Yucca Mountain Project Subsurface Facilities Design

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Abstract-*Yucca Mountain was recently designated as the site for a proposed repository to dispose of spent nuclear fuel and high-level radioactive waste. Work is proceeding to advance the design of subsurface facilities to accommodate emplacing waste packages in the proposed repository. This paper summarizes recent progress in the design of subsurface layout of the proposed repository.*

I. Introduction

Yucca Mountain was recently designated as the site for a proposed repository to dispose of spent nuclear fuel and high-level radioactive waste. Work is proceeding to advance the design of subsurface facilities to accommodate emplacing waste packages in the proposed repository. This paper summarized recent progress in the design of subsurface layout of the proposed repository.

The original Site Recommendation (SR) concept for the subsurface design located the repository largely within the lower lithophysal zone (approximately 73%) of the Topopah Springs formation. Four units of the Topopah Springs formation (volcanic tuff) are considered for the proposed repository: the upper lithophysal, the middle non-lithophysal, the lower lithophysal, and the lower non-lithophysal.

The Site Recommendation characterized area suitable for emplacement consisted of the primary upper block, the lower block and the southern upper block extension. The primary upper block accommodated the mandated 70,000 metric tons of heavy metal (MTHM) at a 1.45 kW/m linear heat load.

Based on further study of the Site Recommendation concept, the proposed

repository siting area footprint was modified to make maximum use of available site characterization data, and thus, reduce uncertainties associated with performance assessment. As a result of this study, a modified repository footprint has been proposed and is presently being review for acceptance by the DOE.

A panel design concept was developed to reduce overall costs and reduce the overall emplacement schedule. This concept provides flexibility to adjust the proposed repository subsurface layout with time, as it makes it unnecessary to "commit" to development of a large single panel at the earliest stages of construction.

A description of the underground layout configuration and influencing factors that affect the layout configuration are discussed in the following sections.

II. Selection Criteria / Goals

The following criteria/goals were selected for the development of the proposed repository footprint:

- The footprint will be capable of disposing a minimum of 70,000 MTHM.
- The Paintbrush nonwelded (PTn) hydrogeologic unit is located above the proposed repository. Include a 100 m (328 ft) standoff from the PTn to avoid thermal and chemical alteration and a minimum PTn thickness of >10 m (33 ft) to limit seepage.
- The Calico Hills nonwelded (CHn) hydrogeologic unit is located below the proposed repository. A standoff of 60 m (200 ft) from the CHn was set to avoid thermal-chemical alteration.
- A standoff of 100 m (328 ft) from current water table was set to allow for water table rise under future (wetter) climates.
- A standoff of 30 m (100 ft) from perched water was set to avoid vaporization.
- A single level may reduce complexity in the unsaturated zone (UZ) process models, particularly coupled process models for high-temperature operating conditions.
- The middle nonlithophysal unit (Tptpmn) is the most characterized unit. Optimally utilize this unit for waste emplacement drifts.
- Minimize rockfall size potential by control of drift orientation.
- No emplacement drifts west of the Solitario Canyon fault (this area is outside the characterized region).
- To reduce impact of potential fault movement, a standoff from Type I faults of 60 m (200 ft) was set.

III. General Layout Description

The proposed repository will be developed in a series of panels. The first panel will provide early access for emplacement of waste by 2010

Panels 1, 2, 3, and 5 are located in the primary area of the proposed repository host horizon (RHH), while Panel 4 is located in the lower block area of the RHH (Figure 1).

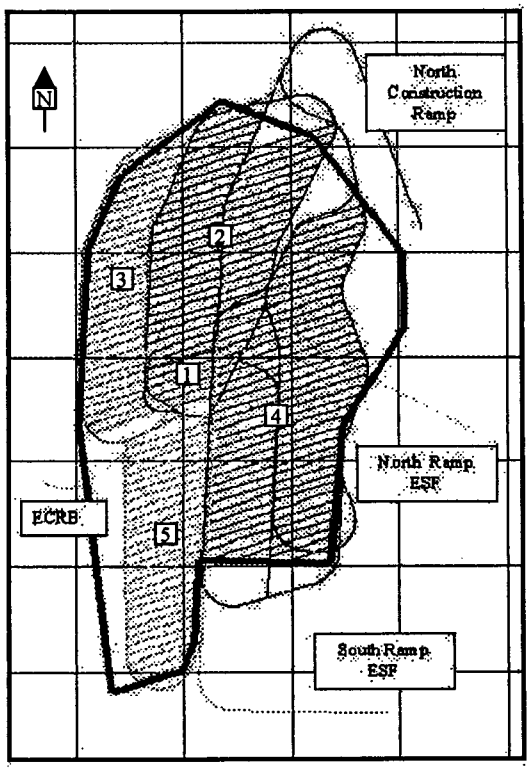

Figure 1. Proposed Footprint and Design

The shape of the panels is slightly irregular. This was done for two reasons: 1) to provide a high utilization of the available footprint area, and 2) to accommodate any potential standoff, if required, for ground conditions. Each panel

consists of access mains on the intake side of the emplacement drifts and an exhaust main at the exhaust side of the emplacement drifts. The access mains and exhaust main are located in the same plane as that of the emplacement drifts.

The Exploratory Studies Facilities (ESF) opening is located such that it can become an integral part of the underground layout configuration. The ramps in the ESF provide access to the RHH, where the North Ramp will support emplacement and the South Ramp will support construction.

For access to the north end of the proposed repository a new north construction ramp will be constructed that will connect with the ESF. This ramp will be sized at 7.62 meters (25 feet) similarly to the ESF ramps.

Subsequently, this new north construction ramp will only be used for construction access, and ventilation, allowing the North Ramp to be used exclusively for waste emplacement.

The location of the new north construction ramp portal is approximately 2,000 meters (6,562 feet) from the existing north portal.

IV. Panel Descriptions

The following sections provide descriptions of each of the emplacement panels.

IV.A. Panel 1

The initial emplacement panel will be located within the central section of the overall layout (Figure 2) and will utilize the ESF for access to the proposed repository horizon. The size of the panel is small in comparison to the other panels in the proposed repository. This was done so that the panel could be developed and outfitted ready for waste emplacement in 2010.

Panel 1 consists of eight emplacement drifts with a total useable waste emplacement length of 4,100 meters (13,451 feet). Provision is made for potential use of one or more emplacement drifts as Test and Evaluation drifts. A performance confirmation (PC) observation drift and test alcove is provided beneath Emplacement Drift 3 for instrumentation and observation purposes.

The emplacement area of Panel 1 will be developed from the north to the south. The North Ramp will supply the intake ventilation for the panel during emplacement and the exhaust will be through Exhaust Raise 1[1] located at the north end of the panel between Emplacement Drifts 1 and 2. By constructing the panel in this manner it is possible to turn over the panel for emplacement in stages: as few as the first two drifts could be in the first turnover package.

[1] The smaller vertical ventilation airways, which are raisebored are designated as raises to distiguish them from the larger airways which are designated as shafts

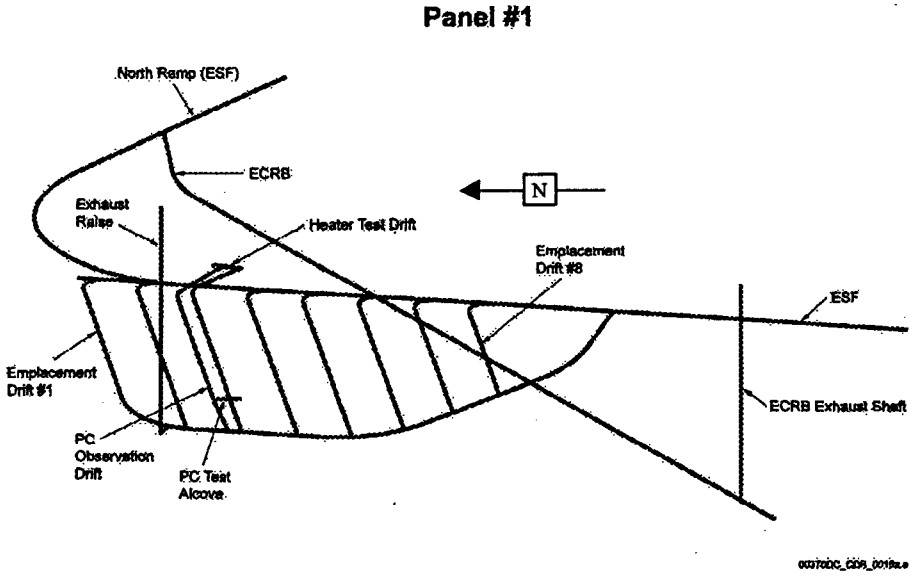

Figure 2. Panel 1 – Isometric View

IV.B. Panel 2

Panel 2 is located in the primary block of the RHH and will be developed north of Panel 1 using the ESF and the new north construction ramp (Figure 3) for construction access. Panel 2 is divided into two zones, the east and the west. The zones share a common intake main that runs down the middle of the panel. The outside perimeter of the panel forms the exhaust mains.

Panel 2 consists of 42 emplacement drifts with a total useable waste emplacement length of

Panel #2

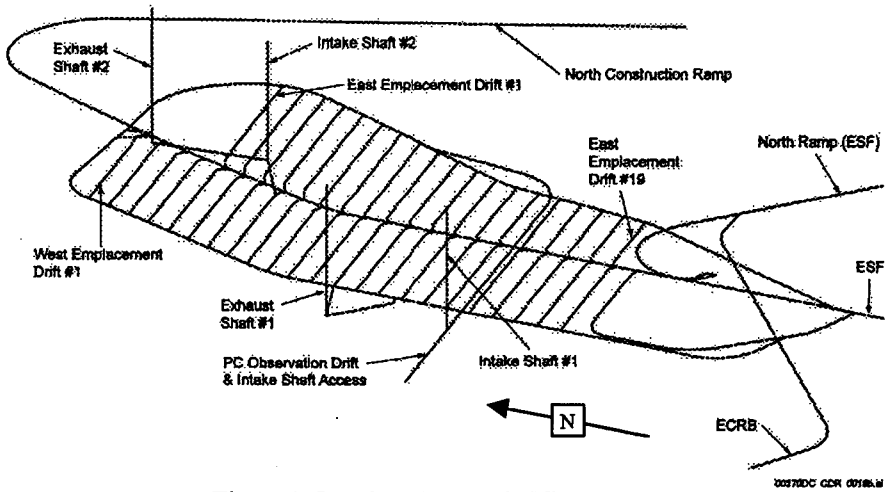

Figure 3. Panel 2 – Isometric View

23,669 meters (77,654 feet). 23 drifts are located in the west zone making up 13,760 meters (45,144 feet) of emplacement length and 19 drifts are located in the east zone making up 9,909 meters (32,510 feet) of emplacement length. Both zones will be constructed simultaneously and turned over together.

The emplacement area of Panel 2 will be developed from the south to the north. The southern portion of both zones will be supplied intake air from the North Ramp, the central portion of the Panel 2 will be supplied from Intake Shaft 1 and the northern portion from Intake Shaft 2. The southern portion of the west zone will exhaust to the Exhaust Raise 1 in Panel 1, the central portion will exhaust to Exhaust Shaft 1, and the northern portion will exhaust to Exhaust Shaft 2. The east zone will exhaust the southern portion through a raise and the Enhanced Characterization of the Repository Block (ECRB) Exhaust Shaft and the northern portion will exhaust to the Exhaust Shaft 2. During construction of the north construction ramp, Panel 2 and the northern portion of Panel 3, Exhaust Shaft 2 will be utilized to help minimize safety concerns such as dust problems. Exhaust Shaft 2 could be used for muck handling if so required. Exhaust Shaft 2 will be positioned to reduce overall lengths of dead end headings that are required to be constructed. Both the north construction ramp and the exhaust main can be connected into Exhaust Shaft 2 as they are being constructed, allowing for flow-through ventilation.

The emplacement drift turnover sequence will start at the south and progress to the north. The size of turnover packages will depend on the amount of initial development that is completed before initial turnover. Initial construction access for Panel 2 will be from the north construction ramp and the South Ramp. Once the emplacement drift turnover starts, construction access from the South Ramp will be lost.

IV.C. Panel 3

Panel 3 is developed in the primary area of the RHH to the western limit of the proposed repository footprint area.

Panel 3 consists of 30 emplacement drifts with a total useable waste emplacement length of 17,476 meters (57,336 feet).

IV.D. Panel 4

Panel 4 is developed in the lower block area of the RHH and will be accessed via a ramp excavated from the new construction ramp at the north and a short waste emplacement ramp excavated from the ESF at the south end of the block. These two ramps will supply two egress pathways out of the panel and allow independent construction and waste emplacement. The western boundary of emplacement for this panel will be offset laterally by 81 meters (266 feet) from the above eastern emplacement boundary of Panel 2 and Panel 5 so that no overlapping of emplacement areas occur.

Panel 4 consists of 65 emplacement drifts with a total useable waste emplacement length of 38,074 meters (124,914 feet). There are 27 drifts located in the west zone making up 15,646 meters (51,332 feet) of emplacement length and 38 drifts are located in the east zone making up 22,428 meters (73,583 feet) of emplacement length. Both zones will be developed and turned over together.

IV.E. Panel 5

Panel 5 is developed at the southern end of the primary area and utilizes the southern portion of the ESF as its eastern limit. A short new main loop is needed to provide the western limit of the panel. Panels 3 and 5 will share a common exhaust main. Panel 5 will utilize the existing ESF as its intake main.

Panel 5 consists of 27 emplacement drifts with a total useable waste emplacement length of 16,036 meters (52,611 feet).

V. Ventilation Interface

The overall ventilation plan is similar for each panel, or in the case where a panel is divided into zones, for each zone. The emplacement access side of the panel will be the intake side and the opposite side will be used only for exhaust. This allows for all normal operations to take place in the cooler intake air stream so no special temperature resistant equipment would be needed. The general airflow pattern will be as follows:

1) The intake air will enter the proposed repository through the ramps or intake shafts;
2) Flow down the intake main, entering the emplacement drifts through the turnouts and the ventilation controls;
3) Flow through the emplacement drifts, exhausting to the exhaust main;
4)
5) Exit the proposed repository through either a full size exhaust shaft or a smaller exhaust raise.

Figure 4 shows the general emplacement airflow for Panel 1.

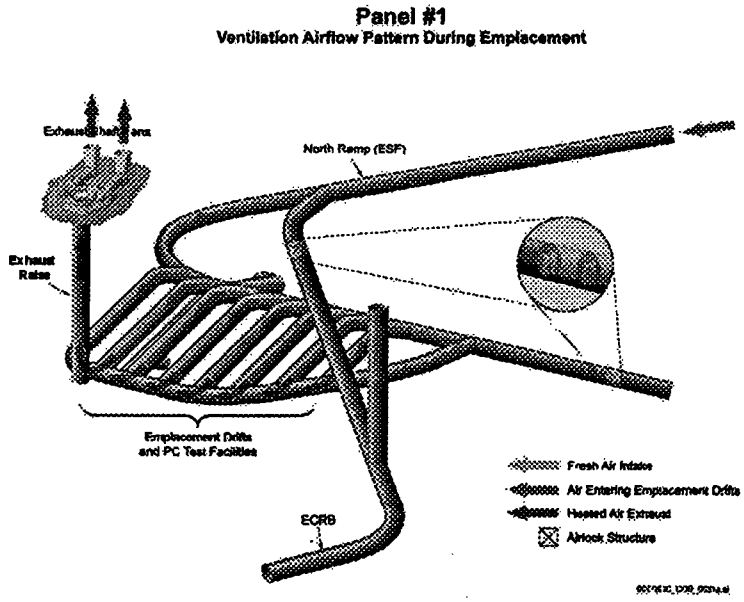

Figure 4. Airflow for Panel 1 – Isometric View

The exhaust system will be set up so that each emplacement drift can be isolated from the rest of the proposed repository during off normal conditions. This will be achieved by positioning exhaust shafts or raises at the ends of each panel. By controlling the airflow through the fans on these shafts the exhaust air can be directed away from the drift or drifts requiring isolation. This would allow off normal access to the isolated drift and the corresponding portion of the exhaust main without any potential exposure to the exhaust air. It would also allow for one or more drifts to be isolated without affecting the overall performance of the proposed repository.

The overall ventilation system consists of 4 shafts and 3 ramps on the intake side and 6 shafts and 2 raises on the exhaust side. These shafts and raises service 172 emplacement drifts in the five panels.

VI. Summation

The major reductions to the site recommendation design have been in the North and the South. The main factors that contributed to these reductions were the water table in the North and the PTn thickness. Reductions to the West and the East were based on the standoffs from the PTn, CHn and faults. The recommended footprint incorporates approximately 80 % of the SR area.

The proposed footprint and design is able to meet all the requirements associated with the site recommendation design and improve the overall performance assessment through reduction of uncertainties.

VI. Bibliography

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