remotely operated vehicle
SR	Site Recommendation
TBM	tunnel boring machine
UZ	unsaturated zone
WWF	welded wire fabric
YMP	Yucca Mountain Project

1. INTRODUCTION

The ground support system in the emplacement drifts, as well as in the nonemplacement openings, consists of support structures installed within the excavated openings, as well as any reinforcements made to the rock surrounding the openings. The system supports the safe construction and operation of the subsurface openings by maintaining the configuration and stability of the openings during repository construction, and during repository operations until permanent closure.

1.1 PURPOSE

The purpose of this report is to present a preliminary maintenance plan for the ground support system that will be used in the License Application (LA) design. The ground support design as well as component materials have evolved since the Site Recommendation, and this report presents a maintenance plan for the LA design ground support system.

The scope of this report consists of the following:

- Provide a description of the subsurface openings requiring ground support, in terms of opening layout, host rock units, and environmental conditions.
- Provide a description of the materials and longevity of the ground support components.
- Provide a plan for monitoring and inspecting both emplacement drifts and non-emplacement openings.
- Provide a plan for maintenance operations, if required, in both emplacement drifts and non-emplacement openings.

This Ground Support Maintenance Plan is preliminary in nature, and many details regarding specific procedures and techniques are not presented at the present time. Some of the maintenance techniques in non-accessible areas (i.e. emplacement drifts) involve remotely operated vehicles (ROVs) and robotics that have yet to be designed. Further details regarding this Ground Support Maintenance Plan will be developed as the design of the repository subsurface facilities evolves from the preliminary design stage to final design.

1.2 QUALITY ASSURANCE

This report was developed in accordance with AP-3.11Q, *Technical Reports*. The report describes the strategy for maintenance of the ground support system in emplacement drifts and in the nonemplacement openings, which is classified as a Non-Safety Category (Non-SC) in the *Q-List* (BSC 2003g, pp. A-4, A-7) because it is not important to safety and is not important to waste isolation. Therefore, this Ground Support Maintenance Plan is not subjected to the *Quality Assurance Requirements and Description* (DOE 2003) requirements.

1.3 GROUND SUPPORT FUNCTIONS

Specific functions of the Ground Support System consists of the following:

- The system provides structural support for ensuring stability of the subsurface repository openings to permit waste emplacement and retrieval during the preclosure period.

- The system provides personnel protection against rock falls, loosening of blocks, and fracturing and surface deterioration of the rock mass surrounding each opening during repository construction and operations.

- The system maintains adequate subsurface operating envelopes through permanent closure to maintain the openings' functionality, and allows for the expected variations in excavated dimensions, lining thickness, alignment, and deformation.

- The system allows for the monitoring of ground support performance parameters, including as a minimum, opening convergence and ground support and rock temperatures.

- The system ensures that ground support materials are consistent with postclosure repository performance goals, and do not result in significant uncertainty in postclosure repository performance analyses.

- The system will accommodate the geologic mapping of the subsurface openings.

- The system allows for any required maintenance of the ground support components.

1.4 SERVICE LIFE REQUIREMENTS

The required operational service life of the ground support system is determined by the duration of the preclosure period, which extends from the time of drift excavation until the time of permanent closure of the repository. Regulatory requirements, as specified in 10 CFR (Code of Federal Regulations) 63.111(e), state that one of the preclosure performance objectives of the repository is to maintain a waste retrieval option throughout the period during which the waste is being emplaced, and thereafter until the completion of the performance confirmation program and review of the resulting information by the U.S. Nuclear Regulatory Commission (NRC). This can be satisfied if the geological repository operations area (GROA) is designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule (one that would permit retrieval in about the same amount of time as that required to construct the GROA and emplace waste), starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the NRC. This requirement establishes the minimal service life of the ground support system for providing safe accessibility to the emplacement drifts for waste retrieval. However, the total service life of the ground support system is currently established at 100 years; this is the duration of the preclosure period, as defined by a Yucca Mountain Project (YMP) licensing position that establishes the operational period of repository subsurface facilities at 100 years (Williams 2003a). This 100-year period is evaluated in the preclosure safety analysis and is the basis for the LA. Consequently, this maintenance plan is for a ground support system designed for a 100-year service life, in order to provide a stable and safe subsurface environment during the anticipated full operational life of the repository.

1.5 UNCERTAINTIES

In dealing with the design of ground support systems, various sources of inherent uncertainty exist. These inherent uncertainties include data uncertainties regarding the measurements of the thermal and mechanical properties of the repository host rock units, as well as the properties of associated rock joint structures. Uncertainties also exist regarding the values of maximum stresses (in situ, thermal, and seismic loads) that will be sustained by the ground support components. Another source of uncertainty to be considered is the effects of emplacement drift environmental conditions on the longevity of ground support components. An evaluation of the effects of prolonged elevated temperatures, relative humidity (RH), and radiation levels on the corrosion rates of steel ground support components has some inherent uncertainty.

To minimize the above uncertainties, the following approaches are used in ground support design:

- Conservative approach in stability assessments and ground support analyses using a wide range of input parameters

- Development of a conservative ground support system, not only from a load-functioning standpoint, but also for corrosion resistance capability

Sensitivity analyses are performed to assess opening stability, using both practical empirical methods and numerical modeling. Numerical modeling is being utilized to define the following (BSC 2003e, BSC 2003h):

- Depth of failure of the rock mass
- Loosening rockfall mechanisms
- Support load/tunnel deformation estimates
- Factor of safety estimates.

The modeling effort consists of both continuum and discontinuum approaches, using 2-dimensional and 3-dimensional software codes. Using conservative bounding values for the input parameters in the preclosure ground support analyses minimizes uncertainties in numerical modeling and ground support.

Uncertainties on corrosion rates can be minimized by using upper-bound temperatures, a 100 percent RH condition, and a maximum exposure period are assumed for estimating corrosion rates and longevity of the ground support components. Using a 100 percent RH condition is highly conservative because the dryout in emplacement drifts due to preclosure continuous ventilation and high temperatures will minimize any occurrences of localized liquid phase water contact with the ground support components. Thus, the estimated corrosion rates of ground support components are conservative values based on environmental conditions more severe than the actual conditions anticipated in the preclosure emplacement drifts.

2. DESCRIPTION OF SUBSURFACE OPENINGS

The current design for the repository subsurface openings is described in the *Underground Layout Configuration* (BSC 2003j, Figure 5), and is illustrated in Figure 1.

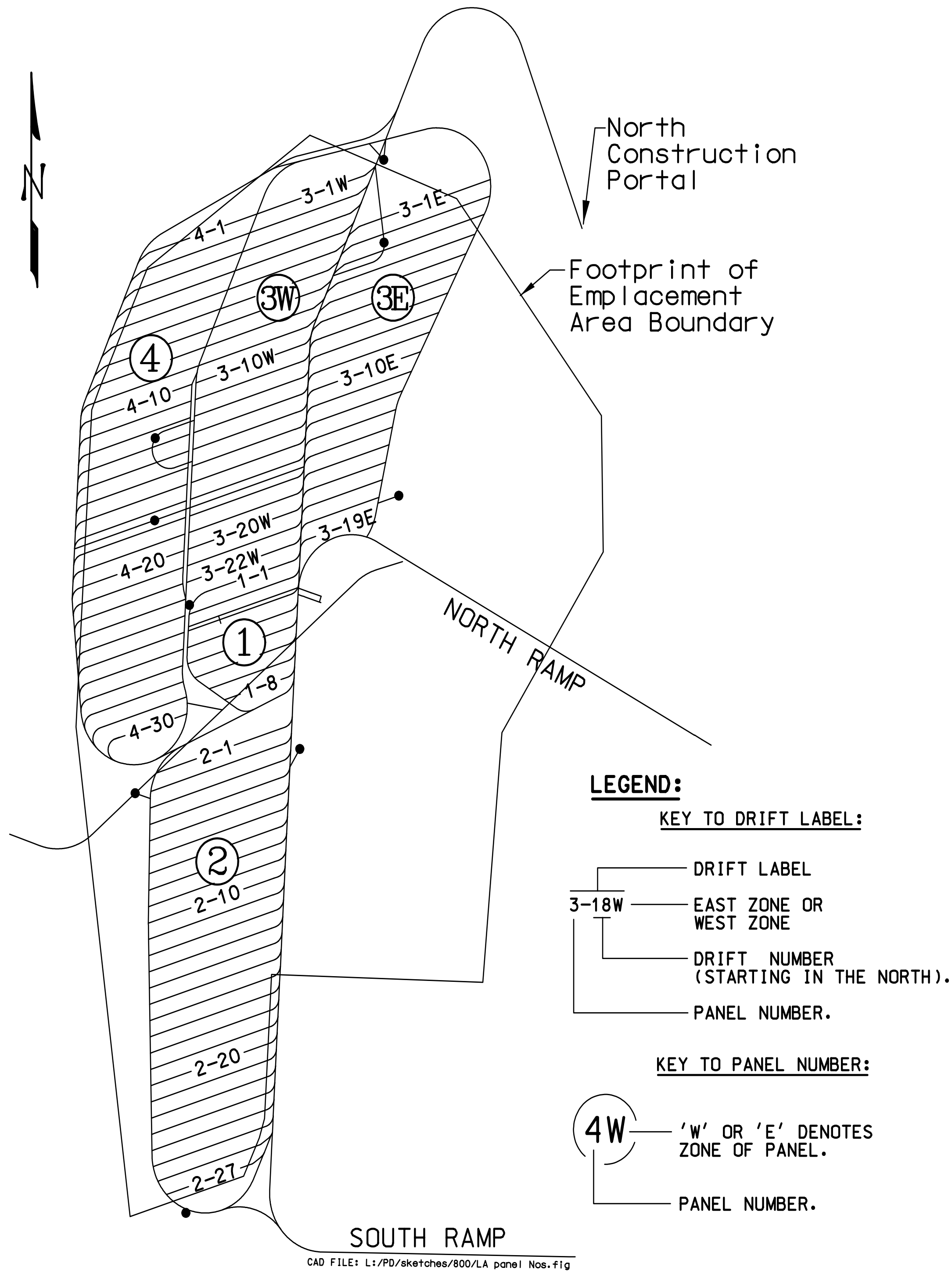
2.1 EMPLACEMENT DRIFTS

Emplacement drifts provide stable disposal space for waste packages, subject to the operating envelope for waste emplacement and retrieval activities, during the preclosure period.

Drift Layout

The emplacement drifts will be excavated using a tunnel-boring machine (TBM) to a diameter of 5.5 meters and a nominal length of 600 meters (actual lengths range from 355 to 808 meters). A total of 107 emplacement drifts will be excavated in a sequence of four panels (Panels 1-4), which will support a 70,000 metric tons of heavy metal waste inventory. Approximately 100 waste packages can be placed in a single emplacement drift of nominal length of 600 meters. In addition, approximately ten of the emplacement drifts (currently at the south end of Panel 2) will be contingency drifts for the possible temporary storage of waste packages, in the event that some of the emplaced waste packages need to be retrieved and re-located from emplacement drifts that may require repairs of their ground support components.

The orientation of the emplacement drifts relative to the orientation of the dominant rock joints influences opening stability. The dominant joints occur primarily in the non-lithophysal rock units. The emplacement drifts will be excavated to an orientation with an azimuth of 252 degrees (BSC 2003j). This orientation will position the emplacement drifts approximately 30 degrees from the dominant joint orientations of the repository host horizon, which minimizes the potential for the formation of unstable blocks. Regarding host rock units (BSC 2003j Table II-2), a total of 4.5 percent of the emplacement drift area will be excavated in the upper lithophysal unit (Tptpul), 12.4 percent in the middle non-lithophysal unit (Tptpmn), 80.5 percent in the lower lithophysal unit (Tptpll), and 2.6 percent in the lower non-lithophysal unit (Tptpln) of the repository host horizon (RHH).



Source: BSC 2003j, Figure 5, p. 35

Figure 1. Proposed Underground Repository Layout

Drift Environmental Conditions

The high levels of radioactivity and heat within the emplacement drifts preclude human accessibility during emplacement and monitoring operations. These harsh conditions have a strong influence on the ground support maintenance plan by limiting human entrance within these areas. As stated in Section 1.4, a conservative approach is used in ground support system design to minimize or eliminate the maintenance within emplacement drifts. If required, maintenance in these areas will require utilizing some special procedures.

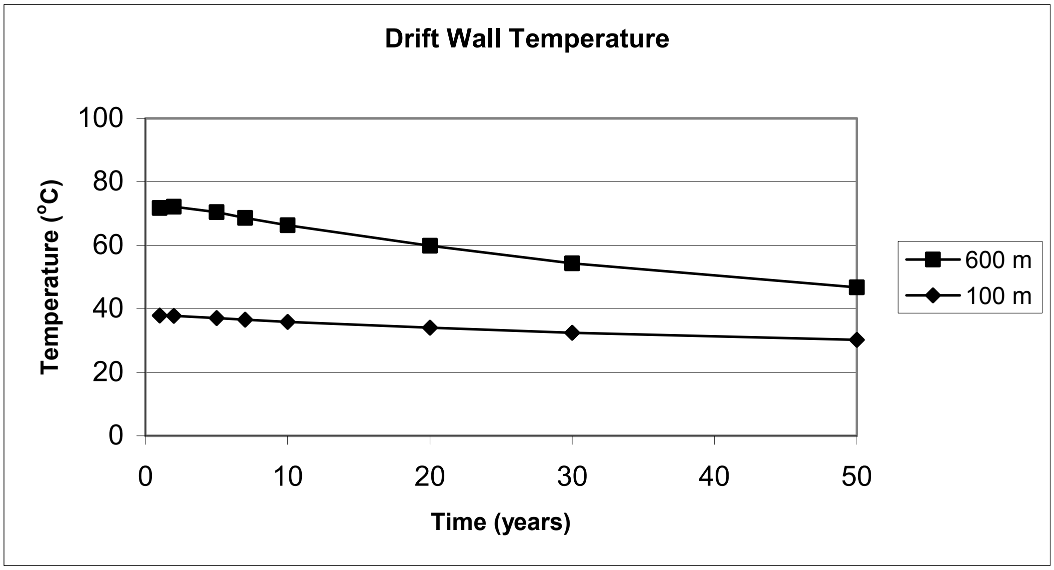
Also, high levels of radioactivity, high temperature and other anticipated environmental conditions such as relative humidity and groundwater have a strong impact on the longevity of the ground support components and thus influence the ground support maintenance plan. Longevity of the ground support materials has been analyzed in *Longevity of Emplacement Drift Ground Support Materials for LA* (BSC 2003f). According to longevity analyses (BSC 2003f), steel corrosion is regarded as the primary factor impacting the longevity of ground support components. The most influential environmental parameters that could effect the corrosion rates of steel, and thus the longevity of ground support components, are temperature, relative humidity, ground water chemistry, and radiation. Anticipated values for these parameters during the preclosure period have been discussed in *Longevity of Emplacement Drift Ground Support Materials for LA* (BSC 2003f, Section 6.2), and are summarized as follows:

Temperature: In unventilated emplacement drifts, the drift wall temperatures will increase due to thermal radiation from the emplaced waste packages. The drift wall temperatures depend on the number of waste packages, the waste package assembly configuration, waste package spacing, drift diameter, and ventilation rates.

The repository design shall ensure that the maximum emplacement drift wall temperature will not exceed 96 °C during preclosure operations, nor exceed 200 °C during the postclosure period (Williams 2003b, Table 1). A number of thermal analyses have been performed to study the temperatures of waste packages, drift wall, and drift air in the past. In a most recent ventilation model and analysis, the heat transfer processes in and around a waste emplacement drift of 5.5 m in diameter was simulated for forced ventilation at 15 m^3/s for 50 years, and an initial line load of 1.45 kW/m (BSC 2003l, pp. 39 and 41). This model and analysis predicts the preclosure temperatures of the waste packages, drift wall, and ventilation air.

With regard to the ground support longevity in emplacement drifts, the most relevant temperature profile is the one corresponding to the drift wall. Figure 2 shows the drift wall temperatures at locations of 100 m and 600 m from the emplacement drift inlet with continuous ventilation. The overall decrease in drift wall temperatures at both locations results from decay of the nuclear waste. As it can be seen from the figure, the temperature for the first portion of emplacement drift (i.e., up to 100 m from the drift inlet) decreases from about 40 °C at year 1 to about 30 °C at year 50 due to the application of ventilation. After ventilation air has carried the elevated temperatures due to the heat released from waste packages along the drift, the drift temperature level increases. The drift wall temperature at 600 m from the emplacement drift inlet indicates higher value and it decreases from about 70 °C at year 1 to about 45 °C at year 50. The drift wall temperature profile clearly shows that the highest temperature at the emplacement drift is less than 96 °C, the upper bound temperature limit for preclosure period.

With regard to the temperatures within the rock, a temperature drop of about 10 to 20 °C was estimated for 1 to 3 m into the rock based on a thermal analysis for a high thermal loading scenario with 25-year ventilation (BSC 2001d, Figure 6-3, p. 27). It is expected that the rock bolts, with length up to 3 m, will experience this same level of temperature gradient.



Source: BSC 2003l, Fig. 6-3, p. 82

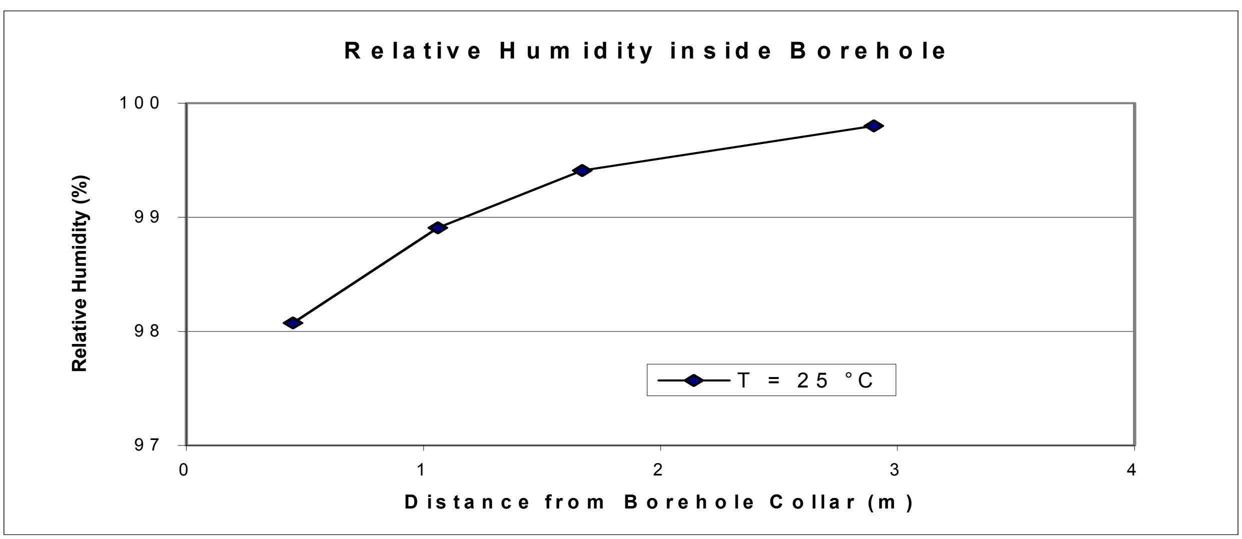
Figure 2. Drift Wall Temperatures as Function of Ventilation Time

Relative Humidity: The RH in an emplacement drift varies with location and time, and depends on the temperature and saturation level in the surrounding rock. Generally, RH is inversely proportional to the temperature and proportional to the rock saturation level. It should be noted that the effects of external environmental conditions such as surface RH on the RH in the subsurface drifts are negligible. For instance, DTN: MO0203SPAESF00.003 presents the surface relative humidity recordings for the year 2000 and plots of surface humidity levels overlain on subsurface plots for the same time periods. The plots presented under MO0203SPAESF00.003 demonstrate no significant increase in subsurface humidity levels as peak nighttime surface humidity gradually increases, and they show little effect from the general 24-hour cyclic fluctuation.

Ventilation will greatly affect the relative humidity in the emplacement drifts. At the drift wall, both in situ rock moisture and water percolation flux through the rock will be removed by the ventilation instead of evaporating and migrating into a cooler rock region, as is the case with the unventilated scenario. Since continuous ventilation will be applied in the emplacement drifts during the preclosure period, the RH inside the drifts will be relatively low. The RH was calculated to range from 3.26 to 10.72 % for the first 100-year period (BSC 2001a, p. XXVII-7, Table XXVII-2). However, these calculations were based on conservative assumptions of a higher percolation rate at the repository horizon and a higher RH at the drift air intake than the actual values. Therefore, the RH in the drifts will probably be somewhat lower.

It should also be pointed out that the above discussion for RH is applicable to all ground support components that are exposed to ventilation air during normal operations. However, hygroscopic salts might be deposited on the surfaces of ground support components by seepage water, as well as dust particles introduced in the ventilation air. The deliquescence points of these salts and dust particles may have a lower RH than that present in emplacement drifts. Additionally, the in-drift RH during off-normal conditions (i.e., ventilation breakdown), as well as the RH inside the rock-bolt holes, will be higher than when exposed to the ventilation air (BSC 2003l).

Figure 3 illustrates the RH inside of a borehole (i.e. rockbolts hole) as a function of distance from the borehole collar. This figure is derived based on a temperature of 25ºC, the data shown in Table 6.8.2-3 of BSC 2001b, and the Kelvin equation with values of water density, ideal gas constant, and molecular weight of water taken from page XIII-6 of the analysis model report document, *Ventilation Model and Analysis Report* (BSC 2003l). This figure indicates that the RH is higher than 98 percent beyond about 0.5 m inside the borehole collar, based on the water potential measured in the borehole in Niche 3107. However, it should be noted that from about 0.5 m to the collar of the borehole the RH drops rapidly to the level of RH inside the emplacement drift. Moreover, it should be pointed out that the water potential measurement was made in the Exploratory Studies Facility (ESF) drift, in which there is no heat source. With heat generated from waste packages in emplacement drifts, the RH inside of the rock-bolt holes will be lower than that shown in Figure 3. Therefore, even though the RH inside the emplacement drift will be very low due to the presence of both ventilation and heat generated by waste packages, the RH inside the rock-bolt holes is expected to be high, especially at the deeper portion near the ends of boltholes, where the RH value is expected to be greater than 90 percent.



Source: BSC 2001b, Table 6.8.2-3 and BSC 2003l, p. XIII-6

Figure 3. Relative Humidity vs. Distance from Borehole Collar

Groundwater Chemistry: Hydrologically, the repository horizon is located in the unsaturated zone (UZ) of Yucca Mountain. Surface water infiltration associated with precipitation events is the natural source of groundwater in the UZ in the Yucca Mountain area. There are two potential pathways for groundwater flow within the unsaturated zone. The first is matrix flow, or the flux of groundwater through the interconnected pores of the rock mass. The second pathway is fracture flow, or the flux of groundwater through fissures in the rock mass. Flow occurs primarily through the matrix in non-welded rocks, and through fractures in welded rocks.

The highest mean total percolation flux (matrix + fracture) at the repository horizon under present-day conditions at Yucca Mountain is 15 mm/year. This value is based on Figure 6.6-1 of the report *UZ Flow Models and Submodels* (BSC 2003k, p. 96); this value is assumed to be the upper bounding value for the present-day conditions. This percolation flux could result in some groundwater seepage into the emplacement drifts.

The most important chemical characteristics of seepage water in the drifts related to the corrosion of steel ground support components are chloride, sulphate, bicarbonate, and pH; the corresponding average and range (in parenthesis) in concentrations for these parameters are 48 (21 – 117), 56 (10 – 116), 352 (200 – 515) mg/l, and 7.9 (7.4 – 8.31), respectively (BSC 2003d). Sulfate and chloride ions are considered by a number of investigators as the most corrosive of the common ions found in naturally occurring waters, with sulfate generally regarded as the most corrosive; whereas, bicarbonate and carbonate ions are considered corrosion inhibitors (Tilman et al. 1984, p. 16). It should be noted that these values are for the initial composition of infiltrating fracture and matrix water. The concentrations of ions in ground water increase as the concentration factor of seepage at the drift crown increases (BSC 2001c, Figure 1, p. 24). Although the concentration of ions in the groundwater will increase due to the evaporation process, it is unlikely that the impact of salt precipitation in the evaporative environment will be significant on the corrosion of steel ground support components in emplacement drifts during the preclosure period.

Radiation: Radiation hazards from spent nuclear fuel come from different types of radiation, including alpha-particles, beta-particles, neutrons, and high-energy photons (gammas and x-rays). Alphas and betas are both stopped completely by the first few millimeters of waste package material, and are therefore unable to affect the ground support. X-rays are rendered harmless by the attenuating effects of the waste package as well. Of major concern are neutrons (with associated secondary gammas) and primary gammas from the fueled region of each spent fuel assembly. Neutrons and gammas are both neutral particles (having no electrical charge), and are able to penetrate through the waste package inner vessel and outer corrosion barrier, and impinge on the emplacement drift walls and inverts. Gammas are stopped by dense material through interactions with atomic electrons, while neutrons are only slowed down by nuclear collisions (most efficiently by collisions with light nuclei, such as hydrogen). A percentage of these particles travel through the ground support and deposit their energy using the foregoing mechanisms. Over time, these sub-atomic disruptions may cause changes in the physical properties of metallic materials.

The quantities of importance for radiation damage are the absorbed dose and the neutron fluence. The cumulative fast neutron fluence based on the current design basis source terms is 1.11×10^{13} n/cm^2 for 340 years of waste emplacement (BSC 2003c, Table 6.4-1, p. 50). The cumulative gamma dose to the ground support material (stainless steel 316) is 69.1 mega-rads for 340 years of waste emplacement (BSC 2003c, Table 6.4-4, p. 55). The cumulative neutron fluence and gamma dose are far too small to cause any appreciable mechanical damage to ground support components over the preclosure period.

In summary, the ground support system in emplacement drifts will consist of 3 m long stainless steel friction type rockbolts and perforated stainless steel sheets. The thickness of rockbolt tube and perforated steel sheets is 3 mm. This ground support system, utilizing 3 mm thick stainless steel (Gr. 316L), will last at least 100 years even in the severe environmental conditions assumed in emplacement drifts. The coverage of perforated steel sheets on an arc of 240° around drifts will prevent small rocks from falling on the Waste Package or track, and therefore minimize or eliminate the need for maintenance within emplacement drifts.

2.2 NONEMPLACEMENT OPENINGS

The nonemplacement openings include all excavated subsurface openings where waste will not be permanently disposed. These openings provide the pathways for access, transportation, ventilation, and monitoring activities. The nonemplacement openings will be excavated using a combination of mechanical excavation methods that include TBMs, roadheaders, and possibly drilling and blasting methods for certain applications. The excavated dimensions and shapes of the nonemplacement openings are variable, depending on their respective operational functions, and are presented in the *Underground Layout Configuration* (BSC 2003j).

Opening Layout

The nonemplacement openings include the following: repository portals and access ramps, access mains, ventilation intake/exhaust air mains and raises, ventilation shafts and accesses, emplacement drift turnouts, chambers, and a PC observation drift with test alcoves. The openings also include the existing ESF and the Enhanced Characterization of the Repository Block (ECRB) cross drift.

The purpose of the portals and access ramps is to connect the surface facility to the subsurface waste emplacement drifts. The access mains delineate the emplacement panels and serve as travel-ways and airways for construction and emplacement operations. The ventilation intake/exhaust air mains and raises, as well as the ventilation shafts and accesses, all support the subsurface ventilation system. Emplacement drift turnouts provide the transitional connections between the access mains and the emplacement drifts for support of drift excavation and waste emplacement operations. Chambers are used for the launching and recovery of the TBMs used for drift excavation. The PC observation drift with test alcoves are subsurface openings that are used to support the monitoring and testing required by the PC Program; this program will be implemented during construction until repository closure to confirm that the design objective of long-term waste isolation in the subsurface facility is accomplished. The PC observation drift will be located beneath two PC thermally accelerated test drifts (Drifts 3 and 4) in Panel 1.

Regarding host rock units, most of the nonemplacement openings, including the ESF and the ECRB, occur mainly in the middle non-lithophysal unit (Tptpmn) and in the lower lithophysal unit (Tptpll) of the RHH. However, some excavation also occurs in the lower non-lithophysal unit (Tptpln) and the upper lithophysal unit (Tptpul) of the RHH. In addition, vertical ventilation shaft openings extend upward from the RHH through several overlying lithophysal and non-lithophysal units of the Topopah Spring Tuff (Tpt), Pah Canyon Tuff (Tpp), Yucca Mountain Tuff (Tpy), and the Tiva Canyon Tuff (Tpc).

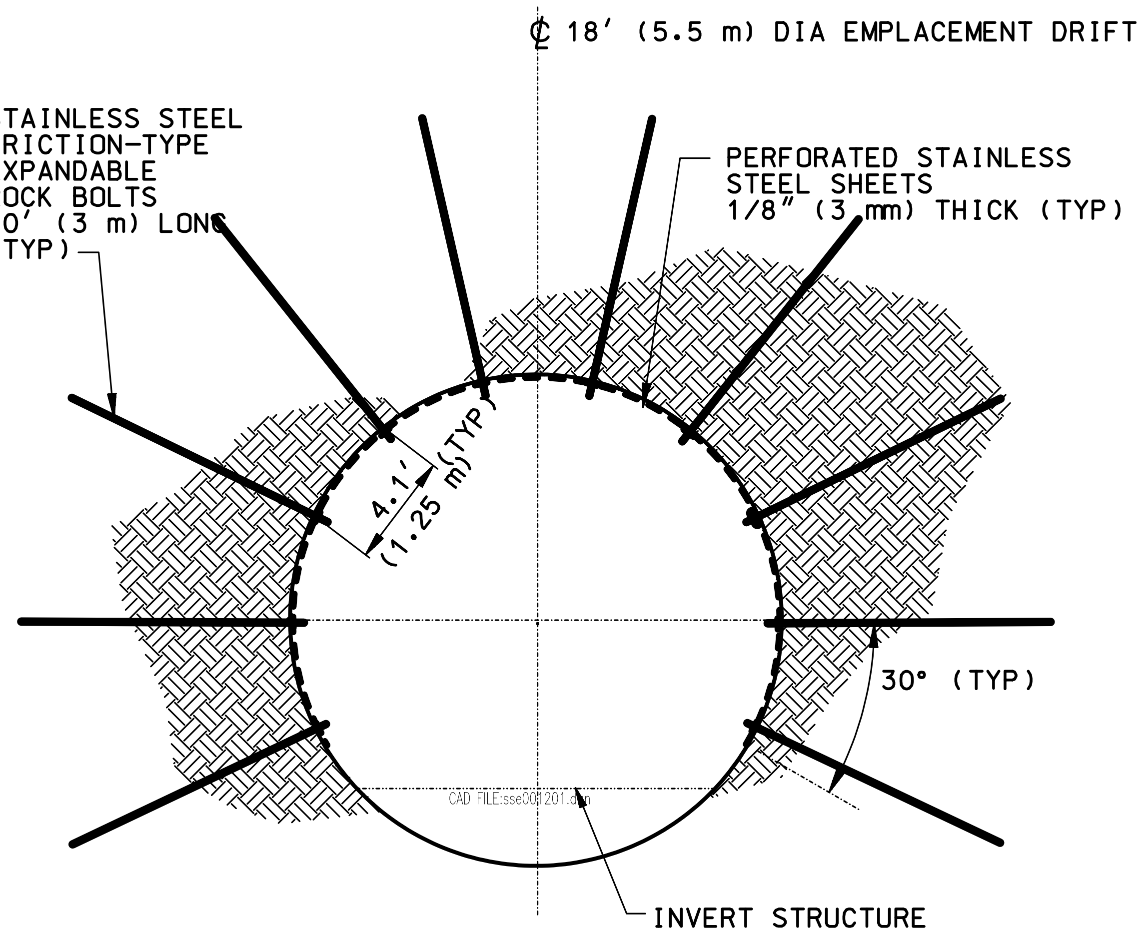
Environmental Conditions

The environmental conditions within the nonemplacement openings except turnouts, exhaust mains, and exhaust shafts will be similar to present conditions in the ESF and ECRB. These conditions will render them safe and accessible for human entry under normal operations, and thus will not impair the Ground Support Maintenance Plan. The turnouts, exhaust mains, and exhaust shafts are nonemplacement openings characterized by high temperature levels and potential high radiation levels, which would render them non-accessible for humans. Maintenance in these openings will require utilizing some special procedures.

3. DESCRIPTION OF GROUND SUPPORT COMPONENTS & LONGEVITY

The repository ground support system is required to maintain drift stability in two basic types of lithostratigraphic rock units, namely, lithophysal rocks and non-lithophysal rocks. The lithophysal rock units are characterized by a relatively high degree of cavities (lithophysae) and high resulting porosities, and have a high density of fracturing with short trace length. In contrast, the non-lithophysal rock units are characterized by a low degree of cavities, lower porosities, and have a higher degree of longer trace length fractures. These two types of rock units represent structural end members, and gradational rock types between the two also occur at the repository host horizon. In should be noted that the change from non-lithophysal to lithophysal rock at the repository host horizon is quite abrupt. This was observed in the ESF at the South Ramp as the long fractures in the non-lithophysal rock disappear abruptly in the lithophysal rock. The rock mass behavior of lithophysal rocks is mainly controlled by lithophysal porosity and short trace-length fractures, whereas the rock mass behavior of non-lithophysal rocks is mainly controlled by longer trace-length fracture geometry. The ground support system must provide stability for both types of rock units; typical ground support components for emplacement drifts are illustrated in Figure 4.

The types and materials of ground support components that are currently considered in the LA design are presented in *Committed Ground Support Materials for LA Design* (BSC 2003a); the effects of emplacement drift environmental conditions on the longevity of the ground support components are presented in *Longevity of Emplacement Drift Ground Support Materials for LA* (BSC 2003f). This information is summarized in the following sections.



Source: modified from BSC 2003i, p. 1

Figure 4. Typical Ground Support Components for Emplacement Drifts

3.1 GROUND SUPPORT COMPONENTS

Emplacement Drift Ground Support

The emplacement drifts are non-accessible openings. Consequently, the ground support system in these openings will consist of durable corrosion-resistant components that should require minimal or no maintenance during the preclosure period.

The ground support components for these openings will consist of friction-type rock bolts and perforated sheets held in place by the rock bolts and plates. The materials for both the rock bolts and sheets are stainless steel. No cementitious materials will be utilized in these openings.

The friction-type stainless steel (Grade 316L) rock bolts are 3.0 m long and 54 mm in outer diameter (OD). The rock bolts will be spaced 1.25 m c/c (center to center) each way, and will cover the crown and extend below the springline, covering a total arc of 240°.

The perforated stainless steel sheets, Type S, will cover the crown and extend below the springline covering an arc of 240°. The overlapping width for connecting sheets will be 120 mm in both directions. Rock bolts, together with stainless steel faceplates will hold the perforated steel sheets tight to the rock surface.

The tube thickness of the rock bolts and the thickness of perforated stainless steel sheets is 3 mm. This is based on an assumed steel corrosion allowance of a 10 percent decrease in thickness over 100 years (BSC 2003b, p. 30). This assumption is considered conservative.

Nonemplacement Openings Ground Support

Accessible Openings: The ground support components for the accessible nonemplacement openings consist of a combination of fully grouted rockbolts, heavy duty welded wire fabric (WWF), fiber-reinforced shotcrete, and possibly lattice girders as well as cast-in-place concrete lining. The specific components used in a particular opening will depend on the rock mass conditions and the environmental conditions in the opening. The installation of the ground support system will be accomplished with either a single-pass (only permanent components) or duel-pass (initial temporary and final permanent components) method, depending on safety considerations and other circumstances.

Fully grouted rockbolts (25.4 mm OD, 3 m long) will be installed in all nonemplacement openings. The fully grouted rockbolts will be installed in 38.1 mm boreholes spaced at 1.25 m c/c each way, and will cover the crown and extend below the springline covering an arc of 240° for circular openings and 2/3 of total surface area for non-circular (horseshoe-shaped) openings.

Wire mesh in forms of W4 x W4 (75 mm x 75 mm) WWF or chain link will be used in all horizontal nonemplacement openings except openings covered with fiber reinforced shotcrete. The WWF will cover the crown and extend below the springline covering an arc of 240° for circular openings and 2/3 of the total surface area in non-circular (horseshoe-shaped) openings. The WWF initially will be held by shorter length split sets bolts (460 mm long, 33 mm nominal tube OD) with plates (150 x 150 x approximately 4 mm thick) spaced at 1.25 m each way.

A 100-mm thick layer of fiber-reinforced shotcrete will be installed in turnout intersections and will be applied above the springline. The turnout intersection between turnout and the access main is approximately 36 m. Fiber reinforced shotcrete will be also used in ramps and shafts/raises. In the North Construction Ramp, the shotcrete will be placed from invert to invert covering an arc of 270°.

Lattice girders will be installed, if required, in turnout intersections and spaced at 1.25 m. The lattice girders will be installed after the rock has been shotcreted. They will extend from invert to invert and will be encased in shotcrete.

Cast-in–place concrete linings might also be used in high-traffic accessible areas such as portals and ramps and in the shafts/raises.

Non-accessible Openings: The nonemplacement openings that are non-accessible for human entry are those that are characterized by high temperatures and potential high radiation levels. These openings consist of the ventilation exhaust mains, exhaust air side intersections, and exhaust shafts, as well as some portions of turnout areas adjacent to the emplacement drift. The ground support components for the ventilation exhaust mains consist of fully grouted rockbolts and heavy duty welded wire fabric (WWF), whereas the ground support for the exhaust air side intersections and exhaust shafts consist of fully grouted rockbolts and fiber-reinforced shotcrete. These ground support components are considered appropriate since the environmental conditions in these openings are considered less severe than in the emplacement drifts. It should be noted that the rockbolts used in these openings are solid fully encapsulated rockbolts rather than the friction tube type which are to be used in the emplacement drifts. The grout prevents the water or humidity from contacting the rockbolts. Therefore, the failure of rockbolts due to corrosion (see Section 3.2) is not anticipated, and the ground support components in these openings will require minimal or no maintenance during the preclosure period.

3.2 GROUND SUPPORT COMPONENT LONGEVITY

The longevity of steel ground support components under assumed emplacement drift environmental conditions during the preclosure period has been evaluated in *Longevity of Emplacement Drift Ground Support Materials for LA* (BSC 2003f). Conclusions from this study are the following:

- The temperature effect on mechanical properties of steel has been evaluated. It is expected that, for the temperature level expected in emplacement drifts during the preclosure period, the temperature effect on mechanical properties of both carbon steel and stainless steel is insignificant.

- For maximum toughness and ductility, the carbon content of carbon steel should be kept as low as possible, consistent with strength requirements. For the temperature level expected in emplacement drifts during the preclosure period, the effect of temperature on the toughness and ductility of stainless steel is insignificant.

- Regarding the thermal properties of steel, the thermal expansion coefficient of stainless steel is higher than that of carbon steel. It is more advantageous to use stainless steel than carbon steel for friction-type rock bolts, in terms of a full-length anchoring mechanism. The impacts of temperature on thermal conductivity and specific heat of carbon steel and stainless steel are insignificant.

- Regarding radiation effects, the cumulative neutron fluence and gamma dose due to waste package radiation are far too small to cause any appreciable mechanical damage to carbon steel or stainless steel over the preclosure period.

- The effects of corrosion on ground support components is an important concern that is expressed in the NRC's Key Technical Issue on Repository Design and Thermal-Mechanical Effects (RDTME). The potential corrosion mechanisms that could occur in the repository environment have been evaluated. These include dry oxidation, humid-air corrosion, aqueous corrosion, pitting/crevice corrosion, stress corrosion cracking, hydrogen embrittlement, and microbiologically influenced corrosion.

  - The impact of dry oxidation on the performance of carbon steel and stainless steel is insignificant or negligible.

  - For humid-air corrosion, ground support components made of carbon steel will fail after a service life of 30 years, whereas only the bolts made of high-strength low-alloy (HSLA) steel will not fail for a service life of 100 years. Ground support components made of stainless steel 316 steel will not fail for a service life of 100 years.

  - Carbon steel and HSLA steel will fail due to aqueous corrosion within 10 years, whereas stainless steel 316 will not fail for 100 years of service life.

  - Stainless steel 316 indicates superior performance against pitting and crevice corrosion. The potential effect of higher temperature on general and localized corrosion for stainless steel 316 is insignificant.

  - Based on the stress level, temperature, and ground water conditions, it is expected that stress corrosion cracking will probably not occur to friction-type rock bolts during the preclosure period. The potential impact of hydrogen embrittlement on friction-type rock bolts is minimal or insignificant.

  - The effect of microbiologically influenced corrosion is significant on carbon steel, whereas it is insignificant on stainless steel 316.

This study indicates that under the ventilated environmental conditions anticipated in the emplacement drifts during preclosure, rock bolts and perforated sheets made of stainless steel with a thickness of 3 mm will not fail due to corrosion for a service life of 100 years. It should be noted that, as per the approach discussed in Section 1.4, conditions conductive to the various types of corrosion involving water or humidity in the emplacement drifts were assumed to evaluate the worst case scenario, even though the likelihood of the extreme occurrence of such conditions is extremely small or non-existent.

The carbon steel ground support components in the non-emplacement openings, particularly in non-accessible openings, will not be subject to the same extreme environmental conditions assumed in the emplacement drifts. Furthermore, the rockbolts used in these openings are solid fully encapsulated rockbolts rather than the friction tube type which are to be used in the emplacement drifts. The grout prevents the water or humidity from contacting the rockbolts. Therefore, the failure of carbon steel rockbolts due to corrosion is not anticipated, and the ground support components in these openings will require minimal or no maintenance during the preclosure period.

4. MONITORING AND INSPECTION

Monitoring and inspecting the emplacement drifts and non-emplacement openings is a key element of the maintenance plan because it will provide the main source of data upon which decisions about maintenance will be made. The maintenance decisions will be based on established criteria that define unacceptable levels of ground support deterioration and drift degradation. Judgments concerning problem areas may depend on repeated observations to record changes in opening behavior and the condition of ground support components, in order to determine if a maintenance operation is actually needed.

Steel and shotcrete ground support components can be monitored and inspected for a variety of possible defects, which include the following (CRWMS M&O 1997, Section 7.8.1.1):

Steel defects include:

- Loss of load bearing section due to corrosion
- Loss of steel lagging load carrying capacity due to corrosion.
- Loss or failure of rock bolts due to corrosion or excessive loads
- Buckling of individual members due to excessive loads.

Shotcrete defects include:

- Application flaws
- Cracks, both microscopic and macroscopic
- Delaminations
- Spalls
- Void development
- Chemical alteration

The severity of these defects will determine the need and extent of the necessary repairs.

Monitoring will include deformation measurements in turnout areas and access mains. Selected emplacement drifts will be monitored for the physical conditions of drifts such as rockfalls, drift degradation or instability using ROVs or robotic technologies. The deformation of the emplacement drifts will be estimated from the rock deformation measured from the PC observation facility.

4.1 EMPLACEMENT DRIFTS

Pre-emplacement Inspections: After drift excavation and ground support installation, the drifts are accessible for human entry and will undergo an initial inspection. During this time, the entire drift will be visually inspected by direct observation and will be geologically mapped in detail and photographed prior to the installation of any waste emplacement equipment. Any observed water seepage areas will be noted. Water seepage areas indicate local ground water sources that should be evaluated as to size and chemical characteristics, in order to prevent future adverse effects on ground support components. Drift degradation areas and any ground support component defects also will be noted. On the basis of the direct observations, a determination will be made of any required repairs. All repairs will then be completed prior to the installation of the waste emplacement equipment. Each emplacement drift will be subjected to a multi-step commissioning process.

After the installation of waste emplacement equipment, the drifts will undergo a final inspection for the possible failure of any ground support components, or indications of drift degradation or instability. If the visual inspection indicate conditions that require repairs, the repairs will be made at that time. If all conditions are favorable, then the drift will be prepared for the emplacement of waste packages.

Post-emplacement Inspections: After the emplacement of waste packages, the emplacement drifts will be non-accessible for human entry except when waste is being transported through them. During this time period, the drifts will be remotely monitored and inspected for drift environmental conditions and waste package integrity as part of the PC Program, as outlined in the *Performance Confirmation Plan* (Snell et al. 2003). This activity will be conducted periodically on a scheduled basis, in order to detect any indications of rockfalls, drift degradation or instability within the drifts that may require unplanned maintenance. The inspection frequency has not yet been established.

Monitoring and inspection of the emplacement drifts after the emplacement of waste packages will be accomplished utilizing both acoustic/ seismic tomography to help detect rockfalls, and ROVs for visual inspections and material sampling. ROV observations by video camera will be made of the drift walls for possible water seepage, drift degradation areas, and ground support component failure; some indicators of ground support failure would include “bagged” or torn stainless steel sheeting, and rock particles on the invert or waste packages. The drift floors, as well as the rail system of the waste package emplacement and retrieval system and inspection ROVs, will be observed for rock fall debris. The volume of any observed rock fall debris will be estimated, and the condition of the waste packages will be assessed. This monitoring and inspection activity will be conducted on a regular scheduled (TBD) basis, and it will provide the necessary information for evaluating any drift degradation effects, ground support deterioration, and the possible need for retrieving any damaged waste packages. In turn, this evaluation will provide the basis for determining any necessary maintenance and repairs of the ground support components, which may be needed to provide continued accessibility to the emplacement drifts for possible waste retrieval operations during the full preclosure period.

4.2 NONEMPLACEMENT OPENINGS

Accessible Openings

Many of the nonemplacement openings of the repository will be safe and accessible for human entry during the entire preclosure period. These openings include the following: portals and access ramps, access mains, ventilation intake shafts/raises and accesses, portions of the emplacement drift turnouts, and the PC observation drift with test alcoves. The accessible openings also include the existing ESF and the ECRB cross drift.

During repository operations qualified personnel will periodically inspect these accessible nonemplacement openings visually by direct observation for the deterioration of ground support components and drift degradation effects. For the inspection of ventilation intake shafts, an inspection gantry will be utilized. These direct observations will be supplemented by geotechnical instrumentation that will provide in situ measurements of rock deformation and opening stability. This information will form the basis for evaluating the need for repairs of the ground support system. A planned schedule of regular inspections by qualified personnel will be implemented, maintenance reports prepared, and any necessary repairs will be determined.

Non-accessible Openings

The nonemplacement openings that are non-accessible for human entry during the preclosure period consist of the ventilation exhaust mains and exhaust shafts, and some turnout areas adjacent to the emplacement drift ventilation doors. High temperatures and potential high radiation levels characterize these areas. These areas may require being remotely monitored and visually inspected for any drift degradation and ground support deterioration, using an ROV equipped with a video camera. Visual indicators of problematic conditions would include failed/ buckled liner segments in exhaust shafts, and failed ground support components and rockfalls in exhaust mains. Ventilation airflow rates also will be monitored to determine if any detected rockfalls have resulted in an unacceptable constriction of airflow. A planned schedule of regular inspections will be implemented, and will form the basis for determining if any necessary maintenance will be required in these non-accessible openings.

5. MAINTENANCE OPERATIONS

A primary objective of the ground support maintenance plan is to provide concepts for maintaining the functionality of both the emplacement drifts and the nonemplacement openings so that they can perform their required functions in repository operations during the entire preclosure period. Similar to the methods for monitoring and inspecting ground support components, the maintenance methods employed are mainly determined by the accessibility of the openings for safe human entry. Safety will be the predominant concern in all maintenance operations. Maintenance equipment would include front-end loaders, scalers, and rock bolting and shotcreting equipment. Ground support maintenance activities can usually be planned well in advance without impacting other repository operations. All maintenance activities will be coordinated with both construction and emplacement operations, as well as with ongoing PC Program activities.

5.1 EMPLACEMENT DRIFTS

5.1.1 Normal Operations

The emplacement drifts environmental conditions render them inaccessible for human entry. Under normal operations, the ground support components in the drifts are designed to be durable, and capable of withstanding the anticipated in situ, thermal, seismic loads and deformations for the entire preclosure period. Therefore, the basic ground support maintenance approach in the emplacement drifts is to have minimal or no planned maintenance requirements, as a result of utilizing durable ground support components and materials that have sufficient operational longevity under the harsh preclosure environmental conditions anticipated in the emplacement drifts. Longevity tests on durable corrosion-resistant ground support materials, such as stainless steel rock bolts and perforated stainless steel sheets, indicate longevity well beyond a 100-year service life, thus requiring minimal or no maintenance under normal conditions during the potential waste retrieval period.

The approach to minimize or eliminate maintenance for emplacement drifts has been taken in response to the full range of anticipated operating conditions that include: (1) working areas that in many places will be limited to the available space between the walls of the 5.5-meter diameter drift and a 2.0-meter diameter waste package, (2) wall rock temperatures approaching 175° C, and (3) radiation levels approaching about 40 rem/hr at the surface of some waste packages (CRWMS M&O 1997, Section 7.8.1). Not only do these circumstances demonstrate a need to minimize or eliminate maintenance, but they also virtually eliminate the ability to carry out maintenance operations in a drift containing emplaced waste packages. Therefore, the approach to a viable maintenance program includes the following elements (CRWMS M&O 1998, Section 7.2.5):

- Pre-emplacement validation and commissioning specifications to eliminate substandard emplacement drift segments.
- Durable ground support design suitable for all expected rock conditions.
- An inspection system to periodically "observe" drift walls and aid in determining the need for maintenance.
- Monitoring of tunnel profile convergence to determine need for preventive maintenance.
- A remotely operated waste recovery system to move waste packages out of emplacement drifts if maintenance is required.
- Empty drifts or contingency drifts at intervals to temporarily store waste packages removed from emplacement drifts needing maintenance.
- Ability to increase ventilation rate to individual emplacement drifts for cooling purposes.

5.1.2 Off-normal Operations

In the event that the monitoring and inspection activities indicate that an unacceptable level of ground support deterioration or drift degradation has occurred, a decision will be made to make the necessary ground support repairs. If this event occurs after some or all of the waste packages have been emplaced in the drift, the following required sequence of maintenance activities will be implemented:

1. **Drift Ventilation Cooling** – After monitoring and inspection activities indicate that the ground support components in a particular drift need repairs or replacement, the initial activity will be to ventilate and blast cool the drift to acceptable temperature levels for human entry (below 50°C) and recovery equipment operations. The drift cooling will be accomplished by forcing ventilation air at a higher rate through the affected drift, which can be accomplished in a short period of time.

2. **Waste Package Recovery** – After drift ventilation cooling, the next activity will be to evacuate the drift of emplaced waste packages to allow safe access for personnel and equipment. For safe operations, repairs in any locations of emplacement drift may require complete removal of all waste packages within the damaged drift. Waste package removal will be accomplished using the remotely operated waste package emplacement and retrieval system.

   The removed waste packages will be relocated from the drift undergoing repairs to an area for temporary storage until the repairs are completed. The temporary storage area could be a nearby vacant emplacement drift or a contingency drift excavated for the purpose of temporary waste package storage (approximately 10 contingency drifts are presently planned). The number of waste packages that will require removal will depend on the number of emplaced waste packages, and the location of the damaged area within the drift.

3. **Ground Support Repairs** – After waste package removal and the drift is safely accessible for human entry, the drift will be visually inspected and an evaluation will be made of any necessary repairs. Any observed rock fall debris will be cleared out of the drift, and all necessary ground support repairs will be made using standard mining or tunneling procedures. Corrective actions could include removal of any failed ground support components, scaling and removal of loosened rock, and reinstallation of new ground support components. If necessary, decisions to not re-emplace waste packages along a specific area of the emplacement drift will also be made at this time. The repaired drift might be left vacant and used for another purpose, or it might become a new contingency drift, thereby reducing the waste handling operation.

   In conducting these maintenance operations by human entry, all applicable Occupational Safety and Health Administration (OSHA) requirements, and as low as is reasonably achievable (ALARA) requirements, will be fulfilled. Maintenance personnel will be provided maximum protection against radiation exposure, which could include utilizing shielded maintenance vehicles, protective clothing, and a self-contained breathing apparatus. Personnel working time at the damaged site will be carefully monitored to avoid any excessive radiation exposure time.

4. **Waste Re-emplacement** - After repairs on the emplacement drift ground support components have been completed, the waste packages temporarily stored in a vacant emplacement drift or contingency drift will be re-emplaced in the repaired drift. This will be accomplished with the remotely operated waste package emplacement and retrieval system. In the event that the waste packages are temporarily stored in an acceptable drift, it may not be necessary to re-emplace them in the repaired drift; this would reduce the handling of waste packages. During re-emplacement operations, the normal ventilation rate will be restored to obtain acceptable thermal distribution levels within the repaired drift. The drift will then be returned to its normal operational mode.

It can be anticipated that the entire maintenance operation for required repairs in an emplacement drift will require a substantial amount of time and effort to implement. The specific amount of time required depends mainly upon the number of waste packages that will require recovery and re-emplacement within a particular drift, and to a lessor degree on the nature of the required repairs.

5.2 NONEMPLACEMENT OPENINGS

Accessible Openings

Some nonemplacement openings environmental conditions render them accessible for human entry. Therefore, the basic ground support maintenance approach in the accessible nonemplacement openings is to have a program of planned periodic visual inspections of the openings by direct observation during the entire preclosure period to evaluate the need for any necessary repairs.

If the visual inspections indicate that the replacement or repair of ground support components is warranted, the necessary repairs will be accomplished, as needed, by human entry. Maintenance activities could include removing rock debris from the opening floor, scaling loose rock from the opening walls, removal of any defective ground support components, and installation of new ground support components (rockbolts, wire mesh, shotcrete). Regarding the maintenance of the initial/ temporary ground support components currently installed in the ESF and ECRB tunnels, repairs will be made as needed, in accordance with the inspection frequency outlined in the LP-OM-042Q-BSC Procedure. In conducting repair operations, all OSHA requirements and ALARA requirements will be fulfilled.

Non-accessible Openings

If the visual inspections by an ROV equipped with a video camera indicate that the replacement or repair of ground support components is warranted in a ventilation exhaust main or exhaust shaft, the exhaust ventilation in the damaged area will be temporarily terminated and re-routed. Repairs can then be made in the damaged area without interrupting ventilation throughout the rest of the repository.

These openings are difficult areas for maintenance operations by human entry because of the high temperatures and potentially high levels of radiation. This is most pronounced in the exhaust mains, as the result of direct line-of-site radiation (shine) from the emplacement drift exists into the exhaust mains. Consequently, if repairs are needed at a specific location in these openings, efforts will be made to make all necessary repairs by remotely operated techniques.

In the event that maintenance operations by remotely operated techniques are not feasible, the following required sequence of maintenance activities will be implemented:

1. **Waste Package Recovery (Optional)** – If the damaged site is only can be accessible through the nearest emplacement drift, then the next activity will be to evacuate the waste packages from the nearest emplacement drift. This evacuated drift will serve as access for personnel and equipment to the damaged area. The removed waste packages will be relocated to an area for temporary storage until the repairs are completed. The temporary storage area could be a nearby vacant emplacement drift or a contingency drift excavated for the purpose of temporary waste package storage (approximately 10 contingency drifts are presently planned). However, if the access through the exhaust main is feasible then this step will be omitted (Note: Detailed panel layouts in process show shielding block at the exhaust end of each emplacement drift. This will make access through the exhaust main more feasible).

2. **Ventilation Cooling** – After removal of all waste packages from the nearest drift (optional, see step 1), the area will be ventilated with cool air for human entry (below 50°C) and recovery equipment operations. The drift cooling will be accomplished by forcing ventilation air at a higher rate through the evacuated drift, which can be accomplished in a short period of time (several days).

3. **Shielding and Repairs** Following the ventilation with cool air, the vicinity of the damaged site will be shielded to make the area accessible for safe human entry for maintenance activities. The damaged area will be visually inspected and an evaluation will be made of any necessary repairs. All observed rock fall debris would be cleared out of the opening, and any loosened rock on the opening walls would be scaled and removed. Any failed ground support components would be removed and replaced with new ground support components.

   In conducting these maintenance operations by human entry, all OSHA requirements and ALARA requirements will be fulfilled. Maintenance personnel will be provided maximum protection against radiation exposure, which could include utilizing shielded maintenance vehicles, protective clothing, and a self-contained breathing apparatus. In addition, personnel working time at the damaged site will be carefully monitored to avoid any excessive radiation exposure time. Specific administrative controls, procedures, and safety guidelines will be developed prior to authorization to receive waste.

4. **Reactivate Ventilation** – After the repairs at the damaged site are completed and inspected, the shielding will be remotely removed, the exhaust ventilation will be

re-activated, and the exhaust main or shaft will be returned to its normal operational mode.

5. **Waste Re-emplacement** - After the exhaust ventilation is re-activated and returned to its normal operational mode, the waste packages temporarily stored in a vacant emplacement drift or contingency drift will be re-emplaced in the drift. This will be accomplished with the remotely operated waste package emplacement and retrieval system. In the event that the waste packages are temporarily stored in an acceptable drift, it may not be necessary to re-emplace them in the evaculated drift; this would reduce the handling of waste packages.

6. SUMMARY

The final ground support system is designed for a 100-year service life. The ground support maintenance plan will ensure the safety and functionality of the subsurface openings during the entire preclosure period.

Monitoring and inspecting the emplacement drifts and nonemplacement openings for ground support failure and drift degradation is a key element of the maintenance plan, and these activities provide the database upon which maintenance decisions will be made. The methods of monitoring and inspecting subsurface opening conditions and ground support components are mainly determined by the accessibility of the openings for safe human entry. Human observations will be utilized in accessible areas, whereas non-accessible areas characterized by high temperatures and high radiation levels will require using remotely controlled techniques.

Planned periodic inspections will be implemented for all subsurface openings. The emplacement drifts will be inspected, validated, and commissioned prior to waste emplacement. The inspection will be done by human entry and direct visual observations, and by in situ instrument measurements of rock deformation and opening stability. During the post-emplacement period, the emplacement drifts will be remotely monitored and inspected for drift conditions and waste package integrity; inspections will utilize both acoustic/seismic event location to help detect rockfalls, and ROVs for visual inspections by video camera and material sampling. The accessible nonemplacement openings will be visually inspected by qualified personnel by direct observation, and supplemented by geotechnical instrumentation that provides in situ measurements of rock deformation and opening stability. The non-accessible nonemplacement openings, such as ventilation exhaust mains and shafts, and some turnout areas adjacent to the emplacement drift ventilation doors, will be remotely monitored and inspected using an ROV equipped with a video camera.

Maintenance methods are also mainly determined by the accessibility of the subsurface openings for safe human entry. In emplacement drifts, the use of durable corrosion-resistant ground support materials such as stainless steel would have longevity in excess of the 100-year preclosure period, thus requiring minimal or no planned maintenance under normal operations during a 100-year service life. In the event that off-normal conditions occur after all of the waste packages have been emplaced in the emplacement drift, the following sequence of maintenance activities will be required: drift cooling by ventilation, waste package recovery and temporary storage, ground support repairs made, and waste package re-emplacement after repairs. In accessible nonemplacement openings, repairs will be accomplished, as needed, by human entry. In non-accessible nonemplacement openings (i.e. exhaust mains), efforts will be made to make all necessary repairs by remotely operated techniques. If remotely operated techniques are not feasible, then the following sequence of maintenance activities will be required: remove all waste packages from nearest emplacement drift and store in temporary drift, cooling damaged site by ventilation, shielding and repairs made, shielding removal, reactivate ventilation and waste package re-emplacement after repairs.

The existing ground support systems in the ESF tunnel and ECRB Cross Drift, are considered initial or temporary and their maintenance is governed by the procedure *Ground Support Walkdown, Maintenance and Repair* LP-OM-042Q-BSC. Upon installation of the final or permanent ground support system the procedure for inspection and maintenance of temporary support will be automatically replaced by a similar inspection procedure to be developed specifically for the permanent ground support systems installed in the underground repository excavations. It is pointed out that proper evaluation of corrosion state for those initial ground support components such as steel sets, bolts, and wire mesh will provide useful information on corrosion rates guiding the design and installation of finial ground support.

Furthermore, this maintenance plan is set as a guideline for development of procedures and resulting actions on how to perform inspection, and how to resolve particular permanent ground support-related issues. This program will evolve, as the field evidence in combination with the theoretical evaluation of the corrosion rates becomes available. Field observations and measurements will be incorporated in a set of guidelines needed to establish the criteria for recommending enhancements/changes to the subsequent design of permanent ground support systems.

In all maintenance operations, safety will be the predominant concern, and all applicable OSHA requirements and ALARA requirements will be fulfilled. All maintenance personnel will be provided with safe working conditions and maximum protection against radiation exposure. All maintenance operations will be coordinated with both construction and emplacement operations, as well as with ongoing activities of the PC Program.

7. REFERENCES

7.1 DOCUMENTS CITED

BSC (Bechtel SAIC Company) 2001a. *ANSYS Calculations in Support of Natural Ventilation Parametric Study for SR.* CAL-SVS-HV-000003 REV 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010613.0250.

BSC 2001b. *In Situ Field Testing of Processes.* ANL-NBS-HS-000005 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20020108.0351.

BSC 2001c. *Precipitates/Salts Model Calculations for Various Drift Temperature Environments.* CAL-EBS-PA-000012 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20011212.0253.

BSC 2001d. *Repository Multiple Waste Package Thermal Calculation.* CAL-WIS-TH-000010 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010814.0330.

BSC 2003a. *Committed Ground Support Materials for LA Design.* 800-K0C-WIS0-00100-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031009.0012.

BSC 2003b. *Corrosion Evaluation of Steel Ground Support Components.* 800-K0C-TEG0-00300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030224.0001.

BSC 2003c. *Dose Rate Calculation for 21-PWR Waste Package.* 000-00C-DSU0-01800-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030903.0003.

BSC 2003d. *Drift-Scale Coupled Processes (DST and THC Seepage) Models.* MDL-NBS-HS-000001 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030804.0004.

BSC 2003e. *Ground Control for Emplacement Drifts for LA.* 800-K0C-TEG0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031016.0001.

BSC 2003f. *Longevity of Emplacement Drift Ground Support Materials for LA.* 800-K0C-TEG0-01200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030922.0004.

BSC 2003g. *Q-List.* TDR-MGR-RL-000005 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030930.0002.

BSC 2003h. *Scoping Analysis on Sensitivity and Uncertainty of Emplacement Drift Stability.* 800-K0C-TEG0-00600-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031125.0002.

BSC 2003i. *Typical Ground Support for Emplacement Drifts.* 800-KM0-SSE0-01201-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031204.0006.

BSC 2003j. *Underground Layout Configuration.* 800-P0C-MGR0-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031002.0007.

BSC 2003k. *UZ Flow Models and Submodels.* MDL-NBS-HS-000006 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030818.0002.

BSC 2003l. *Ventilation Model and Analysis Report.* ANL-EBS-MD-000030 REV 03 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030804.0003.

CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 1997. *Constructibility Considerations for Repository Drifts for Viability Assessment.* BCAA00000-01717-0200-00005 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971229.0302.

CRWMS M&O 1998. *Repository Ground Support Analysis for Viability Assessment.* BCAA00000-01717-0200-00004 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980512.0714.

DOE (U.S. Department of Energy) 2003. *Quality Assurance Requirements and Description.* DOE/RW-0333P, Rev. 13. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20030422.0003.

Snell, R.D.; Beesley, J.F.; Blink, J.A.; Duguid, J.O.; Jenni, K.E.; Lin, W.; Monib, A.M.; and Nieman, T.L. 2003. *Performance Confirmation Plan.* TDR-PCS-SE-000001 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030703.0001.

Tilman, M.M.; Jolly, A.F., III.; and Neumeier, L.A. 1984. *Corrosion of Friction Rock Stabilizers in Selected Uranium and Copper Mine Waters.* Report of Investigations 8904. [Pittsburgh, Pennsylvania]: U.S. Department of the Interior, Bureau of Mines. TIC: 230626.

Williams, N.H. 2003a. "Contract No. DE-AC28-01RW12101 – Licensing Position-034, Preclosure Period Duration." Letter from N.H. Williams (BSC) to J.D. Ziegler (DOE/ORD), December 15, 2003, 1209039726, with enclosure. ACC: MOL.20040107.0059.

Williams, N.H. 2003b. "Thermal Inputs for Evaluations Supporting TSPA-LA, Supplement." Interoffice memorandum from N.H. Williams (BSC) to Distribution, April 4, 2003, 0205035938, with enclosures. ACC: MOL.20030501.0081.

7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR 63. 2002. Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Readily available. [DIRS 158535]

AP- 3.11Q, Rev. 4, *Technical Reports*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20030827.0015.

LP-OM-042Q-BSC, Rev. 0, ICN 1, *Ground Support Walkdown, Maintenance, and Repair*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020409.0002

7.3 SOURCE DTNS

MO0203SPAESF00.003. ESF Temperature and Humidity Monitoring Record. Submittal date: 03/20/2002.