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Geology and Geotechnical Considerations of the SSC Site in Texas:

Summary of the Occurance of Ground Water in the Vicinity of the Super Conducting Super Collider, Ellis County, Texas

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SUMMARY OF THE OCCURRENCE OF GROUND WATER IN THE VICINITY OF THE SUPER CONDUCTING SUPER COLLIDER, ELLIS COUNTY, TEXAS

Hydrologic Framework

The main hydrostratigraphic units in the Ellis County area, in order of increasing depth, are (see Figures 1-5):

(1) water-bearing zones in Quaternary alluvium and porous, weathered, near-surface bedrock;

(2) a regional confining system consisting of the lower Taylor marl (Ozan Formation), Austin Chalk, and Eagle Ford Formation; and

(3) a regionally confined aquifer system called the Trinity Group aquifer by Nordstrom (1982) with principal units in the Woodbine and Twin Mountains Formations and a secondary unit in the Paluxy Sand (see Figure 6). The regional aquifer system includes also minor confining units, such as occur locally in the Washita and Fredericksburg Groups.

Shallow Water Supplies

Shallow water-bearing zones constitute a small resource in Ellis County supplying as many as 75 wells with small amounts of water for domestic and livestock-watering uses (attachment 1). At depths generally less than 35 ft below ground surface in outcrop areas, weathering has significantly increased bedrock porosity and permeability of the Cretaceous Austin Chalk, allowing shallow recharge and storage of ground water in otherwise tight rock strata. Alluvial deposits up to 50-ft thick occur along major stream channels and mainly consist of material eroded from outcropping Cretaceous strata. Generally, coarsest material occurs at the base of the alluvium. Recharge water from infiltration of precipitation forms a perched water table in the alluvium above the low-permeability unsaturated bedrock.

Confining System

Water movement through the near-surface bedrock in the Eagle Ford Shale, Austin Chalk, and Taylor Marl is very restricted by low hydraulic conductivities, measured as less than 1 x 10-7 centimeters/second (cm/s). Much of this confining system, or aquitard, at the SSC site is thought to be unsaturated, that is, pores are incompletely filled with water. However, hydrologic data typically are sparse for unsaturated rocks and for rocks that make up aquitards. Wells in aquitards, of course, yield negligible quantities of water and consequently few wells are completed in low- permeability rocks. The extremely low rate of yield makes it difficult to define the position of a water table in an aquitard. Zones of saturated ground water might be perched locally in somewhat more permeable parts of the aquitard, which themselves may have permeability too low to yield water at appreciable rates of flow. Designing and constructing a tunnel or excavation in the confining layers should not be impeded by rate of water seepage, which must be very slow, as evidenced in tunnels in Austin, Texas.

Aquifer System

Most interest in developing ground water in the area focuses on the Woodbine and Twin Mountains Formations. The 250- to 375-ft thick Woodbine is a medium- to coarse-grained iron-rich sandstone, with some clay and lignite seams. Depth to the top of the Woodbine ranges from 600 to 1,000 ft beneath ground surface at the SSC facility. Guyton and Associates (1987) report that wells are completed in the lower part of the formation, which yields better-quality ground water. Guyton and others (1987) summarize transmissivity values as ranging from 1,320 to 11,300 gpd/ft and averaging about 5,000 gpd/ft.

The Twin Mountains is as much as 550- to 850-ft thick in the area and is composed principally of sandstone with basal gravel and conglomerate section where most wells are completed. To the east and north of Ellis County, the Twin Mountains is laterally equivalent to the Travis Peak Formation. The top of the Twin Mountains Formation lies 1,200 to 1,500 ft below the base of the Woodbine at depths ranging from 2,000 to 3,000 ft beneath ground surface. Guyton and others (1987) summarize transmissivity values as ranging from 5,440 to 16,547 gpd/ft and averaging about 9,000 gpd/ft.

REGIONAL HYDROGEOLOGIC SETTING

The deeply buried aquifer system beneath Ellis County most likely is recharged by infiltration at the outcrop 15 to 30 miles to the west in Johnson County. There is likely some cross-formational flow of ground water between the Woodbine and Twin Mountains; comparison of water-level maps from 1976 suggests the vertical flow component is directed downward.

Thompson (1967) suggested average ground-water flow rate in the Woodbine is 10 to 40 ft/yr. Average flow rate in the Twin Mountains is 1 to 4 ft/yr. These velocity estimates suggest age of ground water in the regional aquifer system is between approximately 8,000 and 40,000 yr, from west to east across the county. There is no direct data to substantiate these estimates.

GROUND-WATER USE

Ground water use has gradually increased during the past 30 yr, resulting in continued decline in water levels in the confined aquifers. Guyton and others (1987, Figure 5) show that while the rate of increase in demand for ground-water supplies may have decreased regionally, pumpage of Twin Mountains ground water continues to increase. Waxahachie and Ennis have turned almost completely to surface water sources. Other municipalities in the area, including Ferris, Italy, Midlothian, Glenn Heights, Ovilla, and Palmer, get 100 percent of their supply from ground water.

The Texas Water Development Board projects a possible net decrease of as much as 60 percent in municipal ground-water use by the year 2030, compared to 1980 usage, although this simple comparison hides local or short-term increases for some cities. Rural and industrial ground-water use is projected to be fairly constant. The projections are based on population growth models.

Water-Level Changes

Water-level declines have been extensive regionally, owing to production of ground water from storage and depletion of subsurface fluid pressures. It is possible that water levels will continue to decline during the next 40 yr even if pumpage decreases, if ground-water withdrawals exceed inflow from recharge areas. The possible magnitude of future decline, considering projected demand, recharge at the distant outcrop, and regional ground-water flow, has not been adequately addressed.

Guyton and others (1987) evaluated a worst case situation of water-level decline for the SSC Project. As summarized in table 1, they assumed future decline would continue at the historic rate in the Woodbine and Twin Mountains aquifers. Another decline rate, one-half of the historic rate was also included for the Twin Mountains and considered as more representative of Ellis County conditions. These rates do not account for possible future decreases in rate of water-level decline due to deceased pumping. Also, the calculations assume that all 100 gpm water requirement at the 10 shaft locations will be met by ground water; obviously a mix of surface and ground water would lessen any impact on water levels. The calculations also assume that the wells will be pumping continuously for the duration of the project. Their calculation was made using the Theis non-equilibrium relation between drawdown and transmissivity. It is not clear to what extent interference of cones of water-level depression was considered. Interference would increase drawdowns, but may be unlikely.

Table 1. Projected Water-Level Changes W. F. Guyton and Associates, 1987, modified by A. R. Dutton per personal communication with M. L. Klug)

Woodbine

	Water-Level Decline Increment (ft)	Projected Depth to Water (ft)§
Original	--	?
Present (west to east)	--	355 to 600
Projected from 1980 to 2020 without SSC	165	520 to 765
Projected to 2020 with SSC	265	620 to 865

Twin Mountains

	Water-Level Decline Increment (ft)	Projected Depth to Water (ft)§
Original	--	100
Present (west to east)	685	495 to 1,000
Dallas Co. Drawdown Model		
Projected from 1980 to 2020 without SSC	495	990 to 1,495
Projected to 2020 with SSC	550	1,045 to 1,550
Ellis Co. Drawdown Model		
Projected from 1980 to 2020 without SSC	220	715 to 1,220
Projected to 2020 with SSC	275	770 to 1,275

§Add 35 ft of drawdown at pumping well.

References

Guyton, W. F., and Associates, 1967, Letter memorandum on availability of ground water for proposed superconducting super collider facility near Waxahachie, Texas: prepared for the Texas National Research Laboratory Commission, June 1987, 18 p.

Nordstrom, P. L., 1982, Occurrence, availability, and chemical quality of ground water in the Cretaceous aquifers of north-central Texas: Texas Department of Water Resources, Report 269, v. 1 and 2.

Thompson, G. L., 1967, Ground-water resources of Ellis County, Texas: Texas Water Development Board, Report 62, 115 p.

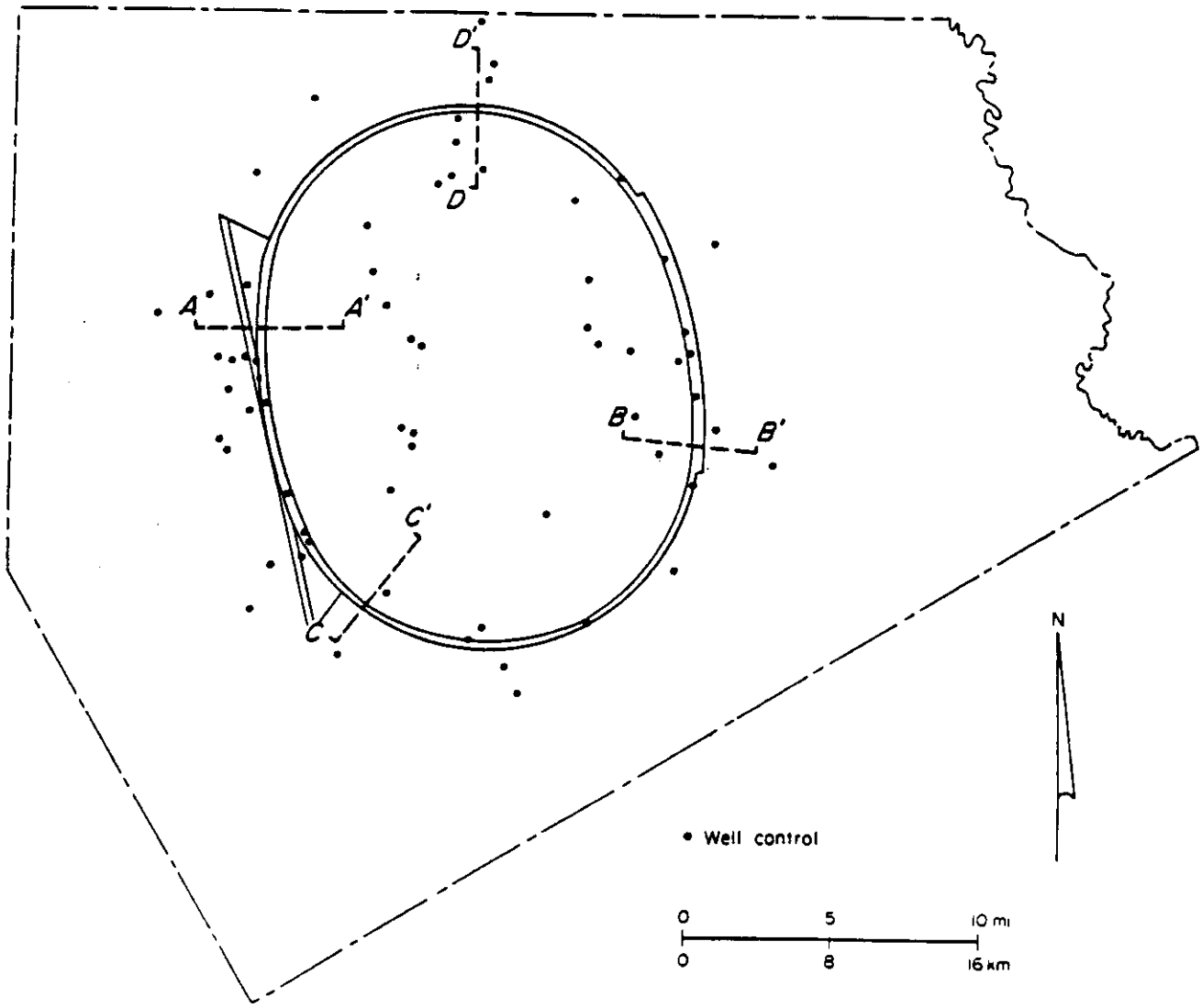

Figure 1. Location of hydrostratigraphic cross sections.

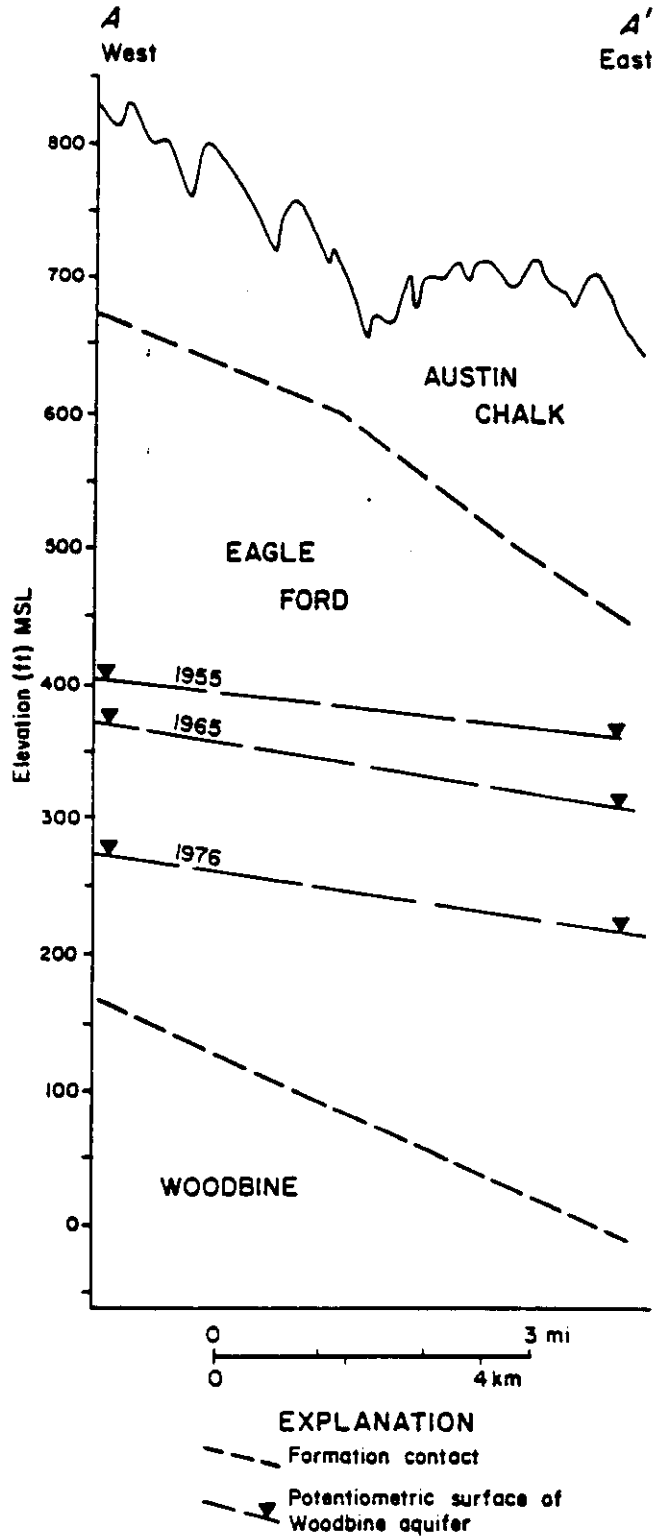

Figure 2. Hydrostratigraphic cross section A-A'.

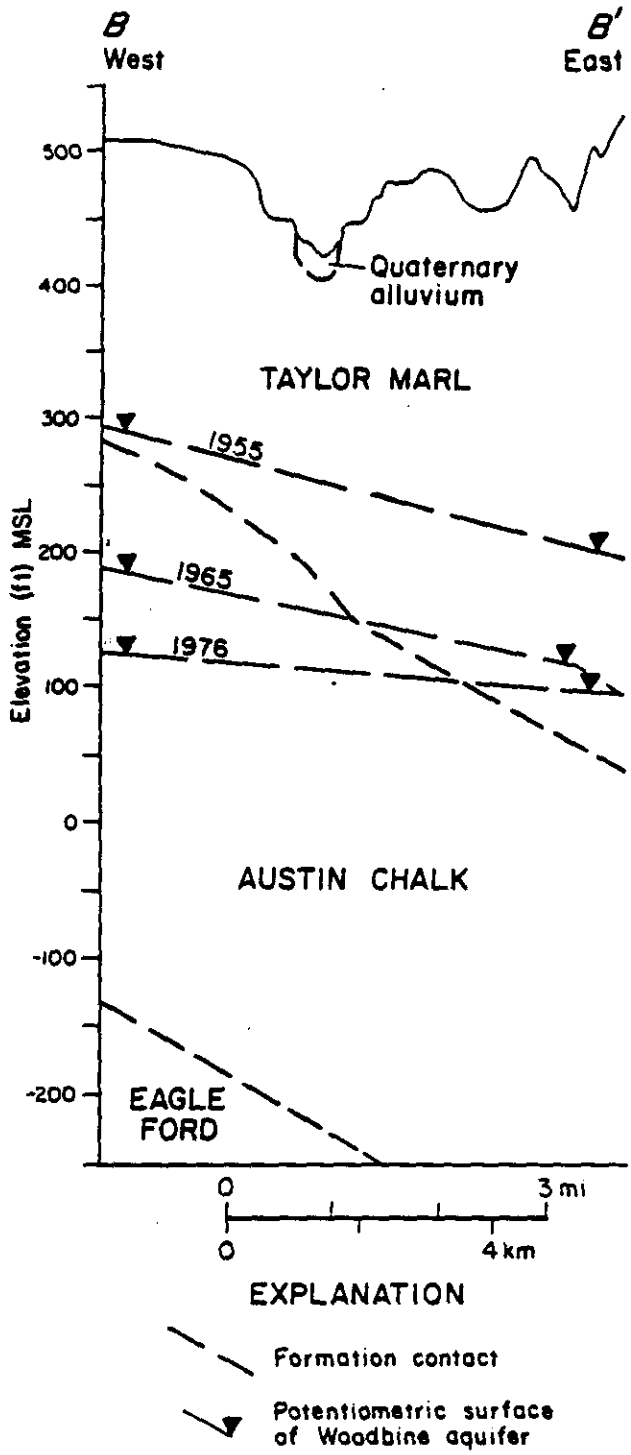

Figure 3. Hydrostratigraphic cross section B-B'

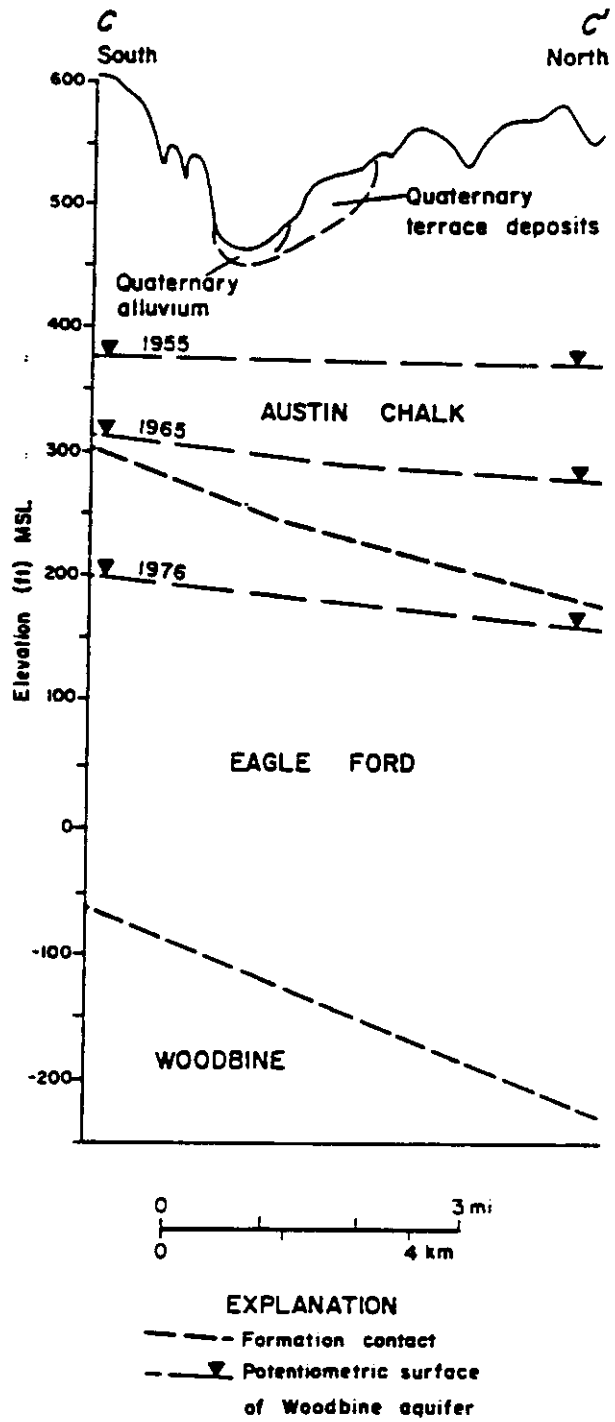

Figure 4. Hydrostratigraphic cross section C-C'

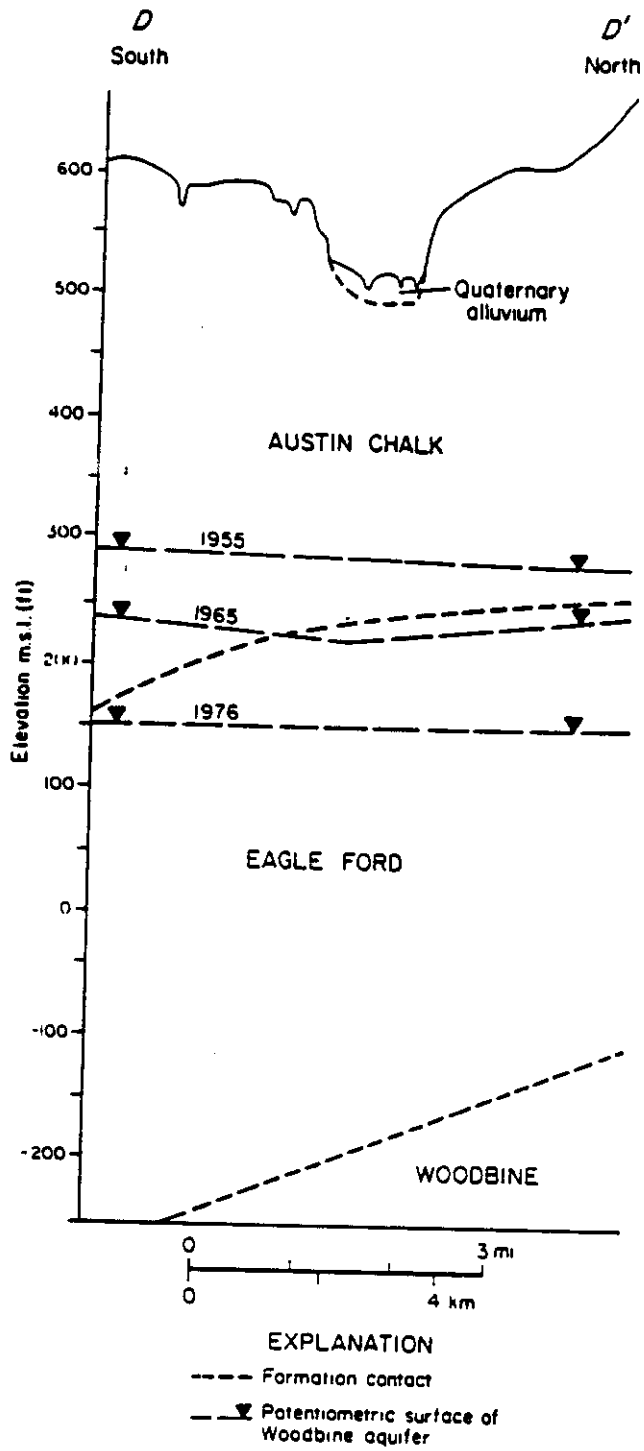

Figure 5. Hydrostratigraphic cross section D-D'

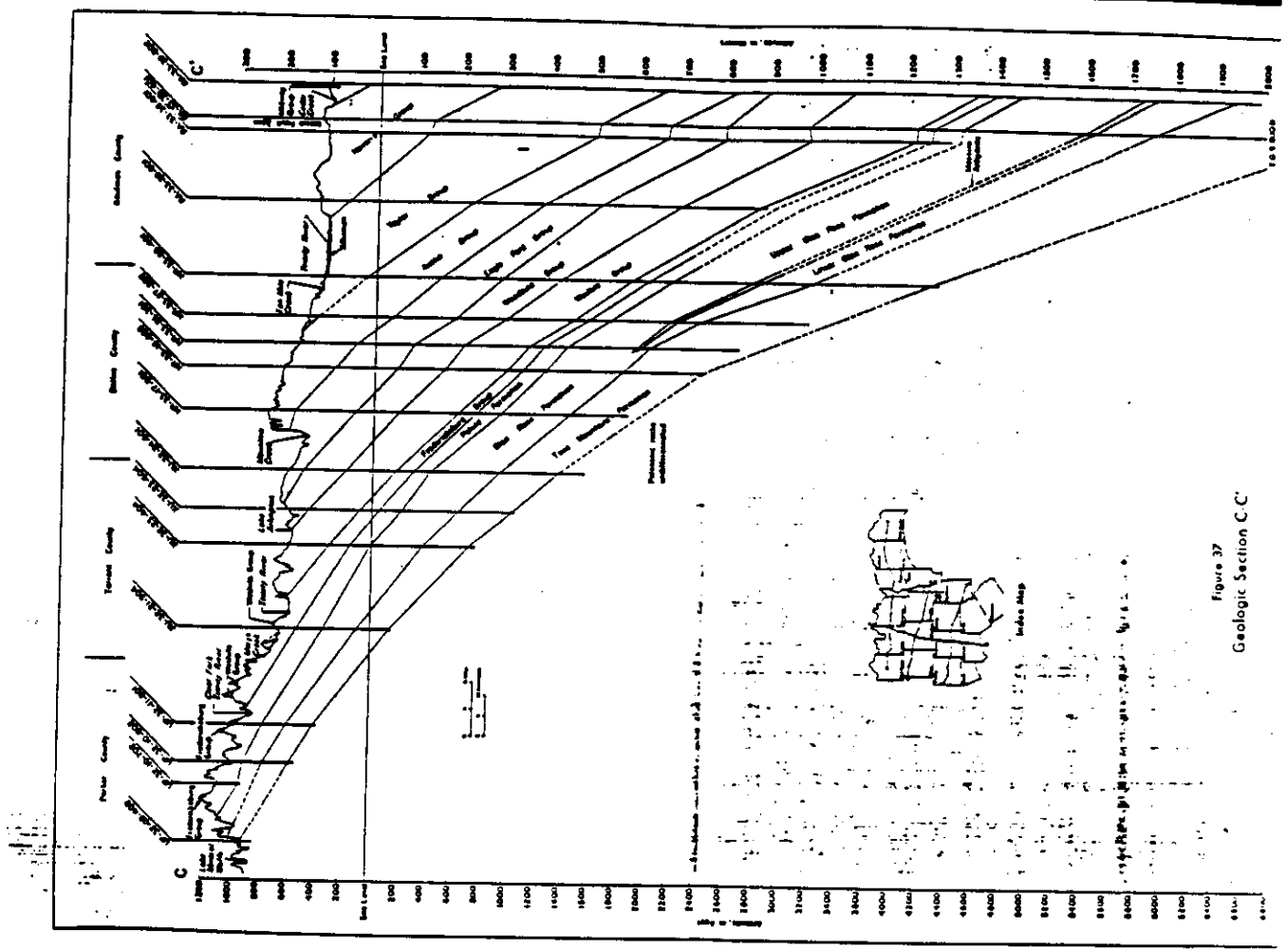

Figure 6. West-east geologic section north of Ellis County (Nordstrom, 1982)

Attachment 1

Potential for Ground-water Inflow in Excavations in Weathered Bedrock and Quaternary Terrace Gravels and Alluvium

In Ellis County, Texas, there are two possible sources of shallow ground water that could affect SSC-related excavations near the ground surface: (1) weathered bedrock of outcropping Austin Chalk, and (2) perched ground water in Quaternary terrace deposits and alluvium. Shallow ground water constitutes a negligible water resource in the area but locally supplies water in limited amounts to domestic and livestock-watering wells.

At depths generally less than 35 ft below land surface in outcrop areas, weathering has significantly increased bedrock porosity and permeability of the Cretaceous Austin Chalk Formation, allowing infiltration into and storage of ground water in otherwise low-permeability rocks. This is the case in some areas of Ellis County. Alluvial deposits up to 50-ft thick occur along major stream and creek channels and consist of material eroded from outcropping strata, particularly along Red Oak Creek to the northeast and Chambers Creek to the southwest. Generally, coarsest material occurs at the base of the alluvium (Thompson, 1967). The alluvium is recharged by infiltration of precipitation. Recharge water stored in the alluvium forms a perched water table above the low-permeability, unsaturated bedrock.

Published reports (Thompson, 1967, and Nordstrom, 1982) and drillers' logs filed at Texas Department of Water Resources Central Records indicate the existence of at least 75 wells and two springs that produce or yield ground water at shallow depths (Table 1). One of those wells produces water from the Eagle Ford Formation in the western part of Ellis County (fig.1). Nineteen wells and two springs produce from the Austin Chalk Formation; 14 of the 19 wells are located in an area west of Red Oak in northern Ellis County. Eighteen wells are completed in the Taylor Marl Formation, all of which occur in the eastern part of the county. Most of the wells that produce water from Quaternary deposits (10 out of 14), are located in eastern Ellis Couty in Trinity River alluvium. Along Red Oak Creek and west of the community of Rockett, five shallow wells produce from a screened interval that includes Quaternary deposits and shallow weathered Austin Chalk strata. The source of water in sixteen shallow wells is undetermined.

Only few estimates of yields of water from shallow wells are available for the area. These estimates range from 5 to 15 gpm (gallons per minute) for the three wells completed in the Austin Chalk in northwestern Ellis County (Table 1, fig. 1) and up to 75 gpm for wells producing from Trinity River alluvium in the east. Reconnaissance studies of ground-water resources in neighboring counties list the following yields from Quaternary alluvium: (a) as much as 30 gpm in Navarro County to the south (Thompson, 1972), (b) from less than 200 gpm to greater than 1,000 gpm in flood-plain alluvium of the Brazos River (Cronin and Wilson, 1967), and (c) as high as 200 gpm from Trinity River alluvium (Peckham and others, 1963).

Quaternary alluvium in the area of the proposed SSC tunnel exists along Chambers Creek, Waxahachie Creek, and Red Oak Creek. There are no water wells that known to produce from shallow depths along Chambers Creek. Test boring E-9, however, encountered water in Quaternary alluvium; measured water levels were 23.0 and 23.4 ft below land surface in June and July, 1987, respectively. Water-table elevations in the well at those tims were 494.6 and 494.2 ft above sea level, which are above the elevations of nearby Chambers Creek and its tributary Mill Branch (Table 1). This elevation difference suggests that ground water in the Quaternary alluvium supplies base flow to Chambers Creek. The same mechanism of ground-water discharge is suggested for Waxahachie Creek, as indicated by water table elevations in wells 33-42-301, 33-42-601, and 33-43-501, and for Red Oak Creek, as indicated by wells 33-34-302 through 33-34-306 (Table 1).

References

Brune, G., 1975, Major and historical springs of Texas: Texas Water Development Board, Report 189, 94 p.

Cronin, J. G., and Wilson, C. A., 1967, Ground water in the flood-plain alluvium of the Brazos River, Whitney Dam to vicinity of Richmond, Texas: Texas Water Development Board, Report 41, 206 p.

Mason-Johnston & Associates, Inc., 1987, Preliminary geotechnical investigation Dallas/Fort Worth Site Superconducting Super Collider Project, Ellis County, Texas: report for Dallas/Fort Worth Superconducting Super Collider Authority, Waxahachie, Texas

Nordstrom, P. L., 1982, Occurrence, availability, and chemical quality of ground water in the Cretaceous aquifers of north-central Texas: Texas Department of Water Resources, Report 269, v. 1 and 2.

Peckham, C. R., Souders, V. L., Dillard, J. W., and Baker, B. B., 1963, Reconnaissance investigation of the ground-water resources of the Trinity River Basin, Texas: Texas Water Commission Bulletin 6309, 110 p.

Southwestern Laboratories, Geotechnical explorations and laboratory testing for Dallas/fort Worth SSC Project, Ellis County, Texas: Contract Report for Dallas/Fort Worth SSC Authority, Waxahachie, Texas, SWL Report No. 87-673.

Texas Natural Resources Information System: computer printout of ground water quality data, 09/01/83.

Thompson, G. L., 1967, Ground-water resources of Ellis County, Texas: Texas Water Development Board, Report 62, 115 p.

Thompson, G. L., 1972, Ground-water resources of Navarro County, Texas: Texas Water Development Board, Report 160, 63 p.

Table 1. Shallow water wells in Ellis County

Well No.	Depth (ft)	Aquifer[1]	Elev (ft)	Depth to Water (ft)	Water table (ft-msl	Date	Remarks	Source[2]
32-40-604	40	Kef(?)	832	6	826	1962		1
32-40-903	Spring	Ka	720	+	-	-		1
33-25-703	15	Ka+Qal?	747	7	740	1972	Yield[3]: 15gpm	4
33-25-704	24	Ka	742	8	734	1972	Yield[3]: 5-10gpm	4
33-25-707	35	Ka	760	26	734	1972	Yield[3]: 5gpm	4
33-26-501	24	Ka	670	19	651	1970		4
33-26-502	20	Ka	670	6	664	1970		4
33-26-503	17	Ka	-	-	-	-		3
33-26-504	22	Ka	-	-	-	-		3
33-26-703	26	Ka	625	14	611	1971		2
33-26-704	50	Qal	682	5	677	1970		2
33-26-803	50	Ka	-	dry	-	1962		4
			-	dry	-	1965		4
			-	21	-	1970		4
33-26-806	15	Ka	612	6	606	1970		4
33-26-807	8	Ka	600	3	597	1970		4
33-26-808	16	Ka	611	5	606	1970		4
33-26-810	15	Ka	575	6	569	1970		4
33-26-811	50	Ka	571	10	561	1970		4
33-26-812	25/50?	Ka	575	21	554	1970	recovers overnight	4
33-26-813	16	Ka	635	4	631	1970		4
33-26-814	15	Ka	622	11	611	1970		4
33-28-704	50	Qal	390	18	372	1973		4
33-28-801	40	Qal	345	19	326	1965	open gravel pit, Trinity R. all.	4
33-28-901	28	-	344	8	336	1971		4
33-29-902	25	-	-	-	-	-		4
33-33-S-1	Spring	Ka	-	+	-	-		5
33-34-201	41	-	-	-	-	-		1
33-34-302	15	Ka-Qal	500	5	495	1975	Red Oak @<480 ft	4
33-34-303	25	Ka-Qal	495	15	480	1975	Red Oak @<470 ft	4
33-34-304	22	Ka-Qal	482	16	466	1975	Red Oak @<470 ft	4
33-34-305	30	Ka-Qal	510	8	502	1975	Red Oak @<460 ft	4
33-34-306	19	Ka	515	13	502	1975	Red Oak @<480 ft	4
33-34-401	50	-	630	-	-	-		1
33-35-F-4	150	Qal	497	5	492	1987		6
			497	6	491	1987		6

Table 1 (continued) Shallow water wells in Ellis County

Well No.	Depth (ft)	Aquifer[1]	Elev (ft)	Depth to Water (ft)	Water table msl (ft)	Date	Remarks	Source[2]
33-35-201	30	Kt	-	9	-	1971		4
33-35-502	24	-	458	-	-	-	too small supply	1
33-35-801	18	-	460	-	-	-	went dry 1957	1
33-35-902	140	Kt	538	80	458	1963		1
33-36-202	35	-	346	9	337	1971		4
33-36-301	31	-	340	13	327	1971		4
33-36-302	23	-	-	17	-	1971		4
33-36-401	50	Kt	490	15	475	1965		1
33-36-501	300	Ktw	427	8	419	1964	salty	1
33-36-601	30	Qal	332	15	317	1963	Trinity R. all.	1
33-36-602	57	-	330	12	318	1971		4
33-36-603	33	-	328	18	310	1972		4
33-36-604	25	-	326	10	316	1972		4
33-36-606	27	-	327	15	312	1971		4
33-36-801	168	Ktw	442	-	-	-	salty	1
33-37-401	28	Qal	332	15	317	-	Trinity R. all.	1
33-37-801	30	Qal	323	12	311	1965	Trinity R. all.	1
33-37-802	30	Qal	323	12	311	1965	Trinity R. all.	1
33-37-803	30	Qal	323	12	311	1965	Trinity R. all.	1
33-37-804	26	Qal	323	10	313	1965	Trinity R. all.	1
33-37-805	30	Qal	323	12	311	1965	Trinity R. all.	1
33-37-806	30	Qal	323	12	311	1965	Trinity R. all.	1
33-42-301	30	-	492	18	474	1964	Wax. Cr.@<470 ft	1
33-42-601	25	Qal	485	17	468	1965	Wax. Cr.@<450 ft	1
33-42-704	36	Ka	621	9	612	1963		1
33-42-706	35	Ka	557	-	-	-	dry	1
33-43-302	230	Ktw	521	38	483	1965	screen: 70-75 ft	1
33-43-501	32	Qal	473	29	444	1965	Wax. Cr.@<430 ft	1
33-44-202	12	Kt	398	3	395	1964	will pump dry but will fill up overnight	1
33-44-303	35	Kt	388	-	-	-	too small supply	1
33-44-403	165	Ktw	488	15	473	1960		1
				23	465	1965		1
33-44-501	50	Kt	460	41	419	1963		1
33-44-701	125	Kt	472	20	452	1955	Perf. @ 50,60.80	1
33-44-702	121	Kt	440	18	422	1964	Perf. @ 60	1
				28	412	1965	slow recovery	1
33-44-802	45	Kt	472	15	457	1955		1
				19	453	1965		1

Table 1 (continued) Shallow water wells in Ellis County

Well No.	Depth (ft)	Aquifer[1]	Elev (ft)	Depth to Water (ft)	Water table msl (ft)	Date	Remarks	Source[2]
33-44-901	40	Kt	438	8	430	1963		1
33-45-201	23	-	335	18	317	1965	old gravel pit	1
33-45-404	52	-	322	26	296	1971		4
33-49-802	-	Ka	-	-	-	-		3
33-50-E-9	241	Qal	518	23	495	1987	Chamb. Cr.@<450	7
33-51-203	28	Kt	463	13	450	1965		1
33-51-302	36	Kt	430	24	406	1965		1
33-51-501	38	Kt	455	24	431	1965		1
33-52-103	18	Kt	398	10	388	1965		1

EXPLANATION

[1] Aquifer

Qal	Quaternary alluvium
Kt	Taylor Marl
Ktw	Wolf City Sand Member of Taylor Marl
Ka	Austin Chalk
Kef	Eagle Ford
Ka-Qal	Austin Chalk/Quaternary alluvium

[2] Source:

1 Thompson, 1967
2 Nordstrom, 1982
3 Texas Natural Resources Information System, 1983
4 Central Records, Texas Water Development Board, 1988
5 Brune, 1975
6 Mason-Johnston & Associates, Inc., 1987
7 Southwestern Laboratories, 1987

[3] estimated yield

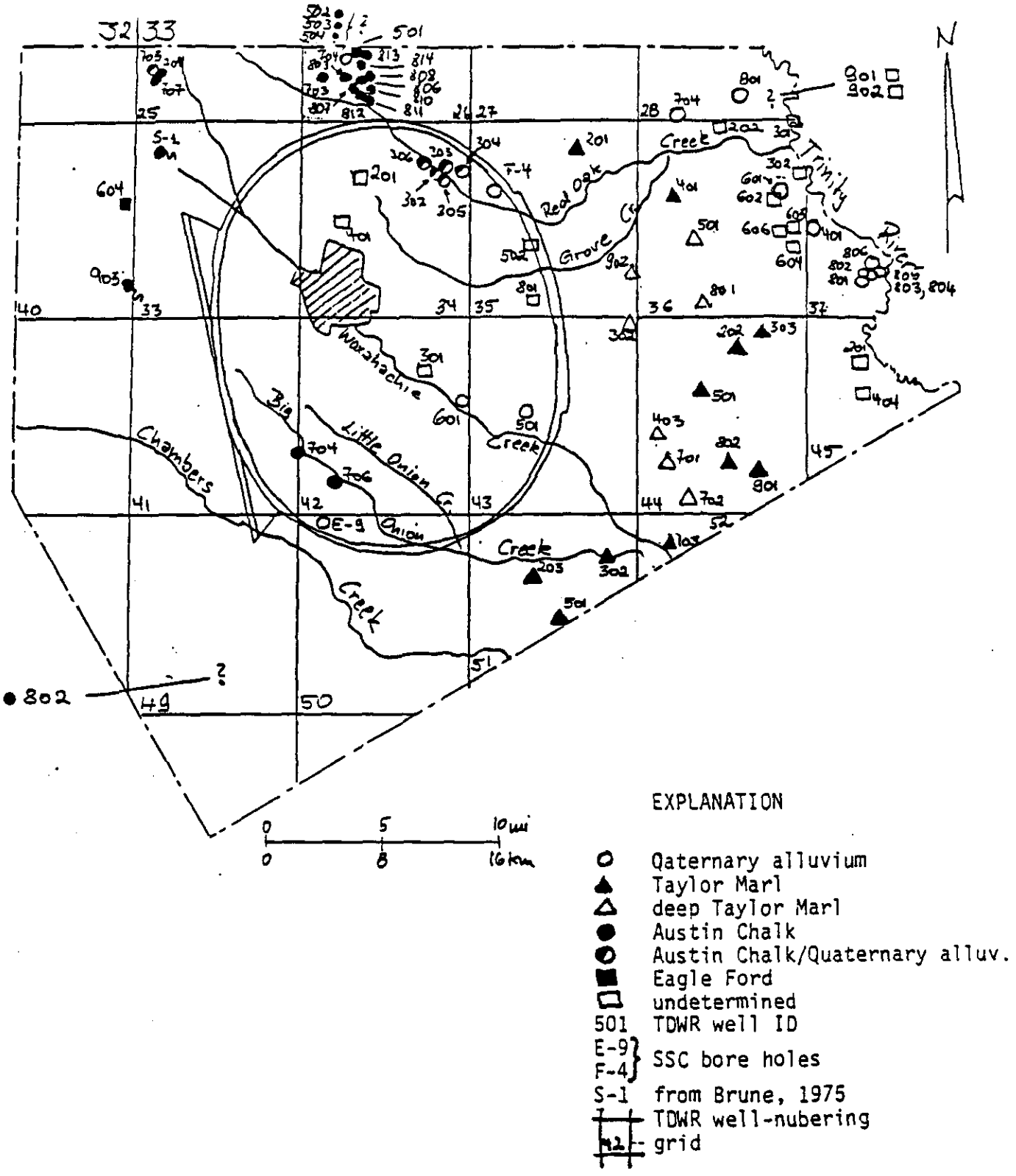

Figure 1 Location map of shallow water wells, Ellis County.

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