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Geology and Geotechnical Considerations of the SSC Site in Texas:

Tunneling and Construction at the Dallas - Ft. Worth SSC Site

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Tunneling and Construction

at the Dallas-Ft. Worth SSC Site

Technical Evaluation Criteria #1

Suitability of

- **Geology**
- **Topography**
- **Geohydrology**

For Efficient and Timely Construction.

Additional Requirements for Efficient and Timely Construction:

1. Selection of the Proper Equipment.

2. Minimum Rock Support Installation.

3. Rapid and Sustained Advance Rate.

- These requirements can be responded to most effectively by having access to analogous case studies of excavation under nearly identical conditions as those to be encountered in SSC construction.

- Fortunately, we have access to precisely these kinds of case studies in the extremely similar rock found in Austin, Texas.

- The rock in Austin is amazingly similar to that in the Waxahachie area, in terms of strength, density, and other physical and mechanical properties.

- In fact, this outcrop view of an exposure of the Chalk in Austin is extremely and obviously similar to those you have already seen as representative of the Chalk rock in the Dallas area.

- As an example of the opportunities to learn from these excellent case studies, consider the Govalle Project, a sewage tunnel facility under current construction in Austin.

The Govalle Project, Austin, TX

> 43,000 ft of 10.5 to 11.5 ft excavated diameter tunnel for a sewer main.

- includes 10 shafts, varying in diameter from 30 ft to more than 100 ft, and excavated depth up to 140 ft.

- about 57% of the tunnel is in the Taylor Marl and 43% in the Austin Chalk.

- bid price was 25.7 million$ (1986), equivalent to an average cost per foot of tunnel of about 575$(1986).

- the notice to proceed was given in October, 1986.

- all tunneling was completed between January, 1987 and April, 1988.

- all work for project completion will be completed by October 1, 1988.

- The completion of excavation and lining for more than 8 miles of tunnel in less than 2 years is very noteworthy....and the contractor will make this completion date!

- Mining in the Taylor section was performed with a Lovat shield Tunnel Boring Machine, with an 11.5 ft-diameter rotating cutterhead.

- A system of three conveyors, operated in series, were used to transfer the mined rock to the rear of the Tunnel Boring Machine and into the cars of a muck train.

- The muck train was towed with a diesel locomotive to a shaft where the cars were lifted by a crane and dumped at the top of the shaft.

The overall advance rate for Taylor Marl excavation was 130 ft/day. Rates for much of the excavation were in excess of 150 ft/day.

- Steel rib and wood lagging support was installed behind the TBM.

- The final lining for this sewer tunnel is cast-in-place concrete.

- Concrete placement rates are typically 275 to 300 ft/day.

- Mining in the Austin Chalk was performed with a hard rock Tunnel Boring Machine, equipped with disc cutters.

- The contractor tried several methods for removing the broken rock from the heading.

With the identical mucking equipment used for tunnel excavation in the Taylor Marl, the contractor was able to make sustained advance rates in excess of 150 ft/day.

For the last three months of tunneling, more than two miles of excavation was completed at an average advance rate in excess of 180 ft/day.

- The tunnel required very little support in the Austin Chalk.

- A minimal pattern of 3 and 6 ft-long rock bolts were installed along the tunnel.

- At no location did the tunnel in the Chalk require steel ribs for support.

- There was no evidence that the rock bolts installed in the Austin Chalk took any load, or that the bolts were required for other than anchors to hang the air vent line.

- In this tunnel, a final lining of cast-in-place concrete is being installed. The decision to place such a lining was made solely for hydraulic considerations and concern for rock deterioration when in contact with flowing sewage.

Average for all Rock in the CDR	118 ft/day
Average for all Soil in the CDR	110 ft/day
Expected at the DFW Site for Austin Chalk	215 ft/day
Expected at the DFW Site for Taylor Marl	150 ft/day

- The advance rate information presented for the Austin Chalk and Taylor Marl includes sumary average data from the Conceptual Design Report on expected advance rates for rock and soil tunneling.

- Advance rates are for progress in the Austin Chalk and Taylor Marl, anticipated based on construction records and predictions using the Trondheim Study (Norwegian Report 1-83), a reference utilized by consultants to the Central Design Group in their cost-estimation exercise.

- The advance rates experienced in tunneling situations analogous to those expected at the Texas Dallas-Ft. Worth Site are clearly significantly higher than those expected for tunneling in other geologic materials.

- It is clear that we have knowledge in hand to allow contractors to select the proper equipment.

- It is clear that rock support requirements will be minimal.

- It is clear that a rapid and sustained advance rate can be expected with reliability.

Technical Evaluation Criteria #2

Stability Against Settlement and Seismicity

- The Dallas area is demonstrably free from the effects of significant seismic activity.

- All underground construction will be completed in rock (albeit weak rock, but strong enough for intended purposes of bearing geologic and applied stresses).

- No regional settlement has occurred in the area.

As a comment on overall stability of completed structures, some sewer tunnels in Austin, completed 15 years ago in the Austin Chalk and Taylor Marl, have been recently inspected, and show absolutely no indications of either distress from accumulated ground loads or deterioration in the far-from-benign environment.

Some concern might be expressed for the location of the foundations for the Near Cluster Interaction Halls, which extend into the Eagle Ford Shale.

In its weathered, near-surface condition, this material does exhibit an ability to develop shrinkage or swelling volume changes. In its unweathered condition, however, the shale will <u>not</u> exhibit appreciable volume changes. We anticipate that the facility could be constructed easily and satisfactorily as proposed.

However, any concern for the presence of the Eagle Ford Shale at the base of the Interaction Hall excavations can be alleviated by exchanging the injector area (Area B) with the future expansion area (Area C). The benefits of such a relocation are shown in the next slide.

This relocation, an example of the flexibility present throughout the proposed site, yields the following benefits:

1. the depths of the base of the Near Cluster Interaction Halls is reduced,
   from about 210 ft to 160 ft for the K-1 Hall, and
   from 220 ft to about 140 ft for the K-2 Hall.

2. the base of the Near Cluster Interaction Halls is in the Austin Chalk, with more than 20 feet of intact Chalk remaining above the Eagle Ford Shale.

Technical Evaluation Criteria #3

Installation and Operational Efficiency Resulting from Minimal Depths for the Accelerator Complex and Experimental Halls.

Facility Depth Summary

Facility Component	Depths (ft) Average	Maximum	Minimum
Shafts			
Intermediate Areas (E-1 to E-10)	137	235	95
Service Area (F-1 to F-10)	155	229	85
Interaction Halls			
Near Cluster	215	210	220
Far Cluster	215	260	198

- The average and maximum shaft depths are easily achieved by conventional construction capabilities, and these depths are well-within those noted as desirable in the ISP.

- The depths of the Interaction Halls are well within the abilities of conventional construction operations.

- The depths of the Far Cluster Interaction Halls can be reduced, if desired, by introducing a hinge or fold in the ring plane.

- The fold location is in the arc areas, at points of symmetry, and the hinge angle is about 6.5 minutes, less than the maximum hinge specified in the Invitation for Site Proposals.

- The hinge operates to reduce the depth of the Far Cluster Interaction Halls significantly.

- For example, the base of the K-3 Hall is brought from about 200 ft depth to less than 120 ft depth by the hinge. The deepest Hall, K-5, is reduced from about 260 ft depth to less than 150 ft depth.

Technical Evaluation Criteria #4

Risk of Encountering Major Problems During Construction

- The final technical evaluation criteria listed in the Invitation for Site Proposals is concerned with the risk of encountering major problems in construction.

- From all that has been presented thus far, it should be clear that the risks for construction at this site are extremely small.

- There is high confidence in the knowledge of geologic conditions. The geological conditions at the site are extremely well defined.

- The variability of ground conditions will be minimal. Groundwater inflow will be minimal to nonexistent. The depth of the tunnel is set to avoid any untoward encounter with water-bearing alluvium.

- There is experience in very similar construction. Knowledge exists to allow the proper equipment selection, which will handle the limited range of ground conditions and support requirements in an expeditious manner.

Average Tunneling Cost (Dollars/Linear Foot)

Average for all Rock in the CDR	$ 940
Average for all Soil in the CDR	$1175
Expected at the DFW Site	$ 595

- includes summary average expected cost data from the CDR for soil and rock tunneling.

- The cost of tunneling the alignment in the Austin Chalk and Taylor Marl as proposed will be less than that expected from CDR estimates, we have estimated approximately 40 percent less.

- The lack of risk at this site will be appreciated by contractors, and will be reflected in their bids.

In fact, engineers familiar with this site would be surprised if the SSC facility, constructed at the Dallas-Ft. Worth site, did not set records for speed of tunneling and completion of construction.

- The tunnel will be 70 percent in the Austin Chalk and 30 percent in the Taylor Marl.

- The ring is planar, dipping to the southwest.

- The dip of the ring follows the sense of the dip of the geologic sedimentary formations.

- The maximum slope along the ring is less than 2 vertical feet per 1000 ft of length (0.14 degrees).

- The tunnel and injector facility at the Near Cluster are located in the Austin Chalk.

- The Interaction Halls at the Near Cluster extend into the top part of the Eagle Ford Shale.

- The Far Cluster Interaction Halls extend through the Taylor Marl into the Austin Chalk as a foundation material.

- The rock is uniform for long stretches of tunneling.

- The rock strength is adequate to resist applied loads but the strength is low enough to allow easy excavation.

- The topographic elevation difference across the ring is about 350 feet.

- The natural slopes are gentle; there will be no concerns for construction equipment operating on steep grades.

- The rock material is impermeable and unsaturated.

- Alluvial material may be water-bearing, but it will not be encountered in tunnels and can be handled easily and conventionally in shaft excavations.

- The Austin Chalk and Taylor Marl have been mined beneath water bodies (streams and lakes) in the Austin area. No significant inflows occurred, except in conjunction with the alluvium.