2.5S.5 Stability of Slopes

The following site-specific supplement addresses COL License Information Item 2.40.

The stability of permanent constructed and natural slopes at STP 3 & 4 is addressed. Constructed slopes at the site consist of the existing Main Cooling Reservoir (MCR) embankment slopes, which were constructed as a part of the original STP development, and a new earth berm which are proposed to surround the Ultimate Heat Sink (UHS) Basin/ Reactor Service Water (RSW) Pump Houses.

Overall, the site is relatively flat with no natural slopes.

2.5S.5.1 Slope Characteristics

The characteristics of the two constructed slopes are described below.

2.5S.5.1.1 MCR Embankment

The MCR is located to the south of both STP 1 & 2 and STP 3 & 4. The northern limits of the MCR are shown on Figure 2.5S.4-1. The following MCR description summarizes information from the STP 1 & 2 UFSAR (Reference 2.5S.4-3).

The MCR occupies an area of approximately 3 miles by 4 miles in plan dimensions, or approximately 7000 acres. It includes approximately 65,500 feet of embankment. The top of the embankment varies, ranging from elevation (El.) 65.75 feet to El. 67 feet. Its normal operating reservoir water level is at El. 49 feet, and its minimum operating reservoir water level is at El. 25.5 feet.

The MCR embankment was constructed mainly using compacted clay soils. Interior embankment slopes are 2.5 horizontal : 1 vertical (2.5:1 H/V). Exterior embankment slopes are 3:1 H/V. All interior slopes are protected with a 2.5-foot-thick layer of soil-cement.

2.5S.5.1.2 STP 3 & 4 UHS Basin/RSW Pump Houses Earth Berm

The ground surface at the STP 3 & 4 Power Block area is relatively flat, with no permanent slopes planned other than an earth berm proposed to surround the UHS Basin/RSW Pump Houses. The plan location of those combined structures is shown on Figure 2.5S.4-2. Relevant cross-sections of the UHS Basin/RSW Pump Houses, including the earth berm are shown on Figures 2.5S.4-53 and 2.5S.4-54. As shown on these figures, site grade at the toe of the earth berm is at El. 30 feet, and the top of the earth berm ranges from El. 39 feet to El. 49 feet (i.e., berm height from 9 feet to 19 feet). The berm slope is 2:1 H/V. The berm width at the top, extending from the edge of the UHS Basin/RSW Pump Houses, is approximately 50 feet.

The earth berm serves two functions; (a) it provides vehicular access to the UHS Basin/RWS Pump Houses and (b) it adds increased support in terms of dead load (the foundation mat extending 10 feet beyond the exterior face of the structure) to counteract buoyancy forces acting on those structures. Note that the function of the earth berm in counteracting buoyancy is only needed when both sides of the UHS Basin are completely emptied (and thus STP 3 & 4 are not in service) and there is an exterior water level approaching El. 47.6 feet (i.e., a maximum water level resulting from a postulated MCR dike breach), both of which would be rare occurrences during the STP 3 & 4 period of operation.

The berm is constructed according to detailed design-established fill placement specifications, including testing requirements.

2.5S.5.1.3 Exploration Programs and Geotechnical Conditions

The STP 1 & 2 UFSAR (Reference 2.5S.4-3) describes a detailed subsurface investigation, performed prior to construction of the MCR, and within the planned MCR footprint. Borings were performed at 500-foot intervals along the MCR embankment, extending to depths of 30 feet to 80 feet below original ground surface. Along the planned interior dikes of the MCR, borings were performed at 1000-foot intervals. Additional borings were completed at planned MCR structures and within the reservoir area. Generally, the MCR embankment subgrade soils were found to consist of stiff to hard clays and medium dense to dense sands.

The results of a subsurface investigation in the area of the UHS Basin earth berm, as well as groundwater conditions, sampling, materials and properties, liquefaction potential, and other details are described in Subsection 2.5S.4.

2.5S.5.2 Design Criteria and Analysis

2.5S.5.2.1 MCR Embankment Slopes

Stability analyses for the MCR embankment are described fully in the STP 1 & 2 UFSAR (Reference 2.5S.4-3). The following descriptions summarize information from that reference.

Long-term MCR embankment stability was evaluated with reservoir water level set at maximum operating level, El. 49 feet, and applying effective stress (drained) soil parameters. Calculated factors of safety ranged from 1.7 to 1.8 at the exterior slopes, and from 1.8 to 1.9 at the interior slopes. Reservoir rapid drawdown analyses were completed with reservoir level falling from El. 49 feet to El. 39 feet. Resultant factors of safety ranged from 1.4 to 1.5. The results from Newmark-type permanent deformation analysis indicated that MCR embankment slopes could safely withstand the Safe Shutdown Earthquake (SSE) acceleration of 0.10g. Pseudo-static dynamic slope stability analyses yielded factors of safety ranging from 1.3 to 1.5. Liquefaction potential analyses yielded factors of safety ranging from 1.1 to 1.6 for Operating Basis Earthquake (OBE) conditions, and from 1.7 to 4.7 for SSE conditions.

While the MCR embankment was evaluated for SSE conditions, it was not considered a Seismic Category I structure. STP 1 & 2 Seismic Category I structures are designed to withstand the potential failure of an MCR embankment section, considering up to a 2000-foot-long embankment breach adjacent to the STP 1 & 2 Power Block (Reference 2.5S.4-3, Section 2.4.4.1.1.3). The selection of this breach length was based on sensitivity analyses, with greater breach lengths not significantly increasing the resulting flood level at the STP 1 & 2 Power Block. The resulting flood level that

STP 1 & 2 Seismic Category I structures are designed to withstand is El. 50.8 feet (Reference 2.5S.4-3, Table 2.4-1).

STP 3 & 4 Seismic Category I structures are to have similar flood protection mechanisms to withstand a possible breach in the MCR embankment. Because STP 3 & 4 structures are designed against this condition, a failure in the MCR embankment similarly does not impact the safety of STP 3 & 4 Seismic Category I structures. Because the STP 3 & 4 Power Block area is about 2000 feet from the MCR embankment, or approximately three times the distance of the MCR embankment to the STP 1 & 2 Power Block area, the maximum flood level at STP 3 & 4 (El. 47.6 feet) is somewhat lower than the maximum flood level at STP 1 & 2 (El. 50.8 feet).

The STP 3 & 4 intake structure is approximately 1000 feet south and slightly west of the STP 1 & 2 intake structure. The STP 3 & 4 discharge structure is approximately 1000 feet west of the STP 1 & 2 discharge structure. During the detailed design of STP 3 & 4, the stability of the areas of the MCR embankment impacted by the construction of STP 3 & 4 intake/ discharge structures is checked. A site-specific subsurface investigation is performed in these two areas to support the check analyses.

2.5S.5.2.2 STP 3 & 4 UHS Basin/RSW Pump Houses Earth Berm Slope

Borrow soils for construction of the earth berm surrounding the UHS Basin/RSW Pump Houses are primarily cohesive soils. Material properties for cohesive backfill placed at the earth berm, compacted to minimum 95% modified Proctor maximum dry density, was estimated from available information (Reference 2.5S.4-3). Likely borrow sources to construct the earth berm are materials from Stratum A (i.e., soil layers A_1 and A_2 in the STP 1 & 2 UFSAR nomenclature). An average of the effective stress (drained) strength parameters for these two layers (i.e., soil layers A_1 and A_2) was estimated as drained friction angle (ϕ')=16 degrees, drained cohesion (c')=265 pounds per square foot (psf), and unit weight (γ)=124 pounds per cubic foot (pcf) (Reference 2.5S.4-3, Table 2.5S.4-6). For conservatism, these properties were reduced, with the selected values at ϕ'=15 degrees, c'=250 psf, and γ=120 pcf, for the earth berm evaluation.

The stability of the UHS Basin berm was assessed using limit equilibrium methods. This approach results in a factor of safety (FOS) that can be defined as (Reference 2.5S.5-1):

Equation 2.5S.5-1

$$FOS = \frac{\text{Shear Strength of Soil}}{\text{Shear Stress Required for Equilibrium}}$$

Various limit equilibrium methods are available for slope stability evaluation. The software SLOPE/W (Reference 2.5S.5-2) was used for this evaluation. This software has been independently validated by Bechtel (Reference 2.5S.5-3). The software searches for a critical slip surface by attempting several hundred combinations of surfaces of different shapes/ orientations. Static and pseudo-static analyses were performed at a typical cross-section for the maximum earth berm height of 19 feet.

The result of the static stability analysis for the earth berm is shown on Figure 2.5S.5-1. A minimum FOS=1.68 was calculated, based on the Morgenstern-Price method (an analysis method offered in SLOPE/ W). The calculated FOS=1.68 is greater than the commonly accepted FOS=1.5 for long-term stability of permanent slopes (Reference 2.5S.5-1). This demonstrates that the UHS Basin/RSW Pump Houses earth berm is unlikely to fail and is not a significant risk to the safety of either the UHS Basin/RSW Pump Houses or any other Seismic Category I structures.

A pseudo-static analysis of the earth berm was also performed using the software SLOPE/W. For the pseudo-static analysis, a horizontal inertial effect coefficient k_h=0.10 was used, based on the peak horizontal ground surface acceleration of 0.10g at the site, as discussed in Subsection 2.5S.4.7. The vertical inertial effect coefficient, k_v, was set to zero. A FOS=1.35 for the pseudo-static case was calculated, as shown on Figure 2.5S.5-2. The calculated FOS was again based on the Morgenstern-Price method. The estimated FOS=1.35 is greater than the commonly-accepted FOS=1.0 to 1.2 for infrequent loading conditions (Reference 2.5S.5-1), e.g., during earthquakes. Therefore, the prescribed seismic event is unlikely to cause the UHS Basin/RSW Pump Houses earth berm to fail.

2.5S.5.3 Logs of Borings

The logs of borings and associated references for the MCR embankment are provided in Reference 2.5S.4-3. The logs of borings and associated field testing for work related to the STP 3 & 4 subsurface investigation are provided in Reference 2.5S.4-2 ~~(Appendix 2.5A)~~.

2.5S.5.4 Compacted Fill

Compacted fill requirements and associated references are addressed in Subsection 2.5S.4.5.

2.5S.5.5 References

2.5S.5-1 "State of the Art: Limit Equilibrium and Finite-Element Analysis of Slopes," Journal of Geotechnical Engineering, ASCE, Volume 122 (7), pp. 577-596, Duncan, J.M., 1996.

2.5S.5-2 "SLOPE/W, User's Manual," Geo-Slope International, Version 6.13, 2004.

2.5S.5-3 "Validation Manual for GE262, SLOPE/W, Version 6.13," A Computer Program for Slope Stability Analysis, Revision 1, 2005.

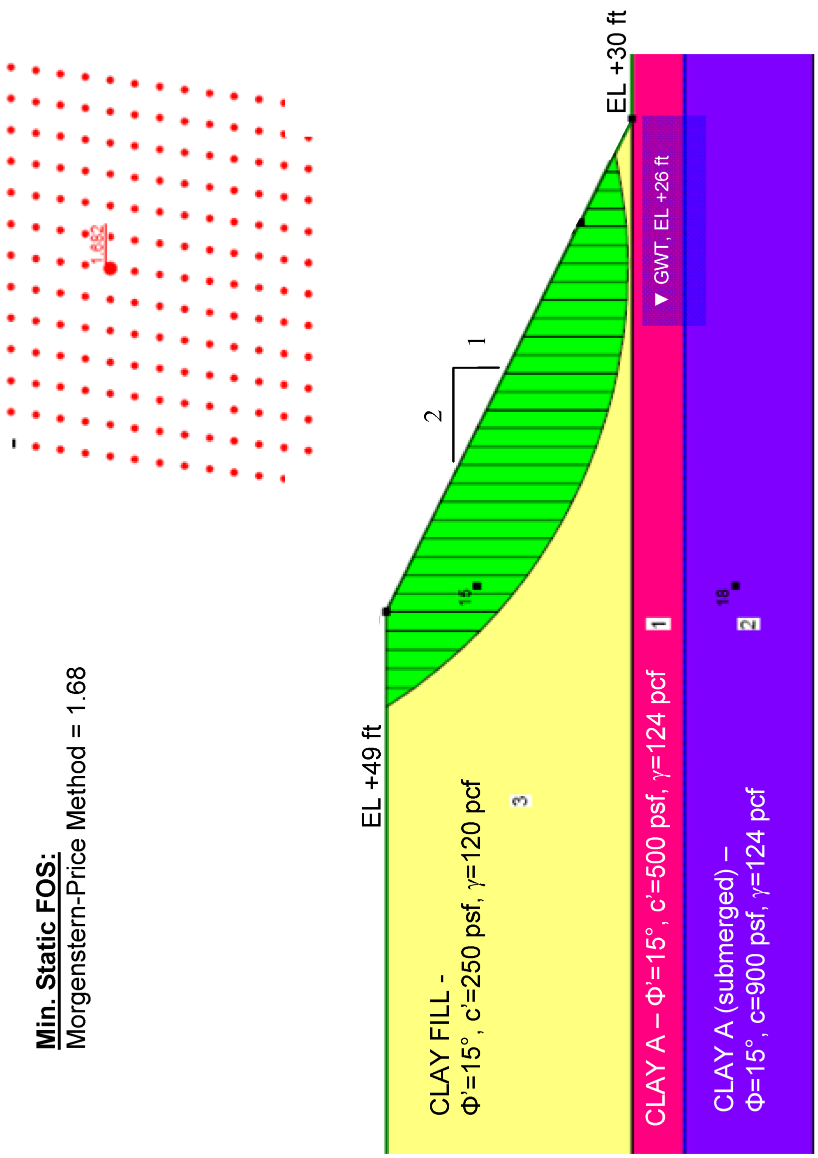

Figure 2.5S.5-1 Static Stability of the UHS Basin/RSW Pump Houses Earth Berm

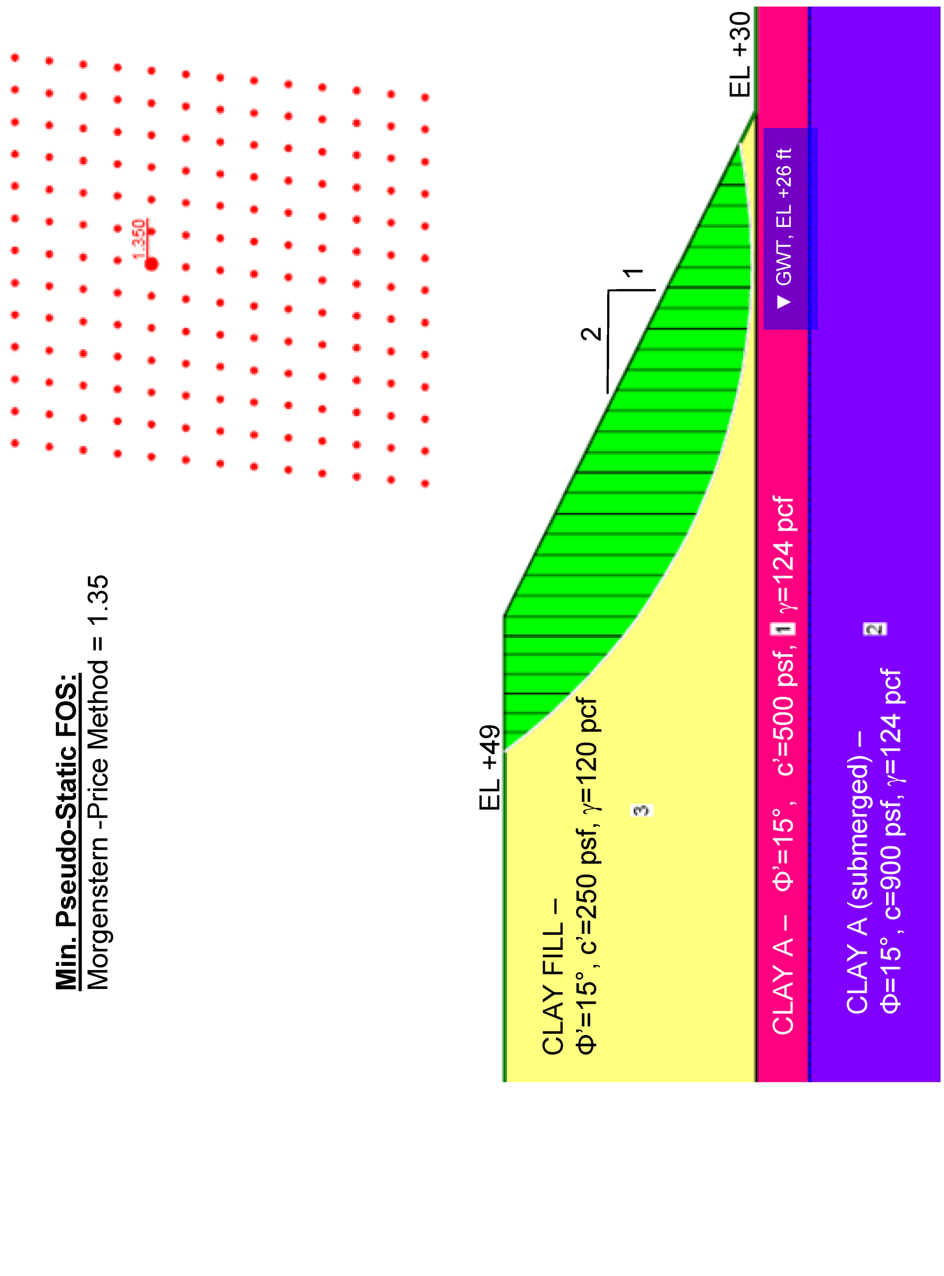

Figure 2.5S.5-2 Pseudo-Static Stability of the UHS Basin/RSW Pump Houses Earth Berm