Qualifying Frac Sand Resources Using Cutting Edge Technology

Summit Envirosolutions

May 15, 2014

- Sample prep & handling
- Data correlation
- PSD as decision tool
- PSD for "fingerprinting"


725

Conclusions

- Camsizer
  - Quick
  - Reliable
  - 21st Century upgrade for PSD and more
- Sample Handling Key to Reproducible Results
- Natural variability on material is different that manufactured product
- Use statistics & trend charts for big data sets vs. time

Prospecting

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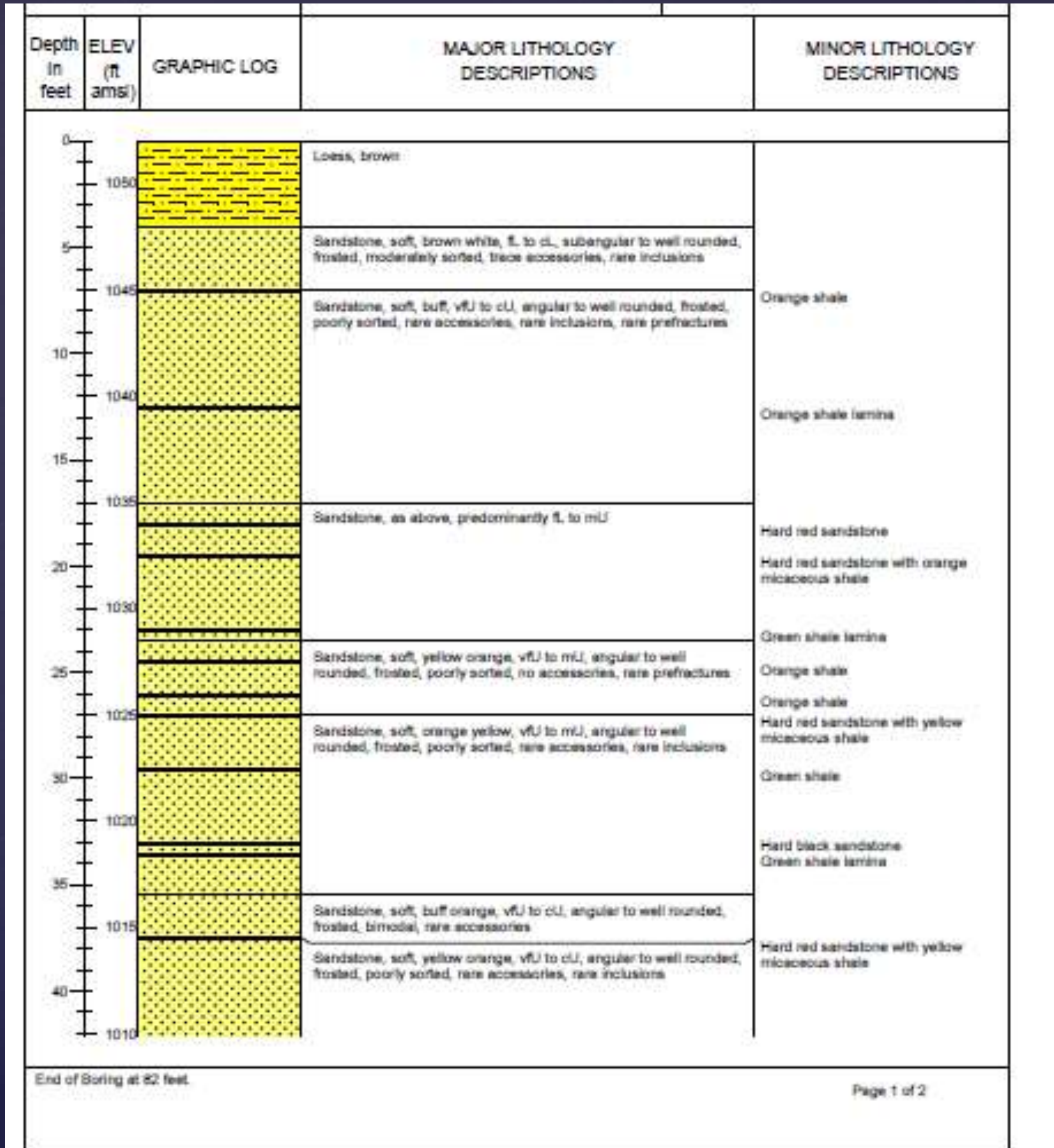

Depth in feet	ELEV (ft amsl)	GRAPHIC LOG	MAJOR LITHOLOGY DESCRIPTIONS	MINOR LITHOLOGY DESCRIPTIONS
0	1050		Loess, brown	
5			Sandstone, soft, brown white, fL to cL, subangular to well rounded, frosted, moderately sorted, trace accessories, rare inclusions	
10	1045 1040		Sandstone, soft, buff, vfU to cU, angular to well rounded, frosted, poorly sorted, rare accessories, rare inclusions, rare prefractures	Orange shale Orange shale lamina
15 20	1035 1030		Sandstone, as above, predominantly fL to mU	Hard red sandstone Hard red sandstone with orange micaceous shale Green shale lamina
25	1025		Sandstone, soft, yellow orange, vfU to mU, angular to well rounded, frosted, poorly sorted, no accessories, rare prefractures	Orange shale Orange shale
30 35	1020		Sandstone, soft, orange yellow, vfU to mU, angular to well rounded, frosted, poorly sorted, rare accessories, rare inclusions	Hard red sandstone with yellow micaceous shale Green shale Hard black sandstone Green shale lamina
	1015		Sandstone, soft, buff orange, vfU to cU, angular to well rounded, frosted, bimodal, rare accessories	
40	1010		Sandstone, soft, yellow orange, vfU to cU, angular to well rounded, frosted, poorly sorted, rare accessories, rare inclusions	Hard red sandstone with yellow micaceous shale

End of Boring at 82 feet.

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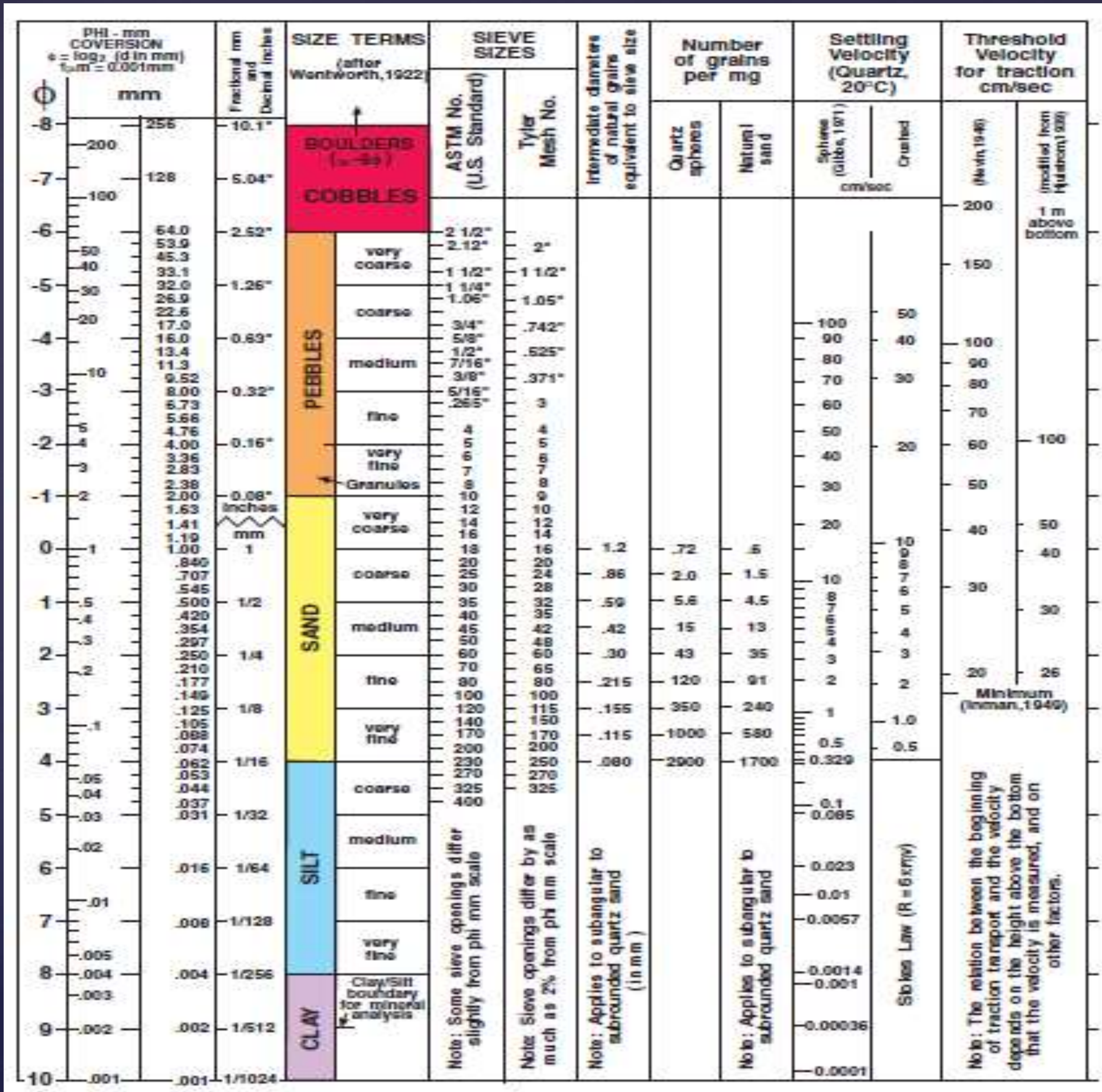

PHI - mm COVERSION
ϕ = log2 (d in mm)
ϕ
mm
Fractional mm and Decimal inches
SIZE TERMS
(after Wentworth,1922)
SIEVE SIZES
ASTM No. (U.S. Standard)
Tyler Mesh No.
Intermediate diameter of natural grains equivalent to sieve size
Number of grains per mg
Quartz spheres
Natural sand
Settling Velocity (Quartz, 20°C)
Spheres (Gibbs, 1971)
Crushed
cm/sec
Threshold Velocity for traction cm/sec
(Nevin,1946)
(modified from Hjulstrom,1939)
1 m above bottom
BOULDERS
COBBLES
PEBBLES
very coarse
coarse
medium
fine
very fine
Granules
SAND
SILT
CLAY
Clay/Silt boundary for mineral analysis
Inches
mm
Minimum (Inman,1949)
Note: Some sieve openings differ slightly from phi mm scale
Note: Sieve openings differ by as much as 2% from phi mm scale
Note: Applies to subangular to subrounded quartz sand (in mm)
Note: Applies to subangular to subrounded quartz sand
Stokes Law (R = 6πrηv)
Note: The relation between the beginning of traction transport and the velocity depends on the height above the bottom that the velocity is measured, and on other factors.

PERFORMING A SIEVE ANALYSIS

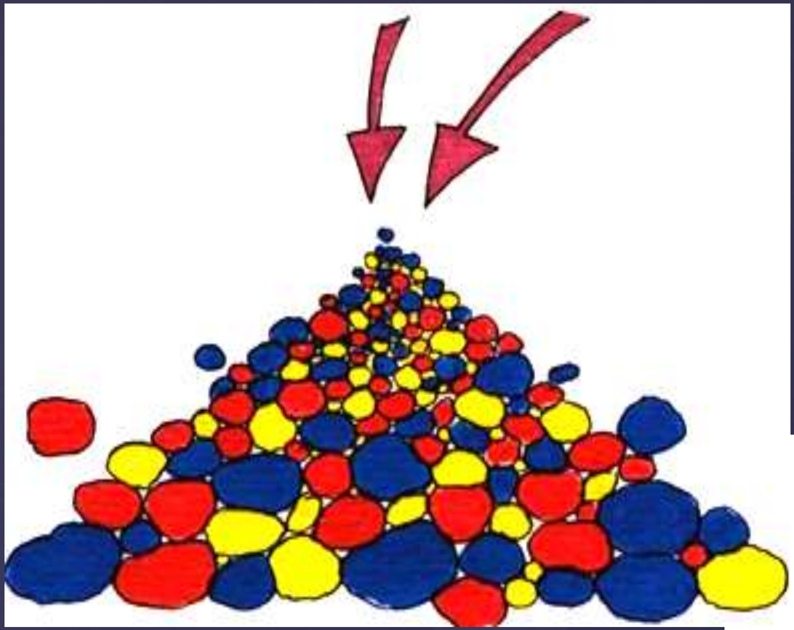
- You can begin your particle size distribution analysis after you properly collect, prepare and size a sample.
- Select test sieves with mesh openings that reveal particle distribution at critical sizes. These are usually stated.
- in a product specification or determined by material processing requirements.

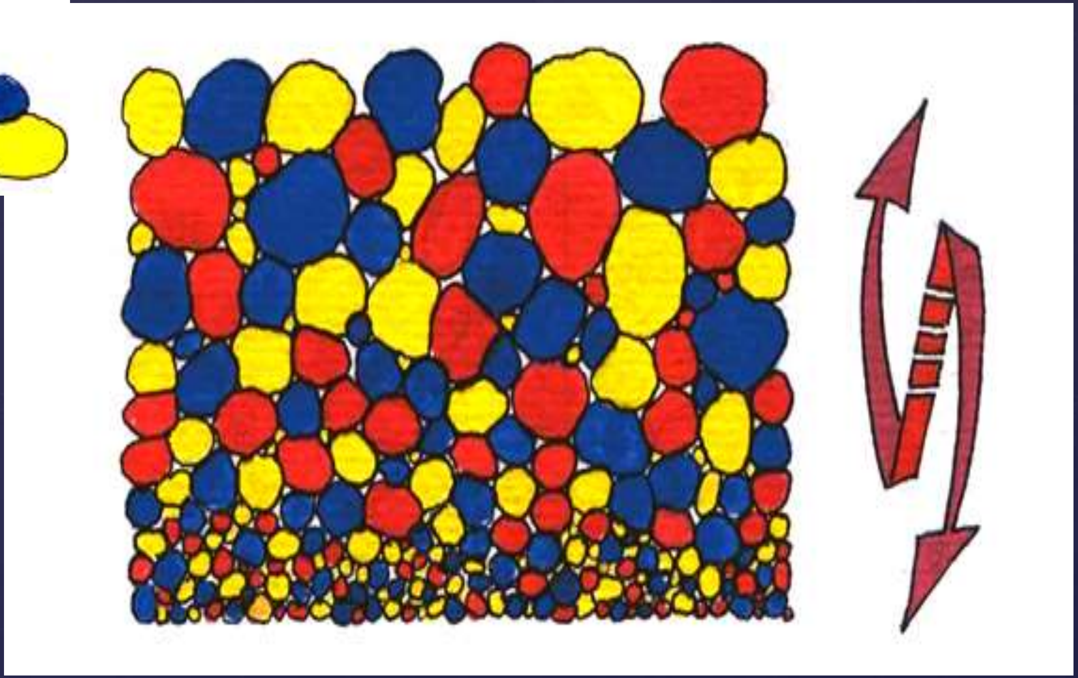
To perform the analysis, do the following:

- 1. Stack the sieves on top of each other with the coarsest (largest) opening on the top of the stack.
- 2. Put a bottom pan under the finest (smallest) opening sieve. This pan collects "fine" material that passes through the last one.
- 3. Use a laboratory scale (accurate to .1 gram) to weigh an empty container (such as an extra empty bottom pan) and establish the tare weight.
- 4. Weigh the sample material.
- 5. Empty the sample into the top of the stack. Make sure you do not overload the surface as this causes "blinding" or blocking of the openings.
- 6. Put the stack into the sieve shaker.
- 7. Place a cover on the top of the stack.
- 8. Make sure the stack is securely in place.
- 9. Set the proper length of time to agitate the material.
- 10. Turn on the shaker and run the test.
- 11. After the shaker stops, empty the material from the coarsest sieve into the empty container that you weighed in step (3). Use a soft bristle brush to gently brush the underside of the sieve to remove all of the particles.
- 12. Tap the side of the frame with the handle of the brush to clean the remaining material from the sieve.
- 13. Weigh the contents in the pan to the nearest 1/10 gram and record the data.
- 14. Return the material to its original sample container.
- 15. Repeat steps 11 through 14, using the container referenced in step (3) for each sieve, including the fine material in the bottom pan.
- 16. Total the weights to make sure the sum of the retained material and the material in the bottom pan is as close as possible to the original weight. Check your specification for allowable variation.
- 17. Divide the weight obtained from each sieve by the weight of the original sample. Record the percentage for each sieve.
- 18. Calculate and record the cumulative percentages as required.

ISO 13503-2/API 19/56


CAMSIZER
OFFICEJET PRO 8100 ePRINTER





*Gert Beckmann
Retsch Technology

“representative sample….”

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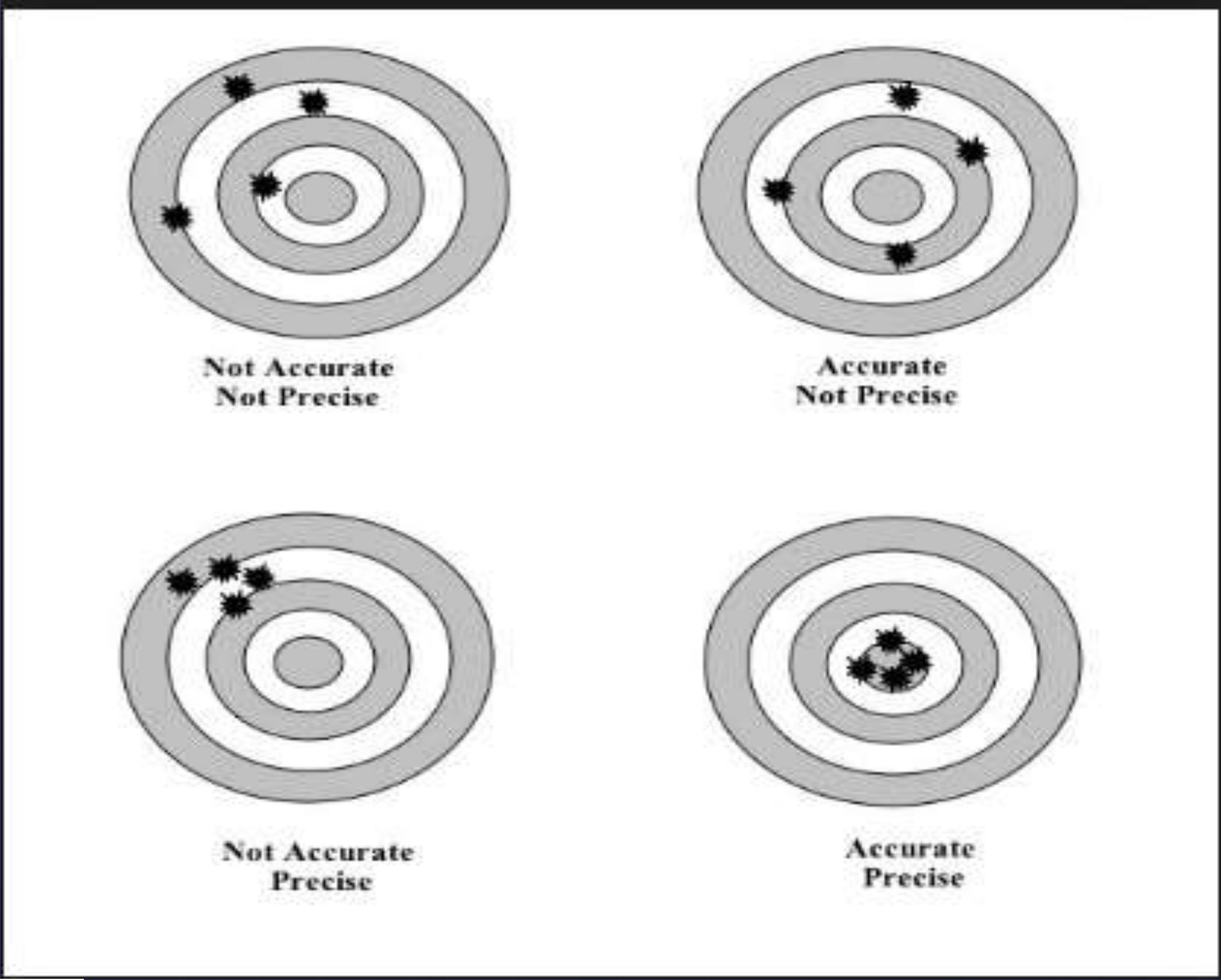
Camsizer vs. Rotap learnings

- **NEVER** scoop always use sample splitter
- No mechanical agitation like RoTap
- Clusters and "coating" source for discrepancy
- Smaller sample size – unforgiving!!

Sample prep

Air dry
Split & weigh
Wash, wet sieve – P200
Dry and calculate %loss
Micro photograph
Archive sample


Not Accurate
Not Precise
Accurate
Not Precise
Not Accurate
Precise
Accurate
Precise

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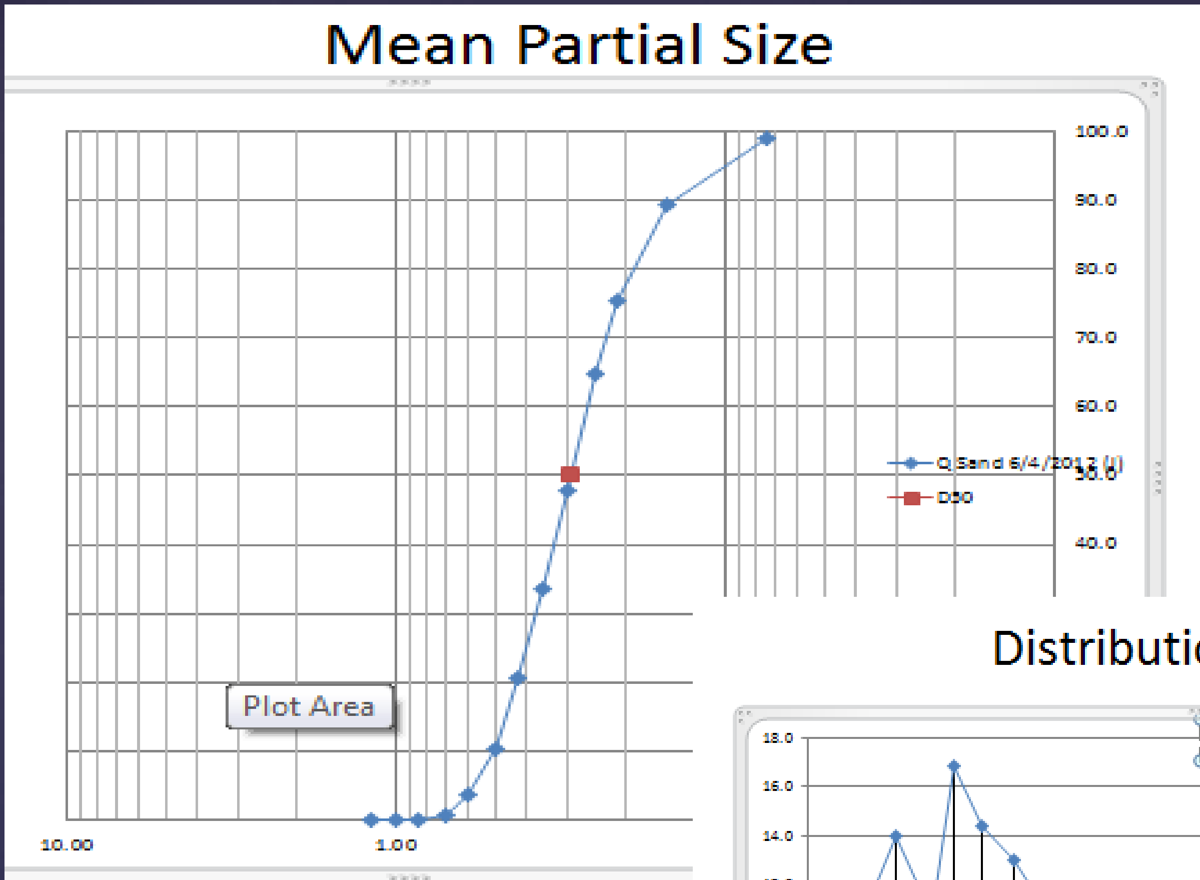
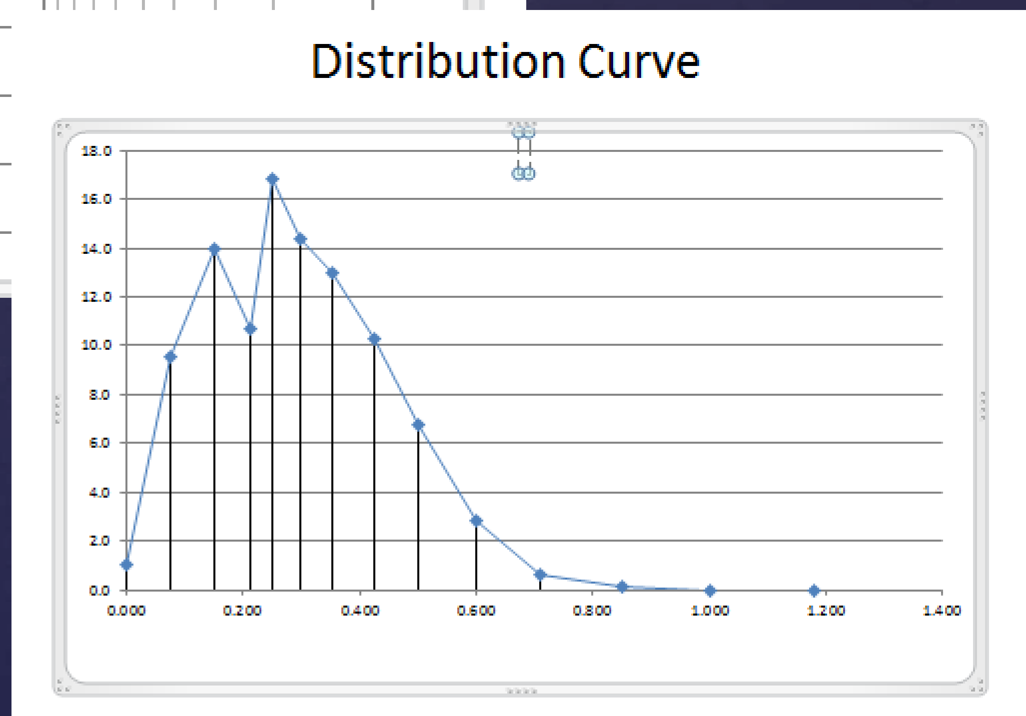

Mean Partial Size
100.0
90.0
80.0
70.0
60.0
40.0
D50
Plot Area
10.00
1.00


Distribution Curve
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.000
0.200
0.400
0.600
0.800
1.000
1.200
1.400

Gradation Analysis

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Proving the "method…"

- Creating a "standard" sample
- Splitting "standard" sample – maintain representative
- Confirm to "ISO equivalence"
- Establish statistically significant like vs. different

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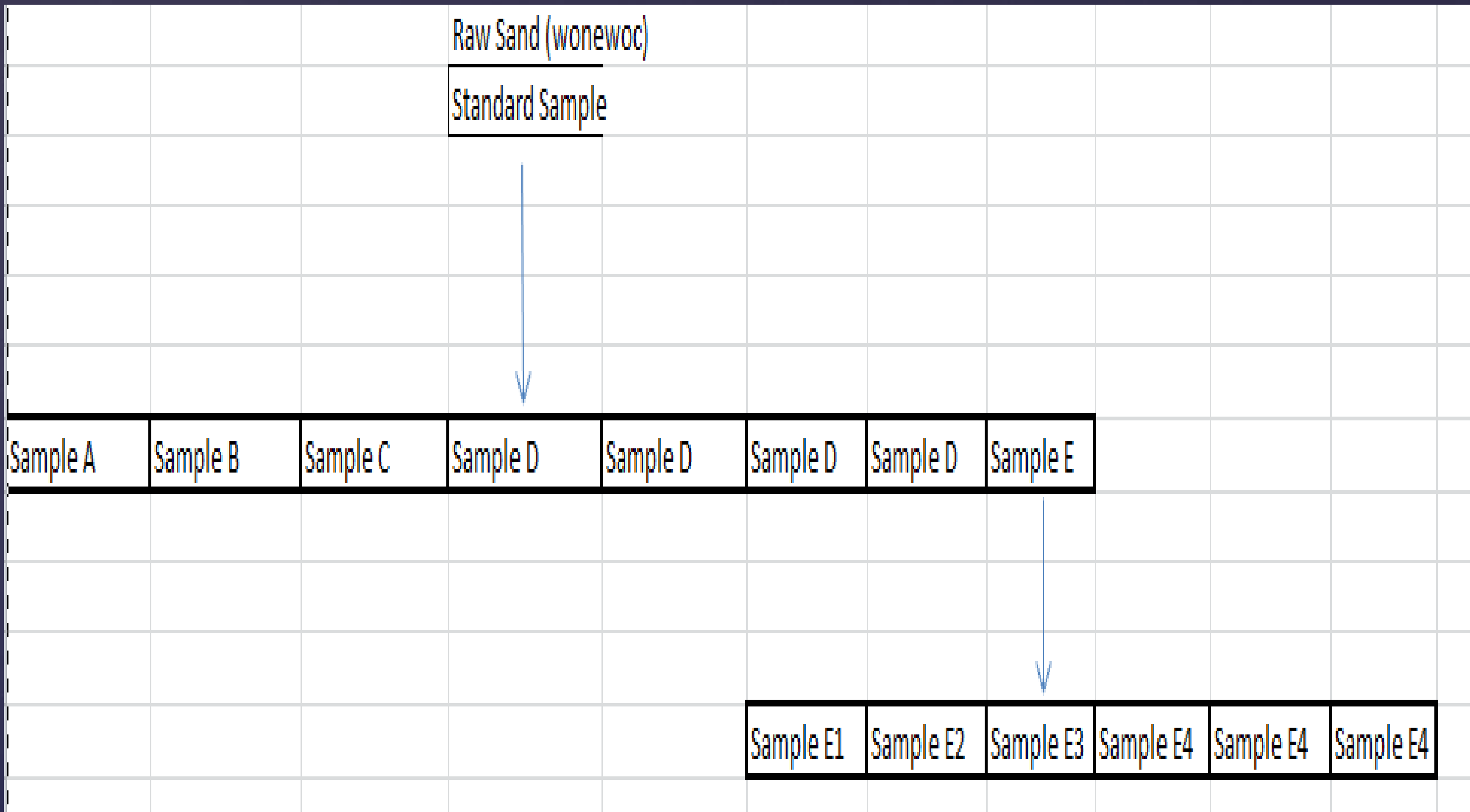
Split sample into 5 parts. 4 splits used for ro-tap. 1 split used exclusively for CAMSIZER					
Run 3 of 4 samples in the ro-tap individually - once (saved 2, 3 and 4 to run through the CAMSIZER)					
Run 4th sample three times through ro-tap					
Split the one sample used for the CAMSIZER into 4 smaller parts					
Run 3 of 4 samples through the CAMSIZER once					
Run the 4th sample through the CAMSIZER three times					
Run sample 2, 3, and 4 from the ro-tap through the CAMSIZER					



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Same split sample using sieves

Ro-tap						
	a	b	c	d	d	d
Sieve Size (US Stand.	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Sample 4 (%)	Sample 4 (%)	Sample 4 (%)
16	0.3	0.3	0.2	0.2	0.5	0.1
18	0.5	0.8	0.6	0.7	0.8	0.6
20	2.2	2.4	2.3	2.4	2.3	2.3
25	6.8	7.6	6.9	7.3	7.4	7.4
30	13.6	13.9	13.9	13.9	13.8	13.6
35	18.6	18.8	18.9	19.0	18.8	19.4
40	21.2	20.9	21.1	20.8	20.9	20.5
45	20.7	20.3	20.7	20.7	20.3	20.6
50	12.0	11.6	11.6	11.8	11.9	12.0
60	2.9	2.7	2.8	2.7	2.6	2.7
70	0.4	0.5	0.5	0.3	0.3	0.4
100	0.4	0.5	0.4	0.4	0.3	0.5
200	0.0	0.1	0.0	0.0	0.0	0.0
Pan	0.0	0.1	0.0	0.0	0.2	0.1
	99.6	100.5	99.9	100.0	99.9	100.0

CAMSIZER

Test 1	Test 2	Test 3	Test 4	Test 4	Test 4	Test 7 - Sa	Test 8 - Sa	Test 9 - Sample 4
(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
0.3	0.8	0.2	0.3	0.4	0.3	0.4	0.2	0.3
1.2	0.9	0.9	0.7	1.1	0.8	0.9	1.1	1.1
2.7	2.8	2.5	2.8	2.8	2.8	2.8	3.0	2.9
8.5	8.8	8.0	7.7	7.6	8.0	8.3	8.1	8.7
13.3	13.3	12.8	12.9	12.9	12.8	12.2	13.7	13.2
20.8	20.9	20.4	21.1	20.4	19.9	21.0	21.2	19.1
21.4	21.1	22.0	20.9	21.3	21.1	22.1	20.2	21.2
19.4	19.5	20.1	20.0	19.9	20.9	19.7	19.2	20.8
8.8	8.4	9.0	9.4	9.6	9.1	8.8	9.3	9.0
2.7	2.5	3.0	3.1	2.8	3.1	2.8	2.9	2.7
0.5	0.6	0.7	0.7	0.7	0.7	0.6	0.7	0.6
0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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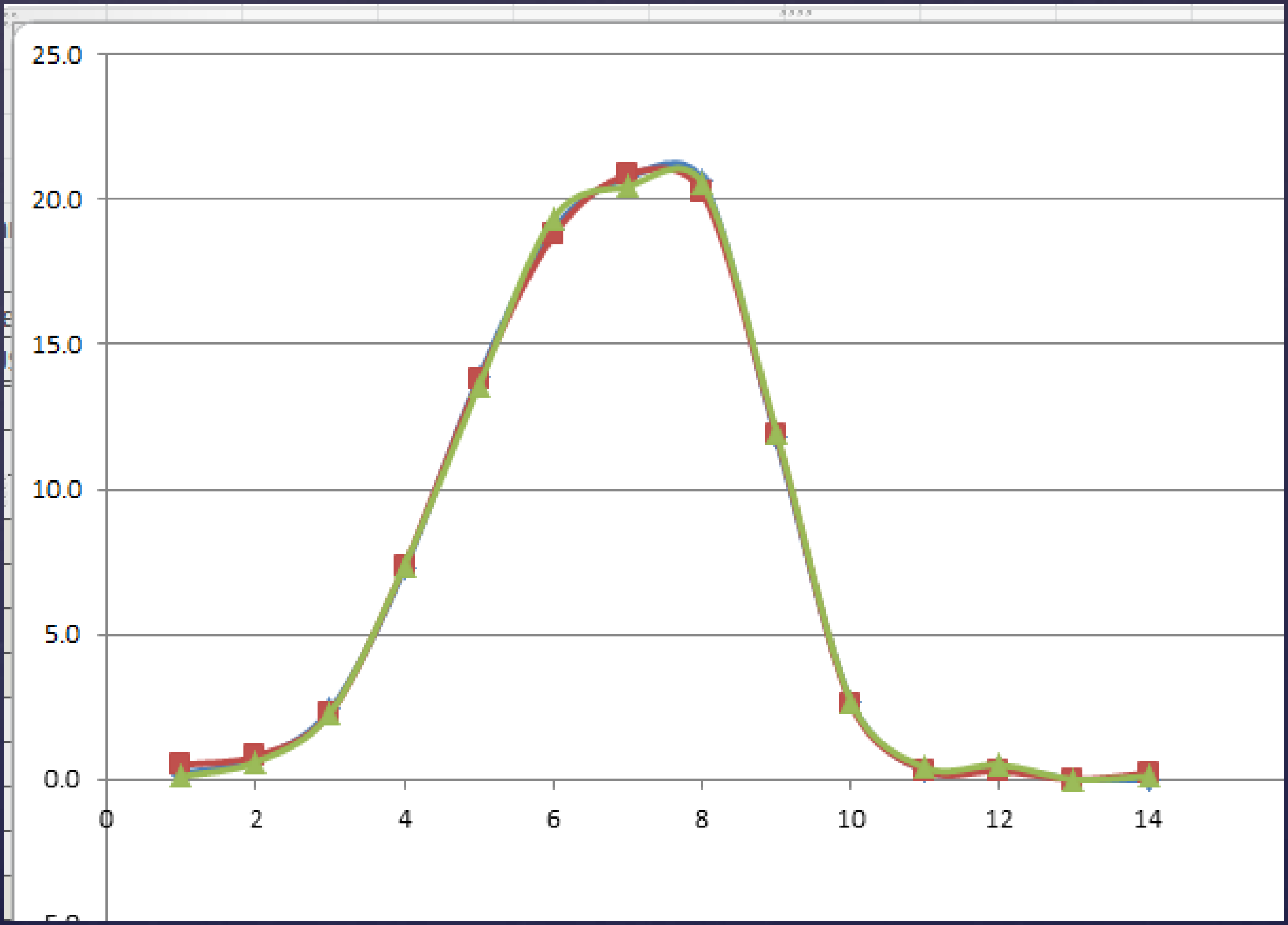
Same sample 3x Rotap



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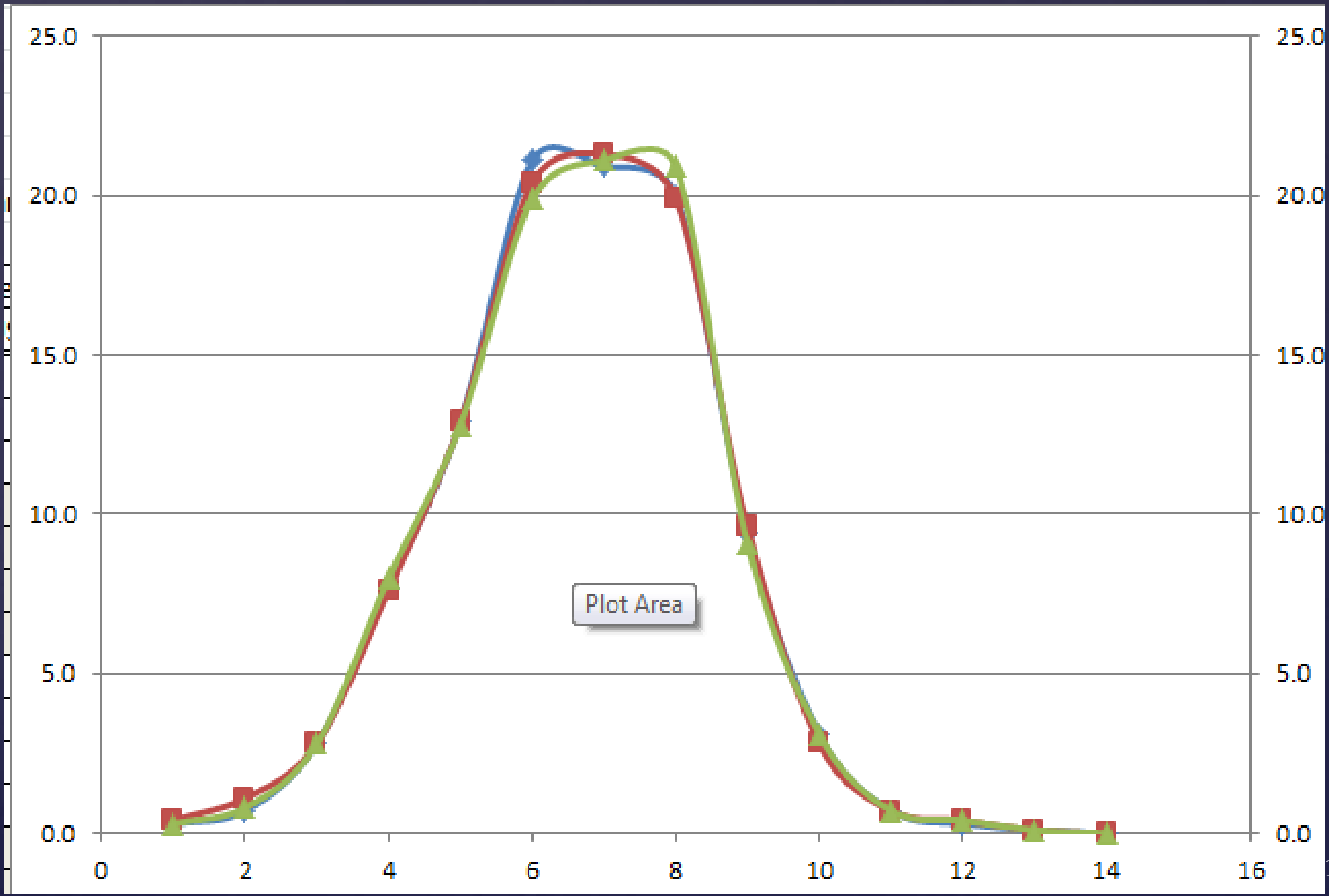
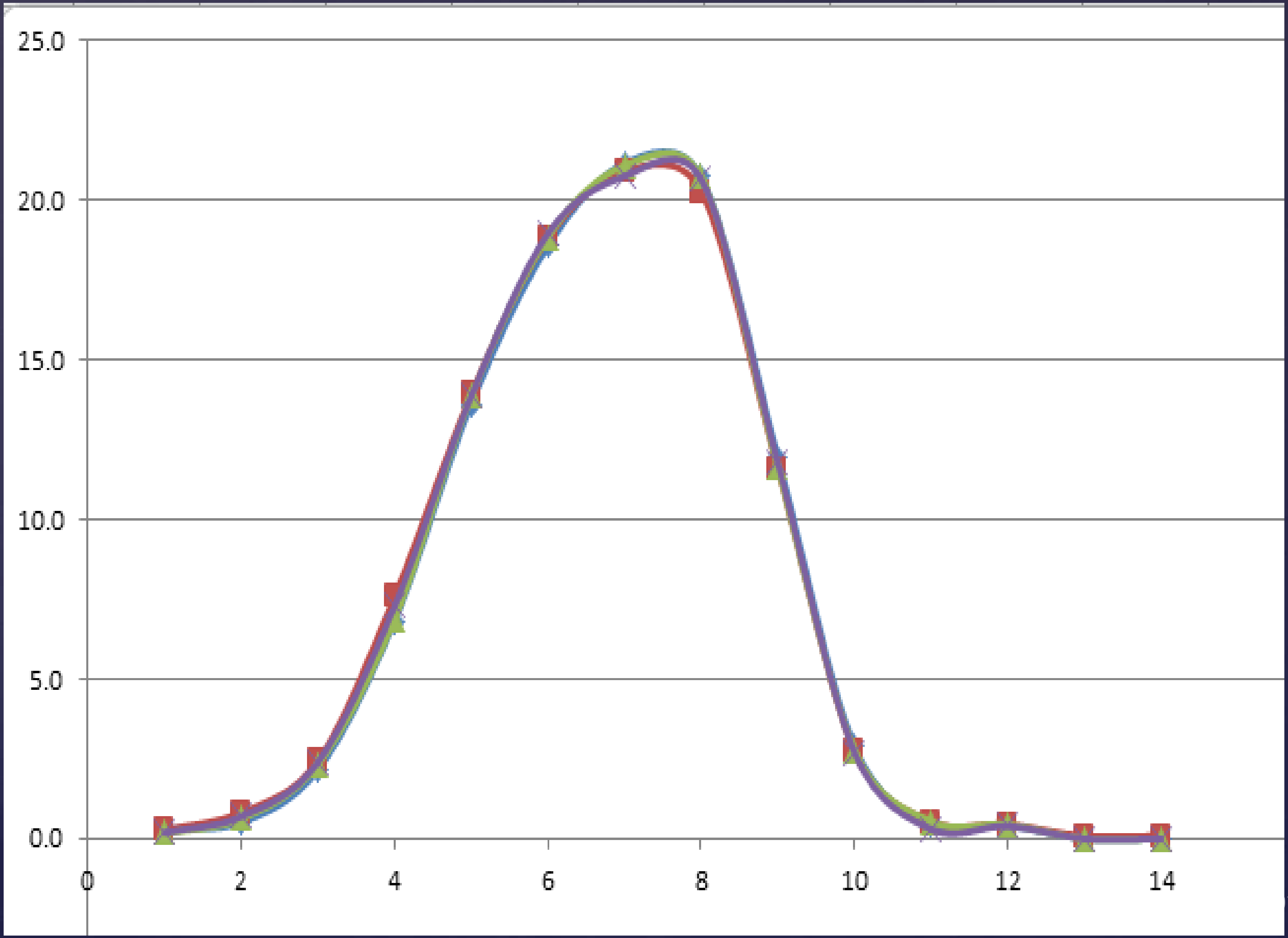
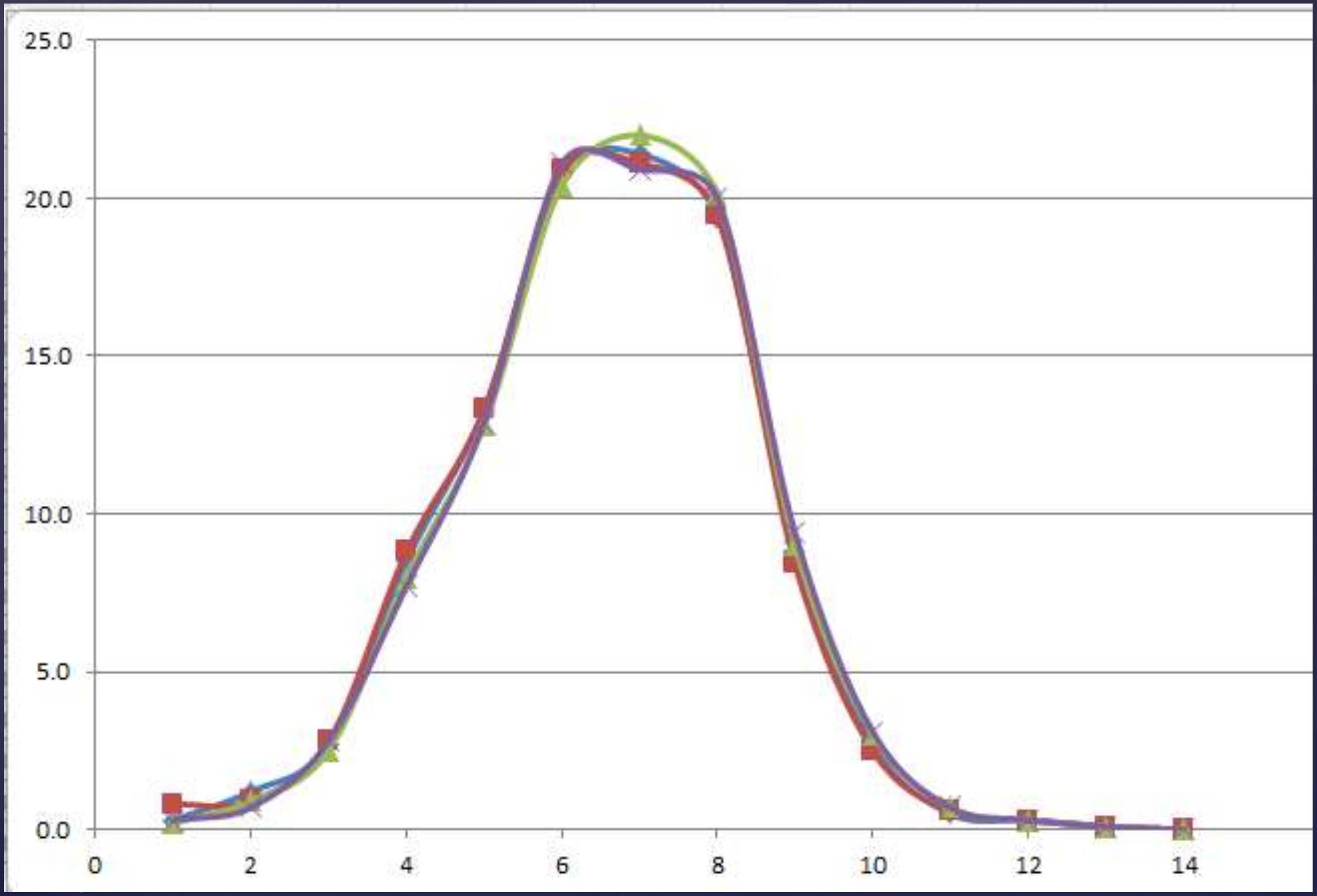
Same sample 3x Camsizer

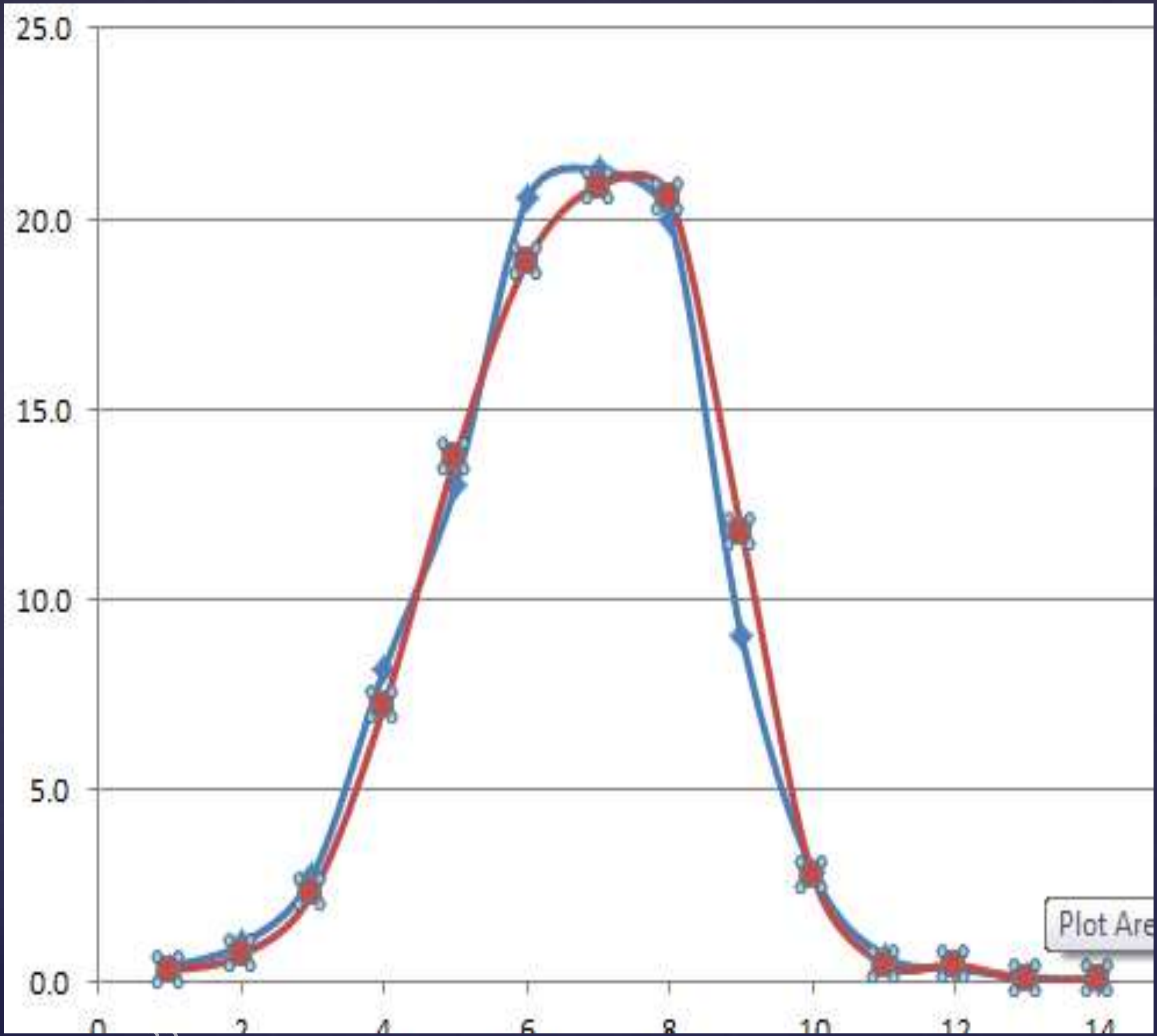


All sets of Rotap data



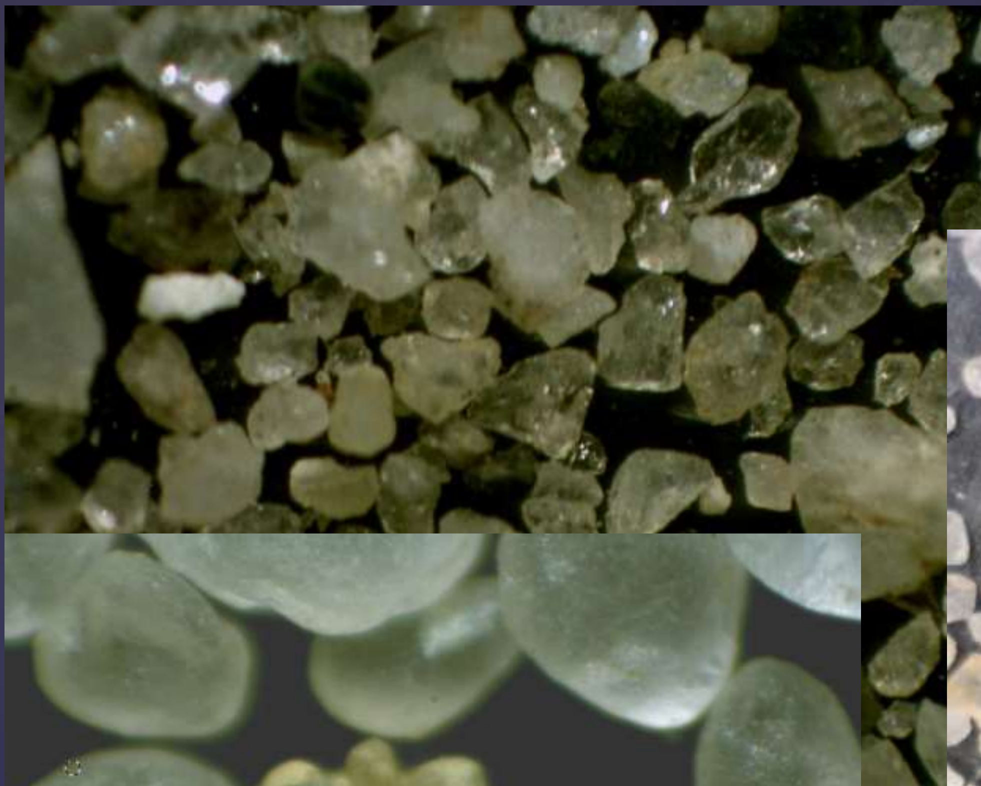
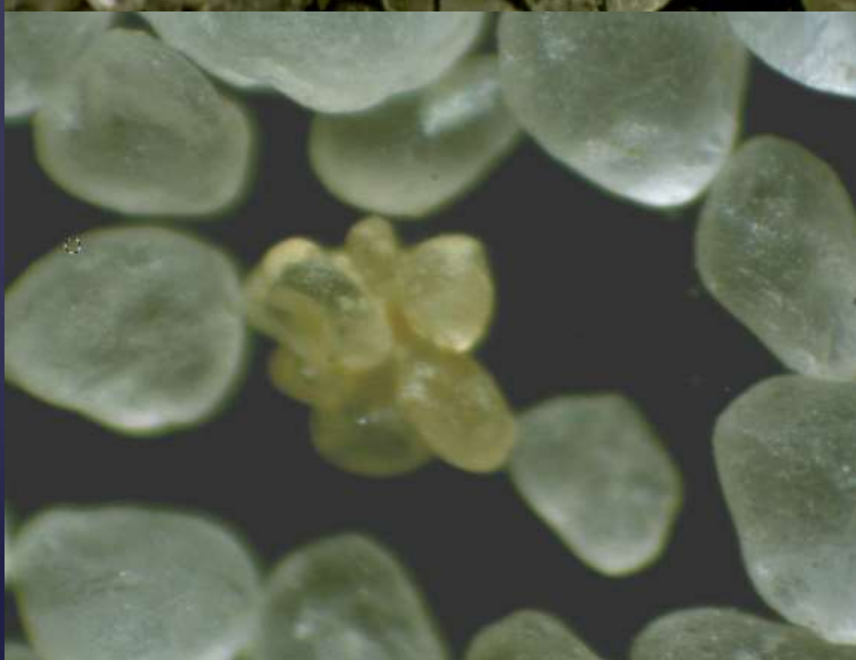
All Sets of Camsizer data



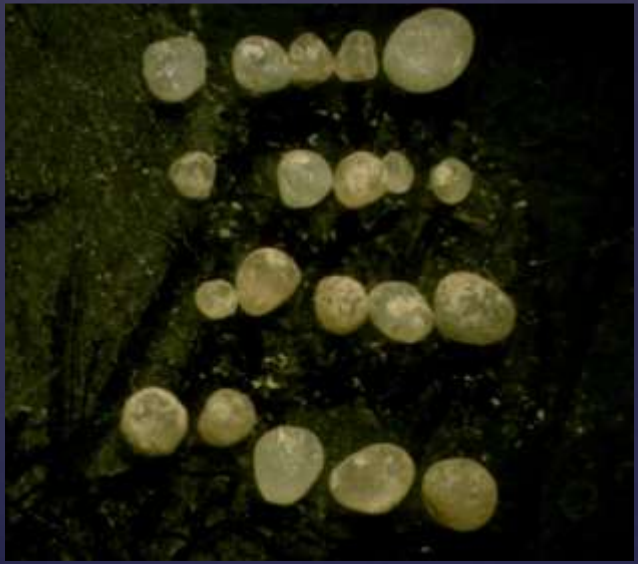


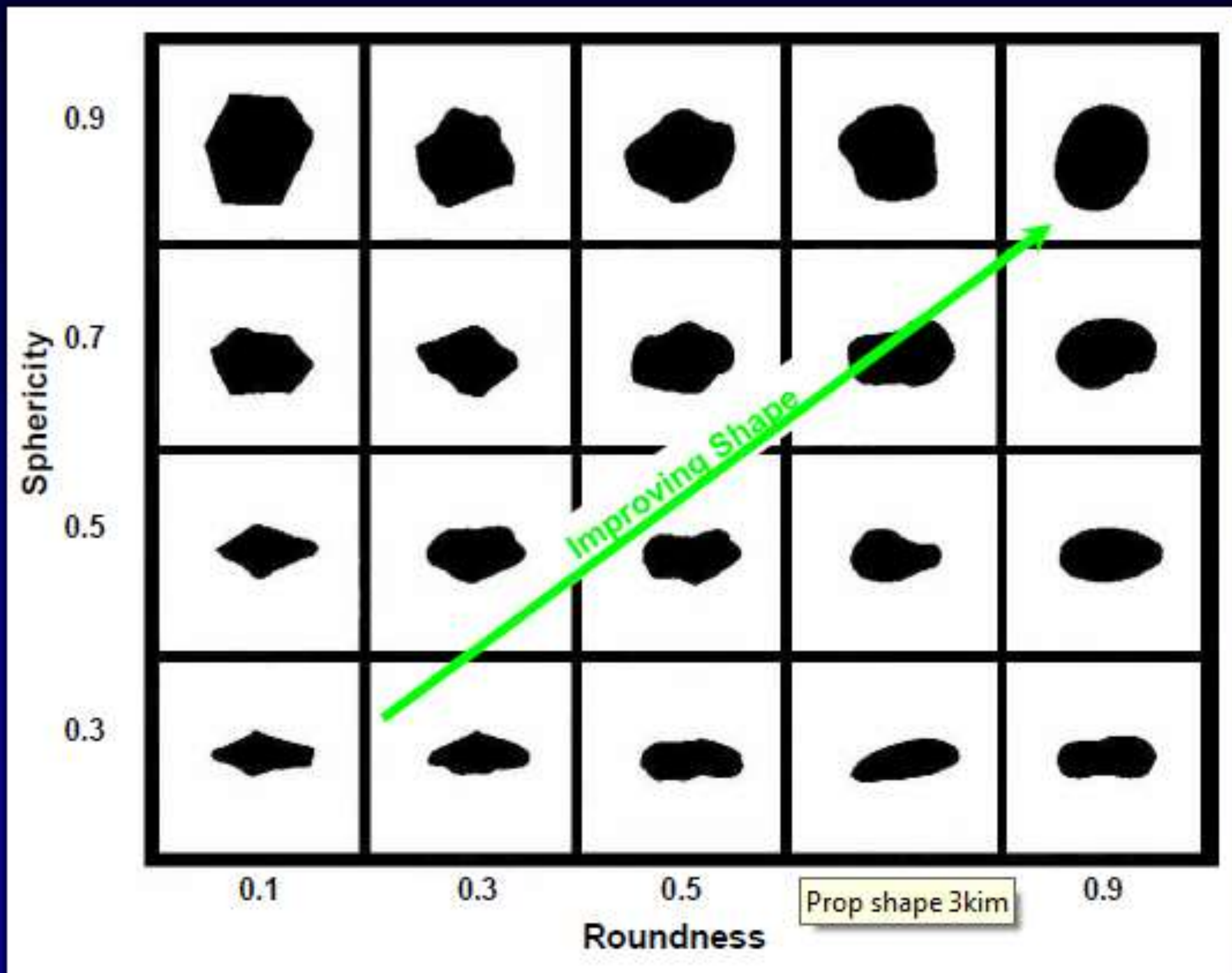
Average of all
Camsizer - Blue
Rotap - Red

ID	Method	20/40 w/ 95% CI		Variance
ABC	Sieve	58.9	62.5	3.5
E4(3x)	Camsizer	60.1	64.3	4.3
D(3x)	Sieve Only	59.4	62.3	2.9
E4(3x)	Camsizer	60.1	64.3	4.3
All Samples	Both	56.9	67.3	10.4
E1E2E3E4(3x)+BCD	Camsizer	58.8	67.2	8.4
ABCD(3x)	Sieve	58.8	62.7	3.9
D(3x)	Sieve	59.4	62.3	2.9
D(1x) recombined	Camsizer		62.2	
D(3x Sieve)+1x Cam	Both	57.8	64.7	6.9

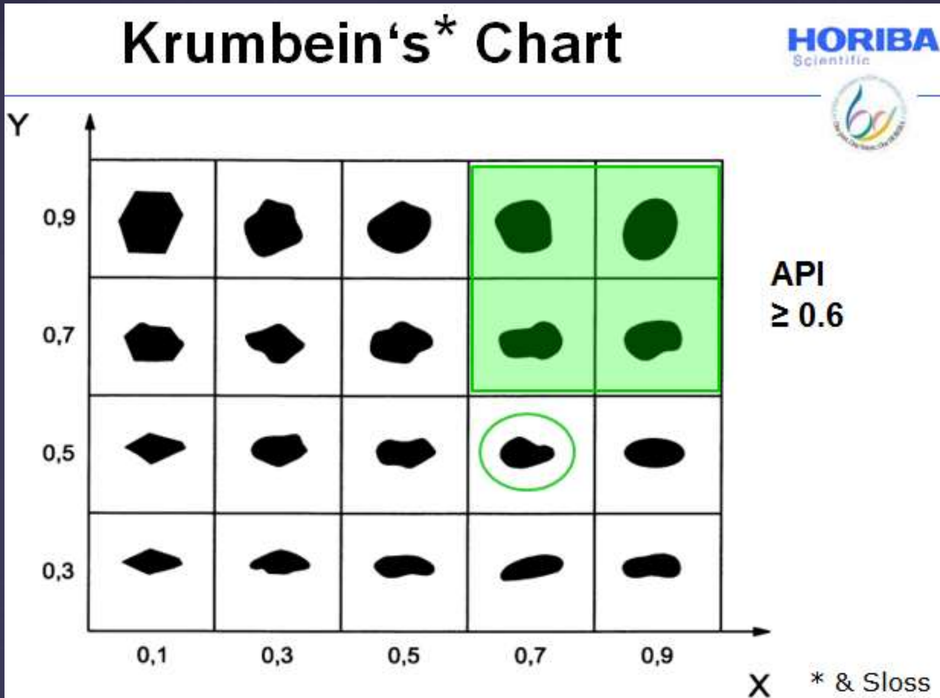



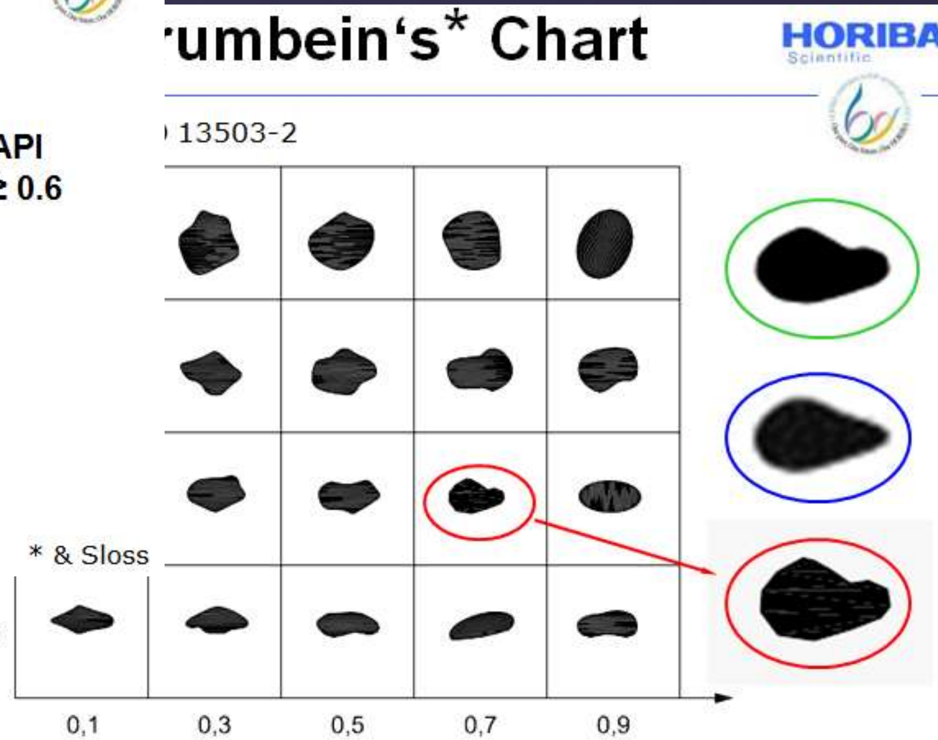

Round/Sphericity….Proving the "method…"

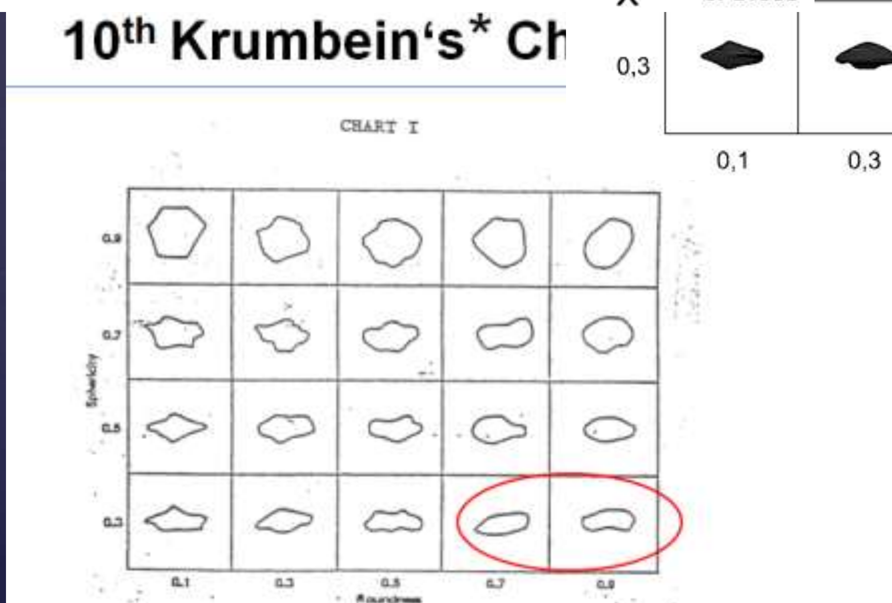




0.9
0.7
0.5
0.3
Sphericity
Improving Shape
0.1
0.3
0.5
Prop shape 3kim
0.9
Roundness

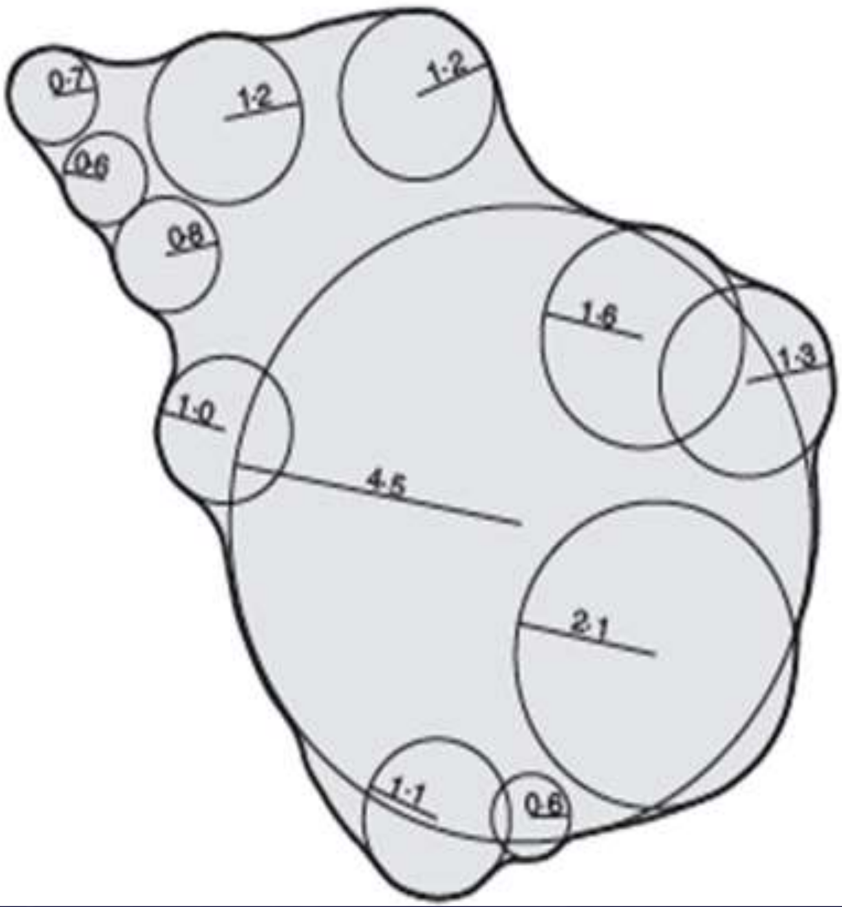

Krumbein's* Chart
HORIBA Scientific
Y
0,9
0,7
0,5
0,3
0,1
0,3
0,5
0,7
0,9
X
API
≥ 0.6


umbein's* Chart
HORIBA Scientific
13503-2
0,3
0,1
0,3
0,5
0,7
0,9
* & Sloss

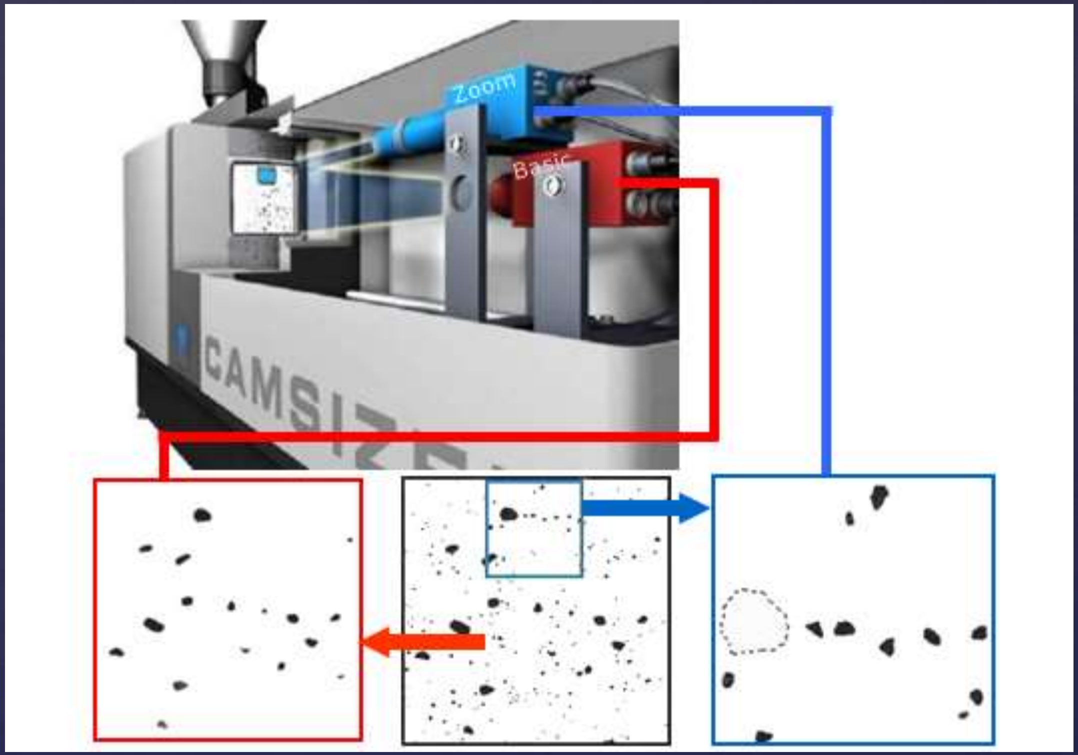

10th Krumbein's* Ch
CHART I

Manual Roundness Measurement

HORIBA Scientific



Roundness/Sphericity



Sphericity								average(dup1-5)	average(dup1-5+org	S.D.(dup1-5)	S.D.(dup1-5+org)		CI(F-2)	
	org	dup1	dup2	dup3	dup4	dup5								
16	0.858	0.958	0.939		0.838	0.906		0.91025	0.8998	0.052740718	0.051304971		0.10548	0.10261
18	0.88													
20	0.845	0.839	0.864	0.815	0.838	0.845		0.8402	0.841	0.01754138	0.015811388		0.03508	0.03162
25	0.831	0.771	0.795	0.772	0.803	0.779		0.784	0.791833333	0.014317821	0.023068738		0.02864	0.04614
30	0.778	0.771	0.801	0.763	0.781	0.78		0.7792	0.779	0.014219705	0.012727922		0.02844	0.02546
35	0.763	0.742	0.762	0.766	0.762	0.76		0.7584	0.759166667	0.009423375	0.008635199		0.01885	0.01727
40	0.764	0.741	0.755	0.736	0.738	0.756		0.7452	0.748333333	0.009576012	0.011500725		0.01915	0.023
45	0.749	0.741	0.746	0.736	0.741	0.733		0.7394	0.741	0.005029911	0.00596574		0.01006	0.01193
50	0.732	0.718	0.728	0.719	0.724	0.724		0.7226	0.724166667	0.00409878	0.005307228		0.0082	0.01061
60	0.721	0.717	0.714	0.713	0.712	0.709		0.713	0.714333333	0.002915476	0.004179314		0.00583	0.00836
70	0.71	0.696	0.699	0.7	0.702	0.698		0.699	0.700833333	0.002236068	0.00491596		0.00447	0.00983

Roundness								average(d	average(d	S.D.(dup1-	S.D.(dup1-5+org)		CI(F-2)	
	org	dup1	dup2	dup3	dup4	dup5								
16	0.665	1	1		0.975	0.625		0.9	0.853	0.18371	0.19068			
18	0.84													
20	0.845	0.653	0.913	0.747	0.791	0.69		0.7588	0.77317	0.1011	0.09703		0.20219	0.19406
25	0.822	0.71	0.809	0.782	0.724	0.744		0.7538	0.76517	0.04106	0.04609		0.08213	0.09218
30	0.801	0.745	0.747	0.74	0.773	0.714		0.7438	0.75333	0.02102	0.02998		0.04203	0.05996
35	0.782	0.774	0.753	0.759	0.769	0.727		0.7564	0.76067	0.01838	0.01948		0.03676	0.03896
40	0.762	0.726	0.756	0.722	0.722	0.733		0.7318	0.73683	0.01425	0.01774		0.02851	0.03547
45	0.716	0.703	0.725	0.704	0.7	0.675		0.7014	0.70383	0.01778	0.01699		0.03557	0.03397
50	0.684	0.67	0.679	0.679	0.68	0.664		0.6744	0.676	0.00709	0.00746		0.01418	0.01491
60	0.653	0.648	0.654	0.653	0.653	0.639		0.6494	0.65	0.00627	0.0058		0.01254	0.01159
70	0.621	0.613	0.627	0.624	0.623	0.597		0.6168	0.6175	0.01226	0.0111		0.02451	0.02219

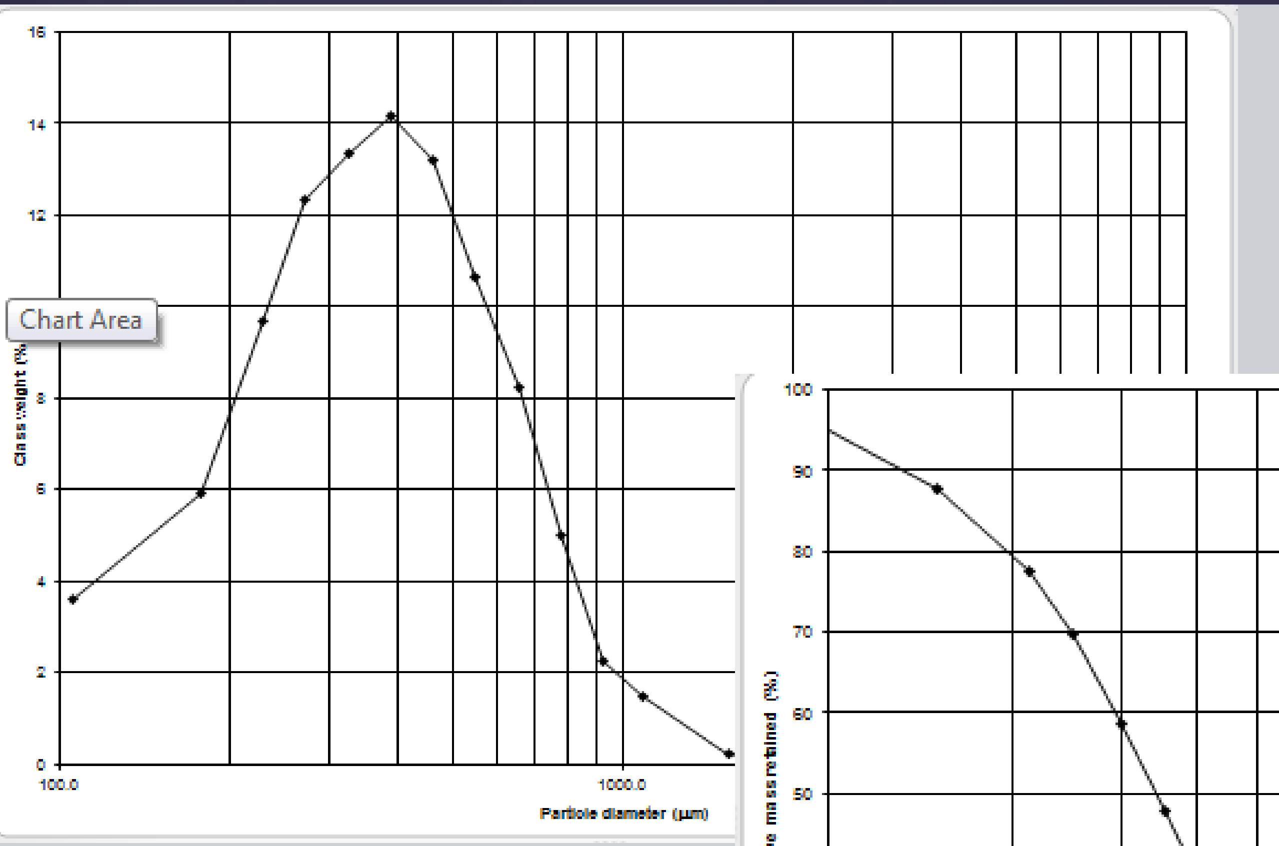
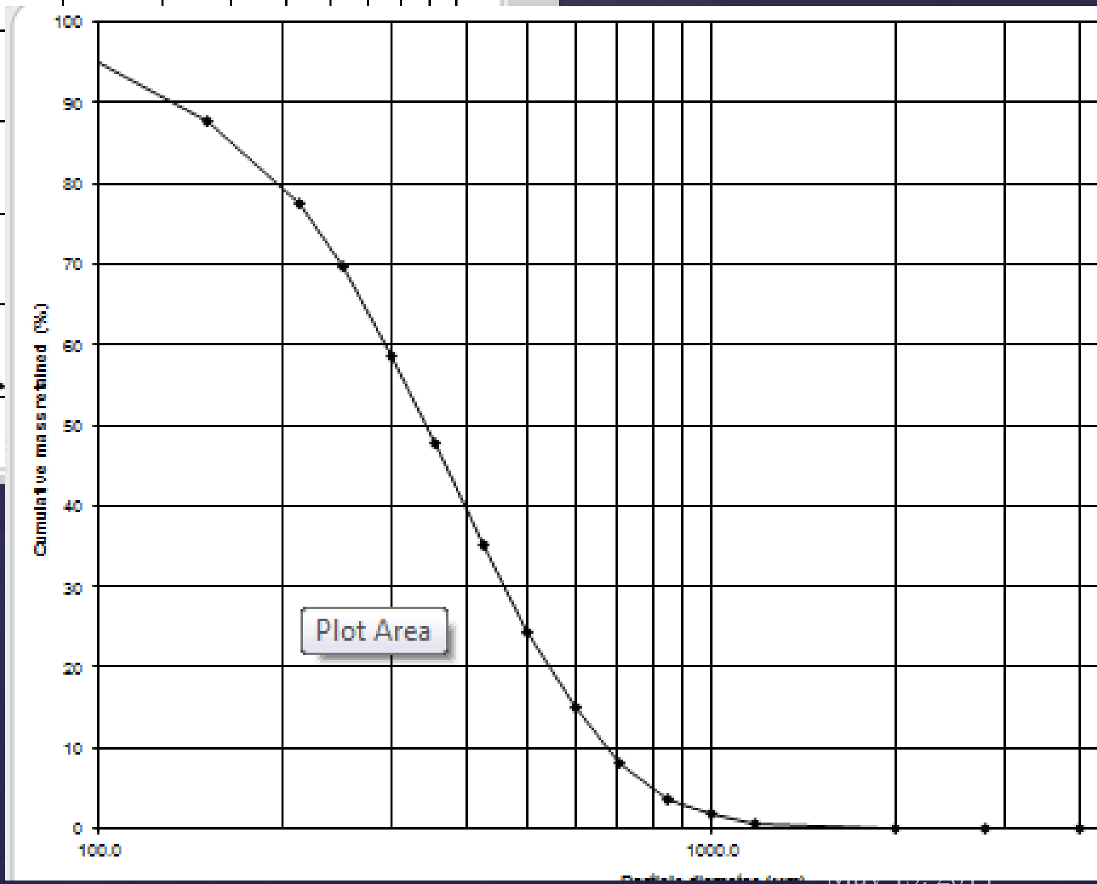
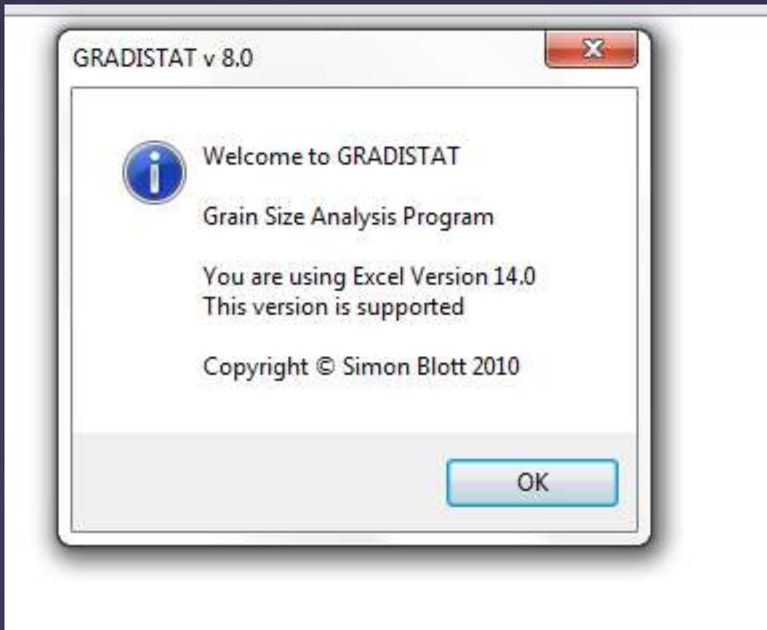


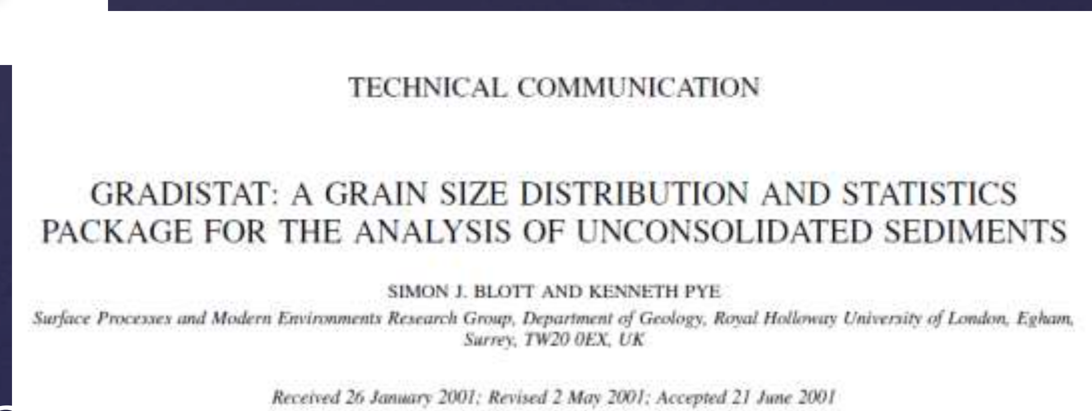
Chart Area
Class weight (%)
Particle diameter (µm)
100.0
1000.0


Cumulative mass retained (%)
Plot Area
100.0
1000.0

	Site 1			Site 2			Site 3			Site 4		
Sieve Size (US Standard)	% Retained	Roundness	Sphericity	% Retained	Roundness	Sphericity	% Retained	Roundness	Sphericity	% Retained	Roundness	Sphericity
#16	0.1	0.92	0.96	0.4	0.91	0.87	0.3	0.91	0.87	0.6	0.67	0.86
#18	0.1	0.83	0.88	0.4	0.87	0.90	0.7	0.87	0.90	1.1	0.84	0.88
#20	0.8	0.75	0.85	1.1	0.83	0.87	1.5	0.83	0.87	1.7	0.85	0.85
#25	2.2	0.77	0.81	3.5	0.77	0.83	4.1	0.77	0.83	4.1	0.82	0.83
#30	6.6	0.78	0.83	5.2	0.82	0.83	7.2	0.82	0.83	6.3	0.80	0.78
#35	14.6	0.76	0.78	9.1	0.79	0.78	11.5	0.79	0.78	8.8	0.78	0.76
#40	17.6	0.73	0.77	10.2	0.79	0.77	12.7	0.79	0.77	9.7	0.76	0.76
#45	22.9	0.74	0.75	12.9	0.76	0.76	14.2	0.76	0.76	11.6	0.72	0.75
#50	20.0	0.70	0.72	10.2	0.72	0.73	11.4	0.72	0.73	10.2	0.68	0.73
#60	10.3	0.65	0.71	8.2	0.67	0.72	9.6	0.67	0.72	10.2	0.65	0.72
#70	2.2	0.61	0.70	5.3	0.63	0.70	5.7	0.63	0.70	7.2	0.62	0.71
#100	0.8	0.34	0.63	7.9	0.23	0.49	6.4	0.23	0.49	9.3	0.49	0.61
#200	0.4	0.19	0.54	16.5	0.22	0.43	8.1	0.22	0.43	11.3	0.24	0.38
PAN	1.5			9.2			6.6			8.0		
20/40	41.0	0.7595	0.797	28.0	0.79275	0.79925	35.6	0.79275	0.79925	28.9	0.79175	0.784
30/50	75.1	0.7	0.8	42.4	0.8	0.8	49.8	0.8	0.8	40.3	0.7	0.8
40/70	55.3	0.7	0.7	36.6	0.7	0.7	40.9	0.7	0.7	39.2	0.7	0.7

4 sites




TECHNICAL COMMUNICATION

GRADISTAT: A GRAIN SIZE DISTRIBUTION AND STATISTICS PACKAGE FOR THE ANALYSIS OF UNCONSOLIDATED SEDIMENTS

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GradStat8

	SAMPLE STATISTICS				
		1	2	3	4
	ANALYST AND DATE:	,	,	,	,
	SIEVING ERROR:				
	SAMPLE TYPE:	Unimodal, Well Sorted	Bimodal, Moderately Sorte	nimodal, Moderately Sorte	nimodal, Moderately Sorte
	TEXTURAL GROUP:	Sand	Sand	Sand	Sand
	SEDIMENT NAME:	Well Sorted Medium Sand	derately Sorted Medium Sa	erately Sorted Medium Sa	erately Sorted Medium Sa
METHOD OF	MEAN $(\bar{x}_a)$:	428.4	363.2	407.0	386.5
MOMENTS	SORTING (σ_a) :	137.7	210.9	203.0	228.2
Arithmetic (μm)	SKEWNESS (Sk_a) :	1.473	1.341	1.161	1.529
	KURTOSIS (K_a) :	9.001	7.112	6.321	7.217
METHOD OF	MEAN $(\bar{x}_g)$:	406.9	301.0	353.9	323.4
MOMENTS	SORTING (σ_g) :	1.361	1.873	1.726	1.829
Geometric (μm)	SKEWNESS (Sk_g) :	-0.068	-0.342	-0.581	-0.258
	KURTOSIS (K_g) :	4.255	2.249	3.068	2.549
METHOD OF	MEAN $(\bar{x}_\phi)$:	1.297	1.732	1.499	1.629
MOMENTS	SORTING (σ_ϕ) :	0.444	0.905	0.787	0.871
Logarithmic (ϕ)	SKEWNESS (Sk_ϕ) :	0.068	0.342	0.581	0.258
	KURTOSIS (K_ϕ) :	4.255	2.249	3.068	2.549
FOLK AND	MEAN (M_G) :	408.7	296.1	363.9	324.9
WARD METHOD	SORTING (σ_G) :	1.346	1.944	1.724	1.870
(μm)	SKEWNESS (Sk_G) :	0.086	-0.276	-0.201	-0.156
	KURTOSIS (K_G) :	0.957	0.975	1.190	1.078
FOLK AND	MEAN (M_Z) :	1.291	1.756	1.458	1.622
WARD METHOD	SORTING (σ_I) :	0.429	0.959	0.786	0.903
(ϕ)	SKEWNESS (Sk_I) :	-0.086	0.276	0.201	0.156
	KURTOSIS (K_G) :	0.957	0.975	1.190	1.078
FOLK AND	MEAN:	Medium Sand	Medium Sand	Medium Sand	Medium Sand
WARD METHOD	SORTING:	Well Sorted	Moderately Sorted	Moderately Sorted	Moderately Sorted
(Description)	SKEWNESS:	Symmetrical	Fine Skewed	Fine Skewed	Fine Skewed
	KURTOSIS:	Mesokurtic	Mesokurtic	Leptokurtic	Mesokurtic

GradStat8

SAMPLE STATISTICS

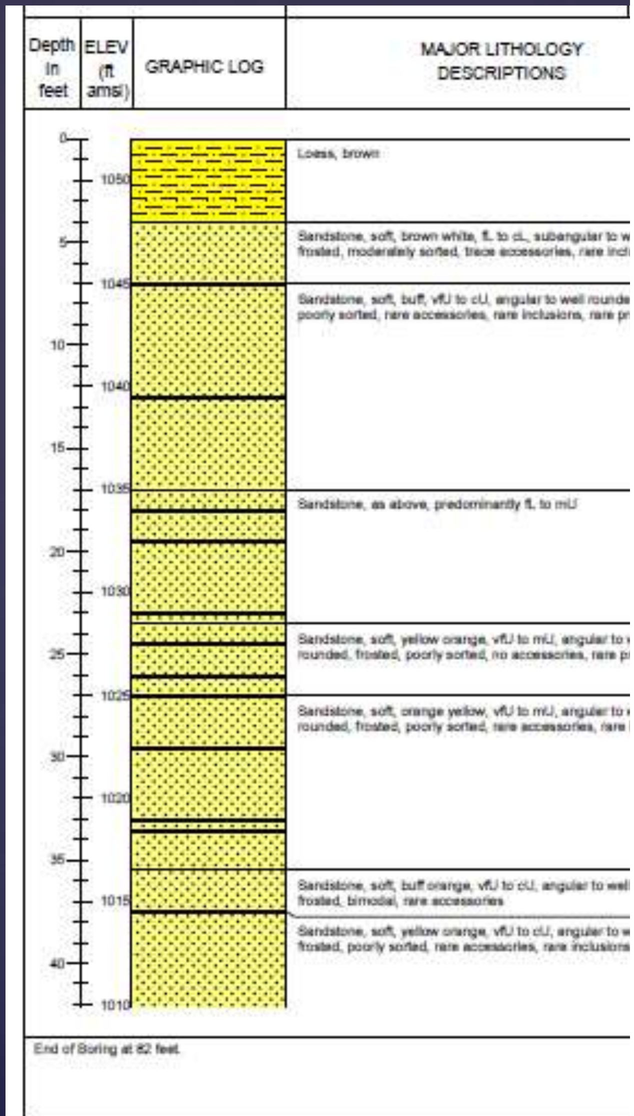
	1	2	3	4
ANALYST AND DATE:	,	,	,	,
SIEVING ERROR:				
SAMPLE TYPE:	Unimodal, Well Sorted	Bimodal, Moderately Sorte	nimodal, Moderately Sorte	nimodal, Moderately Sorted
TEXTURAL GROUP:	Sand	Sand	Sand	Sand
SEDIMENT NAME:	Well Sorted Medium Sand	derately Sorted Medium Sa	erately Sorted Medium S	erately Sorted Medium Sand
MODE 1 [redacted]	390.0	390.0	390.0	390.0
MODE 2 (µm):		112.5		
MODE 3 (µm):				
MODE 1 (ϕ):	1.364	1.364	1.364	1.364
MODE 2 (ϕ):		3.237		
MODE 3 (ϕ):				
D_{10} (µm):	280.5	109.9	160.5	131.8
D_{50} (µm):	401.4	339.5	380.6	342.5
D_{90} (µm):	599.5	628.2	665.9	676.9
(D_{90} / D_{10}) (µm):	2.137	5.716	4.149	5.134
$(D_{90} - D_{10})$ (µm):	319.0	518.3	505.4	545.0
(D_{75} / D_{25}) (µm):	1.516	2.416	1.944	2.213
$(D_{75} - D_{25})$ (µm):	169.8	278.9	250.4	271.9
D_{10} (ϕ):	0.738	0.671	0.587	0.563
D_{50} (ϕ):	1.317	1.559	1.394	1.546
D_{90} (ϕ):	1.834	3.186	2.639	2.923
(D_{90} / D_{10}) (ϕ):	2.484	4.750	4.500	5.192
$(D_{90} - D_{10})$ (ϕ):	1.096	2.515	2.053	2.360
(D_{75} / D_{25}) (ϕ):	1.598	2.188	2.004	2.133
$(D_{75} - D_{25})$ (ϕ):	0.600	1.272	0.959	1.146

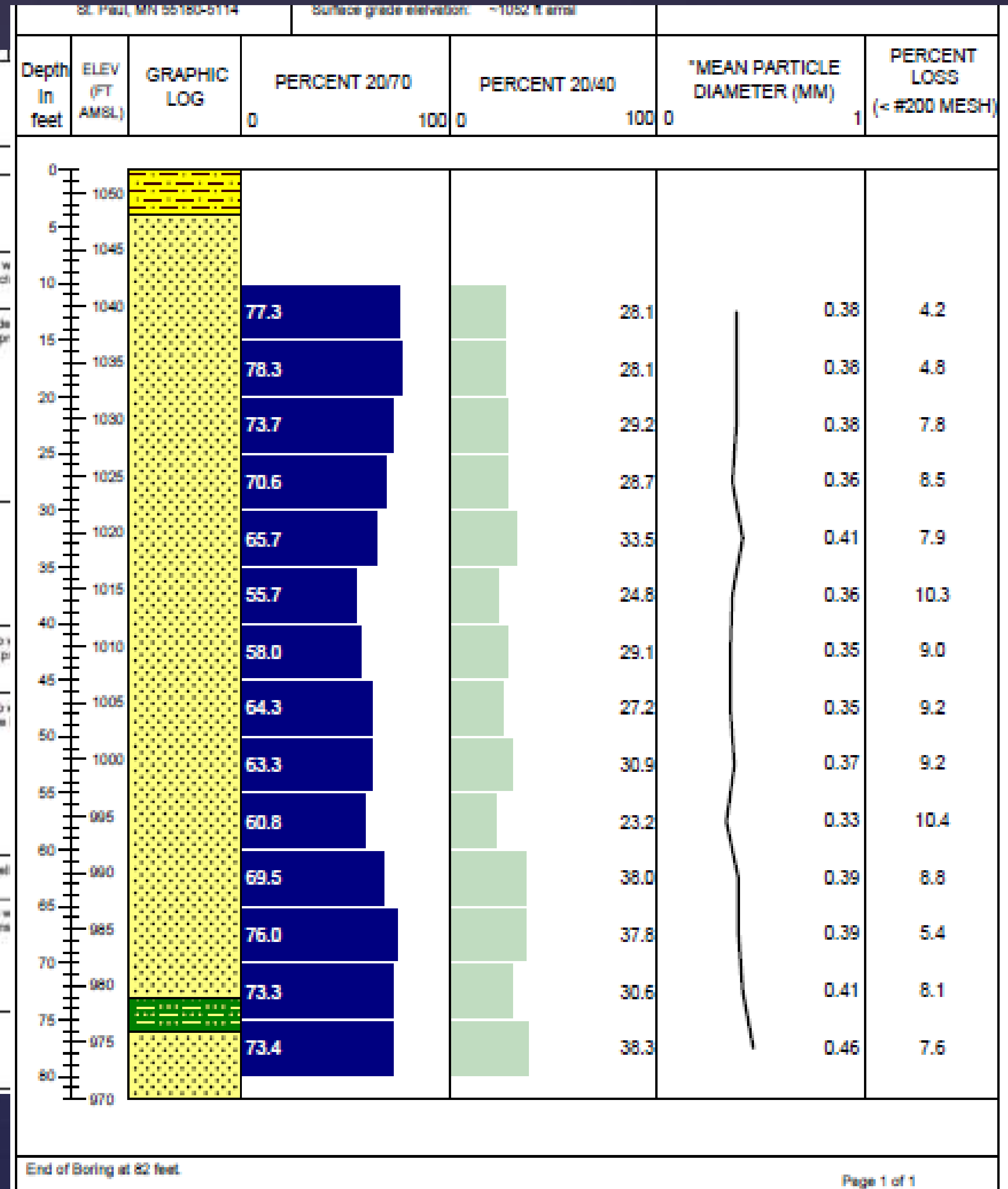
GradStat8 –cont.

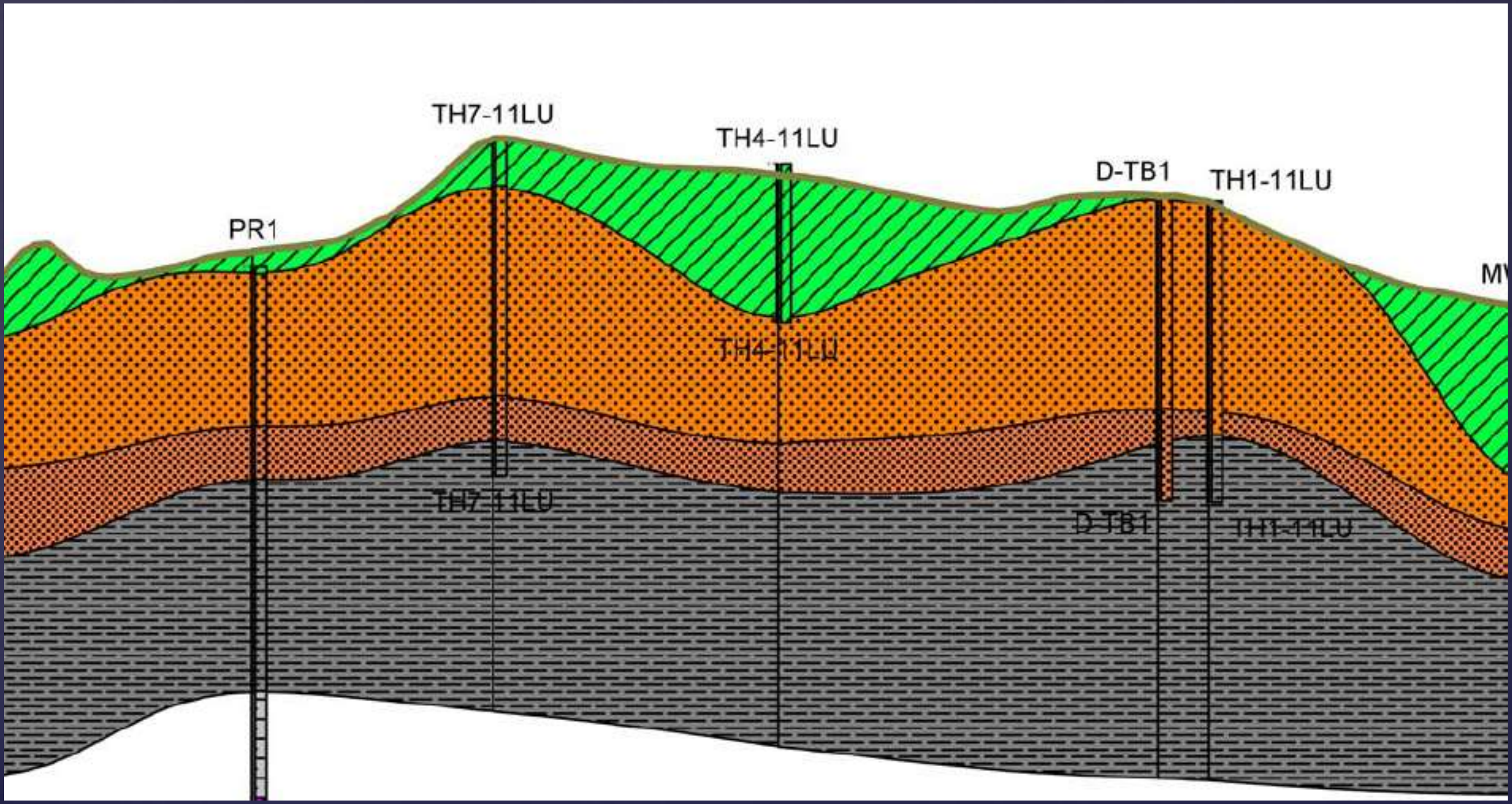
Planning

Summit Envirosolutions

Bore	%ret 20	%ret 30	%ret 40	%ret 50	% ret 60	%ret 70	%ret 100	% 20-40	% 30-50	% 40-70	%70-200	% >200
TB-1 30-35	3.8	19.7	49.8	70.5	79.8	86.3	94.4	46.0	50.8	36.5	11.9	1.8
TB-1 40-45	4.9	16.8	39.8	64.5	74.3	79.4	89.9	34.9	47.7	39.6	17.1	3.5
TB-1 50-55	10.6	31.8	56.3	76.2	84.0	88.1	93.8	45.6	44.4	31.8	10.5	1.4
TB-1 60-65	9.1	32.5	55.6	71.9	78.0	81.6	88.1	46.6	39.4	25.9	15.3	3.1
TB-1 70-75	3.2	12.3	31.7	55.6	69.4	78.2	92.3	28.5	43.3	46.5	20.3	1.5
TB-1 80-85	3.1	12.5	30.8	51.7	63.2	70.7	84.8	27.7	39.2	39.8	26.3	3.0
TB-2 10-15	4.1	24.8	55.3	78.9	86.7	90.8	95.6	51.2	54.1	35.5	7.5	1.7
TB-2 20-25	10.8	35.7	67.2	88.0	93.0	95.1	97.4	56.4	52.3	27.9	3.9	1.0
TB-2 30-35	13.8	49.9	72.4	84.7	88.6	90.6	93.8	58.6	34.8	18.2	7.2	2.2
TB-2 40-45	1.7	8.4	22.9	42.5	55.4	64.9	83.9	21.2	34.1	41.9	33.0	2.1
TB-2 50-55	2.0	12.5	32.3	53.1	64.6	72.0	85.7	30.3	40.6	39.7	25.7	2.3
TB-2 60-65	1.6	10.2	31.2	54.8	66.5	73.6	85.5	29.6	44.5	42.3	23.6	2.8
TB-2 70-75	0.6	6.7	28.0	54.5	67.4	75.2	88.6	27.4	47.8	47.2	22.5	2.3
TB-2 80-85	0.6	4.3	15.8	34.0	48.0	59.0	82.8	15.2	29.7	43.1	37.6	3.4
TB-2 90-95	0.3	3.2	18.5	47.2	65.2	75.8	92.5	18.2	44.0	57.3	22.6	1.6
TB-6 20-25	5.7	24.0	54.9	75.1	83.0	88.3	95.5	49.1	51.2	33.4	10.5	1.2
TB-6 30-35	3.1	20.0	51.8	77.4	84.6	88.1	93.2	48.7	57.3	36.3	9.8	2.1
TB-6 40-45	10.5	31.8	54.9	71.9	79.9	84.9	92.3	44.4	40.1	30.0	13.1	2.0
TB-6 50-55	7.5	22.8	44.4	63.3	72.3	77.9	87.2	36.9	40.5	33.5	18.5	3.6
TB-6 60-65	1.2	8.9	25.4	46.8	60.0	68.8	86.9	24.2	37.9	43.4	29.2	2.0
TB-6 70-75	1.8	11.8	33.5	57.2	69.2	76.6	88.0	31.7	45.4	43.1	21.3	2.1
TB-6 80-85	1.2	10.3	30.7	54.1	65.8	73.1	86.4	29.5	43.8	42.4	24.1	2.8
TB-6 90-93	0.5	4.6	22.3	48.0	61.4	69.6	84.5	21.8	43.4	47.3	26.8	3.6
TB-7 30-35	3.8	18.4	45.3	69.2	78.2	82.8	90.7	41.5	50.8	37.5	14.6	2.6
TB-7 40-45	4.2	18.1	40.2	61.7	70.8	76.5	86.2	36.0	43.5	36.2	19.3	4.2
TB-7 50-55	5.7	20.9	41.4	59.2	67.4	72.7	83.0	35.7	38.3	31.3	23.3	4.0
TB-7 60-65	4.2	18.1	40.2	61.7	70.8	76.5	86.2	36.0	43.5	36.2	19.3	4.2
TB-7 70-75	2.0	11.2	28.3	47.1	58.0	65.3	78.9	26.2	35.9	37.0	27.7	7.0
TB-7 80-85	1.0	8.7	26.2	46.8	59.2	67.7	82.7	25.2	38.1	41.5	27.3	5.0

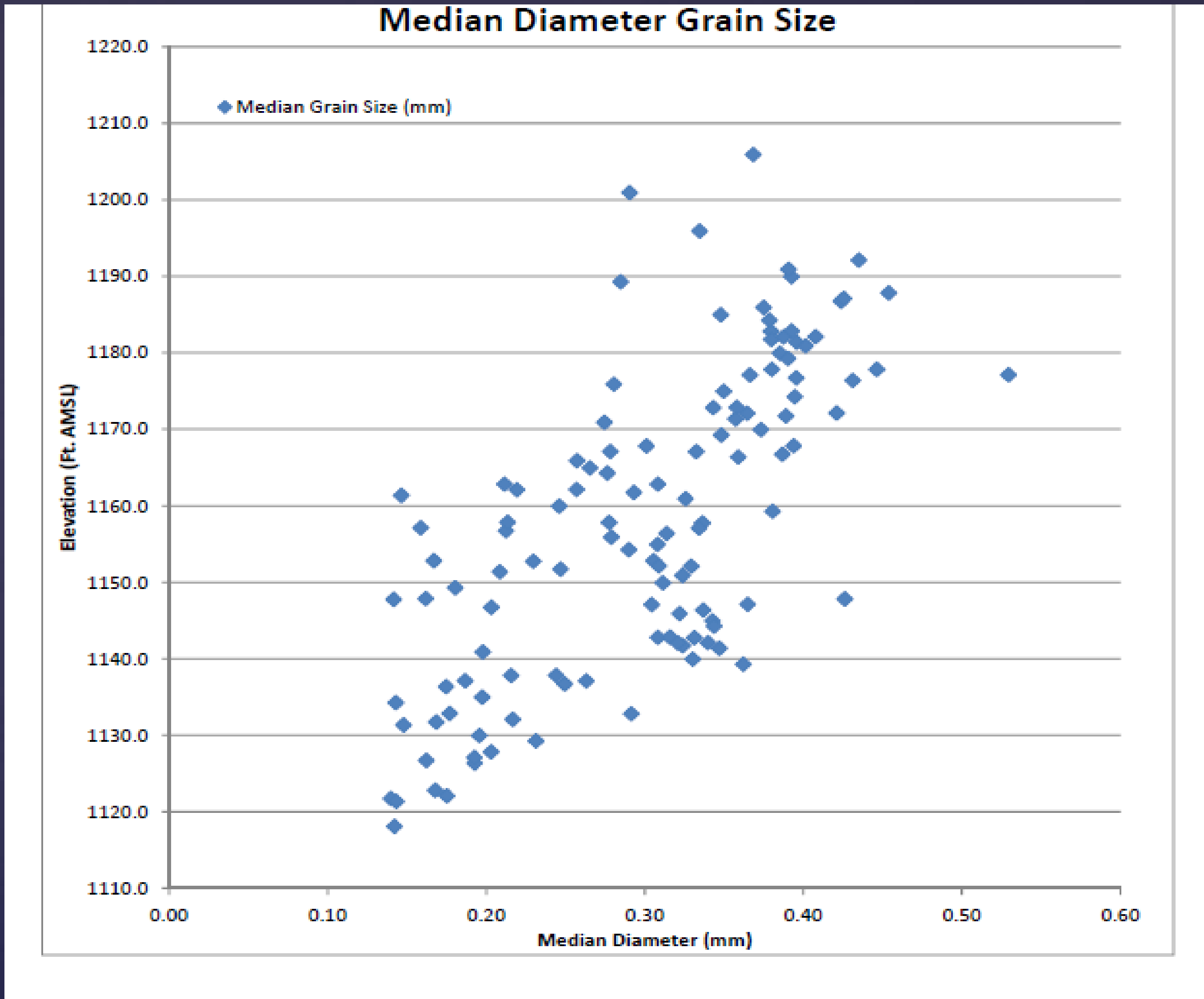

Depth in feet
ELEV (ft amsl)
GRAPHIC LOG
MAJOR LITHOLOGY DESCRIPTIONS
Loess, brown
Sandstone, soft, brown white, fL to cL, subangular to w
frosted, moderately sorted, trace accessories, rare incl
Sandstone, soft, buff, vfU to cU, angular to well rounde
poorly sorted, rare accessories, rare inclusions, rare pr
Sandstone, as above, predominantly fL to mU
Sandstone, soft, yellow orange, vfU to mU, angular to
rounded, frosted, poorly sorted, no accessories, rare p
Sandstone, soft, orange yellow, vfU to mU, angular to
rounded, frosted, poorly sorted, rare accessories, rare
Sandstone, soft, buff orange, vfU to cU, angular to well
frosted, bimodal, rare accessories
Sandstone, soft, yellow orange, vfU to cU, angular to w
frosted, poorly sorted, rare accessories, rare inclusions
End of Boring at 82 feet.


St. Paul, MN 55180-5114
Surface grade elevation: ~1052 ft amsl
Depth in feet
ELEV (FT AMSL)
GRAPHIC LOG
PERCENT 20/70
0 100
PERCENT 20/40
0 100
*MEAN PARTICLE DIAMETER (MM)
0 1
PERCENT LOSS (< #200 MESH)
77.3 28.1 0.38 4.2
78.3 28.1 0.38 4.8
73.7 29.2 0.38 7.8
70.6 28.7 0.36 8.5
65.7 33.5 0.41 7.9
55.7 24.8 0.36 10.3
58.0 29.1 0.35 9.0
64.3 27.2 0.35 9.2
63.3 30.9 0.37 9.2
60.8 23.2 0.33 10.4
69.5 38.0 0.39 8.8
76.0 37.8 0.39 5.4
73.3 30.6 0.41 8.1
73.4 38.3 0.46 7.6
End of Boring at 82 feet.
Page 1 of 1

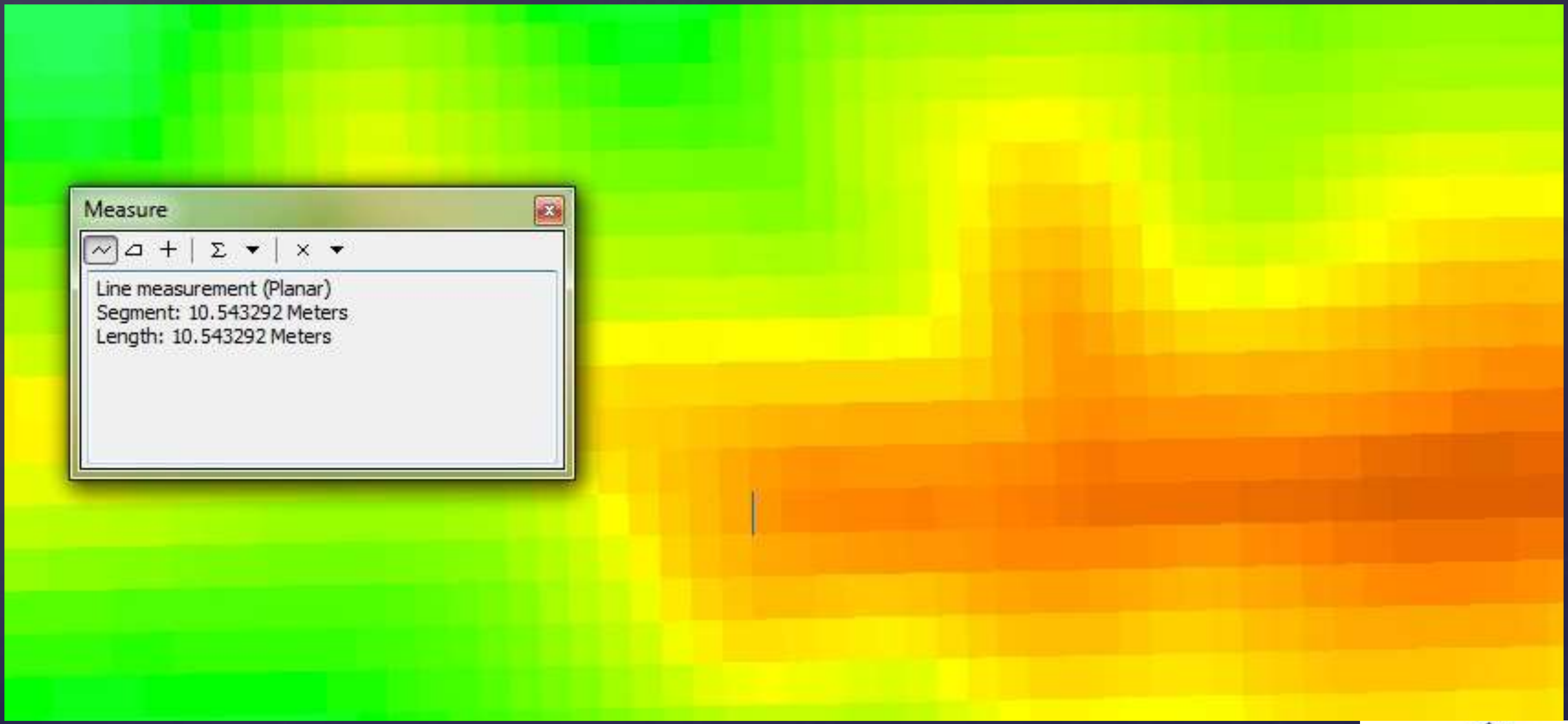


M

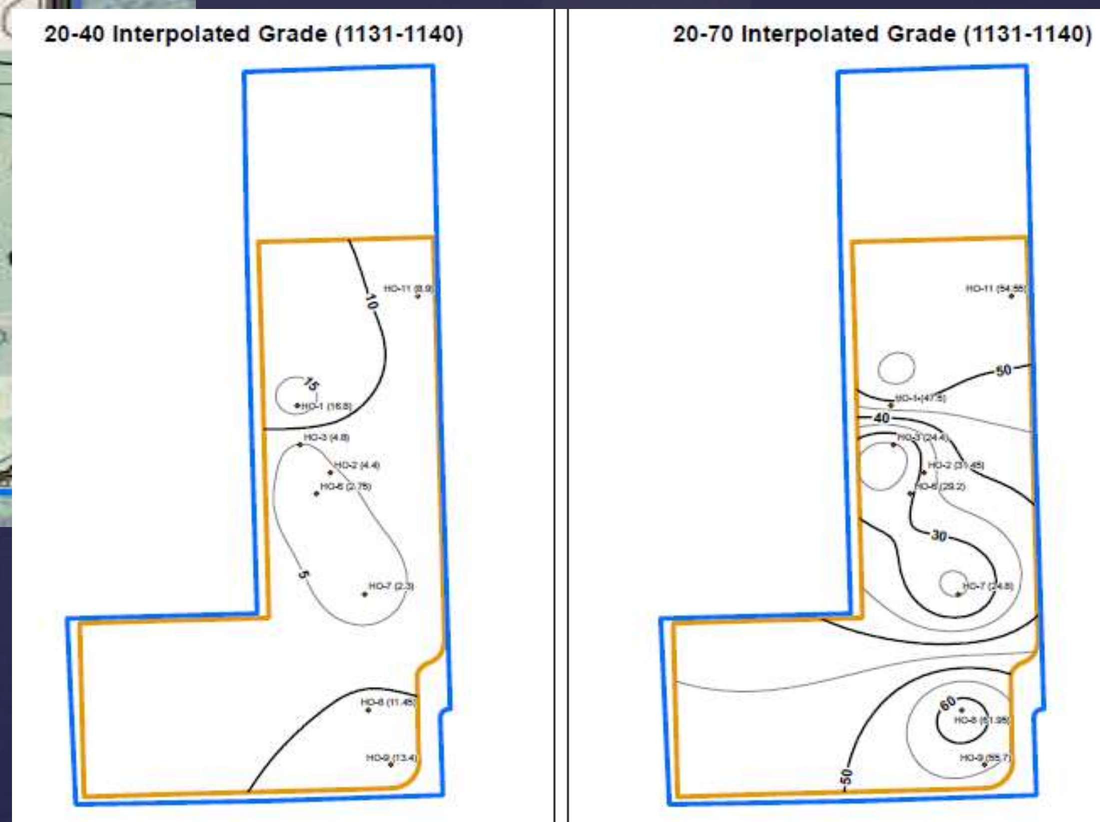
Summit Envirosolutions

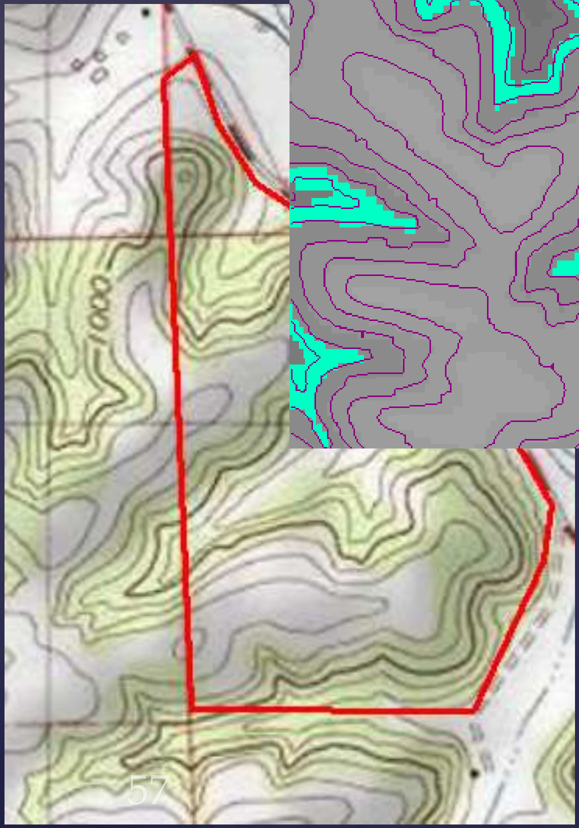

Median Diameter Grain Size
Median Grain Size (mm)
Elevation (Ft. AMSL)
1220.0
1210.0
1200.0
1190.0
1180.0
1170.0
1160.0
1150.0
1140.0
1130.0
1120.0
1110.0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Median Diameter (mm)

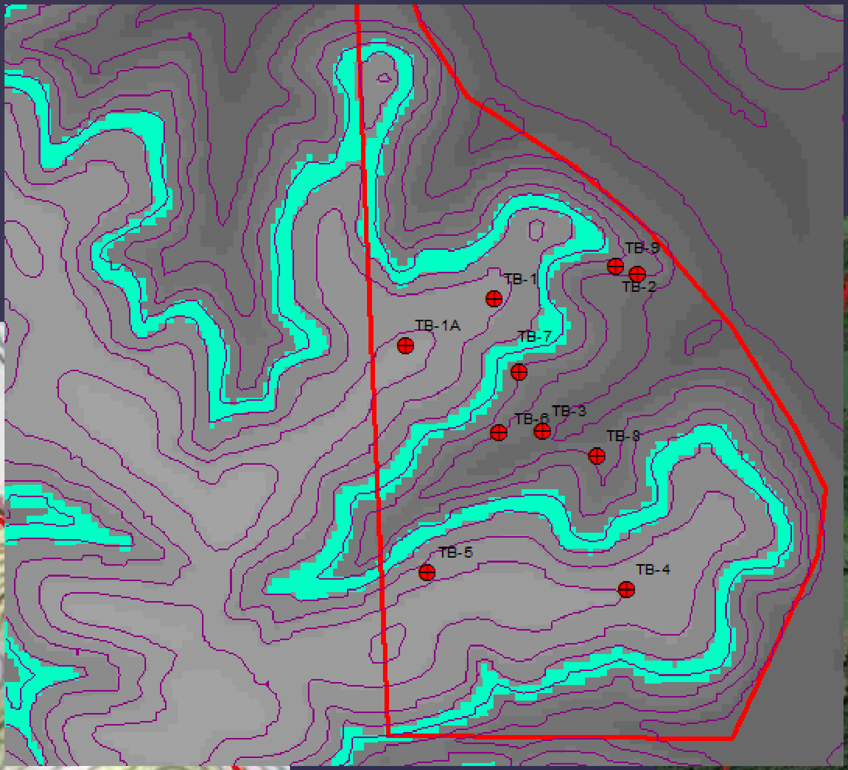
ArcGIS – Raster block allows x,y,z arithmetic



Block modeling




1000


TB-9
TB-1
TB-2
TB-1A
TB-7
TB-6
TB-3
TB-8
TB-5
TB-4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Google earth

Data used to build…..

- 3d model of subsurface
- Estimate potential resource quantity
- Data gaps, uncertainty & risks
- Risk/benefit of additional data collection
- Resource Valuation Model ($$$)

Ideal Proppant….

- Stronger than diamonds
- Lighter than water
- Cheaper than dirt
- Available everywhere

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