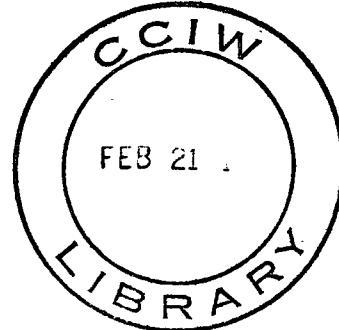


HYDRAULICS RESEARCH DIVISION

Technical Note



DATE: January 1978

REPORT NO: 78-03

TITLE: "Particle Size Data Report 78-1"

AUTHOR(S): D. St. Jacques

REASON FOR REPORT:

The report provides particle size and specific gravity data requested by Dr. P. Shelley, Director, Energy and Environmental Systems, Washington Analytical Services Center, Inc., Environmental Protection Agency, 2150 Field Road, Rockville, Maryland 20850, U.S.A., under project H77 063.

CORRESPONDENCE FILE NO:

2242

1.0 INTRODUCTION

This report provides the results of specific gravity tests and particle size analysis of test material submitted by Dr. P. Shelley, Environmental Protection Agency, under project H 77 063.

2.0 METHODS AND RESULTS

2.1 Specific Gravity

The pycnometer method described by Lambe (1967) was used to determine the specific gravity of the samples. Briefly the method consists of:

- 1) placing a measured amount of sediment in a calibrated pycnometer half full of deaired, distilled water.
- 2) removing the air entrapped in the sediment by boiling
- 3) adding deaired, distilled water to bring level to calibrated volume and weighing the pycnometer with water and sediment in it
- 4) computing specific gravity according to:

$$G_s = \frac{W_s G_T}{W_s - W_1 + W_2}$$

where W_s = dry weight of sediment
 G_T = specific gravity of distilled water at temperature T
 W_1 = weight of pycnometer, water and sediment
 W_2 = weight of pycnometer and water

The results of the tests are given in Table I.

2.2 Particle Size Analysis

Particle size analysis was requested for 11 of the 14 samples. Sieve analysis (Krumbein and Pettijohn, 1938) was used to resolve the sand-sized samples and Sedigraph* analysis for the finer-grained materials. The Sedigraph measures particles in the silt-clay size range by recording the amount of X-rays absorbed by a small prism of sedimenting suspension. The procedure consists of:

- 1) splitting the sample to 3.5 g
- 2) dispersing the sample in 25 ml of Calgon solution (0.05 N) and mixing it for 20 minutes.
- 3) automatic analysis by Sedigraph
- 4) processing of results with Sizdist: a Fortran IV computer program.

In this case, the scanning rates were adjusted to account for differences in the specific gravity of the test samples.

* Micromeritics Instrument Corporation, Norcross, Georgia

SPECIFIC GRAVITY DETERMINATIONS

Sample Identification	Determination		
	1	2	Average
3X Powder	1.49		1.49
Glass Beads Bol 29	2.38	2.38	2.38
Glass Beads Bt 13	2.29	2.31	2.30
Pumice 3F	2.25	2.31	2.28
Pumice 1/9, 0.5	2.21		2.21
Pumice 1/10	2.33		2.33
Pumice 1/11 FFF	2.33		2.33
Pumice 1/11, 1-5 Sack	2.12	2.14	2.13
Pumice 1/11, 1-5 Box	2.10		2.10
Test Sediment 1	2.82	2.81	2.82
Test Sediment 2	2.69	2.66	2.68
Walnut Hulls AD3B	1.38		1.38
Walnut Hulls AD6B	1.47	1.48	1.48
Walnut Hulls AD7B	1.48		1.48

TABLE I

The textural data (Appendix 1) is expressed in terms of gravel, sand, silt and clay percentages and classified according to Folk (1974) and Shepard (1954) (Appendix 2). The data is further subdivided into percentages occurring within each $\frac{1}{2}$ PHI unit (Folk, 1974; Appendix 3). Graphic and moment measure statistics are given in PHI units.

3.0 ACKNOWLEDGEMENT

I wish to acknowledge Dr. Rukavina's assistance in determining the adjustments to be made to the standard procedure for the analysis of this material.

The analyses were performed by G. A. Duncan, L. Oelze and G. LaHaie.

REFERENCES

- Folk, R. L., 1974. "Petrology of Sedimentary Rocks". Hemphill Publishing Co., Austin, Texas, 182 p.
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- Krumbein, W. C. and F. J. Pettijohn, 1938. "Manual of Sedimentary Petrography". Appleton-Century-Crofts, New York, 549 p.
- Lambe, T. W., 1967. "Soil Testing for Engineers". John Wiley and Sons, Inc., New York, 165 p.
- Shepard, F. P., 1954. "Nomenclature Based on Sand-Silt Ratios". Jour. Sed. Petrology, V. 24, p. 151-158.

APPENDIX I
Particle Size Data

GLASS BEADS BOL 29

SEDIGRAPH ANALYSIS

01/25/78

PHI PCT. CUMPCT.

3.50 ASSUMED UPPER LIMIT	
3.39	*****
4.00	9.39
8.02	*****
4.50	17.41
43.12	*****
5.00	60.54
23.48	*****
5.50	84.02
3.79	*****
6.00	92.81
3.11	***
6.50	95.92
1.09	*
7.00	97.01
1.83	**
7.50	98.85
0.66	*
8.00	99.50
0.50	
*****	100.00

NO STATISTICS ARE COMPUTED BECAUSE THE UPPER SIZE LIMIT IS ASSUMED
AND THIS AFFECTS MORE THAN 5 PERCENT OF THE SAMPLE

PERCENTILES	MEDIAN	4.88	5TH*****	16TH	4.41	25TH	4.59	
			75TH	5.31	84TH	5.50	95TH	6.35
PCT. GRAVEL	0.00	SAND	9.39	SILT (PIPETTE)	0.00	CLAY (PIPETTE)	0.00	
				(SEDIGRAPH)	90.11	(SEDIGRAPH)	0.50	
GRAVEL+SAND	9.39	STLT/(SILT+CLAY)	99.45	PCT.GRAV+SAND/SILT+CLAY	0.10			
LABELS SHEPARD -SILT		FOLK(GMS)-MUD				(SCS)-SILT		

STOP

PUMICE 3F

SEDIGRAPH ANALYSIS

01/25/78

PHI PCT. CUMPCT.

3.50	ASSUMED UPPER LIMIT	**
4.00	2.05	
4.50	2.87	***
5.00	4.92	*****
5.50	12.31	*****
6.00	17.23	*****
6.50	19.74	*****
7.00	35.97	*****
7.50	19.81	*****
8.00	55.78	*****
8.50	15.01	*****
9.00	70.79	*****
9.50	19.89	*****
10.00	81.68	*****
10.50	5.87	*****
11.00	88.55	***
11.50	4.02	***
12.00	92.57	
12.50	2.48	**
13.00	95.05	**
13.50	2.48	**
14.00	97.52	**
14.50	2.48	**
15.00	100.00	

MEAN ST.DEV. SKEWNESS KURTOSIS

5.95 1.07 0.27 0.04 KRUMBEN + PETTIGEHN (1938) MOMENT MEASURES
FOR SIZE RANGE 4.0 TO 9.0 PHI5.99 1.16 0.26 1.09 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 5.85 5TH 4.50 16TH 4.95 25TH 5.20
75TH 6.69 84TH 7.17 95TH 8.49PCT. GRAVEL 0.00 SAND 2.05 SILT (PIPETTE) 0.00 CLAY (PIPETTE) 0.00
(SEDIGRAPH) 90.52 (SEDIGRAPH) 7.43

GRAVEL+SAND 2.05 SILT/(SILT+CLAY) 92.42 PCT.GRAV+SAND/SILT+CLAY 0.02

LABELS SHEPARD -SILT FOLK(GMS)-MUD (SCS)-SILT

PUMICE 1/9 0.5

SIEVE ONLY

SAMPLE WT.= 5.8628

PHI PCT. CUMPCT.

01/25/78

1.00	0.05	
1.50	0.05	*****
2.00	32.18	*****
2.50	43.16	*****
3.00	81.39	*****
3.50	14.11	*****
4.00	95.50	**
3.50	2.28	**
3.50	97.78	
4.00	0.18	
4.00	97.96	
4.00	2.04	**
*****	100.00	

MEAN ST.DEV. SKEWNESS KURTOSIS

2.18 0.38 0.32 0.39 KRUMBELIN + PETTIGEHN (1938) MOMENT MEASURES
FOR SIZE RANGE 1.5 TO 4.0 PHI2.17 0.42 0.06 1.05 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 2.18 5TH 1.58 16TH 1.75 25TH 1.89
75TH 2.43 84TH 2.59 95TH 2.98

PCT. GRAVEL 0.00 SAND 97.96 SILT+CLAY 2.04

GRAVEL+SAND 97.96 GRAV+SAND/SILT+CLAY 47.98

LABELS SHEPARD -SAND FOLK(GMS)-SAND (SCS)-

PUMICE 1/10

SEDIGRAPH ANALYSIS

01/25/78

PHI PCT. CUMPCT.

3.50	ASSUMED UPPER LIMIT	
4.50	4.50	*****
4.00	4.50	*****
15.50		*****
4.50	20.00	*****
30.50		*****
5.00	50.50	*****
21.00		*****
5.50	71.50	*****
10.50		*****
6.00	82.00	*****
5.50		*****
6.50	87.50	
4.00		***
7.00	91.50	
4.00		***
7.50	95.50	
3.00		***
8.00	98.50	
1.50		**
*****	100.00	

MEAN ST.DEV. SKEWNESS KURTOSIS

5.20 0.93 0.50 0.60 KRUMBEIN + PETTIGEHN (1938) MOMENT MEASURES
FOR SIZE RANGE 4.0 TO 8.0 PHI5.18 0.97 0.37 1.29 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957

PERCENTILES	MEDIAN	4.99	5TH	4.02	16TH	4.37	25TH	4.58
			75TH	5.67	84TH	6.18	95TH	7.44
PCT.	GRAVEL	0.00	SAND	4.50	SILT (PIPETTE)	0.00	CLAY (PIPETTE)	0.00
					(SEDIGRAPH)	94.00	(SEDIGRAPH)	1.50
GRAVEL+SAND	4.50	SILT/(SILT+CLAY)	98.43	PCT.GRAV+SAND/SILT+CLAY	0.05			
LABELS SHEPARD - SILT		FOLK(GMS)-MUD				(SCS)-STLT		

PUMICE FFF 1/11

SEDIGRAPH ANALYSIS

PHI PCT. CUMPCT.

01/25/78

3.50	ASSUMED UPPER LIMIT
4.00	1.00
4.50	2.00
5.00	3.00
5.50	11.00
6.00	14.00
6.50	21.00
7.00	35.00
7.50	21.50
8.00	56.50
8.50	15.50
9.00	73.00
9.50	11.00
10.00	84.00
10.50	7.50
11.00	91.50
11.50	4.50
12.00	95.00
12.50	3.00
13.00	99.00
13.50	1.00
14.00	100.00

MEAN ST.DEV. SKEWNESS KURTOSIS

5.95 0.95 0.22 -0.21 KRUMBEIN + PETTIGJOHN (1938) MOMENT MEASURES
FOR SIZE RANGE 4.0 TO 8.5 PHI5.97 0.99 0.21 1.02 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 5.85 5TH 4.59 16TH 5.05 25TH 5.25
75TH 6.59 84TH 7.00 95TH 7.89PCT. GRAVEL 0.00 SAND 1.00 SILT (PIPETTE) 0.00 CLAY (PIPETTE) 0.00
(SEDIGRAPH) 95.00 (SEDIGRAPH) 4.00

GRAVEL+SAND 1.00 SILT/(SILT+CLAY) 95.96 PCT. GRAV+SAND/SILT+CLAY 0.01

LABELS SHEPARD -SILT FOLK(GMS)-MUD (SCS)-SILT

PUMICE 1/11 1.5 BOX

SIEVE ONLY

SAMPLE WT.= E.6429

PHI PCT. CUMPCT.

01/25/78

1.00	23.73	*****
1.50	23.73	*****
2.00	56.37	*****
2.50	80.10	*****
3.00	17.99	*****
3.50	98.09	*
4.00	1.44	
	99.53	
	0.15	
	99.67	
	0.21	
	99.89	
	0.11	
****	100.00	

MEAN ST.DEV. SKEWNESS KURTOSIS

1.74 0.36 0.34 1.87 KBUMBEIN + PETTIGEHN (1938) MOMENT MEASURES
FOR SIZE RANGE 1.5 TO 4.0 PHI

1.73 0.39 0.01 1.21 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957

PERCENTILES MEDIAN 1.73 5TH 1.11 15TH 1.34 25TH 1.51
75TH 1.95 84TH 2.11 95TH 2.41

PCT. GRAVEL 0.00 SAND 99.89 SILT+CLAY 0.11

GRAVEL+SAND 99.89 GRAV+SAND/SILT+CLAY 884.72

LABEL'S SHEPARD -SAND FOLK(GMS)-SAND (SCS)-

COMMENTS -
PUMICE 1/11 1.5 BOX MAGNETIC MINERALS REMOVED (WT = 0.0168G)

PUMICE 1/11 1.5 SACK

SIEVE ONLY

SAMPLE WT.= 6.4238

PHI PCT. CUMPCT.

01/25/78

1.00	24.21	*****
1.50	24.21	*****
	57.97	*****
2.00	82.18	*****
	15.06	*****
2.50	98.24	*
	1.18	
3.00	99.42	
	0.25	
3.50	99.68	
	0.08	
4.00	99.76	
	0.24	
*****	100.00	

MEAN ST.DEV. SKEWNESS KURTOSIS

1.73 0.35 0.30 1.44 KRUMBEIN + PETTIJOHN (1938) MOMENT MEASURES
FOR SIZE RANGE 1.5 TO 4.0 PHI1.70 0.38 -0.02 1.23 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 1.72 5TH 1.10 16TH 1.33 25TH 1.51
75TH 1.94 84TH 2.05 95TH 2.40

PCT. GRAVEL 0.00 SAND 99.76 SILT+CLAY 0.24

GRAVEL+SAND 99.76 GRAV+SAND/SILT+CLAY 416.13

LABELS SHEPARD -SAND FOLK(GMS)-SAND (SCS)-

COMMENTS -

PUMICE 1/11 1.5 SACK MAGNETIC MINERALS REMOVED (WT = 0.0203 G)

TEST SEDIMENT 1

SEDIGRAPH ANALYSIS

PHI PCT. CUMPCT.

01/25/78

3.50 ASSUMED UPPER LIMIT

20.17

4.00 20.17

39.67

4.50 59.84

23.00

5.00 87.84

5.50 94.00

0.97

6.00 94.97

0.40

6.50 95.37

1.60

7.00 97.17

1.17

7.50 98.34

0.66

8.00 99.00

1.09

***** 100.00

NO STATISTICS ARE COMPUTED BECAUSE THE UPPER SIZE LIMIT IS ASSUMED
AND THIS AFFECTS MORE THAN 5 PERCENT OF THE SAMPLE

PERCENTILES	MEDIAN	4.38	5TH*****	16TH*****	25TH	4.05		
				75TH 4.77	84TH 4.93	95TH 6.04		
PCT.	GRAVEL	0.00	SAND	20.17	SILT (PIPEITE)	0.00	CLAY (PIPEITE)	0.00
					(SEDIGRAPH)	78.83	(SEDIGRAPH)	1.00
	GRAVEL+SAND	20.17	SILT/(SILT+CLAY)	98.75	PCT.GRAV+SAND/SILT+CLAY	0.25		
LABELS	SHEPARD -SILT		FOLK(GMS)-SANDY MUD			(SCS)-SANDY SILT		

TEST SEDIMENT 2

SEDIGRAPH ANALYSIS

PHI PCT. CUMPCT.

01/25/78

3.50 ASSUMED UPPER LIMIT

3.90 ****

4.00 3.00

30.10 ****

4.50 34.00

24.75 ****

5.00 58.75

15.84 ****

5.50 74.59

8.74 ****

6.00 83.34

5.61 ****

6.50 88.95

4.61 ****

7.00 93.56

1.92 **

7.50 95.49

0.55 *

8.00 96.04

0.74 *

8.50 96.78

3.22 ***

***** 100.00

MEAN ST.DEV. SKEWNESS KURTOSIS

5.00 0.88 0.58 1.15 KRUMBEN + PETTIGEHN (1938) MOMENT MEASURES
FOR SIZE RANGE 4.0 TO 8.5 PHI5.03 0.97 0.43 1.17 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 4.82 5TH 4.02 16TH 4.20 25TH 4.35
75TH 5.52 84TH 6.06 95TH 7.37PCT. GRAVEL 0.00 SAND 3.90 SILT (PIPETTE) 0.00 CLAY (PIPETTE) 0.00
(SEDIGRAPH) 92.14 (SEDIGRAPH) 3.96

GRAVEL+SAND 3.90 SILT/(SILT+CLAY) 95.88 PCT.GRAV+SAND/SILT+CLAY 0.04

LABELS SHEPARD -SILT FOLK(GMS)-MUD (SCS)-SILT

WALNUT HULLS AD69

SIEVE ONLY

SAMPLE WT.= 71.4274

PHI PCT. CUMPCT.

01/25/78

-0.50	0.03	
0.00	0.03	
0.50	20.76	*****
1.00	53.65	*****
1.50	79.44	*****
2.00	13.31	*****
2.50	98.75	*
3.00	0.71	
3.50	95.45	
4.00	0.28	
	2.50	99.74
	3.00	0.14
	3.50	99.88
	4.00	0.08
	4.50	99.96
	5.00	0.03
	5.50	99.99
	6.00	0.01
*****	100.00	

MEAN SI.DEV. SKEWNESS KURTOSIS

0.76 0.36 0.46 4.48 KRUMBEN + PETTIGEHN (1938) MOMENT MEASURES
FOR SIZE RANGE 0.0 TO 4.0 PHI0.75 0.38 0.01 1.23 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 0.75 5TH 0.12 16TH 0.38 25TH 0.54
75TH 0.96 84TH 1.12 95TH 1.40

PCT. GRAVEL 0.00 SAND 99.99 SILT+CLAY 0.01

GRAVEL+SAND 99.99 GRAV+SAND/SILT+CLAY 7848.17

LABELS SHEPARD -SAND FOLK(GMS)-SAND (SCS)-

WALNUT HULLS 407B 170178

SIEVE ONLY

SAMPLE WT.= 50.7000

PHI PCT. CUMPCT.

01/25/78

0.00	0.02	
0.50	0.02	
1.00	4.88	*****
1.50	58.14	*****
2.00	63.05	*****
2.50	34.54	*****
3.00	97.59	**
3.50	2.28	
4.00	99.87	
4.50	0.07	
5.00	99.95	
5.50	0.03	
6.00	99.97	
6.50	0.01	
7.00	99.99	
7.50	0.01	
8.00	100.00	

MEAN ST.DEV. SKEWNESS KURTOSIS

1.42 0.31 0.20 0.87 KRUMBELIN + PETTIGEON (1938) MOMENT MEASURES
FOR SIZE RANGE 0.5 TO 4.0 PHI1.43 0.32 0.18 0.79 FOLK GRAPHIC STATISTICAL PARAMETERS
FOLK AND WARD, 1957PERCENTILES MEDIAN 1.39 5TH 1.00 16TH 1.10 25TH 1.17
75TH 1.67 84TH 1.80 95TH 1.95

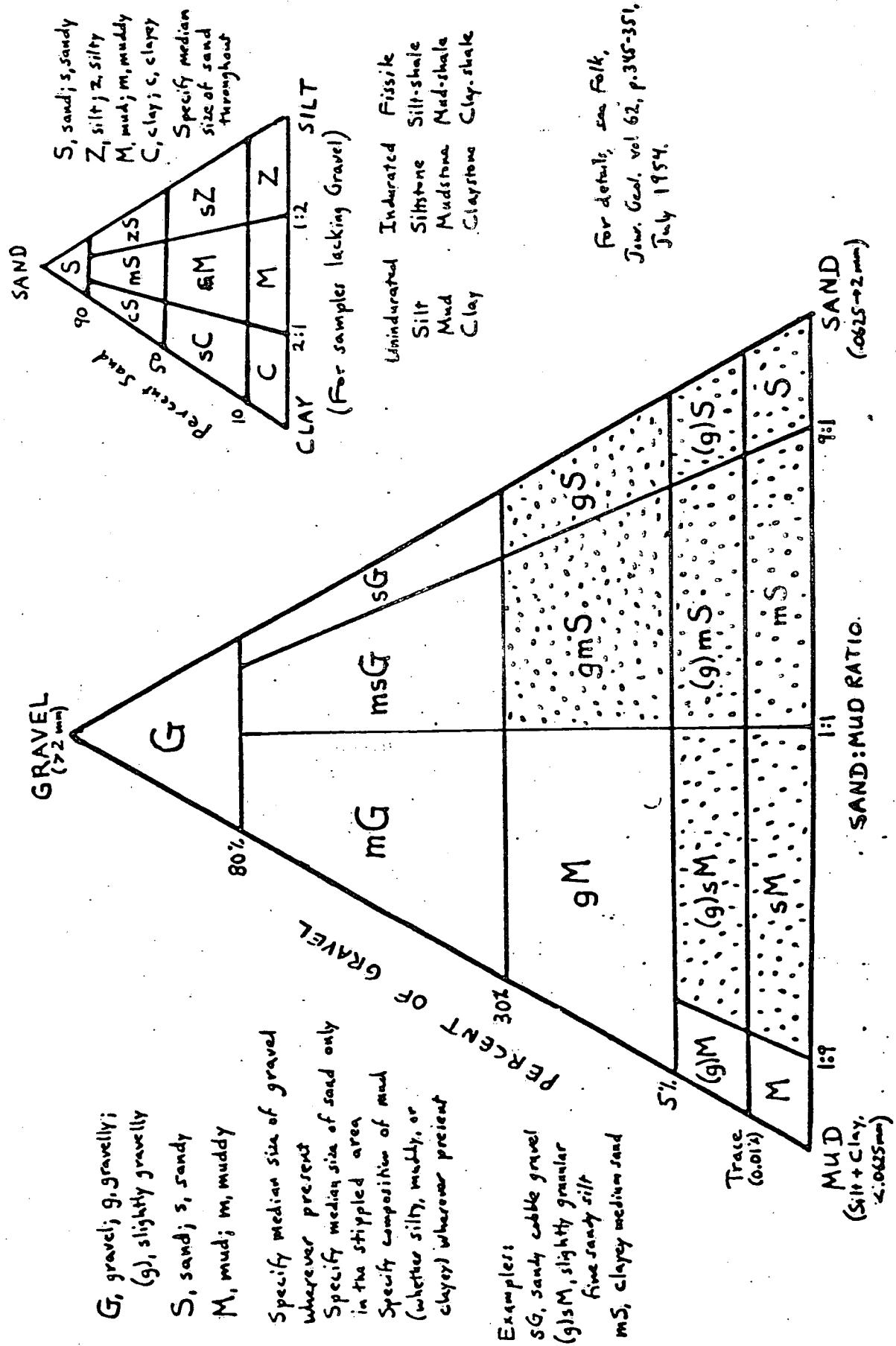
PCT. GRAVEL 0.00 SAND 99.99 SILT+CLAY 0.01

GRAVEL+SAND 99.99 GRAV+SAND/SILT+CLAY 9052.57

LABELS SHEPARD -SAND FOLK(GMS)-SAND (SCS)-

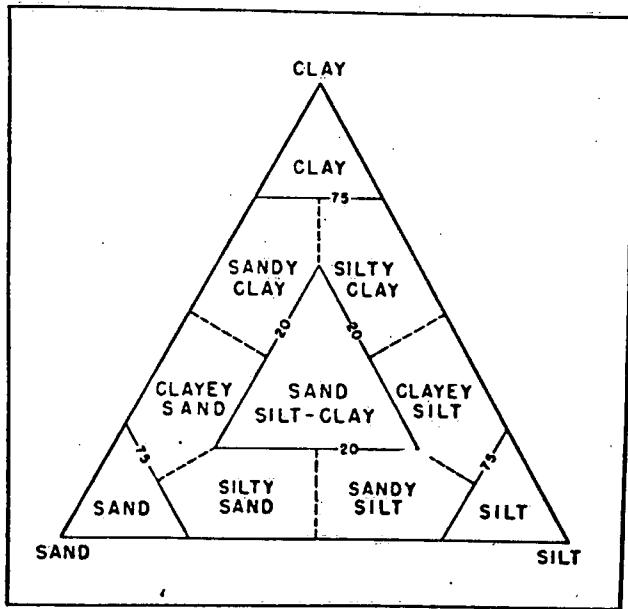
APPENDIX 2

Grain Size Nomenclature (After Folk, 1974, p. 28;
and Shepard, 1954, p. 157)



SAND-SILT-CLAY RATIOS

157



Shepard, 1954

APPENDIX 3
PHI Notation (After Folk, 1974, p. 25)

GRAIN SIZE SCALES FOR SEDIMENTS

The grade scale most commonly used for sediments is the Wentworth (1922) scale which is a logarithmic scale in that each grade limit is twice as large as the next smaller grade limit. The scale starting at 1mm and changing by a fixed ratio of 2 was introduced by J. A. Udden (1898), who also named the sand grades we use today. However, Udden drew the gravel/sand boundary at 1mm and used different terms in the gravel and mud divisions. For more detailed work, sieves have been constructed at intervals $\sqrt[2]{2}$ and $\sqrt[4]{2}$. The ϕ (phi) scale, devised by Krumbein, is a much more convenient way of presenting data than if the values are expressed in millimeters, and is used almost entirely in recent work.

U. S. Standard Sieve Mesh #	Millimeters (1 Kilometer)	Microns	Phi (ϕ)	Wentworth Size Class
	4096		-20	
	1024		-12	
Use	256		-10	Boulder (-8 to -12 ϕ)
wire squares	64		-8	Cobble (-6 to -8 ϕ)
	16		-6	Pebble (-2 to -6 ϕ)
	4		-4	
5	3.36		-2	
6	2.83		-1.75	Granule
7	2.38		-1.5	
8	2.00		-1.25	
— 10	1.68		-1.0	
12	1.41		-0.75	Very coarse sand
14	1.19		-0.5	
16	1.00		-0.25	
— 18	0.84		0.0	
20	0.71		0.25	Coarse sand
25	0.59		0.5	
30	0.50	500	0.75	
— 35	0.42	420	1.0	
40	0.35	350	1.25	Medium sand
45	0.30	300	1.5	
50	0.25	250	1.75	
— 60	0.210	210	2.0	
70	0.177	177	2.25	Fine sand
80	0.149	149	2.5	
100	0.125	125	2.75	
— 120	0.105	105	3.0	
140	0.088	88	3.25	Very fine sand
170	0.074	74	3.5	
200	0.0625	62.5	3.75	
— 230	0.053	53	4.0	
270	0.044	44	4.25	Coarse silt
325	0.037	37	4.5	
— 1/32	0.031	31	4.75	
Analyzed	1/64	0.0156	5.0	Medium silt
by	1/128	0.0078	6.0	
Pipette	1/256	0.0039	7.0	Fine silt
or		0.0020	8.0	Very fine silt
		0.00098	9.0	
		0.00049	10.0	Clay
		0.00024	11.0	(Some use 2 ϕ or
		0.00012	12.0	9 ϕ as the clay
		0.00006	13.0	boundary)
			14.0	

Hydrometer