Flood Control District of MC Library
Property of
Phoenix, AZ 85009

GEOTECHNICAL ENGINEERING INVESTIGATION

on

Agua Fria Soil Cement Design
and
Permeability Study
SLA Project Numbers AZ-MC-06, AZ-MC-07 and AZ-MC-09

at

Agua Fria River
Phoenix, Arizona

for

Simons, Li & Associates
120 West Broadway
Tucson, Arizona 85702

524 N. 6th Ave.
Tucson, Arizona
85705
(602) 623-7774

Desert Earth Engineering

Registered Professional Engineer (Civil)
CERTIFICATE NO.
10296
ROBERT L.
SOGGE
Date Signed 3/1/85
ARIZONA, U.S.A.

February 28, 1985
84-208, 84-209, 84-211
and 84-307

consulting geotechnical engineers

February 28, 1985
84-208, 84-209, 84-211,
and 84-307

Simons, Li & Associates
120 West Broadway, Suite 170
Tucson, Arizona 85702

ATTN: John Lynch

RE: Geotechnical Engineering Report on Agua Fria Soil Cement Design and Permeability Study; SLA Projects: AZ-MC-06 through AZ-MC-09.

Gentlemen:

Desert Earth Engineering is pleased to submit this report covering soil-cement mix design recommendations relating to the above-captioned project. The field investigation consisted of 34 backhoe trenches on the banks and in the riverbed, and various borings along the alignment of the proposed grade control structures and in the siltation basin. Soils encountered were not homogeneous throughout the project area and a summary of individual channel sections under Desert Earth Engineering project numbers 84-208, 84-209, 84-211, and 84-307 will be presented.

LABORATORY TESTING

Samples were analyzed for gradation and classified by the Uniform Soil Classification System. Proctor values were determined for five composite samples representative of soil types found throughout the project site. These samples were mixed with varying amounts of cement and water, and tested for 7-day compressive strength. Soil cement plugs were pounded as per ASTM D

Desert Earth Engineering
524 North Sixth Avenue
Tucson, Arizona 85705
(602) 623-7774

698 using a 4" mold and a -3/4" material, stored in humidifying boxes for 7 days, and compressive strength tested after being soaked for 24 hours and sulfer capped. This is the same method used by the Pima County Department of Transportation. A summary of test results for the representative samples is given in Table 1 and Grain Size Distribution Graphs and Mix Design Graphs are presented in Appendix B. The Pima County Specifications for Soil Cement Testing are presented in Appendix C.

INTERPRETATION AND ANALYSIS

Materials encountered are not homogeneous throughout the project site and, therefore, some materials are not suitable for soil-cement mix design. Silts and fine sands are not suitable for soil-cement mixes due to the high amount of cement required to obtain the appropriate compressive strength, which in this case is 750 PSI for erosion control levies and 1000 PSI for the grade control structures. Unsuitable materials were encountered on the banks and in the upper five feet of the proposed siltation basin; these materials should not be used in soil-cement mixes. Well graded sands are the most suitable for mixing with soil cement although cobbles larger than 1.5 inches must be screened out. Strata throughout the riverbed varies in gradations enough so that once the material is mixed and screened an acceptable gradation for soil-cement design can be achieved. Erosion control in Arizona is usually insured by adding an additional 2% cement.

The following is a summary of representative sample results:

84-208 (SLA Project #AZ-MC-06). Composite sample #1 is representative of the materials found in this section of the channel near Indian School Road Bridge. Four borings were done along the alignment of the proposed grade control structure and four surface samples were used to provide

material for the soil-cement mix design. Generally, sands, gravel, and cobbles were encountered in the upper 25 feet of the borings. At about 25 feet a cobble layer was encountered which prevented further auger penetration. Composite sample #1 is a sand with some gravel and trace silt. The material was tested at 8% moisture content and with the cement content at 6.5% the compressive strength was 200 PSI. Increasing the cement content to 8.0% increased the strength to 700 PSI, at 9.5%, the compressive strength was 1000 PSI and at 11% cement, the strength was 1500 PSI. At 8% moisture content, a compressive strength of 750 PSI requires adding approximately 8.6% cement to this material and adding 9.5% cement gives a compressive strength of 1000 PSI. An additional 2% cement is added in Arizona to ensure erosion control; at 10.6% cement, the compressive strength would be 1300 PST and at 11.5% cement the strength would be 1650 PSI.

84-209 (SLA Project #AZ-MC-07). Composite samples #2 and #3 are representative of materials encountered in this section of channel which begins at McDowell Road and extends downstream to 500 feet south of I-10. Ten backhoe trenches (84-209, T-1 through T-10) were dug in the banks and the riverbed, three borings were made along the proposed grade control structure alignment, and eight borings were done in the proposed siltation basin. The materials encountered in the borings along the grade

control structure alignment were generally sand with trace gravel in the upper 20 feet, with a sand-gravel-cobble layer below 20 feet. The eight borings in the proposed siltation basin indicate that fine to silty sands occur from the surface to various depths from 5 to 15 feet. Beneath the unsuitable silty material is a well-graded sand layer that is suitable for soil-cement mix design.

The two composite samples #2 and #3 represent materials encountered in the trenches. Composite sample #2 represents material from T-4, T-5, T-7, and T-9 which were in the banks. The material is a fine sand with some silt and trace gravel. At 8% moisture content and 9% cement content, a compressive strength of 175 PSI was achieved. Increasing the cement content to 11.0% achieved a strength of 250 PSI and at 12.5% cement content a compressive strength of 300 PSI was achieved. This material is unsuitable for soil cement.

Composite sample #3 represents material from T-1, T-2, T-3, T-6 and T-10 which is riverbed material. The material is a well-graded sand with trace gravel and silt. At 8% moisture content and 11% cement content the compressive strength was 700 PSI. Increasing the cement content to 12.5% increased the strength to 900 PSI, and at 14.0% cement content a compressive strength of approximately 1100 PSI was achieved. At 8.0% moisture content, a compressive strength of 750 PSI requires adding approximately 11.7% cement to this material and adding

13.3% cement gives a compressive strength of 1000 PSI. An additional 2% cement is added in Arizona to ensure erosion control; at 13.7% cement 1050 PSI would result and at 15.3% cement 1300 PSI would result.

84-211 (SLA Project #AZ-MC-09). Composite sample #4 is representative of materials encountered in the channel section extending from Van Buren to Buckeye Road. A total of 20 trenches were done on this section, 5 on each bank and 10 in the riverbed. Surface trenches T-1 through T-10 were not logged and logs T-11 through T-20 are presented in the Appendix. Composite sample #4 is a sand with trace silt and gravel. At a moisture content of 8% and 11% cement content, the compressive strength was 700 PSI. Increasing the cement content to 12% increased the strength to 1150 PSI and at 14% cement content the compressive strength was 1200 PSI. At 8.0% moisture content, a compressive strength of 750 PSI requires adding 11.2% cement to this material and adding 12.5% cement gives a compressive strength of 1000 PSI. An additional 2% cement is added in Arizona to ensure erosion control; at 13.2% cement the compressive strength would be approximately 1100 PSI and at 14.5% cement the strength would be 1350 PSI.

84-307 (SLA Project #AZ-MC-09). Composite sample #5 is representative of materials encountered in the channel section extending from I-10 to Buckeye Road. Three borings were made along the alignment for the proposed grade

control structure. Fine to medium sands and gravelly sands were encountered at various depths to approximately 40 feet. Composite sample #5 is a sand with some silt and trace gravel. At a moisture content of 10% and 8% cement content the compressive strength was 700 PSI. Increasing the cement content to 9.5% increased the strength to 800 PSI, at 11.0% cement the strength was 1100 PSI, and at 12.5% cement content the compressive strength was 1200 PSI. At 8.0% moisture content a compressive strength of 750 PSI requires adding 8.6% cement to this material and adding 11.0% cement gives a compressive strength of 1000 PSI. An additional 2% cement is added in Arizona to ensure erosion control; at 10.6% cement, 975 PSI would result and at 13.0% cement 1250 PSI would result.

CONCLUSIONS

Silts and fine sands are not suitable for soil-cement mix designs. Well graded sands are the most suitable for mixing with soil cement. The soil used in the soil-cement mix should not contain any material retained in a 1.5 inch sieve nor any deleterious material. Strata throughout the riverbed varies in gradations enough so that once the material is mixed and screened an acceptable gradation for soil-cement design can be achieved. Desert Earth Engineering recommends that a soils technician/engineer be present at the time of construction to aid in identifying suitable mix design materials and to aid in obtaining an appropriate mix design.

PERMEABILITY

Five permeability tests were conducted on selected samples from trenches from 84-211. Due to the loose nature of the material encountered, undisturbed samples could not be obtained. Disturbed samples were remolded to their approximate in-situ density and Falling Head Permeability Tests conducted on the remolded samples. Results of the tests are presented in Table 2 in Appendix B.

In general, the bank material is not very permeable even though it is fairly loose. This is due to the relatively high silt content. Fine sands have a range of 1.9×10^{-3}.

LIMITATIONS

The field and laboratory testing relevant to this report was performed, unless otherwise noted, by Desert Earth Engineering. This work was performed in accordance with generally accepted engineering principles and practices.

This report assumes the subsurface conditions are as found in the test bore holes. If any conditions other than those assumed are encountered when making excavations, the owner or his representative should notify the Soil Engineer immediately so that supplementary recommendations can be made.

This report is issued with the understanding that it is the responsibility of the owner or his representative to ensure that the applicable provisions of the recommendations contained herein are called to the attention of the Structural Engineers and incorporated into the plans. Also, it is assumed that the necessary steps are taken to see that the contractor and subcontractors carry out such provisions in the field.

We wish to thank you for the pleasure of being associated with you on this project. If we can be of further assistance, please call us.

Submitted By:

Registered Professional Engineer (Civil)
CERTIFICATE NO.
10296
ROBERT L.
SOGGE
Date Signed .....
ARIZONA, U.S.A.

R. L. Sogge, P.E.

RLS/ajt

Copies: (2) Addressee

TABLE 1

84-208 Indian School Road Bridge
Sands, gravels and cobbles

Composite sample #1: Sand with some gravel

Soil Cement %	Moisture Content %	Compressive Strength (psi)
6.5	8.0	200
8.0	8.0	700
9.5	8.0	1000
11.0	8.0	1500

84-209 McDowell Road downstream to 500 feet south of I-10
Riverbed - sands, gravels, and cobbles
Bank Material - sand with some silt and silty sands

84-209(A) Composite sample #2: Fine sand with some silt and trace gravel

Soil Cement %	Moisture Content %	Compressive Strength (psi)
9.0	8.0	175
11.0	8.0	253
12.5	8.0	319

84-209(B) Composite sample #3: Sand with trace gravel and silt

Soil Cement %	Moisture Context %	Compressive Strength (psi)
11.0	8.0	700
12.5	8.0	900
14.0	8.0	1100

TABLE 1 (continued)

84-211 Van Buren to Buckeye Road

Composite sample #4: Sand with trace silt and gravel

Soil Cement %	Moisture Content %	Compressive Strength (psi)
11.0	8.0	700
12.5	8.0	1150
14.0	8.0	1200

84-307 I-10 to Buckeye Road
Sands and gravelly sands

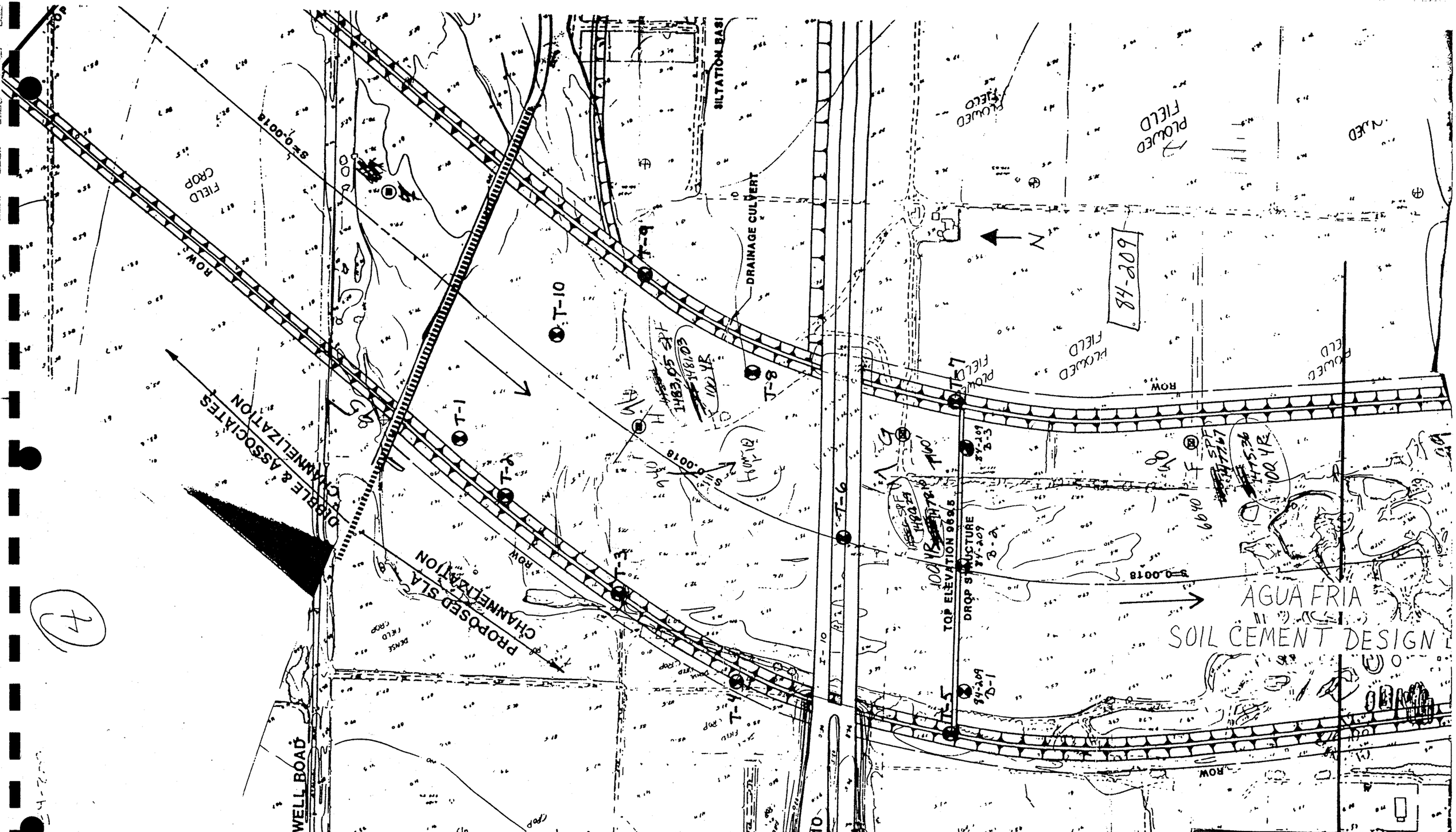
Composite sample #5: Sand with some silt and trace gravel.

Soil Cement %	Moisture Content %	Compressive Strength %
8.0	10.0	700
9.5	10.0	800
11.0	10.0	1100
12.5	10.0	1200

TABLE 2

Sample	Depth	Dry Density	Void Ratio	Permeability	Est. % Compaction
T-11	1	103.2 pcf	.571	2.9×10^{-2} cm/sec	94
T-12		107.3	.512	1.9×10^{-2} cm/sec	96
T-16	3-5	95.4	.701	4.5×10^{-5} cm/sec	93
T-17	5	87.2	.860	4.9×10^{-5} cm/sec	91
T-19	3-4	95.2	.703	7.0×10^{-6} cm/sec	89

1
N
1"=400'
PROJECT SITE
INDIAN SCHOOL ROAD
McDOWELL ROAD
I-10
VAN BUREN ROAD
BUCKEYE ROAD
AGUA FRIA
SPUR DIKE
ROW
350'
550'
47
48
50
53
POST PROJECT FLOODWAY
POST PROJECT 100 YR. FLOOD PLAIN
GRADE CHANGE
TOP ELEVATION 1000.0
PROP STRUCTURE
B-1
B-2
B-3
B-4
T-1
T-2
T-3
T-4
S=0.0032
RID FLUME
DROP STRUCTURE
TOP ELEVATION = 992.6
PRE PROJECT FLOODWAY
INDIAN SCHOOL ROAD
PRE PROJECT 100 YR. FLOOD PLAIN
84-208
AGUA FRIA -
SOIL CEMENT DESIGN
Desert Earth Engineering
consulting geotechnical engineers
Drawn by: RT
Date 2-12-85
Checked by: RJ
2/25/
Sheet 1 of 3
Job No. 84-208
Figure No. 1

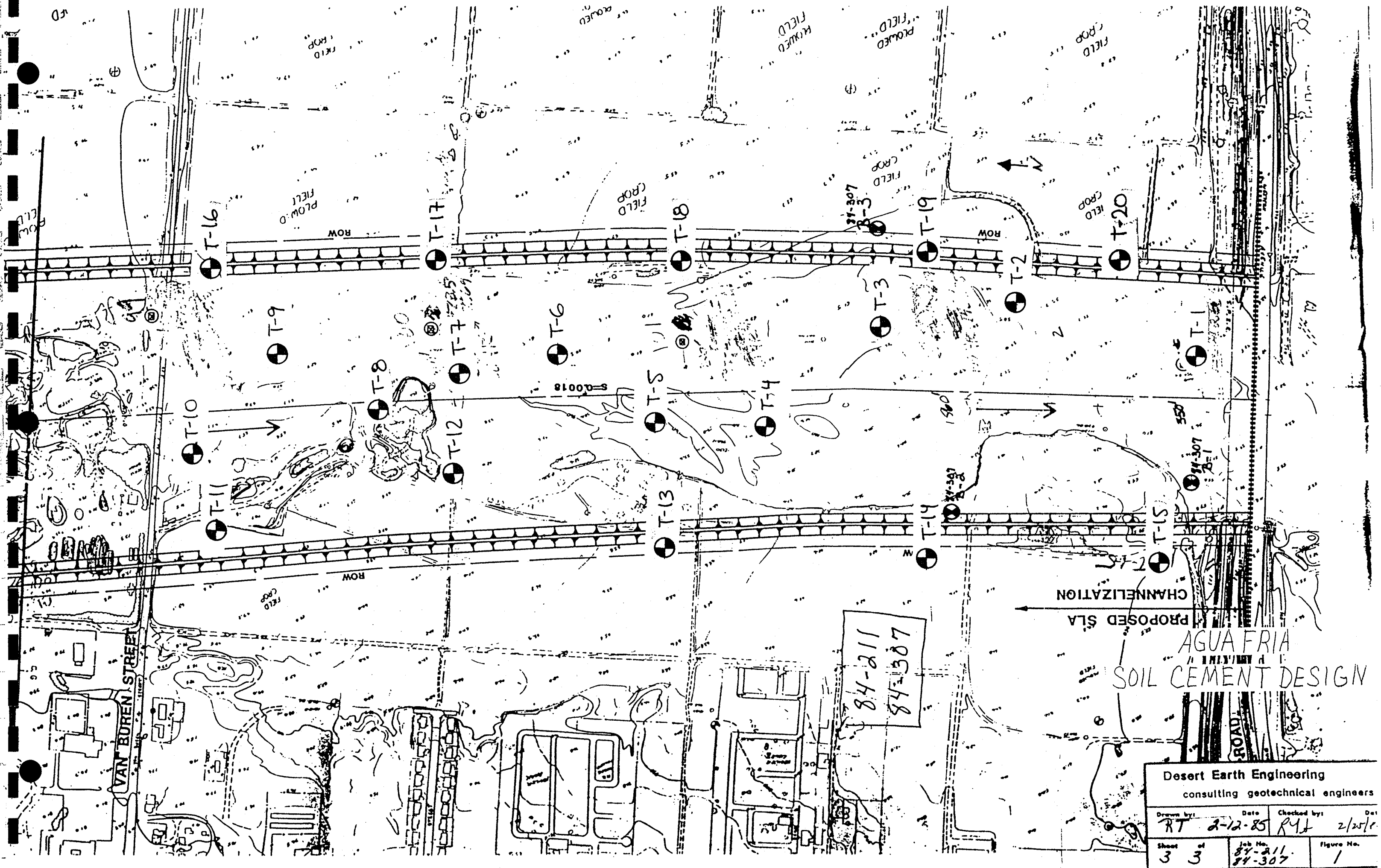


Desert Earth Engineering
consulting geotechnical engineers

Drawn by:	Date	Checked by:	Date
RT	2-12-85	RJ	2/25/85

Sheet	of	Job No.	Figure No.
2	3	84-209	4

(4)


T-1
T-2
T-3
T-4
T-5
T-6
T-7
T-8
T-9
T-10
T-11
T-12
T-13
T-14
T-15
T-16
T-17
T-18
T-19
T-20
ROW
S-00018
VAN BUREN STREET
PROPOSED SLA
CHANNELIZATION
AGUA FRIA
SOIL CEMENT DESIGN
ROAD
84-211
84-307
Desert Earth Engineering
consulting geotechnical engineers
Drawn by: RT
Date 2-12-85
Checked by: RJL
Date 2/25/8
Sheet 3 of 3
Job No. 84-211 84-307
Figure No. 1

APPENDIX A

Soil Boring Logs

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rv

LOCATION OF BORING

See Site Plan Figure #1

DRILLING METHOD & EQUIPMENT: CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers

SAMPLING METHOD: Split-spoon Penetrometer

BORING NO.: B-1

SHEET: 1 OF 2

ENGINEER: RMP

TIME: 7:30

DATE: 12 Sept 84

DATUM

ELEVATION 1000

CASING DEPTH

SURFACE CONDITIONS: River Bottom

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0			(SP) brown M-C SAND w/trace gravel; moist subrounded to subangular, loose
			1			
			2			cobbles
			3			
			4			
			5			
SS	18/18	8/8/6	6			
			7			
			8			
			9			
			10			
SS	18/18	2/1/2	11			
			12			
			13			
			14			
			15			(SW-SC)trace clay, very slightly plastic, well graded,
SS	18/18	11/14/9	16			
			17			
			18			
			19			
			20			coarse gravel & cobbles rounded to

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: CME-55 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers

SAMPLING METHOD: Split-spoon Penetrometer

CASING DEPTH

BORING NO.: B-1

SHEET: 2 of 2

ENGINEER: RMP

TIME: 9:15

DATE: 12 Sept 84

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			20			(SP) brown medium SAND, moist, subrounded
SS	18/18	5/11/14	21			
			22			
			23			rocky drilling, cobbles
			24			rocky
			25			
			26			auger refusal @25.0'
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
	CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-2
		SHEET 1 OF 1
		ENGINEER RMP
	SAMPLING METHOD: Split-spoon Penetrometer	TIME 1:30-2:30
		DATE 12 Sept 84
DATUM	ELEVATION 1000	CASING DEPTH

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS: River bottom
			0			(SP) brown M-C SAND w/trace gravel, moist subangular, gap-graded
			1			
			2			occasional small cobbles
			3			
			4			
			5			split spoon refusal twice @ 5.0' - cobbles at bottom of hole
SS	0 / 0		6			coarse gravel - small cobbles in auger cuttings, rounded to subrounded
			7			
			8			
			9			
			10			(SP-SC) slight trace of clay
SS	11 / 10	7/15(5")	11			split spoon refusal after 11', rock
			12			cobbles
			13			cobbles & coarse gravel
			14			
			15			split spoon refusal after 6", rock
SS	6 / 0	13(6")	16			
			17			
			18			
			19			Auger refusal @ 17.5', rock
			20			

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
10 ft North of B-2	CME-55 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-2a
		SHEET 1 OF 1
	SAMPLING METHOD: Split-spoon Penetrometer	ENGINEER: RMP
		TIME
		DATE: 12 Sept 84
DATUM	ELEVATION 1000 / CASING DEPTH	

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
						River Bottom
			0			(SW) brown SAND with trace gravel
			1			Occasional coarse gravel and cobbles
			2			
			3			
			4			Rocky Auger refusel @ 4.0 ft/ 2 times
			5			
			6			
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY ____

DATE ____

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rv

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
30' NE of B-2	CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-2b
		SHEET 1 OF 1
	SAMPLING METHOD: Split-spoon Penetrometer	ENGINEER RMP
		TIME 2:50-3:30
		DATE 12Sept 84
DATUM	ELEVATION 1000 / CASING DEPTH	

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0			Brown SAND with trace gravel
			1			Occasional cobbles
			2			
			3			Auger refusel @ 3.0 ft/ moved 1.0' SW
			4			
			5			
			6			
			7			Cobbles
			8			
			9			
			10			Boulder @ 10.0 ft
			11			
			12			Cobbles, very rocky
			13			
			14			Auger refusal @ 14.0
			15			
			6			
			7			
			8			
			9			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
See Site Plan, Figure 1	CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-2d
		SHEET 1 OF 1
	SAMPLING METHOD: Split-spoon Penetrometer	ENGINEER: RMP
		TIME: 6:30-6:45
	CASING DEPTH	DATE: 13 Sept 84

DATUM ELEVATION 1002

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
						River Bottom
			0			(SW) Brown SAND with trace gravel, moist subangular to subrounded, loose, wll-graded
			1			
			2			Occasional cobbles
			3			
			4			Rocky
			5			
			6			Auger refusal @ 5.0 ft
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr.

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
See Site Plan, Figure 1	CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-3
		SHEET 1 OF 1
	SAMPLING METHOD: Split-spoon Penetrometer	ENGINEER: RMP
		TIME: 6:45-7:20
		DATE: 13 Sept 84
DATUM	ELEVATION 1003	CASING DEPTH

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS: River Bottom
			0			(SW) Brown SAND w/trace gravel, moist, loose subrounded to subangular, well-graded
			1			
			2			
			3			
			4			
			5			
			6			Rocky
			7			
			8			
			9			Occasional cobbles, rounded to subrounded
			10			
			11			
			12			
			13			Rocky, coarse gravel-and-cobble seam
			14			
			15			
SS	11 / 6	31/50/5"	16			Split spoon on a cobble final 6"
			7			Auger refusal @ 16.0'
			8			
			9			

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr.

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
See Site Plan, Figure 1	CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-4
		SHEET 1 OF
	SAMPLING METHOD	ENGINEER RMP
	Split-spoon Penetrometer	TIME 7:30-7:40
		DATE 13Sept 84
DATUM ELEVATION 1005	CASING DEPTH	

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
						River Bottom
			0			(SW) Brown SAND w/trace gravel & occasional cobbles, loose, dry, well-graded
			1			
			2			
			3			
			4			Large cobble or boulder
			5			
			6			Auger refusal @ 4.5'/ moved 2' south refusal @ 4.5' again
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Avr.

LOCATION OF BORING	DRILLING METHOD & EQUIPMENT	BORING NO.
See Site Plan, Figure 1	CME-55 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers	B-4a
		SHEET 1 OF 2
	SAMPLING METHOD: Split-spoon Penetrometer	ENGINEER: RMP
		TIME: 7:40-
		DATE: 13 Sept 84
DATUM	ELEVATION 1005	CASING DEPTH

SURFACE CONDITIONS: River Bottom

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0			(SW-SC) Brown SAND w/trace gravel, moist, loose
			1			1" layers of varved clay
						occasional cobbles
			2			1st Auger refusal @ 2.0 ft
			3			
			4			
			5			
			6			
			7			Occasional cobbles
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-208	Simons, Li & Associates	Indian School & Aqua Fria Rvr

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: CME-45 Drill Rig equipped with 6 5/8" OD 3 1/4" ID hollow-stem continuous flight augers

SAMPLING METHOD: Split-spoon Penetrometer

CASING DEPTH:

BORING NO.: B-4a

SHEET: 2 OF 2

ENGINEER: RMP

TIME: 8:30

DATE: 13Sept 84

DATUM

ELEVATION 1005

SURFACE CONDITIONS: River Bottom

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			20			Cobbles and coarse gravel
			21			
			22			Auger refusal @ 21.0 ft
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING: See Site Plan, Figure 1

DRILLING METHOD & EQUIPMENT: CASE 580 Backhoe equipped with 18" bucket

BORING NO.: T-1

SHEET: OF

ENGINEER: RMP

SAMPLING METHOD:

TIME:

DATE: 6 Nov 84

CASING DEPTH:

DATUM: ELEVATION:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SW)	brown SAND with trace gravel & occasional cobbles; slightly moist, soft
			1			
			2			
			3			side slopes below 3' nearly vertical
B			4			slightly fewer cobbles, moist
			5			
			6			
			7			
			8			
			9			
			10			harder
			11			
			12			
			13			
			4			bottom @ 12.5'
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

BORING NO. T-2

SHEET OF

ENGINEER RMP

SAMPLING METHOD

TIME 8:20

DATE 6 Nov 84

DATUM ELEVATION

CASING DEPTH

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0			(SP) brown medium SAND with trace coarse gravel slightly moist, side slopes @ 1:1
			1			
			2			occasional 6-18" seams of well-graded SAND with some gravel, few cobbles
			3			
			4		(SM)	SILTY SAND pockets; moist, soft
			5			
			6			
			7			
			8			
			9			
			10			
			11			bottom @ 10.5'
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

BORING NO. T-3

SHEET OF

ENGINEER RMP

SAMPLING METHOD

TIME 9:00

DATE 6 Nov 84

CASING DEPTH

DATUM ELEVATION

SURFACE CONDITIONS

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0			(SP-SM) brown fine SAND with trace silt; dry loose
			1			clean SAND
			2			piece of rebar @2.0', side slopes @ 1:1 to 2:1
			3			some layers of well-graded SAND with some gravel
			4			
			5			
			6			no significant change in material
			7			
			8			
			9			
			10			
			11			bottom @ 10.5'
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe with 18" bucket

BORING NO.: T-4

SHEET: OF

ENGINEER: RMP

SAMPLING METHOD

TIME: 9:55

DATE: 6 Nov 84

CASING DEPTH

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SM)	brown SILTY SAND; medium dense, occasional coarse gravel, vertical side slopes
			1			
			2			
B			3			
			4			
			5			
			6			less silt, some lime cementation
			7			
			8			brown SAND with trace silt; dense
			9			
			10			vertical side slopes entire depth
			11			
			12			backhoe refusal @ 10.5'; very hard caliche layer
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe

BORING NO.: T-5

SHEET ___ OF ___

ENGINEER: RMP

SAMPLING METHOD

TIME: 10:30

DATE: 6 Nov 84

CASING DEPTH

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SM)	brown SILTY SAND, soft
			1			
			2			
			3			
			4			
			5			
			6			Bottom of hole at 6.0'
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY ___

DATE ___

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe with 18" bucket

BORING NO.: T-6

SHEET: OF

ENGINEER: RMP

SAMPLING METHOD

TIME: 10:40

DATE: 6 Nov 84

CASING DEPTH

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SP)	brown fine-to-medium SAND with trace gravel; medium dense, dry
			1			slopes 1:1
			2			
			3			
			4			
			5			coarse gravel seam
			6			
			7			
			8			
			9			material consistent 0-10'. No cobbles encountered
			10			
			11			bottom @ 10.0'
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

BORING NO. T-7

SHEET OF

ENGINEER RMP

SAMPLING METHOD

TIME 11:23

DATE 6 Nov 84

DATUM

ELEVATION

CASING DEPTH

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SP)	brown fine SAND with some silt, dry
			1			some roots
			2			
			3			
			4			
			5			
			6			
			7			slightly moist
			8			material consistent to 8.0'
			9			bottom @ 8.0'
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe equipped with 18" bucket

BORING NO.: T-8

SHEET OF

ENGINEER: RMP

SAMPLING METHOD

TIME: 11:33

DATE: 6 Nov 84

CASING DEPTH

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
						BANK
			0			(SM) brown SAND with some silt; slightly moist
			1			some coarse gravel pockets,
			2			(SP) brown, almost clean, fine-to-medium SAND
			3			
			4			
			5			
			6			(SW) SAND is well-graded
			7			
			8			
			9			
			10			
			11			
			12			
			13			bottom @ 11.5'
			14			
			15			
			16			
			17			
			18			
			19			
			20			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe

BORING NO.: T-9

SHEET: OF

ENGINEER: RMP

SAMPLING METHOD

TIME: 12:16

DATE: 6 Nov 84

CASING DEPTH

DATUM

ELEVATION

SURFACE CONDITIONS: Bank

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0			(SM) brown SILTY SAND
			1			
			2			
			3			
			4			
			5			
			6			
			7			bottom @ 6.0'
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-209	Simons, Li & Associates	AF & I-10

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe

SAMPLING METHOD

CASING DEPTH

BORING NO.: T-10

SHEET OF

ENGINEER: RMP

TIME: 12:22

DATE: 6 Nov 84

DATUM

ELEVATION

SURFACE CONDITIONS: Riverbed - gravel & cobbles on surface

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0		(SW)	brown SAND with trace gravel and occasional cobbles; slightly moist, well-graded, rounded to subrounded
			1			
			2			
			3			large fragments of concrete at 3-4'
			4			bottom @ 4'
			5			
			6			
			7			
			8			
			9			
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING: See Site Plan, Figure 1

DRILLING METHOD & EQUIPMENT: Case 580 backhoe equipped with 18" bucket

BORING NO.: T-11

SHEET: OF

ENGINEER: RMP

SAMPLING METHOD:

TIME: 1:50

DATE: 6 Nov 84

CASING DEPTH:

DATUM: ELEVATION:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(GW)	SANDY GRAVEL
			1		(SP)	brown fine SAND with trace gravel; dry loose
			2			
			3			side slopes @ 1:1 from 0-15'
			4			
			5			
			6		(SW)	SAND is well-graded
			7			
			8			
			9		(SP)	brown clean F-M SAND with trace gravel and occasional cobbles; medium dense, dry
			10			
			11			
			12			
			13			
			14			
			15			bottom @ 15.0'
			16			
			17			
			18			
			19			
			20			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING: See Site Plan, Figure 1

DRILLING METHOD & EQUIPMENT

SAMPLING METHOD

CASING DEPTH

BORING NO. T-12

SHEET OF

ENGINEER RMP

TIME 2:00

DATE 6 Nov 84

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SW)	brown well-graded SAND with trace gravel and occasional cobbles
			1			
			2			
			3			brown-red SAND with trace silt 1-2" gravel & cobble seams every 6-12" from 2.5 - 20'
			4			
			5			
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			
			14			
			15			material consistent 2.5 - 20'
			16			
			17			
			18			
			19			bottom @ 20.0'
			20			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING: See Site Plan, Figure 1

DRILLING METHOD & EQUIPMENT: Case 580 backhoe equipped with 18" bucket

SAMPLING METHOD:

CASING DEPTH:

BORING NO.: T-13

SHEET: OF

ENGINEER: RMP

TIME: 2:11

DATE: 6 Nov 84

DATUM: ELEVATION:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SW)	brown well-graded SAND with trace gravel; dry, medium dense
			1			
			2			
			3			occasional fine gravel seams 2.5 - 4'
			4			
			5			pockets with trace to some silt
			6			
			7			side slopes 1.5:1
			8			
			9			bottom @ 8.0'
			0			
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe

BORING NO.: T-14

SHEET: OF

ENGINEER: RMP

SAMPLING METHOD

TIME: 2:45

DATE: 6 Nov 84

DATUM

ELEVATION

CASING DEPTH

SURFACE CONDITIONS: Farmer's field

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0			(SM) brown SILTY SAND; dry, loose, some organics
			1			
			2			some 3-6" layers of fine SAND
			3			
			4			
			5		(SP)	brown, fine-to-medium SAND
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			bottom @ 12.0'
			14			
			15			
			16			
			17			
			18			
			19			
			20			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe

BORING NO.: T-15

SHEET ___ OF ___

ENGINEER: RMP

SAMPLING METHOD

TIME: 3:10

DATE: 6 Nov 84

CASING DEPTH

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0			red-brown SAND with trace gravel and clay,
			1			intermixed with garbage, very
						odiferous.
			2			tent fabric
			3			bottles, grass cuttings
						tire, tree stump,
			4			newspapers at 4.0' dated July, 1980
			5			palm fronds
						pipe fittings
			6			old telephone wire
						aerosal spray can
			7			mattress, two-by-four
			8			paper plates, grass cuttings
			9			tennis shoe, comics, plastic buckets
			10			hose, tomato juice cans
			11			door screen, August 1980 newspaper
			12			palm verde branch
			3			bottom @ 12.5'
			4			
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT: Case 580 backhoe

SAMPLING METHOD

CASING DEPTH

BORING NO.: T-16

SHEET OF

ENGINEER: RMP

TIME: 1:25

DATE: 7 Nov 84

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SM)	brown SILTY fine SAND
			1			
			2			
			3			
			4			
			5			
			6		(SW)	brown SAND with some gravel; dry,
			7			well-graded
						cobble and coarse gravel seam
			8		(GP)	brown, fine SAND
			9			well-graded, moist
			10			
			11			
			12			
			3			
			4			bottom @12.5'
			5			
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

SAMPLING METHOD

CASING DEPTH

BORING NO. T-17

SHEET OF

ENGINEER RMP

TIME 1:50

DATE 7 Nov 84

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SM)	brown SILTY fine SAND
			1			
			2			
			3			
			4			
			5			varved 6-8" layers of CLAY
			6		(SP)	fine brown SAND
			7		(SW)	well-graded SAND with some gravel
			8			
			9			occasional cobbles
			10			
			11			
			12			
			13			
			14			bottom @13.0'
			15			
			16			
			17			
			18			
			19			
			20			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

SAMPLING METHOD

CASING DEPTH

BORING NO. T-18

SHEET OF

ENGINEER RMP

TIME 2:05

DATE 7 Nov 84

DATUM

ELEVATION

SURFACE CONDITIONS

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	
			0		(ML)	brown SANDY SILT; dry medium dense some roots to about 4.0'
			1			
			2			
			3			
			4			intermittent SAND layers alternating with SILTY SAND and trace gravel
			5			
			6		(SM)	SAND with some SILT; occasional seams of clean sand.
			7			
			8			
			9			gravel seam
			10			
			11			cobble
			12			bottom @ 11.0'
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

SAMPLING METHOD

CASING DEPTH

BORING NO. T-19

SHEET OF

ENGINEER RMP

TIME 2:30

DATE 7 Nov 84

DATUM

ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0			(SM) brown SILTY SAND; dry, medium dense
			1			
			2			
			3			
			4			
			5			slightly moist
			6			
			7			
			8			some varved red-black clay and some in small pockets, moist, very platic
			9			
			10			(SW) brown SAND with trace gravel
			11			
			12			gravel seam
			13			
			14			
			5			bottom @ 14.0'
			6			
			7			
			8			
			9			
			0			

CHKD BY

DATE

desert earth engineering

JOB NO.	CLIENT	LOCATION
84-211	Simons, Li & Associates	AF & VB

LOCATION OF BORING

DRILLING METHOD & EQUIPMENT

SAMPLING METHOD

CASING DEPTH

BORING NO. T-20

SHEET OF

ENGINEER RMP

TIME 2:55

DATE 7 Nov 84

DATUM ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	BLOWS/6" SAMPLER	DEPTH IN FEET	BULL-NOSE BLOWS/FT	SOIL GRAPH	SURFACE CONDITIONS
			0		(SM)	brown SILTY fine SAND, loose
			1			occasional small gravel and sand seams, denser
			2			
			3			
			4			
			5			
			6			
			7			slightly more sand
			8			
			9		(SW)	clean SAND with some gravel
			10			
			11			
			12			
			13			
			14			
			15			bottom @ 14.0'
			16			
			17			
			18			
			19			
			20			

CHKD BY

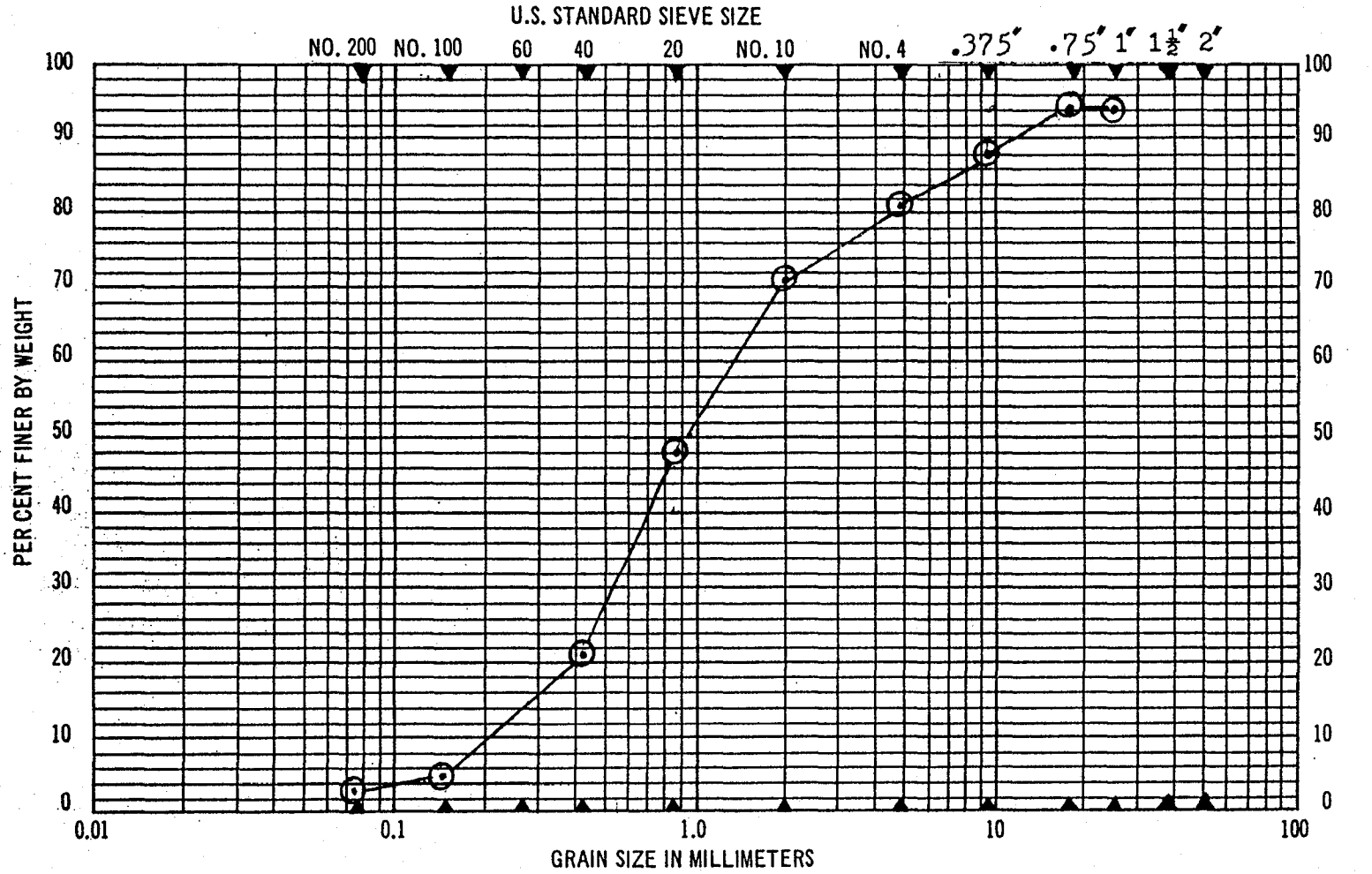
DATE

APPENDIX B

Laboratory Results

JOB NO. 84-208 BY TH DATE 7 Nov 84

KEY	BORING	DEPTH	ELEV.	SOIL CLASSIFICATION
Sample 1				(SW) SAND with some gravel and trace silt

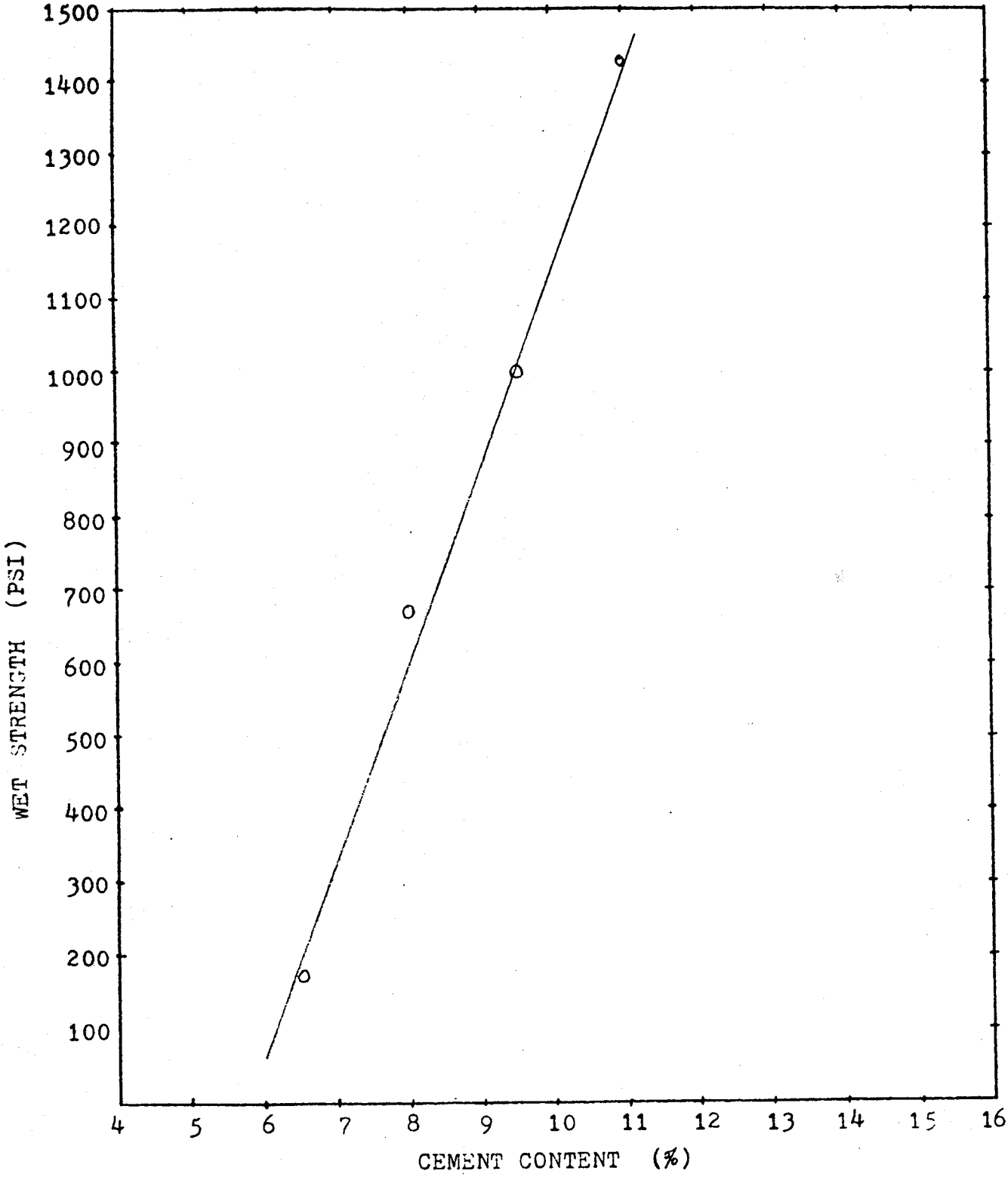


SILT OR CLAY	SAND			GRAVEL		*
	FINE	MEDIUM	COARSE	FINE	COARSE	

*COBBLES

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

desert earth engineering



SOIL-CEMENT
DRY STRENGTH VS. CEMENT CONTENT

Sample Description SAND w/some gravel + trace silt

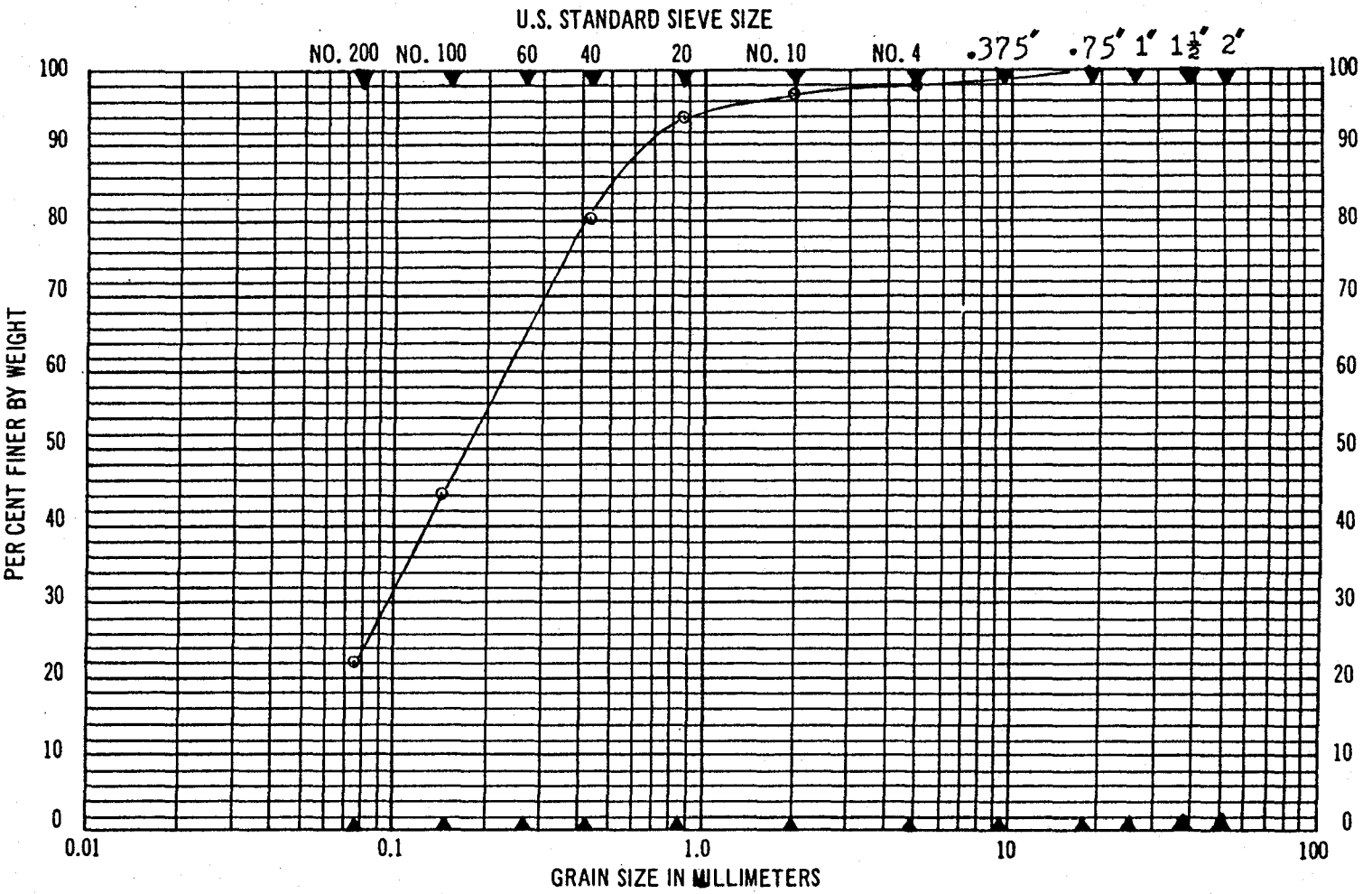
Sample Source

Sample No. 1

Desert Earth Engineering consulting geotechnical engineers			
Drawn by: RMF	Date 1-14-85	Checked by: RMS	Date 2/25/85
Sheet of	Job No. 84-208		Figure No.

JOB NO. 84-209A BY RMP DATE 11 Feb 85

KEY	BORING	DEPTH	ELEV.	SOIL CLASSIFICATION
Sample	2			SAND with some silt and trace gravel

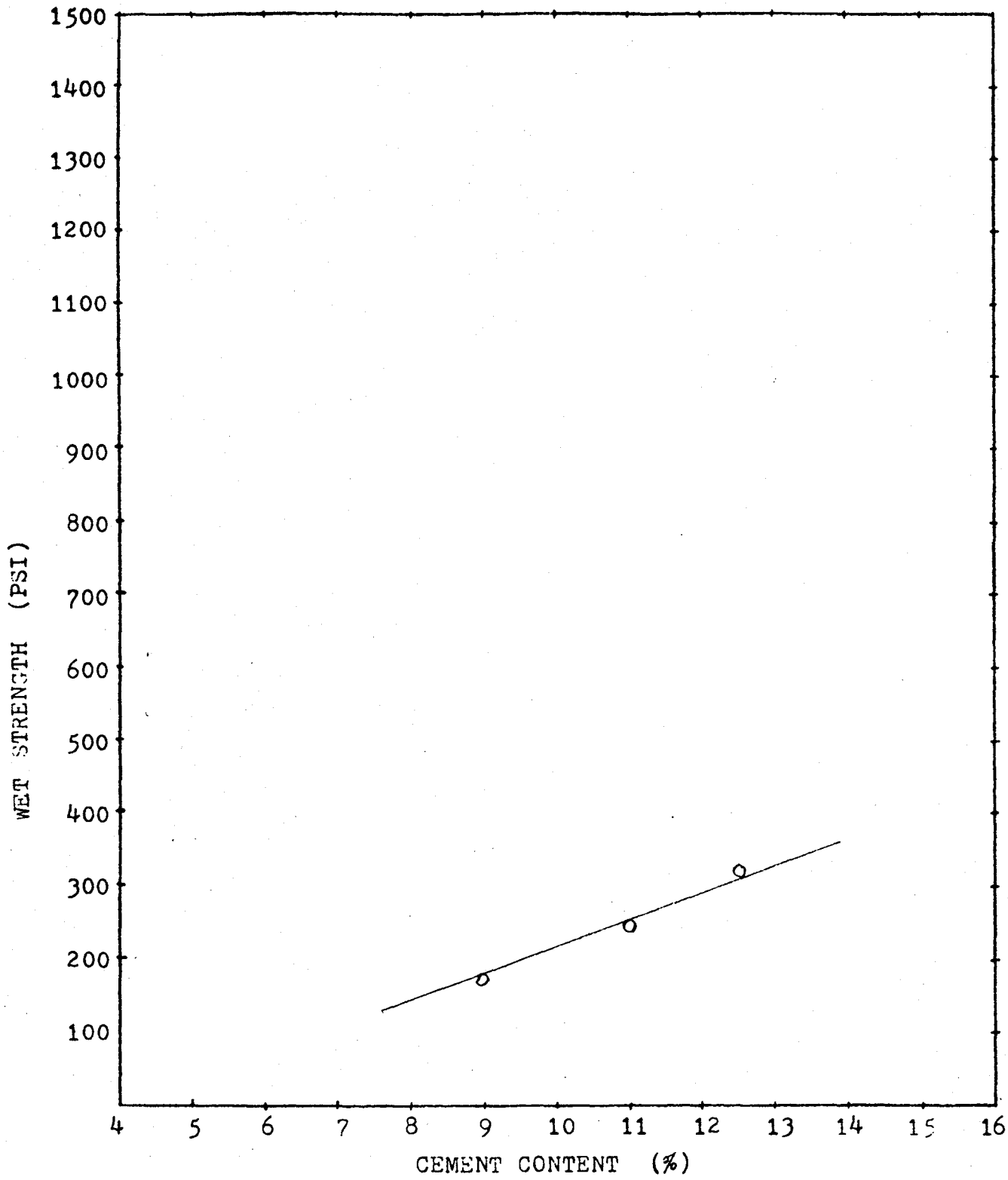


SILT OR CLAY	SAND			GRAVEL		*
	FINE	MEDIUM	COARSE	FINE	COARSE	

*COBBLES

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

desert earth engineering



SOIL-CEMENT
DRY STRENGTH VS. CEMENT CONTENT

Sample Description _____

_____

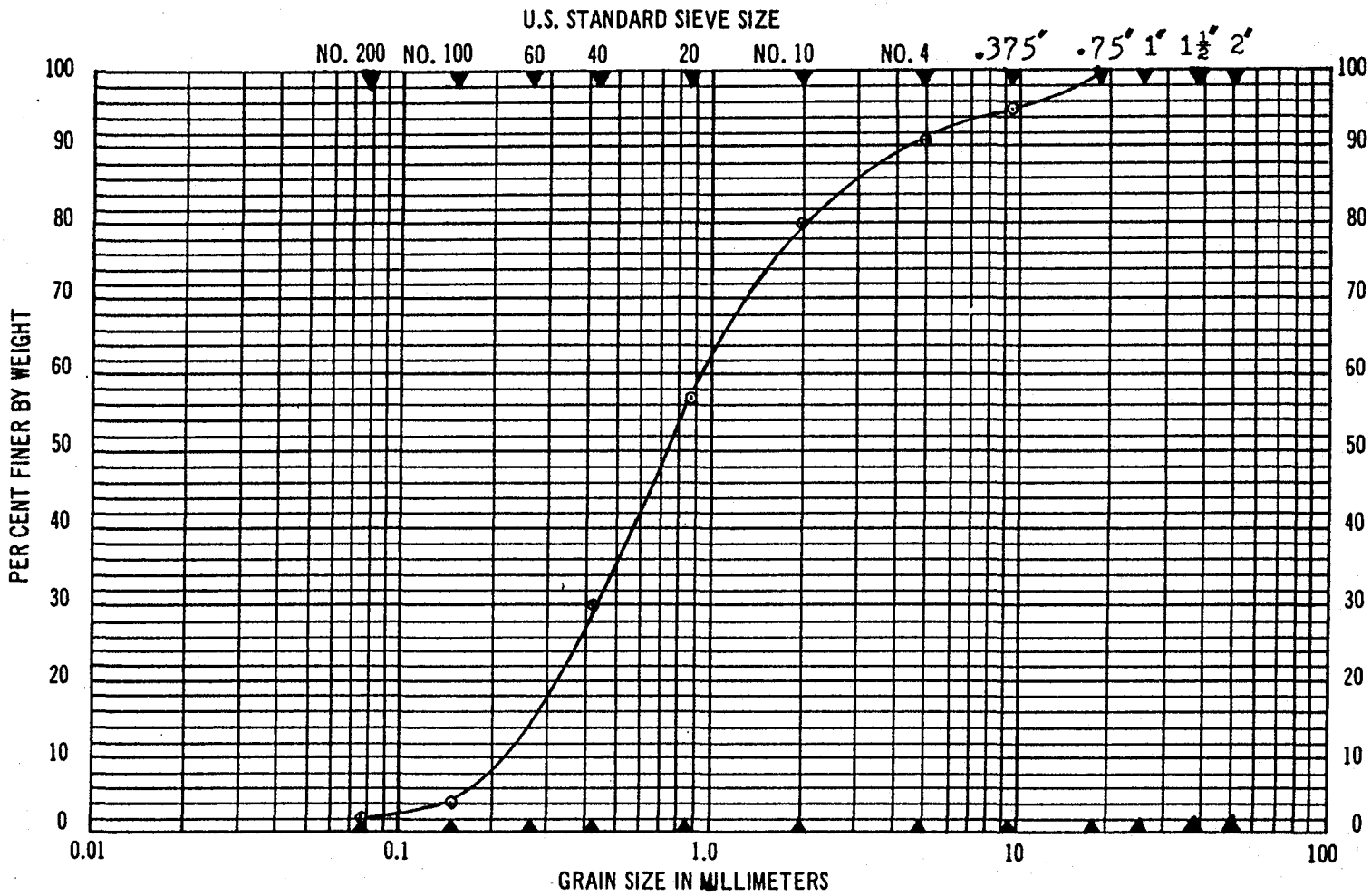
Sample Source _____

Sample No. 2

Desert Earth Engineering consulting geotechnical engineers			
Drawn by: RMP	Date 1-14-85	Checked by: RJ	Date 2/25/85
Sheet of	Job No. 84-209		Figure No.

JOB NO. 84-209B BY RMP DATE 11 Feb 85

KEY	BORING	DEPTH	ELEV.	SOIL CLASSIFICATION
Sample 3				SAND with trace gravel and silt

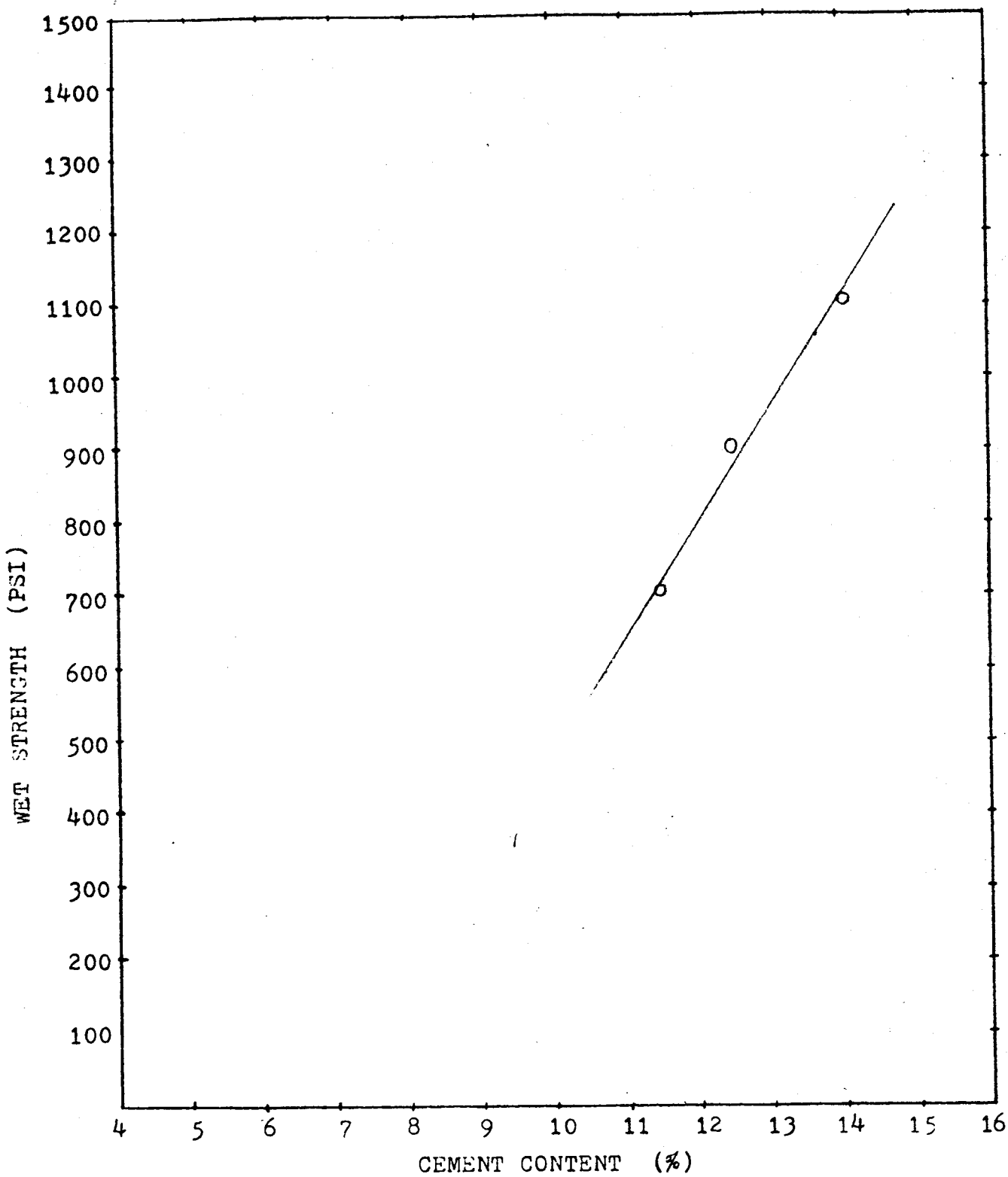


SILT OR CLAY	SAND			GRAVEL		*
	FINE	MEDIUM	COARSE	FINE	COARSE	

*COBBLES

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

desert earth engineering



SOIL-CEMENT
DRY STRENGTH VS. CEMENT CONTENT

Sample Description _____

_____

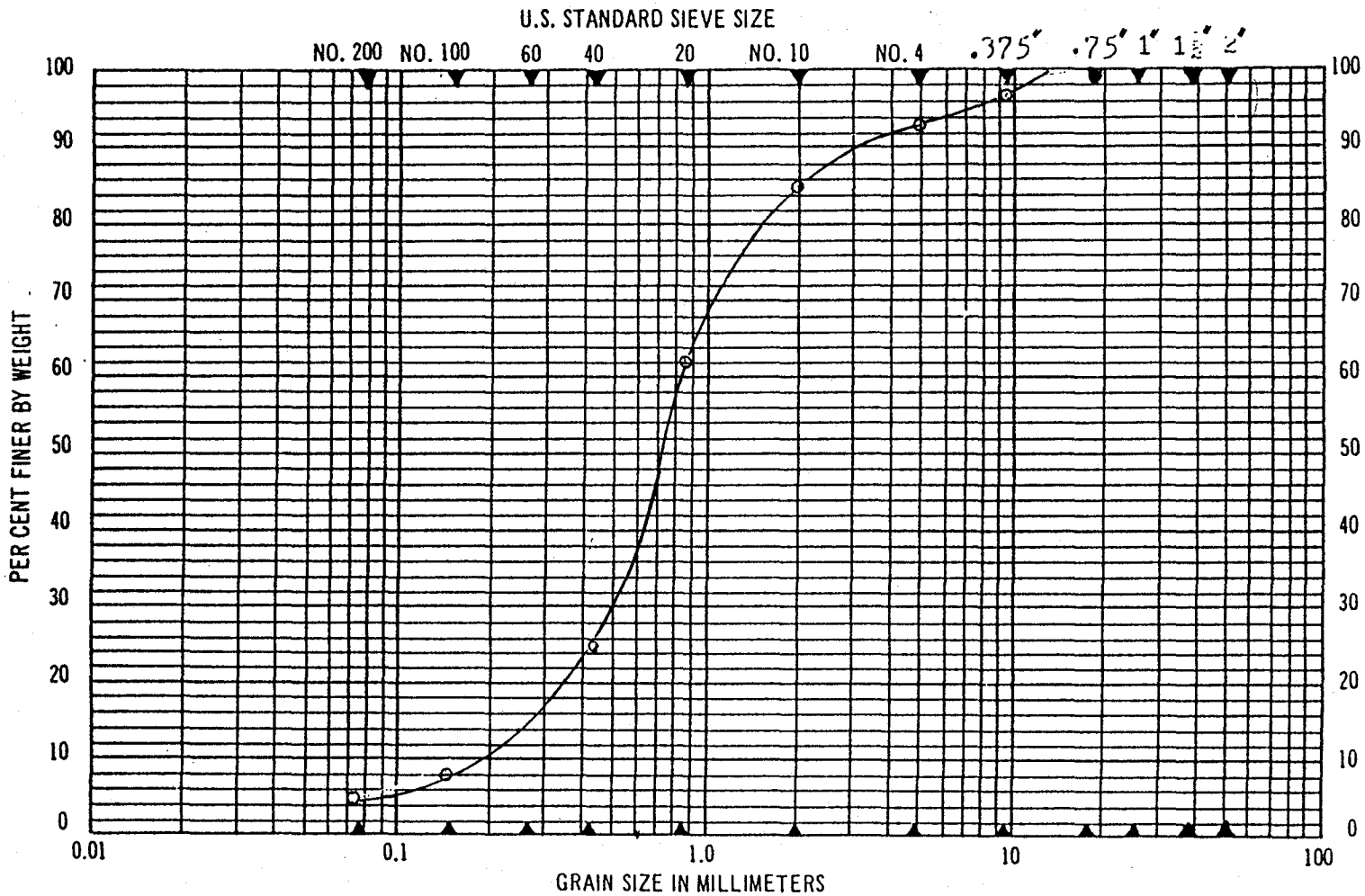
Sample Source _____

Sample No. 3

Desert Earth Engineering consulting geotechnical engineers			
Drawn by: RMP	Date 1-14-85	Checked by: RTL	Date 2/25/85
Sheet of	Job No. 84-209.		Figure No.

JOB NO. 84-211 BY RMP DATE 27 Dec 84

KEY	BORING	DEPTH	ELEV.	SOIL CLASSIFICATION
Sample 4				SAND with trace silt and gravel

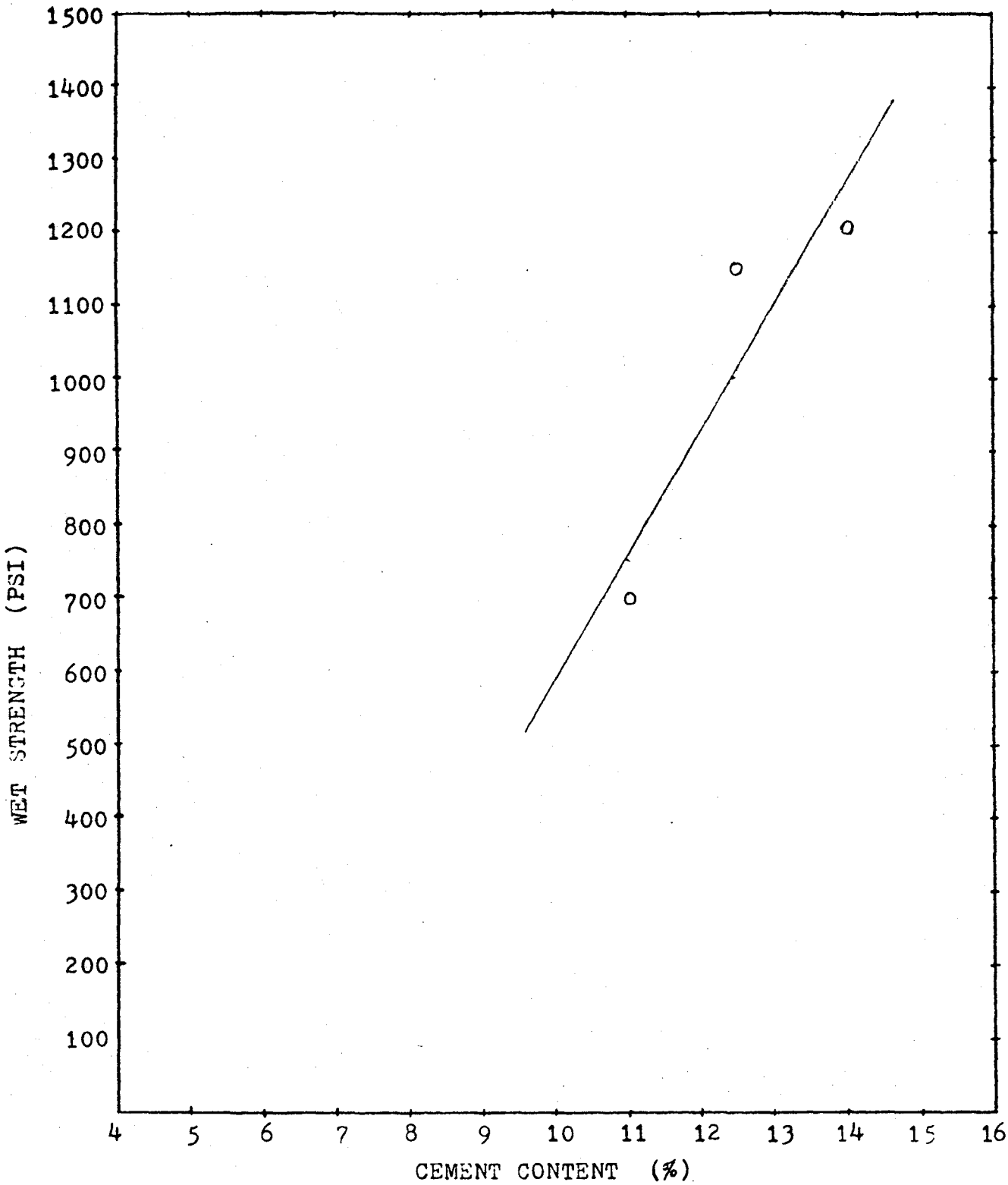


SILT OR CLAY	SAND			GRAVEL		*
	FINE	MEDIUM	COARSE	FINE	COARSE	

*COBBLES

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

desert earth engineering



SOIL-CEMENT
DRY STRENGTH VS. CEMENT CONTENT

Sample Description: SAND w/ trace fines & gravel

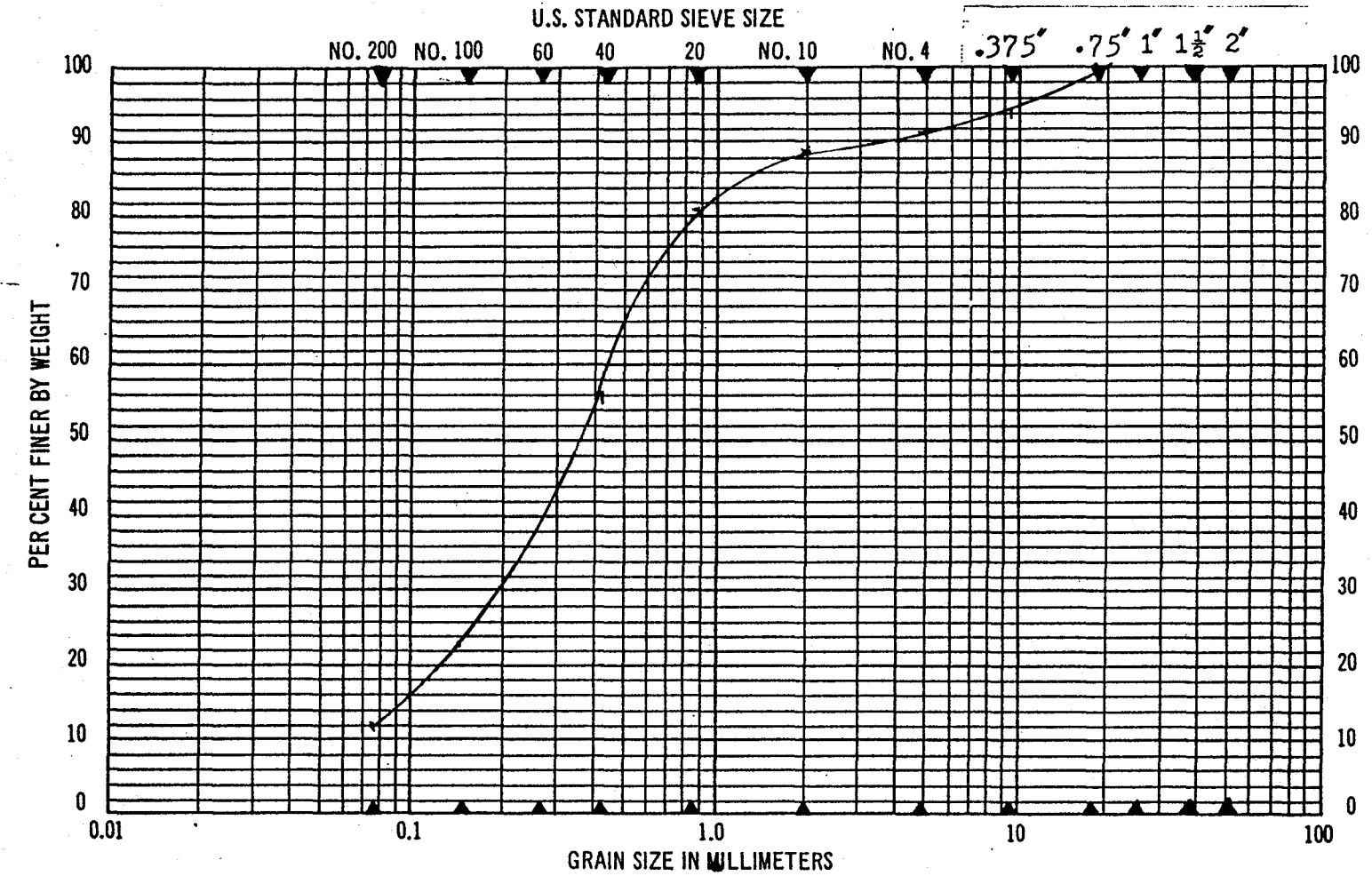
Sample Source

Sample No. 4

Desert Earth Engineering consulting geotechnical engineers			
Drawn by: RMP	Date 1-14-85	Checked by: RJ	Date 2/25/85
Sheet of	Job No. 84-211	Figure No.	

JOB NO. 84-307 BY RMP DATE 22 Jan 85

KEY	BORING	DEPTH	ELEV.	SOIL CLASSIFICATION
Sample 5				SAND with some silt and trace gravel

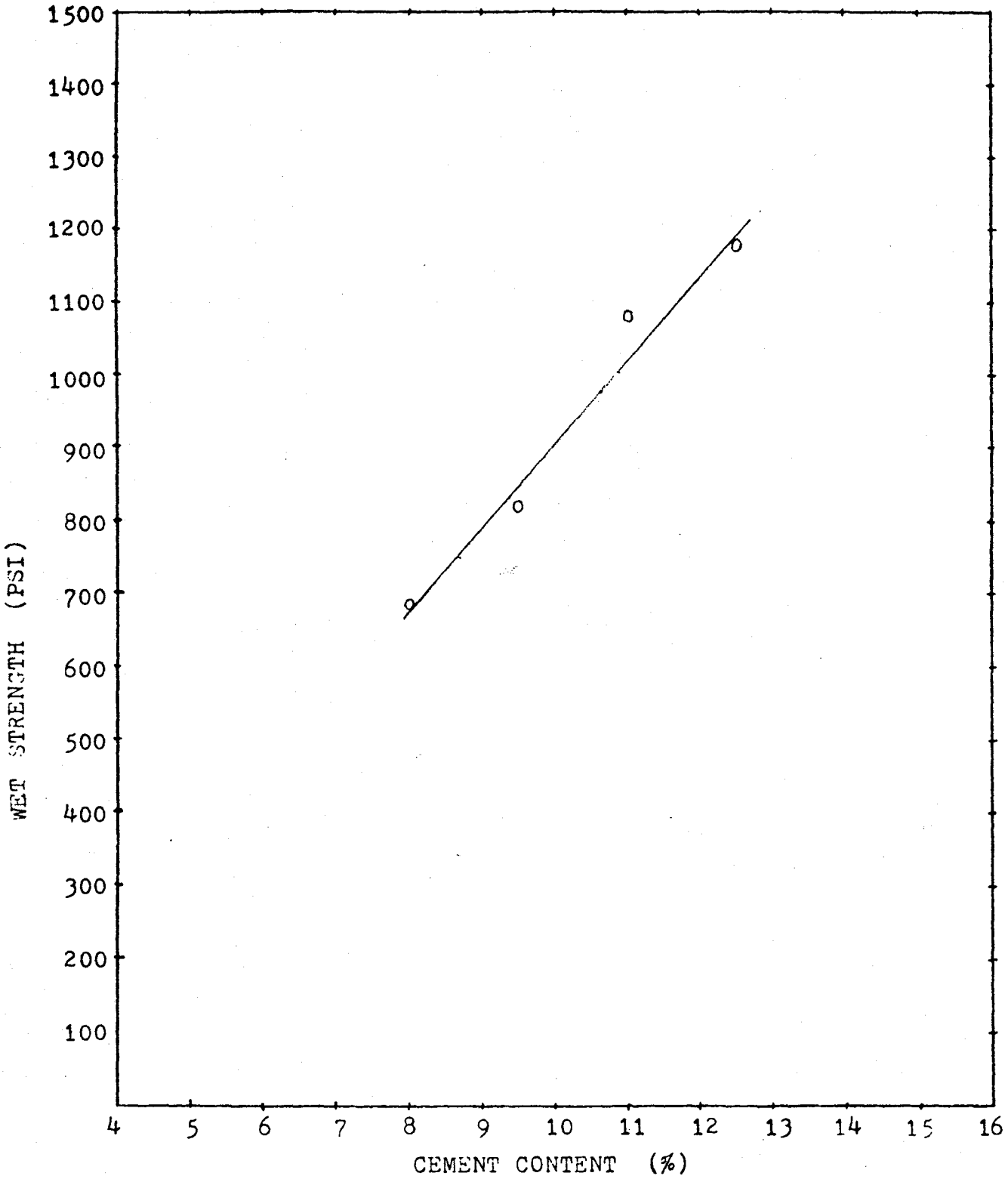


SILT OR CLAY	SAND			GRAVEL		*
	FINE	MEDIUM	COARSE	FINE	COARSE	

*COBBLES

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

desert earth engineering



SOIL-CEMENT
DRY STRENGTH VS. CEMENT CONTENT

Sample Description _____

Sample Source _____

Sample No. 5

Desert Earth Engineering consulting geotechnical engineers			
Drawn by: RMP	Date 1-14-85	Checked by: RJ	Date 2/25/85
Sheet of	Job No. 84-307	Figure No.	

APPENDIX C

Pima County Specifications for Soil Cement Testing

SECTION 913: - SOIL-CEMENT BANK PROTECTION:

913-1 DESCRIPTION:

The work shall consist of the construction of soil-cement bank protection as required by the Plans, including trench excavation, backfill, and dewatering.

913-2 MATERIALS:

913-2.01 PORTLAND CEMENT:

Portland Cement shall comply with the latest Specifications as approved by the engineer, for Portland Cement (ASTM C150, CSA A-5, or AASHTO M85)

913-2.02 WATER:

Water shall be clear and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances.

913-2.03 AGGREGATE:

The soil used in the soil-cement mix shall not contain any material retained on a one and one-half (1-1/2) inch sieve, nor any deleterious material. Soil for soil-cement lining shall be obtained from the required excavations, or from

other borrow areas approved by the Engineer and stockpiled on the jobsite as specified herein. The actual soil to be used shall be analyzed by laboratory tests in order to determine the job mix as set forth herein. The distribution and gradation of materials in the soil-cement lining shall not result in lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from surrounding material.

913-3 PROPORTIONING:

The Contractor shall use the soil aggregate, fly ash content, cement content and moisture content determined by the Engineer in accordance with laboratory tests. The Contractor shall allow a minimum of eight (8) days for the cement content results. During the course of the work, the Engineer shall adjust the job mix proportions whenever necessary in order to achieve the minimum design strength shown in Subsection 913-8. The Contractor may have to blend overbank silty soils with the clean in-situ sands to maintain ideal soil gradations as specified below and avoid cement overrun. Special blending shall require constructing separate stockpiles for materials to be blended and it shall be performed by the utilization of the Separate storage feed bins at the plant to the satisfaction of the Engineer.

Sieve Size	Percent Passing (Dry Weight)
1-1/2"	98 % - 100 %
# 4	60 % - 90 %
# 200	5 % - 15 %

Clay and silt lumps larger than one-half (1/2) inch shall be screened out of the raw soil prior to mixing.

The amount of cement required shall be determined by test results performed by the Materials Section of the Pima County Department of Transportation & Flood Control District in accordance with the procedure specified in Subsection 913-11 herein. The required cement content is shown in Subsection 913-9 herein. Testing during the life of the project may require changes in the cement requirements which shall be made promptly by the Contractor at the direction of the Engineer.

913-4 EQUIPMENT:

The soil-cement bank protection may be constructed with any combination of machines and/or equipment, except as noted herein, that will produce a completed soil-cement lining meeting the requirements for soil pulverization, cement and water application, mixing, transporting, placing, compacting, finishing, and curing as provided in these Specifications.

913-5 CONSTRUCTION REQUIREMENTS:

913-5.01 REQUIRED CONTRACTOR SUBMITTALS:

Prior to the start of construction, the Contractor shall submit, in writing, for approval, the following items:

1... The approximate length of soil cement to be placed prior to starting compaction operations.

2... The type of compaction equipment to be used.

3... The number and type of watering equipment to be used.

4... The method used to keep surfaces continually moist until subsequent layers of soil cement are placed.

5... The method used to cure permanently exposed surfaces.

6... The proposed source of soil, if other than required excavations.

913-5.02 PREPARATION:

Before soil-cement processing begins, the area to be lined shall be graded and shaped to lines and grades as shown on the Plans or as directed by the Engineer. The subgrade shall be compacted to a minimum of ninety (90%) percent.

Immediately prior to placement of the soil-cement mixture, the subgrade shall be moistened if necessary. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

913-5.03 MIXING:

Soil cement shall be central-plant mixed in an approved twin shaft continuous-flow or batch-type pugmill. The plant shall be equipped with screening, feeding and metering devices that will add the soil, cement (Fly Ash, if utilized),and water into the mixer in the specified quantities. It should also be equipped with a hydraulically or mechanically operated discharge hopper having a minimum capacity of six (6) cubic yards. Scales are required at both the cement feed and, either the soil or total mix feed locations. Each scale shall record weight of the material and have a digital read

out, such that the total discharged weight per hour is displayed. These shall also be calibrated, certified and approved by the Engineer at least forty-eight (48) hours prior to the start of production. Each Scale shall be calibrated to an accuracy of plus/minus 2.0%. Soil and cement shall be mixed sufficiently to prevent cement balls from forming when water is added.

The mixing time shall be that time which is required to secure a homogeneous, intimate, uniform mixture of the soil, cement, and water.

Free and safe access to the plant must be provided to the Engineer at all times for inspection of the plant's operation and for sampling the soil-cement mixture and its components.

913-5.04 REQUIRED MOISTURE:

At the time of compaction, the moisture content shall not be below optimum; shall not be more than two (2) percentage points above optimum when the mean air temperature during construction hours does not exceed 90 degrees F. When the mean air temperature does exceed 90 degress F., or there is a breeze or wind which promotes the rapid drying out of the soil-cement mixture, the moisture content of said mix shall be increased as needed at the direction of the Engineer, but shall be less than that quantity that will cause the soil cement to become unstable during compaction and finishing operations.

913-5.05 HANDLING:

The soil-cement mixture, if transported, shall be transported from the mixing area to the embankment in clean equipment provided with suitable protective devices in unfavorable weather. The total elapsed time between the addition of water to the mixture and the start of compaction shall be the minimum possible. In no case should the total elapsed time exceed thirty (30) minutes. (This time may be reduced by the Engineer when the air temperature exceeds 90 degrees F or when there is a breeze or wind which promotes rapid drying of the soil-cement mixture.)

The Contractor shall take all necessary precautions to avoid damage to completed soil cement by the equipment and to avoid the deposition of raw earth or foreign materials between layers of soil cement. Earth ramps crossing completed soil cement must have at least two (2) foot compacted thickness. Where ramps are constructed over soil cement that is not to grade, all foreign materials and the uppermost one (1) inch of the previously placed soil-cement mixture must be removed prior to continuation of the soil-cement construction.

913-5.06 PLACING:

The mixture shall be placed on the moistened subgrade embankment, or previously completed soil cement with spreading equipment that will produce layers of such widths and thicknesses as are necessary for compaction to the required dimensions of the completed soil-cement layers. The compacted layers of soil-cement shall not exceed eight (8) inches in thickness, nor be less than four (4) inches in thickness.

Each successive layer shall be placed as soon as practicable after the preceding layer is completed and certified.

All soil-cement surfaces that will be in contact with succeeding layers of soil cement shall be kept continuously moist by fog spraying until placement of the subsequent layer, provided that the Contractor will not be required to keep such surfaces continuously moist for a period longer than seven (7) days.

Mixing shall not proceed when the soil aggregate or the area on which the soil-cement is to be placed is frozen. Soil cement shall not be mixed or placed when the air temperature is below forty-five (45) degrees F (seven [7] degrees C), unless the air temperature is at least forty (40) degrees F (5 degrees C) and rising.

913-5.07 COMPACTION:

Soil cement shall be uniformly compacted to a minimum of 98% of maximum density as determined by field density tests. Optimum moisture and maximum density shall be determined in accordance with Ariz. 221, 222b procedures. Wheel rolling with only hauling equipment shall not be an acceptable method of compaction.

At the start of compaction, the mixture shall be in a uniform, loose condition throughout its full depth. Its moisture content shall be as specified in Section 913-5.04 herein. No section shall be left undisturbed for longer than thirty (30) minutes during compaction operations. Compaction of each layer shall be done in such a manner as to produce a

dense surface, free of compaction planes, in not longer than one (1) hour from the time water is added to the mixture. Whenever the Contractor's operation is interrupted for more than two (2) hours, the top surface of the completed layer, if smooth, shall be scarified to a depth of at least one (1) inch with a spike-tooth instrument prior to placement of the next lift. The surface, after said scarifying, shall be swept using a power broom or other method approved by the Engineer to completely free the surface of all loose material prior to actual placement of the soil-cement mixture for the next lift.

913-5.08 FINISHING:

After compaction, the soil cement shall be further shaped, if necessary, to the required lines, grades, and cross sections and rolled to a reasonably smooth surface.

913-5.09 CURING:

Temporarily exposed surfaces shall be kept moist as set forth in Subsection 913-5.06.

Care must be exercised to ensure that no curing material other than water is applied to the surfaces that will be in contact with succeeding layers.

Permanently exposed surfaces shall be kept in a moist condition for seven (7) days, or they may be covered with some suitable curing material, subject to the Engineer's approval. Any damage to the protective covering within seven (7) days shall be repaired to satisfaction of the Engineer.

Regardless of the curing material used, the permanently exposed surfaces shall be kept moist until the protective cover is applied. Such protective cover is to be applied as soon as practicable, with a maximum time limit of twenty-four (24) hours between the finishing of the surface and the application of the protective cover or membrane.
When necessary, the soil cement shall be protected from freezing for seven (7) days after its construction by a covering of loose earth, straw, or other suitable material approved by the Engineer.

913-5.10 CONSTRUCTION JOINTS:

At the end of each day's work, or whenever construction operations are interrupted for more than two (2) hours, a transverse construction joint shall be formed by cutting back into the completed work to form a full-depth vertical face.

913-5.11 MAINTENANCE:

The Contractor shall be required, within the limits of his contract, to maintain the soil cement in good condition until all work is completed and accepted. Maintenance shall include immediate repairs of any defects that may occur. This work shall be done by the Contractor at his own expense and repeated as often as necessary. Faulty work shall be replaced for a full depth of the layer.

913-6 INSPECTION AND TESTING:

The Engineer, with the assistance and cooperation of the Contractor, shall make such inspections and tests as he deems necessary to insure the conformance of the work to the contract documents. These inspections and tests may include, but shall not be limited to: (1) the taking of test samples of the soil cement and its individual components at all stages of processing and after completion, and (2) the close observation of the operation of all equipment used on the work. Only those materials, machines, and methods meeting the requirements of the Contract Documents shall be approved by the Engineer.

All testing of soil cement or its individual components, unless otherwise provided specifically in the Contract Documents, shall be in accordance with the latest applicable ADOT, ASTM or AASHTO Specifications in effect as of the date of advertisement for bids on the project.

Testing for proper compaction shall be done on at least every other lift of compacted soil-cement at any location chosen by the testing personnel. If the lift being tested does not pass the minimum 98% density requirements, it must be reworked as directed by the Engineer until it passes or be removed at the Contractor's expense. The Contractor shall not be permitted to continue placing lifts of soil cement of any lift which has failed the compaction tests until such time as that lift has been reworked, retested, and passed as to meeting density requirements.

913-7 MEASUREMENT AND PAYMENT:

913-7.01 MEASUREMENT:

This work shall be measured (1) in Cubic Yards of completed-in-place soil-cement slope protection as determined by the specified lines, grades, and cross sections shown on the Plans; and (2) in tons of cement incorporated into the soil cement used for tests and for the slope protection in accordance with the instructions of the Engineer. Any waste of cement and/or soil cement by the Contractor during the handling, mixing, placing, etc. operations shall not be paid for.

913-7.02 PAYMENT:

This work shall be paid for at the Contract Unit Price per cubic yard of soil-cement protection and at the Contract Unit Price per ton of cement furnished, multiplied by the quantities obtained in accordance with Subsection 913-7.01. Such payment shall constitute full reimbursement for all work necessary to complete the soil-cement slope protection, dewatering, trench excavation, watering, mixing, placing, compacting, curing, inspection and testing assistance, and all other incidental operations.

Transport field plugs after matrix

913.8 MIX DESIGN METHODOLOGY:

The design requirements for the soil-cement bank protection shall be such that it has a compressive strength of 750 psi at the end of seven (7) days plus 2% additional cement added for erosion resistance. The minimum acceptance strength shall be that developed as a result of adding 2% cement to the base amount determined. For example, if the mix design shows that 6% cement is required to achieve 750 psi in seven (7) days, the total cement content shall be 6.0% + 2.0% = 8.0%. Hence, the governing strength shall be that strength which is acquired by the mix design at 8%. A 24-hour test will be run to monitor the mix design on a daily basis. Experience has shown that 24-hour compressive strength results for moist cured samples are approximately 50 to 60 percent of the corresponding seven (7) day compressive strength results (moist cured for six (6) days and soaked in water for 24 hours). In the example cited herein, once the design strength mix of 6.0% + 2.0% or 8.0% cement is determined, a 24-hour test will be run using the mix to obtain a 24-hour compressive strength which will be used to monitor the daily output of the central plant. Seven (7) day samples will also be taken for final acceptance. The amount of cement thus determined by laboratory testing shall continue to be monitored throughout the life of the project with modification as required to meet existing field conditions.

913-9 MIX DESIGN FOR THIS PROJECT:

For bidding-purposes only the estimated mix design for this project shall be as follows:

Base Cement Content	8%
Addition for Durability & Erosion	2%
TOTAL CEMENT REQUIRED	10%

The percent of cement to be used in the mix shall be calculated to be the weight of cement divided by the total weight of the dry compacted soil cement. The actual mix design used on this project shall be determined by laboratory tests on material stockpiled.

* Fly ash may be used at the approval of the Engineer. A maximum of fifteen (15) percent of the total weight of cement may be replaced with fly ash, in accordance with the requirements detailed in Section 1006 of the Standard Specifications. An additional scale shall be required for the fly ash and shall conform to Section 913-5.03 Mixing of these Special Provisions. Fly ash shall be paid for per ton used, at the Contractor's cost plus 15% for handling and profit.

913-10 STOCKPILING OF AGGREGATE:

Soil aggregate stockpile shall be constructed on level, firm ground free of brush, trees, stumps, roots, rubbish, debris and other objectionable or deleterious material and shall be located so as to provide a distance of not less than fifty (50) feet from the outside bottom edge of the conical stockpile built up under the processing plant conveyor or any other existing stockpile. The stockpile shall be constructed in layers; each layer not exceeding two (2) feet in thickness. Ramps formed for stockpile construction shall be of the same material as that being stockpiled, and will be considered a part of the stockpile. Before steepening a ramp, any contaminated surface material shall be removed.

Stockpiled material should be thoroughly mixed throughout its depth, width and length before utilization. The material should

be homogeneous and uniform in color, gradation and moisture throughout. Stockpiled material shall conform to the requirements of Subsection 106.11 - ACCEPTANCE OF MATERIALS PRODUCED AT MATERIAL PITS, as revised by these Contract Documents.

Stockpile sampling will be done by the Pima County's Material Lab after the required amount of soil aggregate for the entire soil-cement job has been excavated and stockpiled. After the stockpile has been sampled and approved, no material will be added to it without approval of the Engineer.

Stockpile(s) shall be completed and approved at least eight (8) days prior to start of soil-cement production. Mix design shall then be performed by Pima County Materials Lab, to determine job mix proportions.

913-11 TESTING PROCEDURE FOR: DETERMINATION OF CEMENT CONTENT REQUIRED FOR SOIL-CEMENT MIXTURES

(A Modification of Arizona 220 Test Method)

913-11.1 DESCRIPTION:

(A) This method of test is intended for determining the percentage of Portland Cement required in developing Soil Cement mixtures by the determination of the compressive strength of molded specimens at varying cement contents.

(B) Equipment Required:

(1) Mold - A cylindrical metal mold having a capacity of 1/30 Cubic foot with an internal diameter of 4.0 plus/minus .005 in. and a height of 4.585 plus/minus .005 in. equipped with a detachable collar approximately 2-1/2 in. in height.

(2) Rammer - A metal rammer materially or mechanically operated having a 2 in. diameter circular face and weighing 5.5 lbs. The rammer shall be equipped with a suitable arrangement to control the height

of drop to a free fall of 12 in. above the elevation of the cement treated mixture.

(3) Balance - A balance or scale of at least 5 kg. capacity sensitive to 0.5 gm.

(4) Drying Oven - A thermostatically controlled drying oven capable of maintaining a temperature of 230 degrees plus/minus 9 degrees F (110 degrees plus/minus 5 degrees C).

(5) Straightedge - A rigid steel straightedge 12 in. in length having one beveled edge.

(6) Sieve - 3/4 in. sieve conforming to the requirements of the Specifications for sieves for Testing Purposes (ASTM E11-81 and AASHTO M 92).

(7) Miscellaneous mixing tools and plans.

(8) Speedy Moisture Tester (optional).

(9) Equipment required for the determination of the Compressive Strength of Cylindrical Concrete Specimens (ASTM C39, C42, C511).

913-11.2 SAMPLE PREPARATION:

(A) If the sample is damp when received, it shall be dried until it becomes friable under a trowel. Drying may be accomplished by air drying or by the use of drying apparatus such that the temperature of the sample does not exceed 140 degrees F (60 degrees C).

(B) After drying prepare the sample for testing by separating the aggregate retained on the 3/4 inch sieve and breaking up the remaining soil aggregations to pass the 3/4 inch sieve in a manner which will avoid reducing the natural size of individual particles.

(C) Select and prepare eight separate test charges of dry soil cement of approximately 2500 gm. each. Two samples are to be made for every cement percentage selected.

(D) Add the first of the cement contents to be used and mix thoroughly together.

Example: If the percent cement selected is 10%

Dry Soil Weight	=	2250 gms.	(90%)
Portland Cement	=	250 gms.	(10%)
TOTAL		2500 gms.	(100%)

(E) The moisture content to be added to each test charge is determined by making a maximum density-optimum moisture determination with the anticipatd required cement content (according to AASHTO T 99-74 Method C) and using this developed optimum-moisture thereafter for all specimens prepared.

913-11.3 COMPACTION:

(A) Form a specimen by compacting the prepared mixture in the mold with the collar attached in three equal layers to give a total compacted depth of 5 in. Compact each layer by applying 25 uniformly distributed blows from a 5.5 lb. (2.5 kg.) rammer dropping free from a height of 12 in. (305 min). Following compaction, remove the extension collar, carefully trim the compacted mixture even with the top of the mold by means of a straightedge and weigh. Multiply the weight of the specimen (in gms.) by 0.06614 to obtain the wet weight per cubic foot. The factor 0.06614 is valid only if the volume of the mold is 1/30 cubic foot. If calibration shows any change in volume, a new factor shall be calculated.

NOTE: Assuming the mold has a volume of 1/30 (0.0333) cubic foot the factor is derived as follows:

$$.06614 = \frac{1}{0.0333 \text{ cu. ft.} \times 453.6 \text{ g./lb}}$$

In case of a change in volume of the mold 0.0333 cu. ft. shall be replaced by the decimal fraction for the new volume.

(B) Compact a duplicate specimen in the same manner as Step (A).

(C) Extrude both samples from their respective molds using caution and place on glass or non-absorptive plates and store for curing in a moist condition, i.e., a moist cabinet or a Moist Room meeting the requirement of ASTM C-511-80.

(D) Determine the moisture content of the prepared samples from the residue.

(E) Determine the Wet Density and Dry Density of the samples.

(F) Repeat steps (A) - (D) on additional samples with increased cement content (in 2% increments) until a complete bracketing of specification requirements is met.

913-11.4 DETERMINATION OF COMPRESSIVE STRENGTH:

(A) All specimens must be cured as specified in a moist condition for six days and then immersed for a period of 24 hours in water maintained at 73.4 plus/minus 3 degrees F (23 plus/minus 1.7 degrees C).

(B) Specimens shall then be prepared for the compression test in accordance with ATSM C 617.

(C) The compressive strength of the cylinders shall then be determined in accordance with ASTM C-39 and ASTM C-42.

(D) The results shall be reported in a format similar to that shown in the following report form: