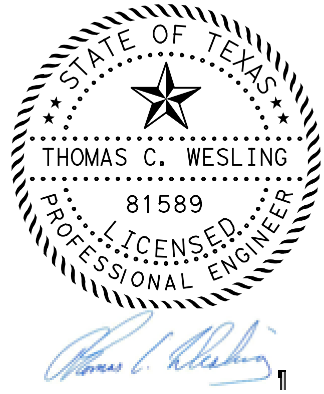
APPENDICES C

PRELIMINARY GEOTECHNICAL BRIDGE FOUNDATION RECOMMENDATIONS MEMO

Memo



Date:	Wednesday, January 16, 2019
Project:	Pleasant Valley Road Multi-Use Pedestrian Bridge Over Colorado River near Longhorn Dam Austin, Texas
Proj. No.	10124016
To:	Project Team
From:	Thomas C. Wesling, P.E.

Subject:	Conceptual/Preliminary Geotechnical Bridge Foundation Recommendations

Introduction

The City of Austin, Texas (COA) has retained HDR Engineering, Inc. (HDR) to evaluate the feasibility of constructing a new multi-use pedestrian bridge over the Colorado River near the Longhorn Dam. Three slightly different bridge alignments are being considered, each option will include crossing about 500 linear feet of open water. This memorandum includes a summary of available geotechnical information and conceptual/preliminary geotechnical bridge foundation design and construction recommendations.

Geology

Based on a review of the Geologic Map of the Austin Area[1] the project site is underlain by alluvium and Lower Colorado River terrace deposits, which in turn are underlain by clay, clay shale, and shale of the Taylor Group. A portion of the referenced Geologic Map showing the geology around the Longhorn Dam is included as Exhibit 1. Alluvial soils and Lower Colorado River terrace deposits both consist of various proportions of unconsolidated gravel, sand, silt and clay. The Taylor Group generally consists of dark gray shale that weathers to a greenish gray and brown, calcareous, montmorillonitic clay and marly clay in the Austin Area, which is generally referred to as the Taylor Clay.

Limestone of the Austin Group is mapped just west of the Longhorn Dam and underlies the Taylor Group. The Austin Group consist of light gray chalk, limestone, marly limestone and marl that is generally referred to as the Austin Chalk. The transition between the Taylor Clay and Austin Chalk is gradual and not a distinct well-defined boundary.

The terms shale and clay shale are often used to describe the unweathered portion of the Taylor Clay. Shale is a fine-grained detrital sedimentary rock, formed by the compaction of clay and silt, which has a finely laminated structure.[2] Clay shale is shale that is composed primarily of argillaceous (substances composed of clay minerals) material.[3] Classifying the two terms based on strength, shale has a compressive strength greater than 36 ksf and clay shale has a strength less than 36 ksf.[4]

Available Subsurface Information

The contract drawings for the City of Austin Low Water Dam (Longhorn Dam) were prepared by Brown and Root, Inc. in 1959. According to the Site Map sheet, and Profile and Core Borings sheet included herein as Exhibits 2 and 3, respectively, 17 borings were drilled for the Longhorn Dam project. The Site Map includes locations of the 17 borings drilled and the Profile and Core Borings sheet includes graphical stratigraphy logs.

Based on the borings drilled (from north to south 1, 16, 18, 17, 20, 19, 13, 12, 14, 15, 11, and 3) between Stations 0 and 11+00 alluvial soils (clay, silt, sand and gravel) overlie shale. The alluvial soils had been eroded away at the boring 16 through 20 locations. The top of the shale slopes down from north to south; on the north side of the river (boring 1) the top of the shale was encountered at about El 418 feet and on the south side of the river (boring 3) the top of the shale was encountered at about El 397 feet. Over the past 60 years the shale has weathered further and likely eroded to some degree.

The graphical stratigraphy logs included in the contract drawings for the Longhorn Dam do not include any engineering properties for the shale, such as: core recovery, Rock Quality Designation (RQD), compressive strength, and/or Texas Cone Penetration (TCP) values. The upper portion of the shale may be a clay shale (lower strength and more argillaceous than shale), while at some depth the shale may transition into a stronger material more like limestone.

Supplemental Subsurface Information

To supplement the available subsurface information for the proposed pedestrian bridge, the author of this memorandum reviewed four past projects within the vicinity of the subject project and summarized general subsurface conditions encountered at those four projects herein. The information provided herein is for general information only and not for final design of the bridge foundations. Prior to final design, geotechnical borings and supplemental laboratory testing will be required along the alignment selected for the pedestrian bridge. The approximate location of the four past projects reviewed are included on Exhibit 1.

<u>Project 1 (confidential project).</u> Three 35- to 40-ft deep borings were reviewed from this project. The following information is summarized in Table 1: elevation of the top of the dark gray clay shale, percent recovery, RQD, water contents, unit dry weights, and compressive strengths. The surficial soils encountered consisted of very loose to medium dense clayey sand fill, very loose clayey sand and hard fat clay to depths between 19 and 22 feet.

Table 1. Summary of Geotechnical Soil Properties for the Dark Gray Clay Shale

	Top El Clay Shale (feet)	Core Recovery (%)	RQD (%)	Water Content (%)	Unit Dry Weight (pcf)	Compressive Strength (tsf)
number	3 bores	10 5-ft runs	10 5-ft runs	9 tests	9 tests	9 tests
range	502 - 521	64 - 100	16 - 100	15 - 19	108 - 120	3.9 - 17.7
average	509	95	85	16	114	12.7

Project 2 (US 183 from Patton Avenue to Boggy Creek). Twenty-nine 40- to 90-ft deep bridge borings were reviewed from this project. Six of the 29 borings encountered dark gray shale and 25 of the 29 borings encountered gray shaly limestone. The following information is summarized in Table 2a for shale and Table 2b for shaly limestone: elevation of the top of the dark gray clay shale or gray shaly limestone, percent recovery, RQD, water contents, unit dry weights, compressive strengths, and TCP values. The surficial soils encountered consisted of clay, silt, sand, and gravel, but primarily soft clay and loose sand to depths between 22 and 72 feet (average 42 feet).

Table 2a. Summary of Geotechnical Soil Properties for the Dark Gray Shale

	Top El Shale (feet)	Core Recovery (%)	RQD (%)	Water Content (%)	Unit Dry Weight (pcf)	Compressive Strength (tsf)	TCP Values (" / 100 blows)
number	6 bores	23 5-ft runs	23 5-ft runs	14 tests	14 tests	14 tests	27 tests
range	397 – 417	40 - 100	15 - 100	11 - 19	110 - 127	5 - 87	1 - 15
average	411	95	70	16	117	15.9	3

Table 2b. Summary of Geotechnical Soil Properties for the Gray Shaly Limestone

	Top El Shale (feet)	Core Recovery (%)	RQD (%)	Water Content (%)	Unit Dry Weight (pcf)	Compressive Strength (tsf)	TCP Values (" / 100 blows)
number	25 bores	74 5-ft runs	74 5-ft runs	47 tests	47 tests	47 tests	100 tests
range	383 - 417	67 - 100	38 - 100	7 - 13	102 - 136	10 - 119	0 - 5
average	396	95	81	11	127	55	1

Project 3 (COA 2018 Corridor Program – East Riverside Drive Project). Two 80-ft deep bridge borings were reviewed from this project that were drilled near the intersection of East Riverside Drive and South Pleasant Valley Road. The following information is summarized in Table 3: elevation of the top of the gray limestone, percent recovery, RQD, water contents, unit dry weights, compressive strengths, and TCP values. The surficial soils encountered consisted of soft to hard lean and fat clays to a depth of 43 feet.

Table 3. Summary of Geotechnical Soil Properties for the Gray Limestone

	Top El Limestone (feet)	Core Recovery (%)	RQD (%)	Water Content (%)	Unit Dry Weight (pcf)	Compressive Strength (tsf)	TCP Values (" / 100 blows)
number	2 bores	14 5-ft runs	14 5-ft runs	4 tests	4 tests	4 tests	16 tests
range	434 – 435	32 - 100	23 - 100	10 - 13	125 - 131	74 - 114	0.5 - 3
average	435	78	72	12	128	99	1

Project 4 (confidential project). Four 60- to 85-ft deep borings were reviewed from this project. The following information is summarized in Table 4: elevation of the top of the dark gray clay shale, percent recovery, RQD, water contents, unit dry weights, and compressive strengths. The surficial soils encountered consisted of very stiff to hard fat clay to depths between 46 and 66 feet.

Table 4. Summary of Geotechnical Soil Properties for the Dark Gray Clay Shale

	Top El Clay Shale (feet)	Core Recovery (%)	RQD (%)	Water Content (%)	Unit Dry Weight (pcf)	Compressive Strength (tsf)
number	4 bores	14 5-ft runs	14 5-ft runs	11 tests	11 tests	11 tests
range	516 - 533	98 - 100	52 - 100	15 - 23	106 - 130	8.5 - 33.5
average	522	100	90	20	116	15.3

Evaluation of Foundation Types

The design loads, superstructure geometric requirements, subsurface conditions and any special considerations should be evaluated when selecting the foundation type for a superstructure. It is generally preferred that an entire structure be founded on similar foundation system; i.e. it is not common practice to found abutments on spread footings then found bents on drilled shafts or driven piles. The bent foundations will be constructed at the bottom of the Colorado River, under water, therefore spread footings are not considered an option to support this structure. Further, the 2018 TxDOT Geotechnical Manual indicates foundations for new bridges should be either drilled shafts or driven piles.

Drilled shafts can be installed in soft soils and/or hard rock. Hard material (TCP values of 100 blows for 12 inches of penetration or less) at or near the surface makes driven pile installation difficult. The subsurface conditions likely consisting of clay shale, shale and/or shaly limestone would lead to drilled shafts as the preferred foundation type for this project.

Methods of Analyses

Preliminary drilled shaft capacities were calculated using two different methods which are described herein. However, it is likely that the COA will follow TxDOT requirements for preliminary drilled shaft design.

TxDOT Preliminary drilled shaft axial design parameters for the proposed bridge structure were evaluated in accordance with TxDOT 2018 Geotechnical Manual[5]. The TxDOT procedure for developing allowable point (end) bearing and skin friction capacities for drilled shafts is based on an empirical database of TCP blow counts. Allowable capacity charts for skin friction and point bearing are presented in the TxDOT Geotechnical Manual for two materials; one with less than 100 blows for 12 inches of penetration (soils) and another with more than 100 blows for less than 12 inches of penetration (bedrock). Alternatively, the computer software program WinCore Version 3.1 can be used in conjunction with the boring logs (TCP data) to develop drilled shaft capacity curves.

FHWA Preliminary drilled shaft axial design parameters for the proposed bridge structure were also evaluated in accordance with FHWA Design Procedures[6]. The FHWA procedure for developing allowable end bearing and skin friction capacities for drilled shafts is based the compressive strength and rock quality of the clay shale, shale and/or limestone. If the compressive strength is between 2.5 and 25 tsf the material is considered an Intermediate Geomaterial (IGM). If the compressive strength is greater than 25 tsf the material is considered a rock. The formulas for calculating skin friction are different for IGM and Rock, however the same formula is used to calculate end bearing in IGM and Rock using the referenced FHWA design procedures.

Preliminary Axial Design Analyses

Based upon available subsurface information the alluvial soils are likely loose or soft, therefore the surficial soils should be neglected for preliminary design. Preliminary ranges (likely upper and lower boundaries) of allowable skin friction and allowable end bearing are provided below using both the TxDOT and FHWA design procedures.

TxDOT. Based on the subsurface information discussed herein, the average TCP value in the dark gray clay shale is 3 inches of penetration for 100 blows. Limestone and/or shaly limestone generally has TCP values of 2 inches or less of penetration for 100 blows.

- The allowable skin friction lower boundary would be on the order of 1.5 tsf (4 inches of penetration for 100 blows) and the upper boundary would be on the order of 3 tsf (2 inches or less of penetration for 100 blows).
- The allowable point (end) bearing lower boundary would be on the order of 15 tsf (4 inches of penetration for 100 blows) and the upper boundary would be on the order of 30 tsf (2 inches or less of penetration for 100 blows).

FHWA. Based on the subsurface information discussed herein, the average compressive strength for clay shale is on the order of 15 tsf, and the average compressive strength for the limestone or shaly limestone is on the order of 50 tsf.

- The allowable skin friction lower boundary would be on the order of 1 tsf for clay shale and the upper boundary would be on the order of 2 tsf for shaly limestone and limestone.
- The allowable end bearing lower boundary would be on the order of 20 tsf for clay shale and the upper boundary would be on the order of 40 tsf for shaly limestone and limestone.

Preliminary Axial Design Recommendations

For this conceptual phase of the project the following recommendations are provided for preliminary design. Axial design capacities will have to be confirmed by supplemental borings at actual abutment and bent locations, and additional laboratory testing.

- use a minimum disregard depth of 10 feet, this value may have to be increased after a scour analysis is performed;
- disregard all embankment fills and any other fill material;
- disregard all alluvial soils;
- for preliminary design the top of the clay shale, shale or shaly limestone may be estimated from the profile included as Exhibit 3;
- use an allowable skin friction of 1.5 tsf and an allowable end bearing of 15 tsf in the depth range of 0 to 10 ft below the disregard depth within clay shale and shale;
- use an allowable skin friction of 3 tsf and an allowable end bearing of 30 tsf at depths greater than 10 ft below the disregard depth within shale and/or shaly limestone;
- drilled shafts should have a length of at least 20 feet;
- drilled shafts should have a minimum diameter of 3 feet; and
- drilled shaft loads not exceed the maximum allowable drilled shaft service load set forth in Table 5-1 of the 2018 TxDOT Geotechnical Manual.

Lateral Design Parameters

The lateral capacity of the drilled shafts will also have to be evaluated: deflections, moments, and shear forces due to lateral loads and moments. However, specific subsurface information at the abutment and bent locations will be required to estimate the lateral soil/rock design parameters. Ultimately the structural engineer will select the required length, diameter, and percent of steel for drilled shafts with regard to lateral and axial loads.

Construction Recommendations

Drilled shafts should be constructed in general accordance with TxDOT Standard Specifications[7], Item 416. Drilled shaft operations should be inspected, on a full-time basis, to (a) verify plan depth and/or penetration into the bearing stratum, (b) verify shaft dimensions and proper reinforcement, (c) monitor cleanness and amount of water in shaft excavations, (d) monitor slurry, if used, (e) monitor placement of concrete and use of tremie or pumps, (f) monitor the extraction of casing, if used, and (e) maintain accurate records.

It is recommended that the drilled shaft inspection plan include Thermal Integrity Profiling (TIP) on a percentage of the drilled shafts. There are experienced drilled shaft contractors in Central Texas, however drilling over water always complicates the process. Therefore supplemental testing to confirm the quality of the drilled shafts is warranted.

It is also recommended that the Geotechnical Engineer of Record (GEOR) or their qualified representative be present onsite during construction. Based on onsite observations, the GEOR may aid in recognizing and reconciling unanticipated soil/rock or groundwater conditions, and the GEOR will endeavor to verify that design recommendations are appropriate and properly implemented during construction. Quality control testing should also be performed during construction.

Recommendations for Final Geotechnical Study

The final geotechnical study for the proposed Pleasant Valley Road Multi-Use Pedestrian Bridge over Colorado River near Longhorn Dam should include supplemental borings and additional laboratory testing. It is suggested that a boring be drilled at each abutment (land borings) and at least two new water borings be drilled. Ideally, a boring would be drilled at each abutment and bent location.

Limitations

The conceptual/preliminary geotechnical engineering recommendations presented herein are based on the geotechnical engineer's experience and professional opinion. These services were performed with the degree of skill and care normally utilized by other members of the geotechnical engineering profession practicing in this location and at this time. There is no warranty, either express or implied. The results, conclusions, and recommendations contained herein are directed at, and intended to be utilized within our contracted scope of work. This memorandum is not intended to be used for any other purposes.

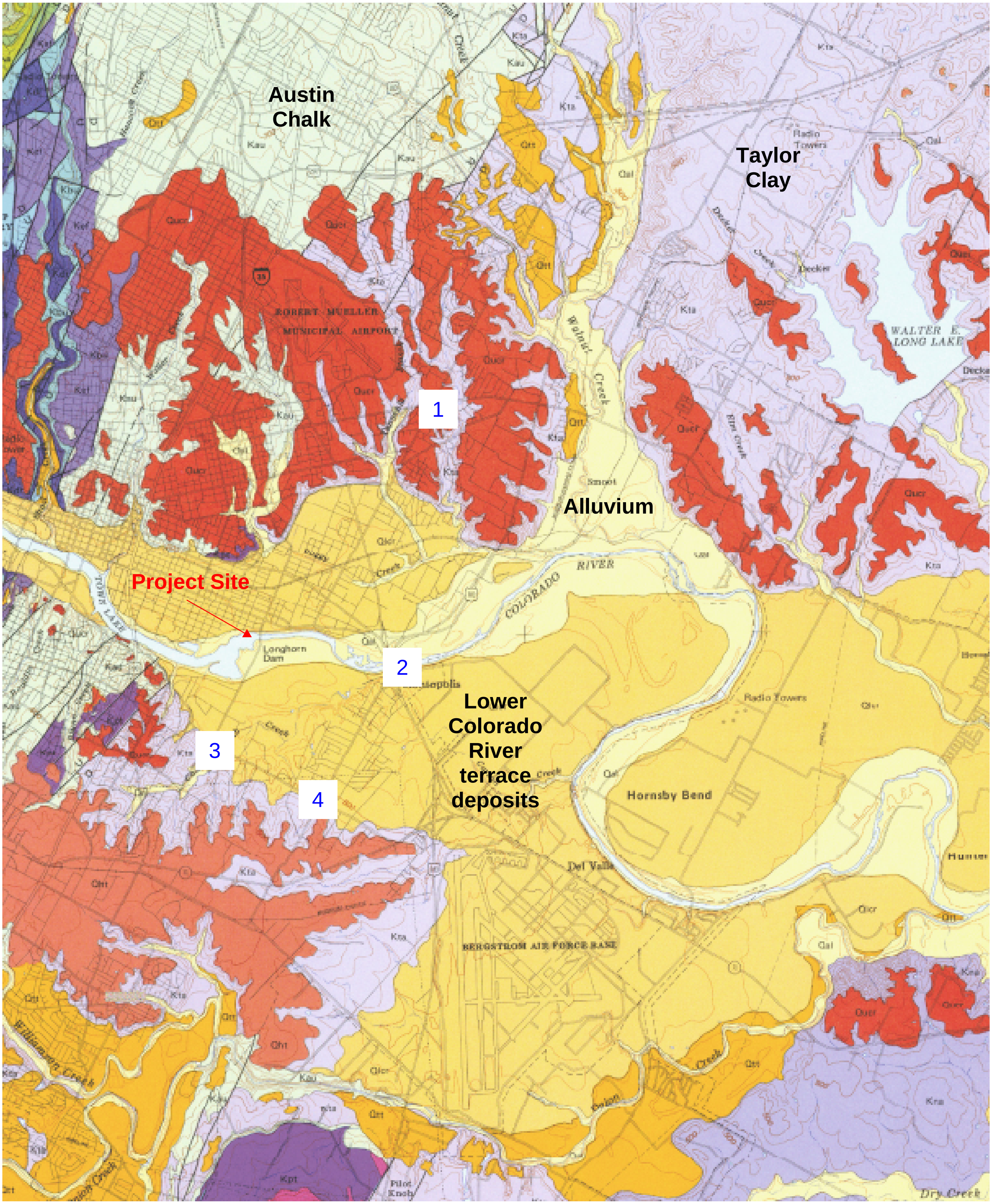
The conceptual/preliminary analyses, conclusions, and recommendations in this memorandum are based on generalized subsurface conditions. The memorandum does not reflect variations in subsurface conditions that may exist at the site. Variations in soil/rock conditions should be expected between the borings, the nature and extent of which may not become evident until construction is undertaken. Subsurface conditions can change over time due to both natural and manmade forces, including changes in condition and/or use of adjacent properties.

Attachments

- Exhibit 1 – Geologic Map and Past Project Locations
- Exhibit 2 – Site Map with Boring Locations
- Exhibit 3 – Generalized Subsurface Profile

References

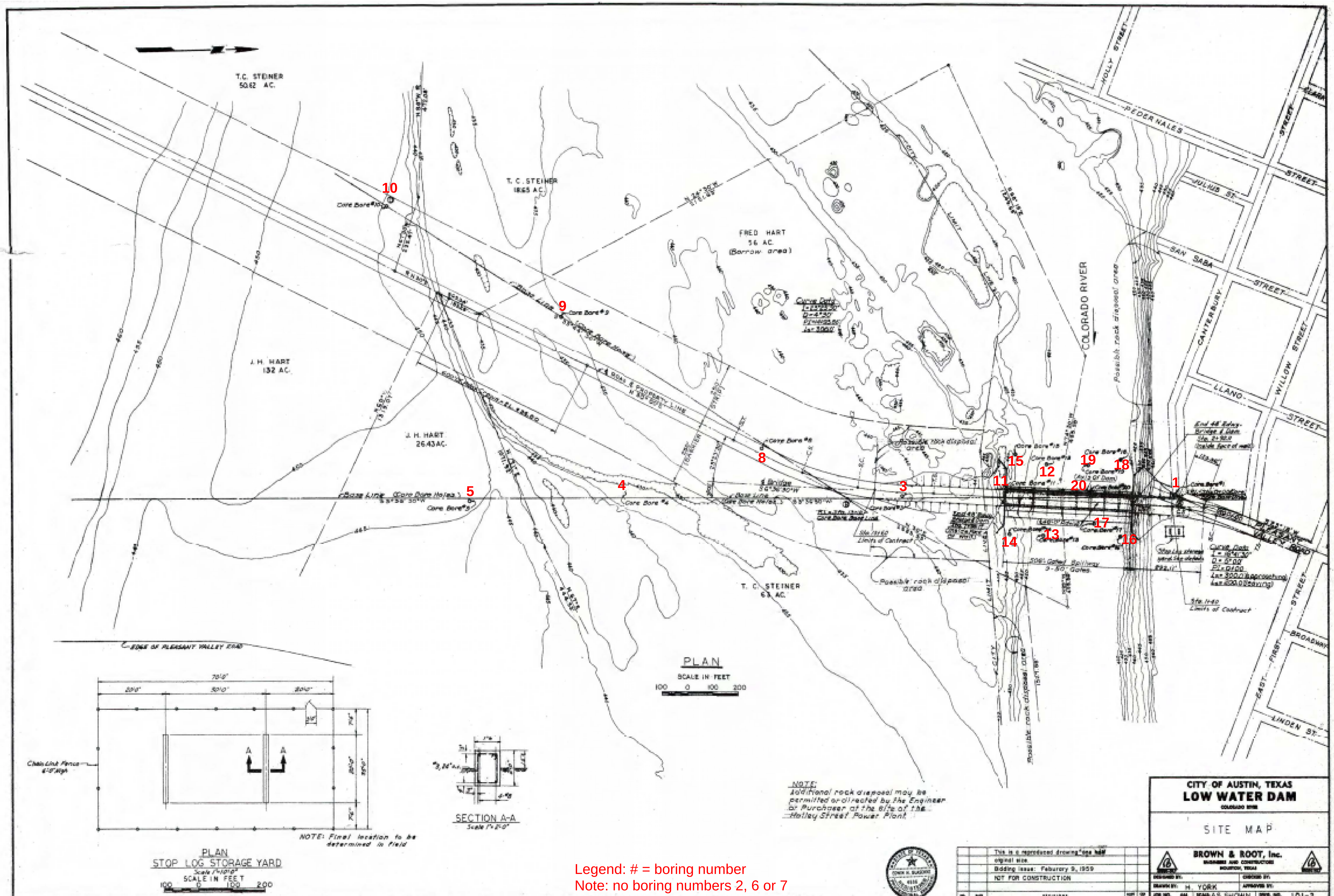
1. Geologic Map of the Austin Area, Texas (reprinted 1992) prepared by the Bureau of Economic Geology at The University of Texas at Austin
2. Bates, R.L. and Jackson, J.A., Dictionary of Geologic Terms, 3rd Edition, prepared by The American Geological Institute, 1984.
3. Ibid.
4. Morgenstern, N.R. and Eigenbrod, K.D., Classification of Argillaceous Soils and Rocks, Journal of the Geotechnical Engineering Division, Proceeding of the American Society of Civil Engineers, 1974.
5. Texas Department of Transportation (TxDOT), *Geotechnical Manual*, March 2018.
6. US Department of Transportation, Federal Highway Administration (FHWA), Drilled Shafts: Construction Procedures and Design Methods, by M.W. O'Neill and L.C. Reese, Publication No. FHWA-IF-99-025.
7. Texas Department of Transportation (TxDOT), Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges, November 2014



Geologic Map and Past Projects

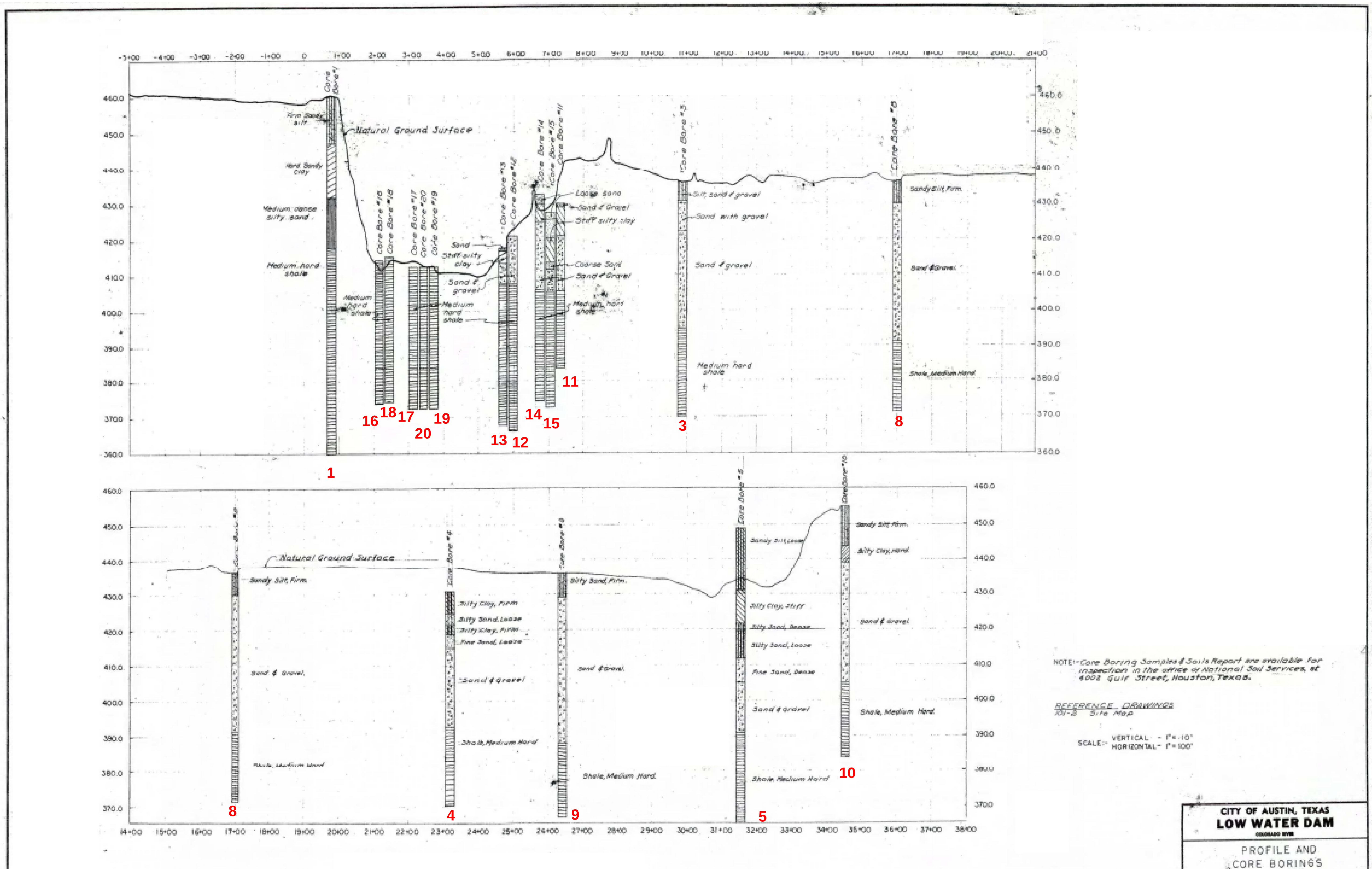
Exhibit 1

Geologic Map from the Bureau of Economic Geology, The University of Texas at Austin.



T.C. STEINER 50.62 AC.
T. C. STEINER 18.65 AC.
FRED HART 56 AC. (Borrow area)
J. H. HART 132 AC.
J. H. HART 26.43 AC.
T. C. STEINER 63 AC.
COLORADO RIVER
Possible rock disposal area
PEDERNALES
JULIUS ST.
SAN SABA STREET
LLANO STREET
CANTERBURY
WILLOW STREET
HOLLY STREET
BROADWAY
EAST FIRST STREET
LINDEN ST.
EDGE OF PLEASANT VALLEY ROAD
Base Line (Core Bore Holes)
Core Bore #1
Core Bore #3
Core Bore #4
Core Bore #5
Core Bore #8
Core Bore #9
Core Bore #10
Core Bore #11
Core Bore #13
Core Bore #15
Core Bore #16
Core Bore #17
Core Bore #18
Core Bore #19
10
9
8
5
4
3
1
11
12
13
14
15
16
17
18
19
20
PLAN
SCALE IN FEET
100 0 100 200
Chain Link Fence 6'-0" High
PLAN
STOP LOG STORAGE YARD
Scale 1"=10'0"
SCALE IN FEET
100 0 100 200
NOTE: Final location to be determined in field
SECTION A-A
Scale 1"=2'-0"
NOTE: Additional rock disposal may be permitted or directed by the Engineer or Purchaser at the site of the Holly Street Power Plant.
CITY OF AUSTIN, TEXAS
LOW WATER DAM
COLORADO RIVER
SITE MAP
BROWN & ROOT, Inc.
ENGINEERS AND CONSTRUCTORS
HOUSTON, TEXAS
This is a reproduced drawing
Bidding Issue: Feburary 9, 1959
NOT FOR CONSTRUCTION
H. YORK
AS SHOWN
101-2
Legend: # = boring number
Note: no boring numbers 2, 6 or 7

Exhibit 2



Legend: # = boring number
Note: no boring numbers 2, 6 or 7

Exhibit 3