GENTERRA
CONSULTANTS, INC.
ENGINEERING & ENVIRONMENTAL SERVICES

TECHNICAL MEMORANDUM

TO: Rex Wait, Vice President
The Nevada Hydro Company, Inc.

FROM: Joseph J. Kulikowski, P.E., G.E.
GENTERRA Consultants, Inc.

SUBJECT: Comparative Review of Geotechnical Conditions at Three Candidate Powerhouse Sites: Ortega Oaks, Santa Rosa and Evergreen
Lake Elsinore Advanced Pumped Storage Project (LEAPS)
FERC Project No. 11858

DATE: March 24, 2006

This Technical Memorandum presents the results of a comparative review of geotechnical conditions at three alternative powerhouse sites for the proposed Lake Elsinore Advanced Pumped Storage Project (LEAPS) in Riverside County, California. The review was performed by GENTERRA Consultants, Inc. (GENTERRA) for The Nevada Hydro Company, Inc. (Nevada Hydro) in accordance with the scope of work authorized on February 20, 2006.

This review was undertaken in response to the Federal Energy Regulatory Commission's (FERC) "Draft Environmental Impact Statement – Lake Elsinore Advanced Pumped Storage Project, California, FERC Project No. 11858" (DEIS), dated February 2006, and the identification of the Ortega Oaks as the "staff alternative" powerhouse therein. At the request of Nevada Hydro, GENTERRA was asked to validate or to refute the document's contention that "the effects of construction at the Ortega Oaks powerhouse site would be similar to the proposed Santa Rosa site."

The review consisted of a re-examination of available background reports and information, combined with a geologic reconnaissance of the proposed alternative powerhouse sites and the two alternative upper reservoir sites. The site reconnaissance was performed on February 21, 2006 by Michael Wolff, C.E.G., a GENTERRA engineering geologist.

SUMMARY OF CONCLUSIONS

Geotechnical factors have the potential to significantly affect construction cost of a project that has extensive subsurface facilities and is sited in a seismically active area, as is the case with the LEAPS project. Based on the data and information available at this time, GENTERRA concludes that all three alternative powerhouse sites appear to be feasible from a geotechnical perspective; however, the Santa Rosa and Evergreen sites will involve less construction complexity and attendant cost than will the Ortega Oaks site, and they also offer greater flexibility to adjust the powerhouse location should underlying geologic faults be discovered. The Santa Rosa and Evergreen sites are therefore rated higher than the Ortega Oaks site. This is shown in the following matrix; the issues are discussed further in the sections that follow.

Powerhouse Site	Excavation and Shoring of Access Shaft	Stability of Underground Chambers	Proximity of Powerhouse Cavern to Faults	Foundation for Tailrace Tunnels and Inlet/Outlet Structure	Averaged Score
	Relative Score 1 to 3 (3 best)				
Ortega Oaks	1	1	1	1	1
Santa Rosa	2	2	2	3	2.25
Evergreen	3	3	2	3	2.75

BACKGROUND

Environmental impacts of the proposed LEAPS project, including geotechnical considerations, have been assessed and are presented in the DEIS. Preliminary geotechnical data and analyses have been reported by GENTERRA in the Geotechnical Feasibility Report, dated August 28, 2003. These reports present the geological and geotechnical framework of the project area and specific alternative sites. This analysis is limited to geotechnical variables and does not address other decision-making considerations.

The three alternative powerhouse sites are the Ortega Oaks, Santa Rosa, and Evergreen sites (Figure 1). The three sites are situated at the base of the steep northeast-facing slope of the Elsinore Mountains immediately west of Lake Elsinore. The Ortega Oaks site is located near the base of the slope on the southeast side of Ortega Highway (State Route 74), a short distance south of the intersection of Ortega Highway and Grand Avenue. The Santa Rosa site is located near the base of the slope approximately 0.9 miles southeast of the Ortega Oaks site, and a short distance south of the intersection of Santa Rosa Drive and Grand Avenue. The Evergreen site is located near the base of the slope another approximately 0.5 miles southeast of the Santa Rosa site and a short distance south of the intersection of Evergreen Street and Grand Avenue.

The current project concept involves a subsurface powerhouse, transformer gallery and surge chamber created in large caverns mined within the buried bedrock that underlies each of the three alternative sites at varying depths. The main powerhouse cavern will measure on the order of 350-feet long, 80-feet wide, and 130-feet high, with the transformer gallery and surge chambers being substantially smaller than the powerhouse.

The powerhouse will be connected to an upper reservoir located at the crest of the adjacent mountains by twin penstock tunnels of approximately 16-foot diameter, or a single penstock tunnel approximately 30-feet in diameter. These tunnels will be bored within bedrock and will rise approximately 1,700 feet in elevation from the powerhouse to the upper reservoir. The powerhouse will also be connected with Lake Elsinore by two gently upward-sloping tailrace tunnels connected to an inlet/outlet structure located within Lake Elsinore. These tailrace tunnels will be constructed using a combination of hard rock and soft-ground tunneling techniques owing to the variable geologic conditions that they will encounter (Figure 2).

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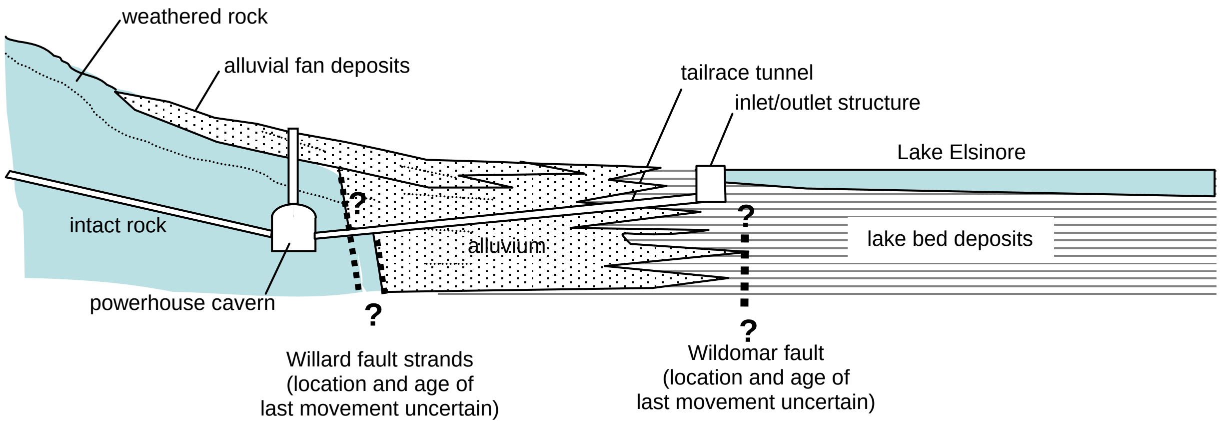
The following sections discuss specific geotechnical considerations that affect the selection of the three powerhouse sites.

Figure 1 – Proposed Alternative Powerhouse Locations

Note: Locations are approximate

Figure 2 – Schematic Cross Section



GEOTECHNICAL CONSIDERATIONS FOR POWERHOUSE SITING

Excavation and Shoring

A large portion of the project construction cost is related to the excavation and construction of the underground powerhouse, transformer gallery and surge chamber, and the tunnels that project outwards from these facilities. These facilities will occupy underground chambers mined in the bedrock at depths of up to roughly 300 feet beneath the ground surface. Access to excavate these chambers will be provided by first excavating a large-diameter access shaft from the ground surface down to the chamber depths.

The conditions encountered in the access shaft excavation will impact the cost of construction. The portion of the access shaft excavation that is in loose alluvium or highly fractured and weathered bedrock will require installation of a complex and expensive shoring system to stabilize the walls of the shaft while still allowing sufficient access to lower the large tunnel boring machine (TBM) that will be required to bore the penstock and tailrace tunnels. Once the TBM is working underground, all of the tunnel spoils will need to be brought to the ground surface through the access shaft. When tunneling is complete, the TBM will need to be retrieved through the access shaft. The portion of the shaft excavation within intact bedrock will require less shoring; therefore, sites with substantial depth to bedrock will involve substantially more extensive and costly shoring than a site with bedrock close to the ground surface.

Based on geophysical investigations performed by GENTERRA, the depth to bedrock at the Ortega Oaks site is estimated to be from 110 to 160 feet below ground surface (bgs). Depth to bedrock at the Santa Rosa site is estimated to range from 70 to 145 feet bgs. Geophysical investigation was not performed at the Evergreen site because bedrock was observed to occur at or near the ground surface at this site.

Based on this criterion, construction costs for shoring the access shaft excavation will be greatest at the Ortega Oaks site, less at the Santa Rosa site, and least at the Evergreen site.

<u>Stability of the Powerhouse Cavern, Surge Chamber and Transformer Gallery</u>

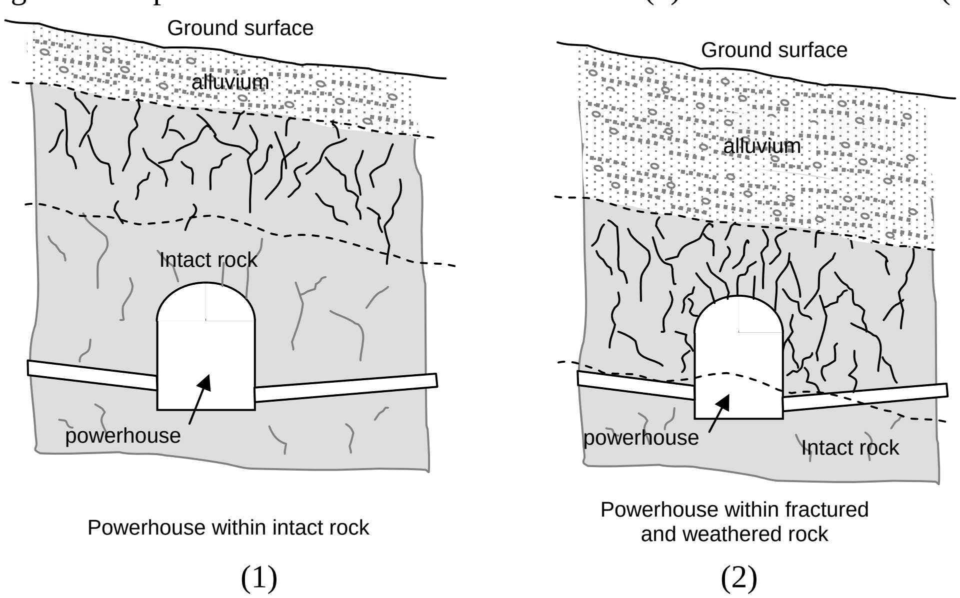
Construction cost will be greatest at sites where the underground chambers are within fractured, broken or weathered rock because underground chambers with these conditions would require complicated and costly shoring and bracing systems on both a temporary and permanent basis. Conversely, underground chambers sited within intact rock will be more stable and require less shoring and bracing. The rock quality at the cavern depth is therefore a key geotechnical consideration for selection of the powerhouse site.

Rock quality and strength generally improve with increasing depth below the buried rock surface. The rock quality is likely to be greatest at a powerhouse location where the thickness of rock cover above the cavern roof is greatest. This is shown diagrammatically in Figure 3.

As described above, geophysical investigations indicate that the depth to bedrock is from 110 to 160 feet bgs at the Ortega Oaks site, from 70 to 145 feet bgs at the Santa Rosa site, and at or near the ground surface at the Evergreen site. At the present stage, deep exploratory borings and core holes at the three candidate sites have not yet been installed. Because of the cost of gathering this information, potential disruption to existing land uses, and needless work effort on sites that are not selected, this information is appropriately gathered at a later stage in the process.

Based on present information, relative rock quality at the proposed cavern depths is likely to be poorest at the Ortega Oaks site, better at the Santa Rosa site, and best at the Evergreen site. Underground construction costs are therefore likely to be greatest at the Ortega Oaks site, less at the Santa Rosa site, and least at the Evergreen site.

Fig. 3 – Comparison of Powerhouse in Intact Rock (1) vs. Fractured Rock (2)



Proximity of Powerhouse Cavern to Faults

The powerhouse locations are within the Elsinore trough, which is an area of active faulting. The Willard fault, a branch of the Elsinore fault zone, has been mapped on the west side of Lake Elsinore and may exist close to the three powerhouse locations. The precise location of the Willard fault is not known with certainty in the project area, so there is a chance that a strand of the fault may lie beneath any of the three sites. The recency of movement on the Willard fault is also not known with certainty, but for preliminary design purposes, this fault has been assumed to have a potential for movement during an earthquake. Detailed investigations of faulting will be done at a later stage of the project.

The presence of a potentially active fault beneath the powerhouse would present major design challenges, and could introduce a risk of facility disruption during an earthquake; therefore, the flexibility to shift the cavern location towards the southwest (into the hill) to avoid faults is an important consideration in selecting the powerhouse site. The Ortega Oaks site is bordered on the uphill side by Highway 74, which limits the distance that the powerhouse cavern could be shifted towards the hill in the event that a fault is discovered beneath the site. By contrast, the Santa Rosa and Evergreen sites have no such limitation. The greater flexibility of the Santa Rosa and Evergreen sites favor them over the Ortega Oaks site with respect to proximity to faults.

Foundation Conditions for Tailrace Tunnels and Inlet/Outlet Structure

The project area is prone to strong ground shaking owing to its proximity to major active faults. Strong ground motion triggered by displacement on nearby faults could potentially cause high ground accelerations and resulting liquefaction of saturated unconsolidated sediments, such as those adjacent to and underlying Lake Elsinore. This means that the tailrace tunnels from all three candidate powerhouse sites will need to be supported on materials that are mitigated for liquefaction by ground improvement techniques, at least for a portion of their length (see Figure 2). Detailed investigations of the geotechnical properties of foundation materials will be appropriately investigated as part of the subsequent design phase, following final site selection by FERC.

As shown in Figure 1, the tailrace tunnels are longest at the Ortega Oaks site, and have similar length at the Santa Rosa and Evergreen sites. Based on preliminary data and information, construction cost due to foundation improvement requirements for the tailrace tunnels and inlet/outlet structure will be greatest for Ortega Oaks, and less for the Santa Rosa and Evergreen sites.

CONCLUSIONS

Geotechnical factors have the potential to significantly affect construction cost of a project that has extensive subsurface facilities and is sited in a seismically active area, as is the case with the LEAPS project. Based on the data and information available at this time, GENTERRA concludes that all three alternative powerhouse sites appear to be feasible from a geotechnical perspective;

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Should you have any questions, please call the undersigned at 949-753-8766.

Respectfully Submitted,
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