GEOTECHNICAL INVESTIGATION REPORT

Camelback Ranch Levee Design
Agua Fria River & New River
113th Avenue & Camelback Road
Maricopa County, Arizona

SHB Job No. E88-36

Consulting Geotechnical Engineers
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APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING • HYDROLOGY

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March 31, 1988

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SHB Job No. E88-36

Attention: Ashok C. Patel, P.E., R.L.S.

Re: Camelback Ranch Levee Design
Agua Fria River & New River
113th Avenue & Camelback Road
Maricopa County, Arizona

Gentlemen:

Our Geotechnical Investigation Report on the referenced project is herewith submitted. The report includes results of test drilling and laboratory analysis, and recommended criteria for levee design and related earthwork.

Should any questions arise, please do not hesitate to contact us.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By _____
CHENG Suang

And _____
Norman H. Wetz, P.E.

Reviewed by _____
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TABLE OF CONTENTS

SHB Job No. E88-36

1. INTRODUCTION

This report is submitted pursuant to a geotechnical investigation made by this firm of the site of the proposed levee alignment for the Camelback Ranch to be located south of New River and east of the Agua Fria River in Maricopa County, Arizona. The object of this investigation was to evaluate the physical properties of the subsoils underlying the site to provide recommendations for the design of the levees and related earthwork.

2. PROPOSED CONSTRUCTION

Preliminary details of the project were provided by Ashok C. Patel, P.E., R.L.S. and David W. Dust, P.E. of Coe and Van Loo Consulting Engineers, Inc.

It is understood that about 13,000 linear feet of earthen levees are planned for the site. These dikes will provide flood protection from both the New River and the Agua Fria River. The existing channel of the New River will be widened to accept flood waters. The levees will be about 8 to 10 feet in height. It is proposed that the river side of the embankment be protected with soil-cement. The soil-cement treatment will extend about 6 to 8 feet below grade. It is further understood that 4:1 (horizontal to vertical) slopes are planned for the land side of the levees and about 1:1 slopes for the river side.

A levee freeboard of 5 feet is anticipated for the 100-year flood. The 100-year flood will result in flows of about 95,000 cubic feet per second (cfs) in the Agua Fria River and 39,000 cfs in the New River. Stream flow velocities are estimated to be about 5 1/2 to 8 1/2 feet per second (fps) in the Agua Fria River and 6 to 7 1/2 fps in the New River. It is further understood that the duration of the 100-year flood in the New River will be less than six hours.

Should details involved in final design vary significantly from those outlined above, this firm should be notified for review and possible revision of recommendations.

3. INVESTIGATION

3.1 Subsurface Exploration

Twenty-two exploratory borings were drilled to depths of 11 to 26 feet below existing grade. All borings were drilled with our CME-55 drill rig advancing 6 5/8-inch O.D. hollow stem auger. Standard penetration testing and open-end drive sampling were performed at selected intervals in the borings.

The results of the field investigation are presented in Appendix A, which includes a brief description of drilling and sampling equipment and procedures, a site plan

showing the boring locations and logs of the test borings. The field investigation was supervised by Roman Y. Jauregui, staff engineer of this firm.

3.2 Laboratory Analysis

The moisture content and dry density of selected samples recovered were determined. The results of these tests are shown on the boring logs in Appendix A. Grain-size analysis, Atterberg limits and direct shear tests were performed on selected samples. The results of these tests are presented in Appendix B.

4. SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 Site Conditions

The general site area is relatively level and currently is farmland consisting of irrigated fields. No crops were planted at the time of our field investigation, but irrigation ditches are located along the fringes of the irrigated fields. The property does include some undeveloped areas adjacent to the Agua Fria River and the New River. The land surface generally slopes toward the river channel in these areas and contains a light to moderate growth of grass, brush and some scattered trees. It appeared that some grading had taken place in the northeast portion of the property along the banks of the New River.

4.2 Geotechnical Profile

As indicated by the boring logs, the subsurface profile generally can be described as a two strata system as follows:

A. From the surface to a depth of 2 to 5 feet sandy silts and sandy clays of low plasticity were encountered. The plasticity index of these soils varied from 2 to 20. The soils generally are weakly cemented and soft to moderately firm at their present moisture contents.

B. Beneath Stratum A silty to clayey sands and clean sands with some gravel were encountered to the full depth of the borings. These soils are medium dense to very dense and are generally weakly cemented.

4.3 Groundwater & Soil Moisture Conditions

No free groundwater was encountered in the borings. Soil moisture contents varied from 6 to 20 percent in Stratum A and from 2 to 11 percent in Stratum B.

5. DISCUSSION & RECOMMENDATIONS

5.1 Analysis of Results

As indicated by their index properties, the soils of Stratum A, particularly, are somewhat moisture sensitive. Assuming a volume change on wetting of 5 percent and a 5-foot depth of moisture sensitive soils, a

settlement of 3.0 inches is calculated. It is likely that the variation in potential settlement on wetting is 1 to 4 inches, and that differential settlements of 2 to 3 inches could occur over relatively short distances. Because of the potential for settlement and differential settlement, it is recommended that the upper 4 to 5 feet of native soil be removed and recompacted to prevent damage to the proposed soil-cement erosion protection.

Most of the sampled materials are acceptable for use as backfill and soil-cement. Blending and mixing may be required depending on the exact gradation of material generated for embankments. Careful selection and some blending will be required for selection of soils to be used in soil-cement. It is anticipated that material can be mixed during grading operations, at the discretion of the representative of the geotechnical engineer, to provide high quality embankments. Site grading, embankment design and soil-cement design criteria are presented in the following sections.

5.2 Surface Treatment

It is recommended that all vegetation, debris and trash be removed from the site. At the discretion of the representative of the geotechnical engineer, surficial deposits of loose sand and finer grained materials should be overexcavated and removed for use elsewhere on the project site. It appears that 2 to 4 feet of Stratum A soils will require overexcavation.

The upper 6 inches of exposed native soils beneath cut surfaces should be scarified, brought to within 2 percent of the optimum moisture content and compacted to at least 95 percent of maximum dry density as determined by ASTM D698.

5.3 Embankment Fill

All fill required to raise the levee up to design elevation should be free of excessive vegetation, debris and other deleterious materials, and contain no particles larger than 6 inches in diameter. It appears that most of the on-site materials are acceptable for use as embankment fill.

All fill should be compacted to a minimum of 95 percent of maximum dry density as determined in accordance with ASTM D698. The moisture content during compaction should be maintained within 2 percent of optimum moisture.

5.4 Typical Levee Sections

Embankment slopes of 1:1 (horizontal to vertical) for soil-cement treated slopes and 4:1 for unprotected slopes are proposed. Three typical cross sections were developed for analysis. Figures 1, 2 and 3 in Appendix C illustrate typical levee sections along the New River,

the Agua Fria River and the unprotected section, respectively. Shown on these figures are the proposed levee geometry, water surface elevations and freeboard, assumed maximum phreatic surface that could develop in the levee and the extent of recommended overexcavation of native soils.

It is noted that the location of the phreatic surface within the levee was assumed, and is considered very conservative. Soil-cement typically has a very low coefficient of permeability relative to the native and embankment soils. Thus, seepage below the soil-cement is anticipated prior to seepage through the soil-cement section. The phreatic surface would develop laterally from the river and, considering the hydrograph for the design storm, would likely not fully develop as shown in Figures 1, 2 and 3.

5.5 Levee Stability

5.5.1 Analysis Procedure

The slope stability of the levee sections shown in Figures 1 through 3 were analyzed using the computer program STABL developed by Purdue University (Siegel, 1975a, 1975b; Lovell, Sharma and Carpenter, 1984)*. This program (up to and including version STABL4)

*References are listed at end of report.

considers a generalized shear surface utilizing a limiting equilibrium (simplified Janbu or simplified Bishop) method of slices. Irregular trial shear surfaces are generated and analyzed to determine the critical shear surface.

In the simplified Janbu procedure, parallel side shear forces are assumed, and vertical and horizontal force equilibrium of the individual slices are satisfied, but overall moment equilibrium and moment equilibrium of the individual slices are not satisfied. The computed factor of safety is conservative relative to more accurate methods satisfying complete equilibrium.

5.5.2 Soil Parameters

Based on the direct shear test results and our general experience with similar soils, the soil strength parameters and unit weights listed in Table 1 were assumed for the analyses. Because of the predominantly granular nature of the soils, the soils were assumed to be cohesionless. The cohesion values assigned to the soil-cement are representative of uniaxial compressive strengths of this material.

5.5.3 Analysis Results

The pertinent results of the stability analyses are listed in Table 2, which presents minimum computed

TABLE 1

Soil Parameters Assumed
for Stability Analyses

Material	Unit Weight Total (pcf)	Saturated (pcf)	Friction Angle (degree)	Cohesion (psf)
Compact fill, dry	115	125	33	0
Compact fill, saturated	115	125	31	0
Native sand, dry	100	108	30	0
Native sand, saturated	100	108	28	0
Soil-Cement, dry	130	142	0	5,000
Soil-Cement, saturated	130	142	0	3,000

TABLE 2

Results of Stability Analyses

Typical Section	Condition	Slope	Factor of Safety
Figure 1	Case I	River side	3.78
	Case II	River side	1.82
	Case III	River side	2.39
	Case III	Land side	2.28
Figure 2	Case I	River side	4.00
	Case II	River side	1.92
	Case III	River side	2.70
	Case III	Land side	2.31
Figure 3	Case I	River side	2.73
	Case II	River side	1.62
	Case III	River side	2.27
	Case III	Land side	2.21

Note: Case I - end of construction.

Case II - full phreatic surface subject to sudden drawdown.

Case III - full phreatic surface at flood stage.

safety factors for both river and land side slopes for several conditions. Three conditions were considered, including end of construction without a phreatic surface, full development of the phreatic surface and sudden drawdown.

Of the three conditions assumed, sudden drawdown subsequent to development of a full phreatic surface results in the minimum computed safety factor for the river side of the embankment. Computed safety factors vary from 1.62 to 1.92 for the three levee sections analyzed, which exceed the recommended minimum of 1.5 for this condition. For all other conditions, computed safety factors exceeded 2.0, indicating the levees should not be subject to slope stability problems once constructed.

5.6 Settlement Analysis

The settlement of the Agua Fria levee section was estimated to determine if the potential settlement of the levees will impact the performance of the levees. The settlement estimate was based on the following assumptions or procedures:

- The depth to an incompressible layer is 30 feet.
- The average standard penetration test (SPT) blow count is 20 blows per foot.
- Deformation modulus is related to SPT blow count as described by Schmertman (Wrench and Nowatzki, 1986).

- Vertical stress due to embankment loading was determined using the influence chart of Osterberg (1957).
- Poisson's ratio for the foundation soils is 0.35.
- Since the finer grained material will be over-excavated, consolidation settlements are ignored.

The results of settlement analysis are shown as a settlement profile in Figure 4 in Appendix C.

A levee having a maximum height of 9 feet was assumed, resulting in a maximum embankment load of 1,125 pounds per square foot. For this loading, a maximum settlement of 0.28 inch occurring below the midpoint of the crest was computed. As shown on Figure 4, estimated maximum and differential settlements are anticipated to be small. It is further expected that the major component of the settlement will occur during construction, since the predominantly granular foundation soils are not subject to long-term consolidation settlements.

5.7 Erosion Protection

5.7.1 Protection Alternatives

Several alternatives for erosion protection are possible, including gabions, placed riprap and soil-cement. Gabions and riprap would require a graded rock-fill having a mean particle size in the range of 3 to 5 inches. Sources of a significant quantity of

this type of aggregate within 5 miles of the project site are limited. Both the haul distance and the grading restriction increase the cost of these options. Placement of the rock-fill on a 2:1 or 3:1 slope would also be difficult, unless a large horizontal thickness were used. Considering the total length of the dike and the above factors, these alternatives are not recommended.

5.7.2 Soil-Cement

Soil-cement is recommended for erosion protection on the river slope of the levees. The native soils of Stratum B typically contain 10 to 30 percent material finer than the no. 200 sieve, and have a maximum particle size of 1/2 inch or less. The soil-cement protection should be constructed in 6- to 8-inch lifts with a minimum horizontal width of 8 feet.

For estimating purposes, the cement content of soil-cement should be 12 percent. The exact cement content should be determined in accordance with ASTM D558, D559 and D560 using the on-site soil that will be used for the soil-cement treatment. Shrinkage cracks and some maintenance should be expected with soil-cement erosion protection.

5.8 Temporary Slopes During Construction

Temporary slopes during construction will depend upon

the soils used to construct the levees and the native soils encountered during excavation. Soils with fines contents on the order of 20 percent or more probably will stand at a slope of 1:1. For the cleaner sands, a temporary allowable cut slope of 1 1/4:1 to 1 1/2:1 will be required to prevent slumping or sloughing of levee materials before the soil-cement section can be constructed. The construction of the soil-cement section, and estimates of the quantity of soil-cement required, should consider that temporary slopes of 1 1/4:1 to 1 1/2:1 may be required.

REFERENCES

Lovell, C.W., Sharma, S.S. and Carpenter, J.R., 1984, Slope Stability Analysis with STABL4, Summary Informational Report, Purdue University, Report JHRP-84-19, School of Civil Engineering, October.

Osterberg, J.O., 1957, Influence Value for Vertical Stresses in Semi-Infinite Mass Due to Embankment Loading, Proceedings of the 4th International Conference on Soil Mechanics and Foundation Engineering, Volume 1, London, August, pp. 393-394.

Siegel, R.A., 1975a, Computer Analysis of General Slope Stability Problems, Purdue University, Report JHRP-75-8, School of Civil Engineering, June.

Siegel, R.A., 1975b, STABL User Manual, Joint Highway Research Project No. 75-9, School of Civil Engineering, Purdue University, West Lafayette, Indiana, May.

Wrench, B.P., and Nowatzki, E.A., 1986, A Relationship Between Deformation Modulus and SPT N for Gravel, Proceedings of In Situ 1986, A Specialty Conference Sponsored by Geotechnical Engineering Division of ASCE, Publication No. 6, Virginia Tech., Blacksburg, Virginia, June, pp. 1163-1177.

TEST DRILLING EQUIPMENT & PROCEDURES

Drilling Equipment Truck-mounted CME-55 drill rigs powered with 4 or 6 cylinder Ford industrial engines are used in advancing test borings. The 4 cylinder and 6 cylinder engines are capable of delivering about 4,350 and 6,500 foot/pounds torque to the drill spindle, respectively. The spindle is advanced with twin hydraulic rams capable of exerting 12,000 pounds downward force. Drilling through soil or softer rock is performed with 6 1/2 O.D., 3 1/4 I.D. hollow stem auger or 4 1/2 inch continuous flight auger. Carbide insert teeth are normally used on the auger bits so they can often penetrate rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid. Where auger and tricone gear bits cannot be used to advance the hole due to cobbles or caving conditions, the ODEX (overburden drilling with the eccentric method) is used. A percussion down-the-hole hammer underreams the hole and 5 inch steel casing is introduced into the hole during drilling. The drill bit is eccentric and can be removed from the center of the casing to allow sampling of the material below the bit penetration depth.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 procedure. In many cases, 2" O.D., 1 3/8" I.D. samplers are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" O.D. samplers lined with 2.42" I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the samplers in 6 inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2 or 3 inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per foot on the logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587). Where samples of rock are required, they are obtained by NX diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings.

Continuous Penetration Tests Continuous penetration tests are performed by driving a 2" O.D. blunt nosed penetrometer adjacent to or in the bottom of borings. The penetrometer is attached to 1 5/8" O.D. drill rods to provide clearance to minimize side friction so that penetration values are as nearly as possible a measure of end resistance. Penetration values are recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the penetrometer in one foot increments or less.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487) with appropriate group symbols being shown on the logs.

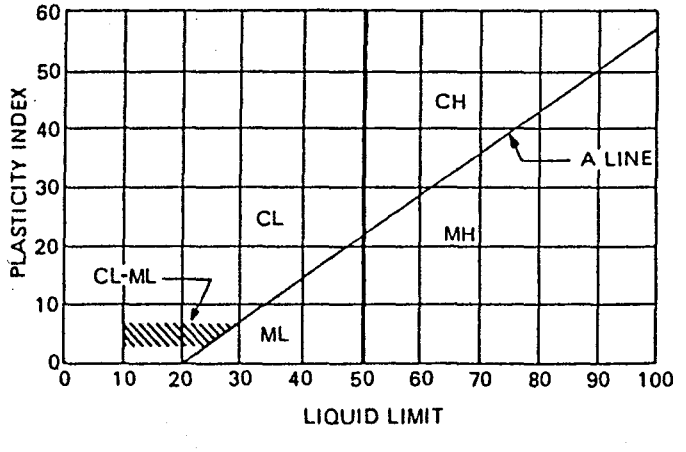
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 seive)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits plot below "A" line & hatched zone on plasticity chart)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (Limits plot above "A" line & hatched zone on plasticity chart)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

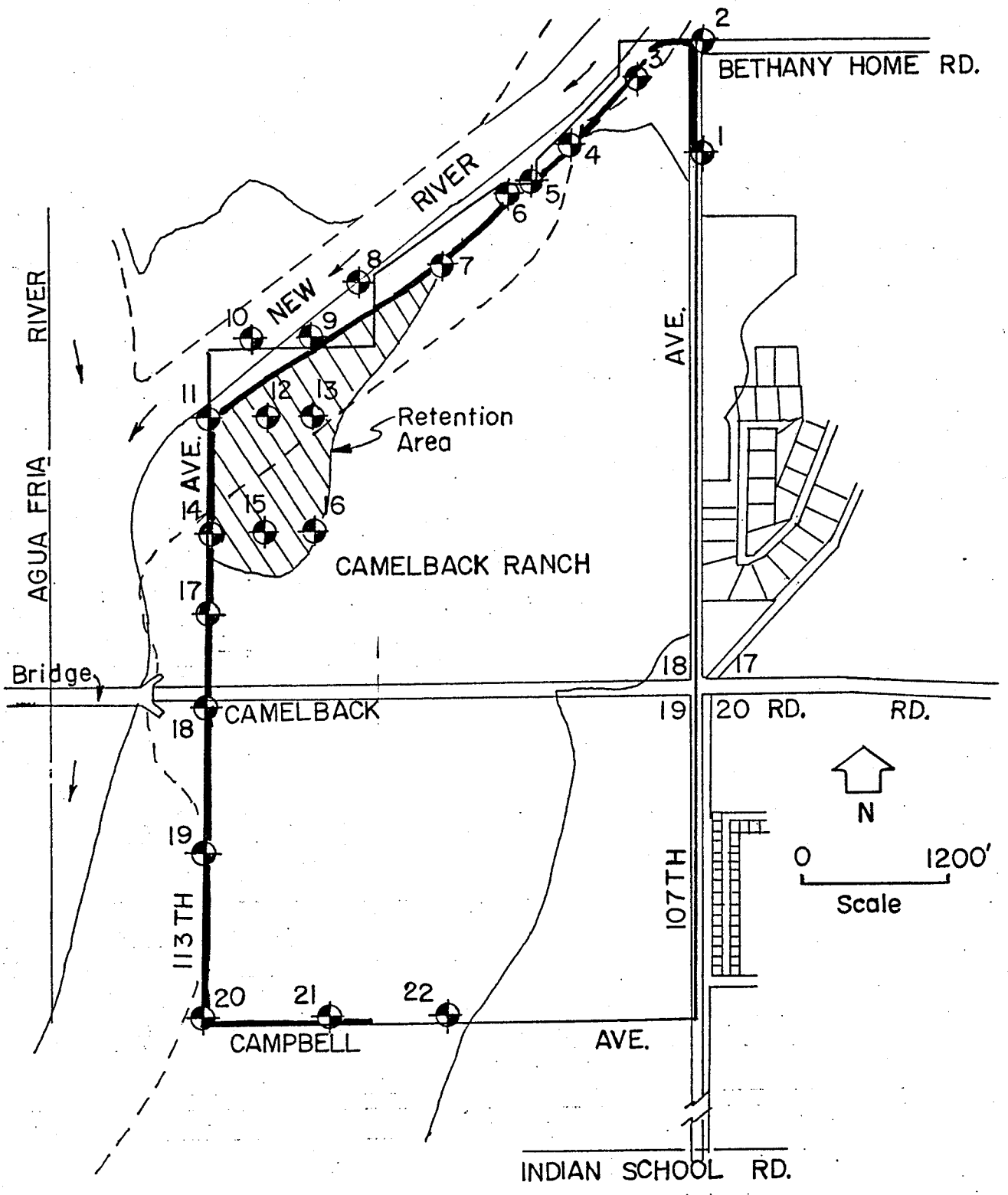
N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. Relative Firmness. Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

SITE PLAN

SHOWING LOCATIONS OF TEST BORINGS



Reference Drawing: "Camelback Ranch A.L.T.A." by Coe & Van Loo Consulting Engineers, Inc., dated 9/14/87

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PROJECT Camelback Ranch Levee Design

JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 1

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1038'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	31			CL-ML	moist very firm to firm	SANDY SILT, some clay, low plasticity, brown
			X	S	17		14			
5			X	S	12			SM	moist medium dense	SILTY SAND, predominantly fine to medium grained, subangular, nonplastic, brown note: some gravel at 8'
10			X	S	29 (no recovery)					
										Stopped auger at 9'6" Stopped sampler at 11'
15										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT Camelback Ranch Levee Design

JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 2

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1041'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	18				moist firm to moderately firm	Man-made FILL CLAYEY SAND, considerable gravel, poorly graded, subangular, low plasticity to non-plastic, brown
			X	S	23			SC-SM		
5			X	S	13					
10			X	S	70			SP-SM	moist very dense to dense	SILTY SAND, predominantly fine to medium grained, subangular, nonplastic, brown note: considerable gravel from 11' to 14'
15			X	S	37					
20			X	S	50/6"			GP-GM	moist very dense	SILTY SAND & GRAVEL, poorly graded, subrounded, nonplastic, brown
25										Auger refused at 23' on gravel

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT Camelbach Ranch Levee Design

JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 3

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1044'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	6		5		moist to dry	SILTY SAND, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, brown
				A			5		very loose to dense	
				S	3		4			
5				S	4 (no recovery)					note: trace of cobbles from 21'6" to 23'
10				S	18		1	SM		
15				S	13		7			
20				U	48	104	3			
25				S	50/3½"		12	SC	moist hard	CLAYEY SAND, trace of gravel, predominantly fine to medium grained, subangular to subrounded, weakly to moderately lime cemented, low plasticity, reddish brown
30										Auger refused at 25'6" on gravel & cobbles

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 4

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1039'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	25				slightly moist firm	SANDY SILT, low plasticity to nonplastic, brown
				A			6	ML		
				S	17					
5				U	10	87	10		slightly moist soft	SANDY CLAY, low plasticity, brown
								CL		
								SP-		
10				S	17			SM	slightly moist medium dense	SAND, considerable gravel, some silt, predominantly fine to medium grained, subangular, nonplastic, brown
15										Stopped auger at 9'6" Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 5

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1036.5'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	13				moist moderately firm	SILTY SAND, predominantly fine grained, low plasticity to non-plastic, brown note: some clay below 4'
				S	14		11			
5				A U	16			SM		
10				S	20				moist medium dense to very dense	SAND, some silt & gravel, predominantly fine to medium grained, subangular, nonplastic, light brown
15				S	33			SP-SM		
20				S	50/2"					Stopped auger at 19'6" Sampler refused at 20'2"
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 6

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1035'±
DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	27			CL	moist firm	SANDY CLAY, low plasticity, brown
			X	S	10		4			
5			X	S	6			SW-SM	moist loose	SAND, considerable silt, well graded, subangular, nonplastic, brown
								SM-SC	moist firm	SILTY SAND, some clay & gravel, predominantly fine to medium grained, subangular, weakly lime cemented, low plasticity, brown
10			X	S	17					
15										Stopped auger at 9'6" Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 7

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1033.5'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	26		8	ML	moist	SANDY SILT, some clay, weakly lime cemented, low plasticity, brown
				A					firm	
				S	17		4	SM		
5				U	8	92	4		slightly moist	SILTY SAND, predominantly fine grained, subangular, weakly lime cemented, nonplastic, brown
								SP-SC	firm	
10				S	30		3		slightly moist	SAND, some clay, predominantly medium grained, subangular to subrounded, nonplastic, brown
								SP-SM	very loose	
15				S	31 (no recovery)				moist to slightly moist	SAND, some gravel & silt, predominantly fine to medium grained, subangular to subrounded, nonplastic, brown
20				S	50/2" (no recovery)				medium dense to very dense	
										Stopped auger at 19'6" Sampler refused at 19'8"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-15-88

LOG OF TEST BORING NO. 8

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1033'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	9		14		moist	SANDY SILT, low plasticity, brown
				S	6			ML	soft to moderately firm	
5				S	11					
				A			6		moist	SILTY SAND, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, light brown
								SM	loose to medium dense	
10				U	16					
										Stopped auger at 9'6" Stopped sampler at 10'6"
15										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 9

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1030.5'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	35			CL	moist very firm to firm	SANDY CLAY, low plasticity, brown
			X	S	20		9			
5			X	S	15				moist medium dense to very dense	SAND, some silt, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, brown
10			X	S	20			SP-SM		
15			X	S	58					
								SC	moist hard	CLAYEY SAND, considerable gravel, predominantly fine to medium grained, subangular, weakly lime cemented, low plasticity, reddish brown
20			X	S	50/5"					
25										Stopped auger at 19'6" Sampler refused at 20'5"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 10

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1030'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	9		5	SM	slightly moist	SILTY SAND, predominantly fine to medium grained, subangular, nonplastic, brown
				A						
				S	17		2		moderately firm	
5				S	20		2			
								SP-SM	slightly moist	SAND, trace of silt & gravel, predominantly fine to medium grained, subangular, nonplastic, brown
									medium dense	
10				S	22					
										Stopped auger at 9'6"
										Stopped sampler at 11'
15										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 11

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1028'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	7		4	SM	slightly moist soft	SILTY SAND, predominantly fine grained, subangular, nonplastic, brown
			X	S	10		3			
5			X	S	10		3		moist loose to medium dense	SAND, trace of silt & fine grained gravel, predominantly fine to medium grained, subangular, nonplastic, light brown
								SP-SM		
10			X	U	19 (no recovery)					
								SW-SM	moist very dense	SAND, considerable gravel, trace of silt, well graded, subangular, nonplastic, light brown
15			X	S	50/6"		3			
20										Auger refused at 16' on gravel

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 12

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1027.5'±
DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	11		11	SM	moist moderately firm	SILTY SAND, predominantly fine to medium grained, subangular, nonplastic, brown
				A						
				S	31					
5				S	7			SP-SM	moist loose to dense	SAND, some silt, predominantly medium to fine grained, subangular, nonplastic, light brown note: trace of gravel at 9'
10				S	17					
15										Stopped auger at 9'6" Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 13

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1028'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	11			CL	moist medium firm	SANDY CLAY, low plasticity, brown
			X	S	4		7			
5			X	S	8				moist very loose to medium dense	SILTY SAND, predominantly fine to medium grained, subangular, nonplastic, light brown
								SM		
10			X	S	13					
										Stopped auger at 9'6" Stopped sampler at 11'
15										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 14

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1025.5'+

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	6				moist very soft to firm	SANDY CLAY, low plasticity, dark brown
			X	S	4		16	CL		
5			X	U	36	91	16			
									moist loose to very dense	SAND, trace of silt & gravel, predominantly fine to medium grained, subangular, nonplastic, light brown note: considerable gravel from 12'6" to 20'
10			X	S	8					
								SP=SM		
15			X	S	50/6"					
20			X	S	40					
										Stopped auger at 19'6" Stopped sampler at 21'
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 15

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1026'±
DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	7				moist soft to moderately firm	SANDY CLAY, low plasticity, dark brown
				A			17	CL		
				S	14					
5				S	8				moist loose to medium dense	SAND, trace of silt, predominantly fine to medium grained, subangular, nonplastic, light brown note: trace of gravel at 7'6"
								SP-SM		
10				S	17					
15										Stopped auger at 9'6" Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 16

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1026'±
DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	18				moist	SANDY CLAY, weakly lime cemented, low plasticity, dark brown
				A				CL		
				S	10				firm to moderately firm	
5				S	7		7		moist	SILTY SAND, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, light brown
								SM	loose to dense	
10				S	37				note: considerable gravel at 8'	
15										Stopped auger at 9'6" Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 17

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1024.5'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	6			SM-	moist	SILTY SAND, some clay, predominantly fine grained, subangular, nonplastic, brown
			X	S	7		13	SC	loose	
5			X	S	13				moist	SAND, trace of silt, predominantly fine to medium grained, sub-angular, nonplastic, light brown
									medium dense to very dense	
10			X	S	54			SP		note: some gravel at 8' & considerable gravel at 12'6"
15			X	S	32					
20										Auger refused at 16' on gravel

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-17-88

LOG OF TEST BORING NO. 18

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1022'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	28		8	SM-SC	slightly moist firm	SILTY SAND, trace of clay, predominantly fine grained, subangular, weakly lime cemented, low plasticity to nonplastic, brown
			X	S	10		8			
5			X	S	12		4	SM		
									moist medium dense	SILTY SAND, predominantly fine grained, subangular, nonplastic, brown
10			X	S	16		6			
								SP-SM	moist medium dense to very dense	SAND, some silt, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, light reddish brown
15			X	S	43		6			
										note: considerable gravel from 16' to 20'
20				S	50/3½" (no recovery)					
										Stopped auger at 19'6" Sampler refused at 19'9½"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E88-36 DATE 2-17-88

LOG OF TEST BORING NO. 19

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1019'±
DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	19			GL	moist	SANDY CLAY, weakly lime cemented, low plasticity, brown
			X	U	12	94	2		firm	
5			X	S	42				slightly moist to moist	SAND, trace of silt, predominantly fine grained, subangular, nonplastic, light brown
									medium dense to very dense	note: trace of gravel at 7'6" & considerable gravel from 15' to 20'
10			X	S	15			SP-SM		
15			X	S	47					
20			X	S	50/5½"					
										Stopped auger at 19'6" Sampler refused at 20'5½"
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT Camelback Ranch
Levee Design

JOB NO. E88-36 DATE 2-17-88

LOG OF TEST BORING NO. 20

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1016'±
DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	17		6	SM	moist firm to moderately firm	SILTY SAND, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, brown
				A						
				S	11		8			
5				S	14		3			
								SP-SM	slightly moist to moist medium dense	SAND, trace of silt, predominantly fine to medium grained, subangular, nonplastic, light brown note: trace of gravel at 7'6"
10				S	22		5			
15				S	62		7		moist very dense	SILTY SAND, considerable gravel, poorly graded, subangular, weakly lime cemented, nonplastic to low plasticity, light reddish brown
								SM		
20				S	69		5			
25										Stopped auger at 19'6" Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
– 3" O.D. 2.42" I.D. tube sample.
– 3" O.D. thin-walled Shelby tube.

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PROJECT Camelback Ranch Levee Design

JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 21

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1019.5'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	22				moist firm to soft	SILTY CLAY, some sand, medium plasticity, dark brown
				A						
				S	10		20	CL		
5				S	8					
								SP-SM	moist loose	SAND, trace of silt, predominantly fine to medium grained, sub-angular, nonplastic, light brown
10				S	6					
15										Stopped auger at 9'6" Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT Camelback Ranch Levee Design

JOB NO. E88-36 DATE 2-16-88

LOG OF TEST BORING NO. 22

RIG TYPE CME-55

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV. 1020'±

DATUM Plan & Profile

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	9			CL	moist, moderately firm	SANDY CLAY, low to medium plasticity, brown
			X	S	9					
5			X	U	11			SC	moist, moderately firm	CLAYEY SAND, considerable silt, predominantly fine grained, subangular, low plasticity, light brown
								SP-SM		
10			X	S	47			CL	moist	SAND, some silt, trace of gravel, predominantly fine to medium grained, subangular, nonplastic, light brown
15									moist, very firm	SILTY CLAY, some sand, weakly lime cemented, medium plasticity, brown
										Stopped auger at 9'6". Stopped sampler at 11'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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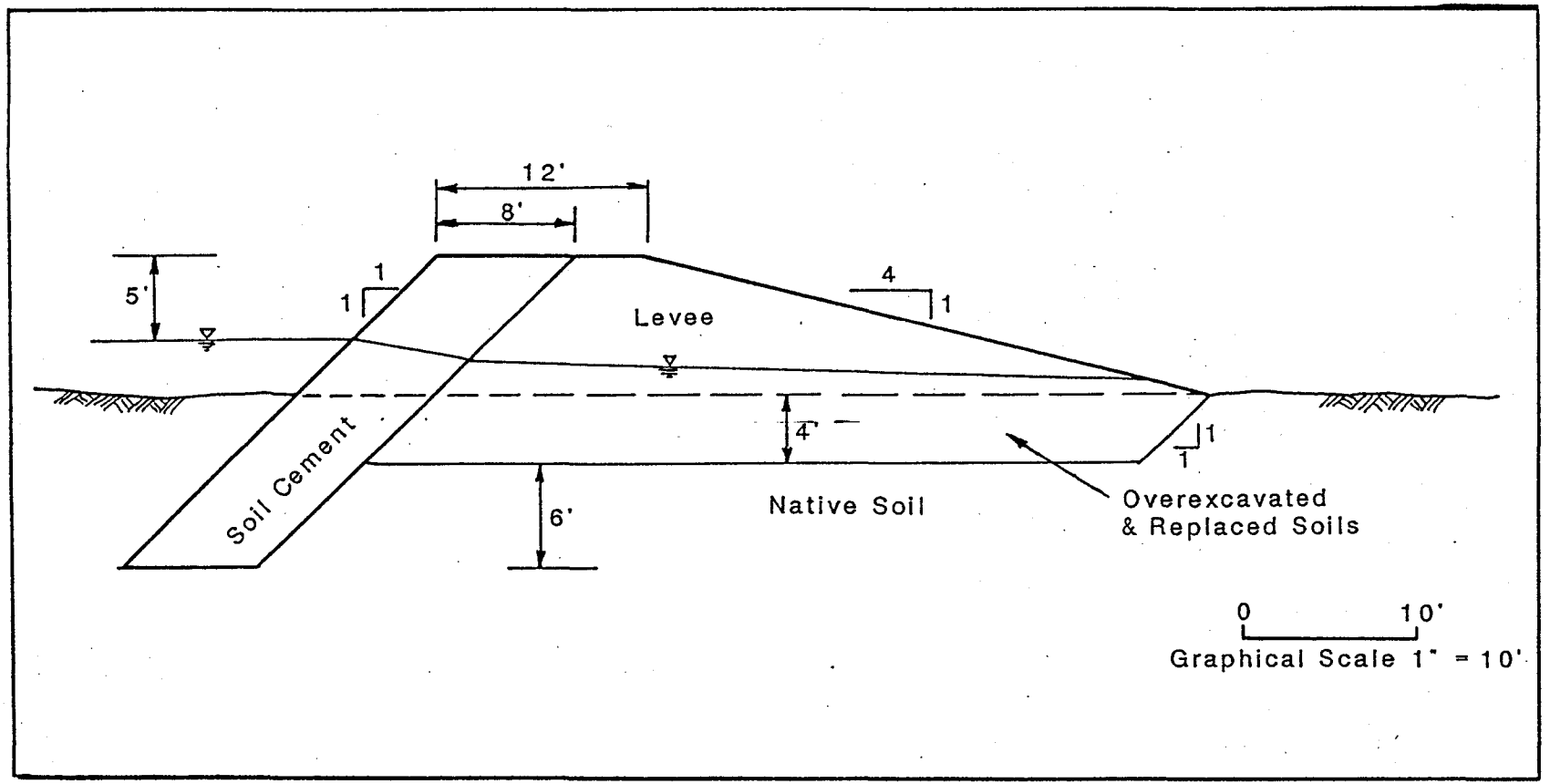

FIGURE 1

Typical Levee Section At New River

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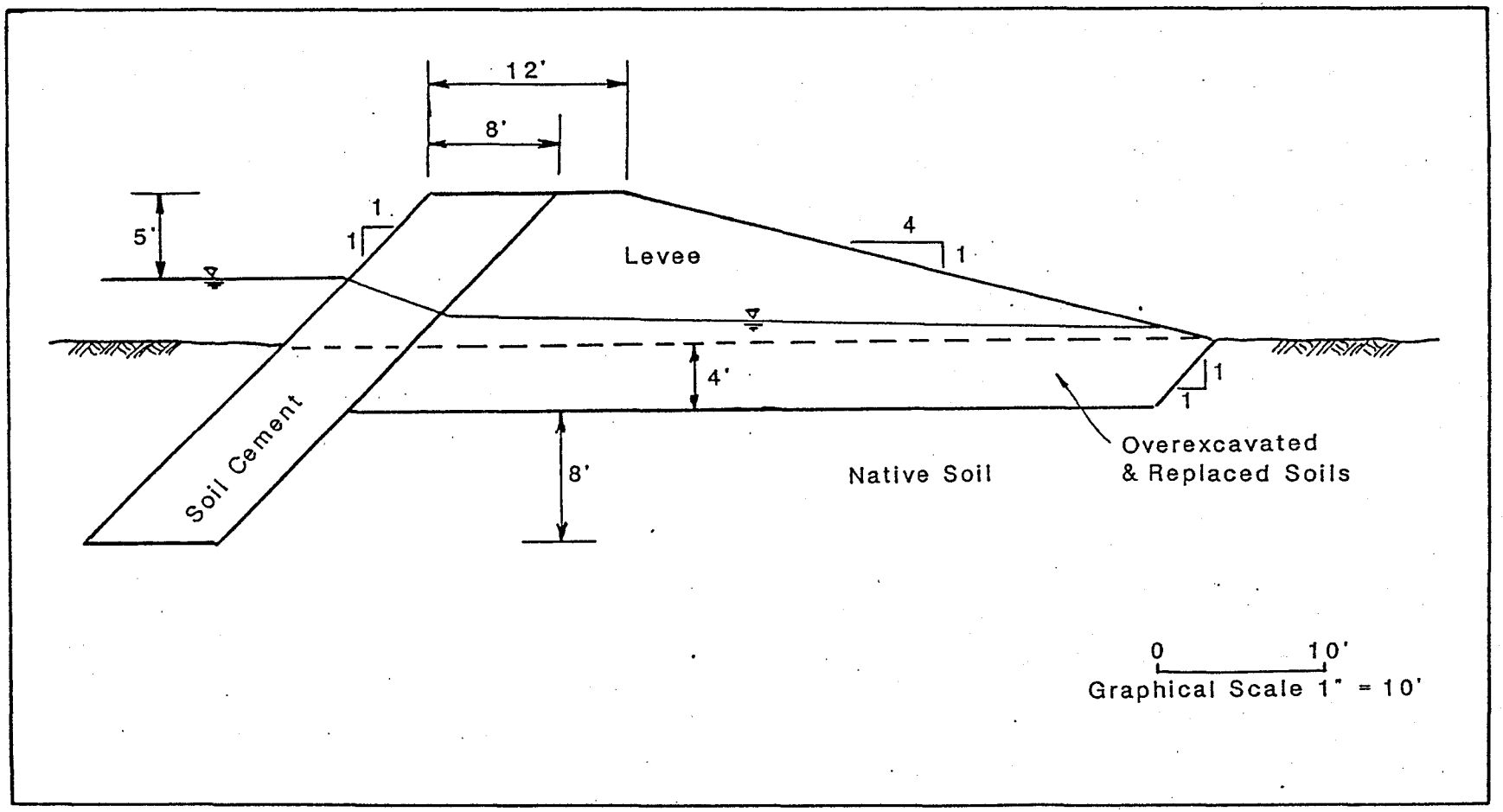

FIGURE 2

Typical Levee Section At Aqua Fria River

SHB Job No. E88-26

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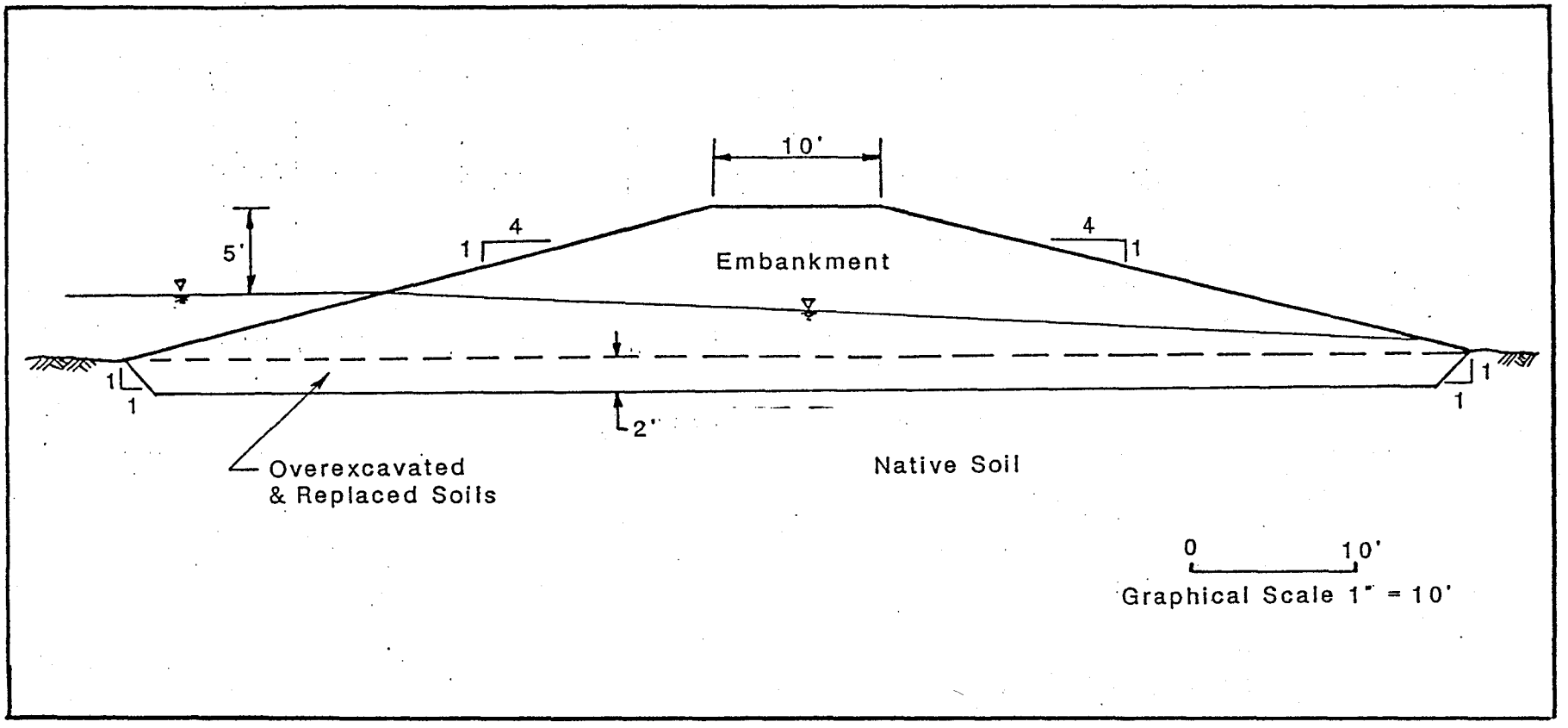

FIGURE 3

Typical Unprotected Levee Section

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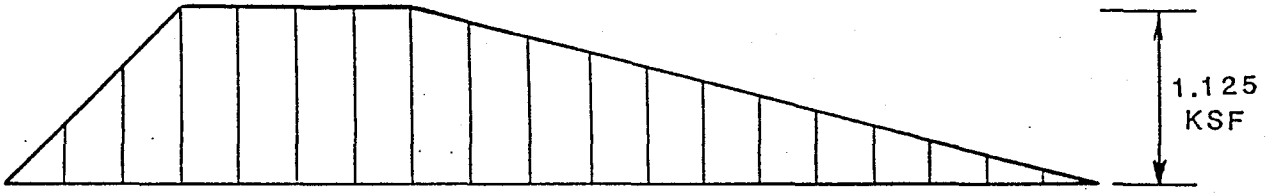
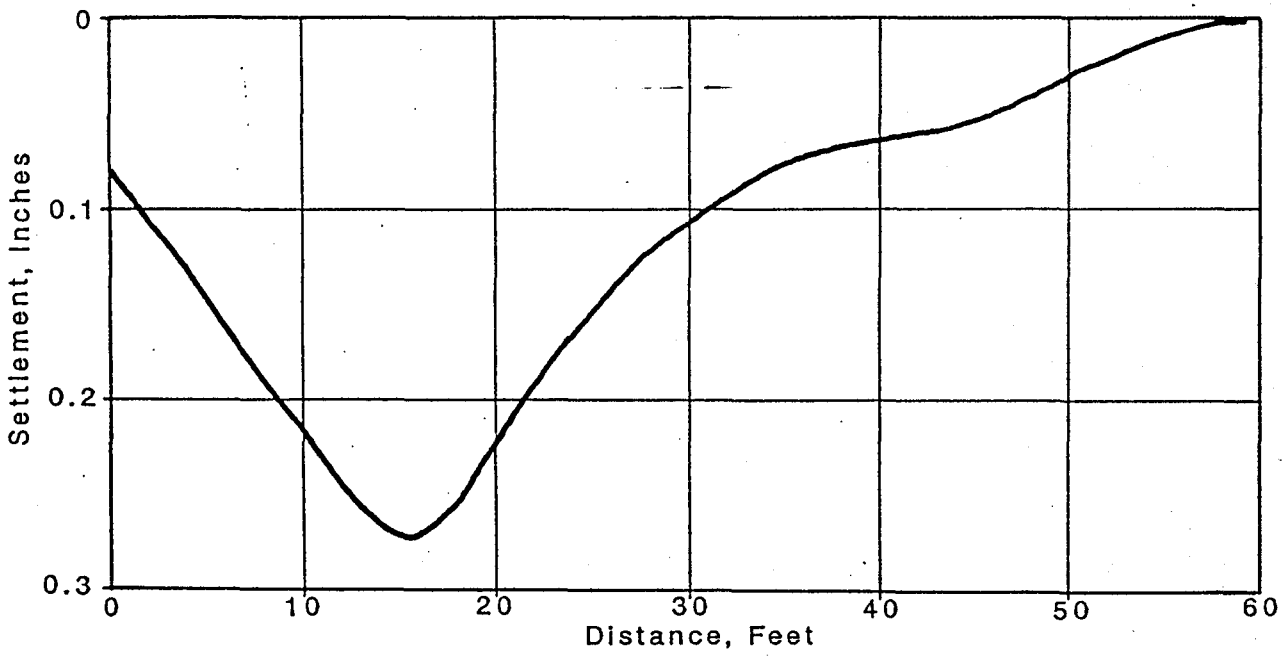


(a) LOADING DUE TO LEVEE



(b) SETTLEMENT PROFILE

FIGURE 4

Settlement Profile For Typical Aqua Fria Levee Section

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LABORATORY TESTING PROCEDURES

Consolidation Tests Soiltest or Clockhouse apparatus of the "floating-ring" type are employed for the one-dimensional consolidation tests. They are designed to receive one inch high 2.5 inch O.D. brass liner rings with soil specimens as secured in the field. Procedures for the tests generally are those outlined in ASTM D2435. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. For soils which are essentially saturated, each increment of load is maintained until the deformation versus log of time curve indicates completion of primary consolidation. For partially saturated soils, each increment of load is maintained until the rate of deformation is equal or less than 1/10,000 inch per hour. Applied loads are such that each new increment is equal to the total previously applied loading. Porous stones are placed in contact with the top and bottom of the specimens to permit free addition or expulsion of water. For partially saturated soils, the tests are normally performed at in situ moisture conditions until consolidation is complete under stresses approximately equal to those which will be imposed by the combined overburden and foundation loads. The samples are then submerged to show the effect of moisture increase and the tests continued under higher loadings. Generally, the tests are continued to about twice the anticipated curve due to overburden and structural loads with a rebound curve then being established by releasing loads.

Expansion Tests The same type of consolidometer apparatus described above is used in expansion testing. Undisturbed samples contained in brass liner rings are placed in the consolidometers, subjected to appropriate surcharge loads and submerged. The loads are maintained until the expansion versus log of time curve indicates the completion of "primary swell".

Direct Shear Tests Direct shear tests are run using a Clockhouse or Soiltest apparatus of the strain-control of approximately 0.05 inches per minute. The machine is designed to receive one of the one inch high 2.42 inch diameter specimens obtained by tube sampling. Generally, each sample is sheared under a normal load equivalent to the effective overburden pressure at the point of sampling. In some instances, samples are sheared at several normal loads to obtain the cohesion and angle of internal friction. When necessary, samples are saturated and/or consolidated before shearing in order to approximate the anticipated controlling field loading conditions.

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TABULATION OF TEST RESULTS

Job No. E88-36
W/O 1

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	SIEVE ANALYSIS-ACCUM % PASSING #200 .75"	#100 1"	#50 1.5"	#40 2"	#30 2.5"	#16 3"	#10 3.5"	#8 4"	#4 6"	.25" 8"	.375" 10"	.5" 12"	LAB NO
#1	2'6"-4'	CL-ML	26	6	64	75	84	88	91	97	99	99	100				8-36-2
#3	0-4'6"	SM	NV	NP	13	21	39	55	67	86	94	96	100				8-36-10
#4	0-4'6"	ML	21	1	51	66	80	86	92	98	99	99	100				8-36-17
#5	2'6"-4'	SM	NV	NP	37	72	84	92	98	99	99	99	100				8-36-24
#6	2'6"-4'	SW-SM	NV	NP	12	16	27	37	48	69	83	86	92	92	93	96	8-36-30
					100												
#7	4'6"-5'6"	SP-SC	28	9	8.4	9	13	24	45	87	98	99	100				8-36-36
#8	6"-2'	ML	23	2	63	78	91	96	98	99	100						8-36-38
#8	5'-9'	SM	NV	NP	26	34	46	58	71	89	95	96	100				8-36-41
#9	2'6"-4'	CL	31	11	55	69	81	88	93	98	99	100					8-36-44
#10	6"-2'	SM	NV	NP	24	33	48	60	72	90	96	97	100				8-36-50
#10	4'6"-6'	SP-SM	NV	NP	5.4	9	21	37	54	75	84	85	90	90	91	96	8-36-52
					100												
#11	2'6"-4'	SP-SM	NV	NP	5.6	13	34	56	76	94	96	97	98	99	100		8-36-55
#12	6"-2'	SM	NV	NP	39	50	70	81	88	95	97	98	99	99	100		8-36-59
#13	2'6"-4'	SM	NV	NP	21	30	48	62	79	97	99	100					8-36-64
#14	2'6"-4'	CL	28	12	54	66	85	92	96	99							8-36-68

SERGENT, HAUSKINS & BECKWITH

TABULATION OF TEST RESULTS

Job No. E88-36
W/O 1

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	SIEVE ANALYSIS-ACCUM % PASSING												LAB NO
					#200 .75"	#100 1"	#50 1.5"	#40 2"	#30 2.5"	#16 3"	#10 3.5"	#8 4"	#4 6"	.25" 8"	.375" 10"	.5" 12"	
#15	0-4'	CL	32	14	52 92	61 94	71 97	75 100	79	82	83	83	84	85	87	90	8-36-73
#16	4'6"-6'	SM	NV	NP	15	31	60	74	85	94	96	97	98	98	100		8-36-81
#17	2'6"-4'	SM	NV	NP	39	51	69	81	89	96	99	99	100				8-36-84
#21	2'6"-4'	CL	41	20	79	88	94	96	98	99							8-36-90
#18	2'6"-4'	SM	23	2	47	57	75	85	91	97	98	99	99	100			8-36-98
#19	2'6"-3'6"	SP-SM	NV	NP	6.5	14	42	72	89	98	100						8-36-103
#20	6"-2'	SM	24	2	47	57	71	80	87	94	96	96	97	99	100		8-36-109

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REPORT OF LABORATORY TESTS

PROJECT: CAMELBACK RANCH

LOCATION:#5 @ 4'6"-5'6"

DATE 2/29/88

JOB NO. E88-36

W.O.NO. 1

LAB NO. 25

DIRECT SHEAR TEST(SATURATED)ASTM D-3080

POINT NO. 1 (NORMAL STRESS 0.995 KSF)

Initial Moisture Content	17.9%
Dry Density	105.1 LB/CU FT
Moisture at Saturation	21.7%
Maximum Vertical Deformation @ T max.	0.003 IN
Shearing Stress, T max.	0.7 KSF

POINT NO. 2 (NORMAL STRESS 2.059 KSF)

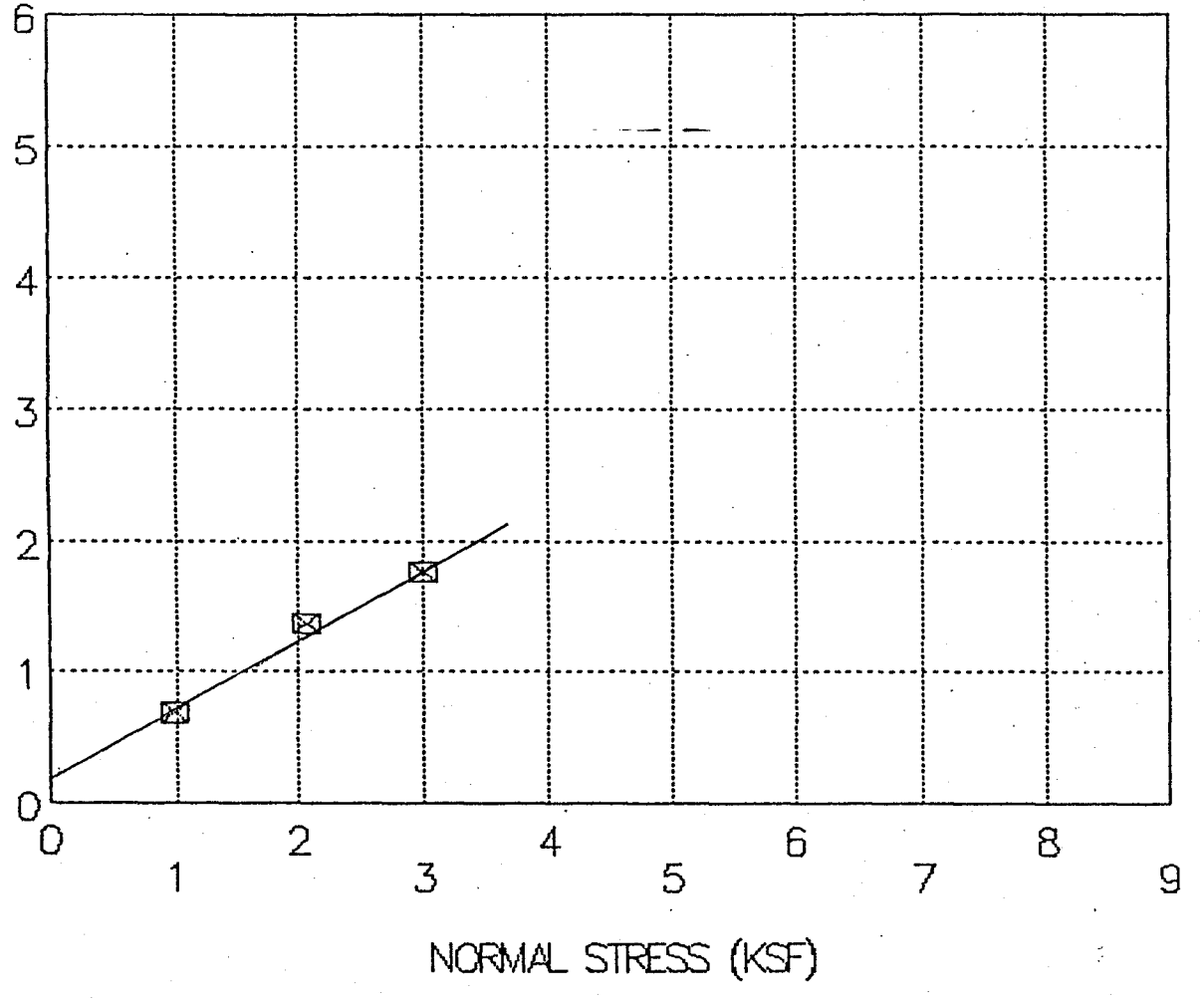
Initial Moisture Content	18.1%
Dry Density	106.0 LB/CU FT
Moisture at Saturation	21.5%
Maximum Vertical Deformation @ T max.	-0.006 IN
Shearing Stress, T max.	1.4 KSF

POINT NO. 3 (NORMAL STRESS 2.998 KSF)

Initial Moisture Content	16.8%
Dry Density	106.4 LB/CU FT
Moisture at Saturation	21.5%
Maximum Vertical Deformation @ T max.	-0.014 IN
Shearing Stress, T max.	1.8 KSF

DIRECT SHEAR

#5 @ 4'6"-5'6"



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REPORT OF LABORATORY TESTS

PROJECT: CAMELBACK RANCH

LOCATION:#7 @ 4'6"-5'6"

DATE 2/29/88

JOB NO. E88-36

W.O.NO. 1

LAB NO. 36

DIRECT SHEAR TEST(IN SITU)ASTM D-3080

POINT NO. 1 (NORMAL STRESS 0.995 KSF)

Initial Moisture Content	3.3%	
Dry Density	90.5	LB/CU FT
Maximum Vertical Deformation @ T max.	0.009	IN
Shearing Stress, T max.	0.9	KSF

POINT NO. 2 (NORMAL STRESS 2.059 KSF)

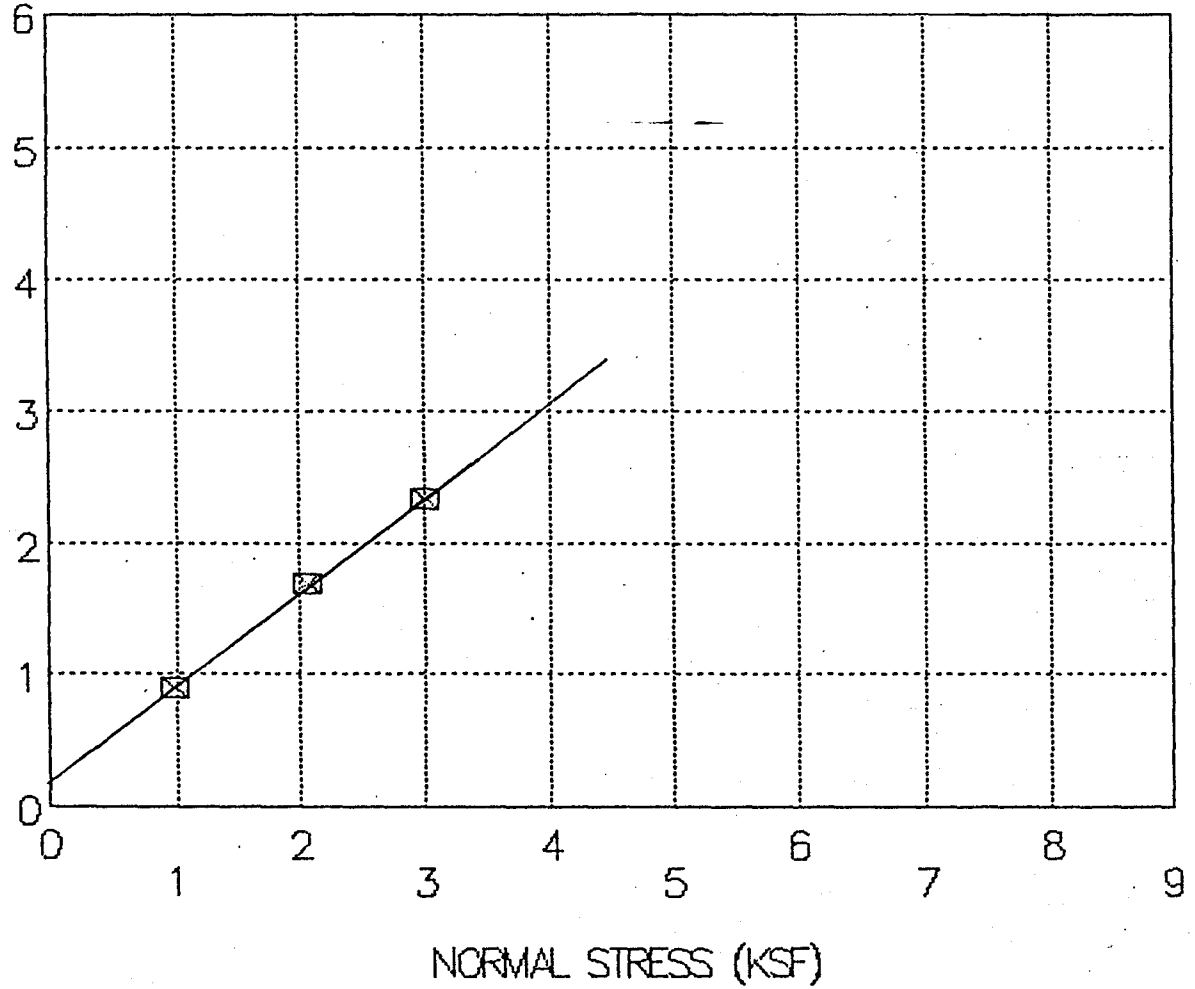
Initial Moisture Content	14.1%	
Dry Density	80.2	LB/CU FT
Maximum Vertical Deformation @ T max.	-0.002	IN
Shearing Stress, T max.	1.7	KSF

POINT NO. 3 (NORMAL STRESS 2.998 KSF)

Initial Moisture Content	3.7%	
Dry Density	92.5	LB/CU FT
Maximum Vertical Deformation @ T max.	-0.003	IN
Shearing Stress, T max.	2.3	KSF

DIRECT SHEAR

#7 @ 4'6"–5'6"



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REPORT OF LABORATORY TESTS

PROJECT: CAMELBACK RANCH

LOCATION:#8 @ 9'6"-10'6"

DATE 2/29/88

JOB NO. E88-36

W.O.NO. 1

LAB NO. 42

DIRECT SHEAR TEST(IN SITU)ASTM D-3080

POINT NO. 1 (NORMAL STRESS 0.995 KSF)

Initial Moisture Content	3.5%
Dry Density	97.4 LB/CU FT
Maximum Vertical Deformation @ T max.	0.007 IN
Shearing Stress, T max.	0.8 KSF

POINT NO. 2 (NORMAL STRESS 2.059 KSF)

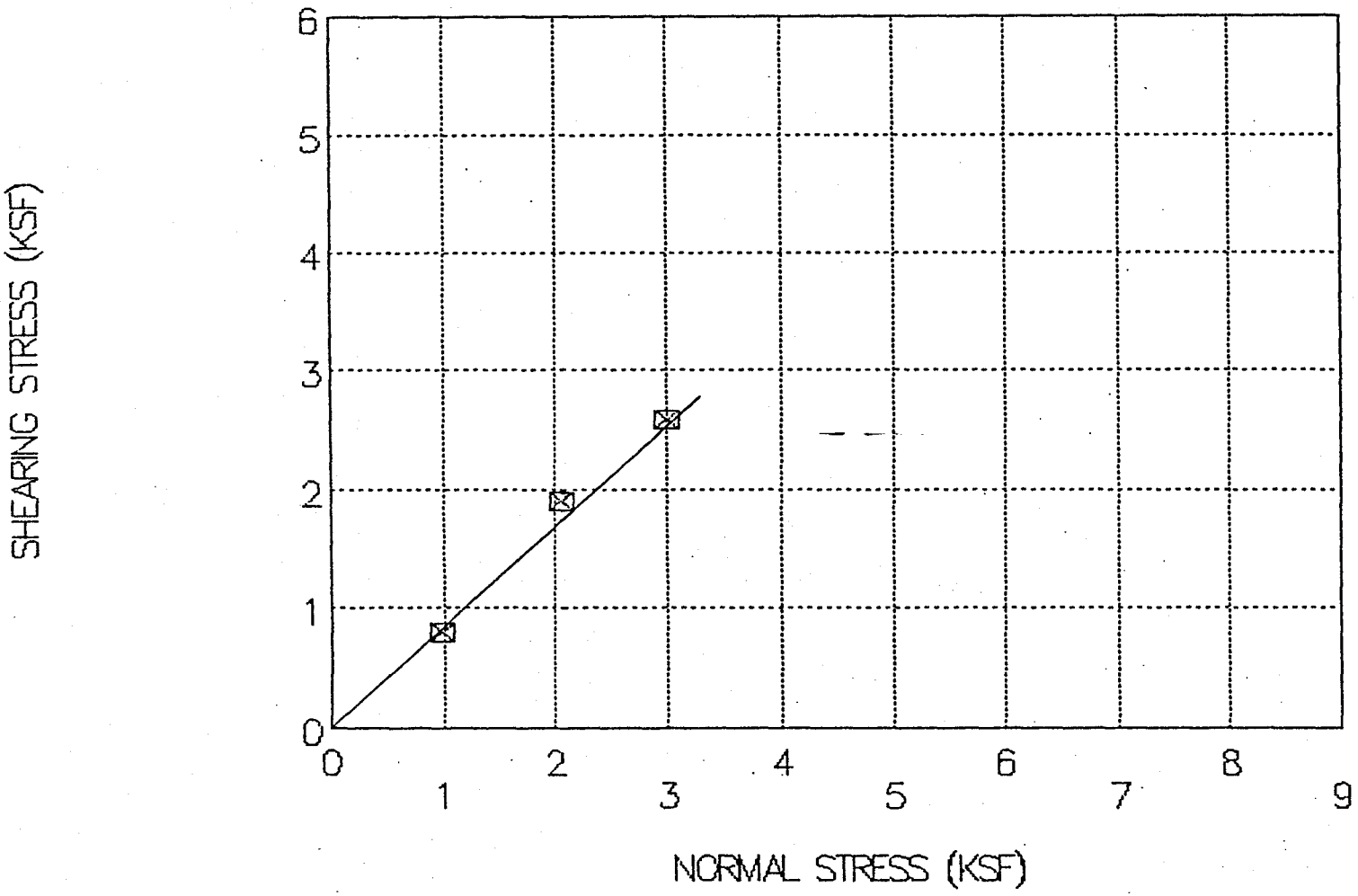
Initial Moisture Content	2.2%
Dry Density	94.6 LB/CU FT
Maximum Vertical Deformation @ T max.	0.014 IN
Shearing Stress, T max.	1.9 KSF

POINT NO. 3 (NORMAL STRESS 2.998 KSF)

Initial Moisture Content	3.1%
Dry Density	98.8 LB/CU FT
Maximum Vertical Deformation @ T max.	0.014 IN
Shearing Stress, T max.	2.6 KSF

DIRECT SHEAR

#8 @ 9'6"-10'6"



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REPORT OF LABORATORY TESTS

PROJECT: CAMELBACK RANCH

LOCATION:#19 @ 2'6"-3'6"

DATE 2/29/88

JOB NO. E88-36

W.O.NO. 1

LAB NO. 103

DIRECT SHEAR TEST(IN SITU)ASTM D-3080

POINT NO. 1 (NORMAL STRESS 0.995 KSF)

Initial Moisture Content	2.4%
Dry Density	94.5 LB/CU FT
Maximum Vertical Deformation @ T max.	0.012 IN
Shearing Stress, T max.	0.9 KSF

POINT NO. 2 (NORMAL STRESS 2.059 KSF)

Initial Moisture Content	2.4%
Dry Density	93.9 LB/CU FT
Maximum Vertical Deformation @ T max.	0.013 IN
Shearing Stress, T max.	1.7 KSF

POINT NO. 3 (NORMAL STRESS 2.998 KSF)

Initial Moisture Content	2.3%
Dry Density	93.4 LB/CU FT
Maximum Vertical Deformation @ T max.	0.01 IN
Shearing Stress, T max.	2.4 KSF

DIRECT SHEAR

#19 @ 2'6"–3'6"