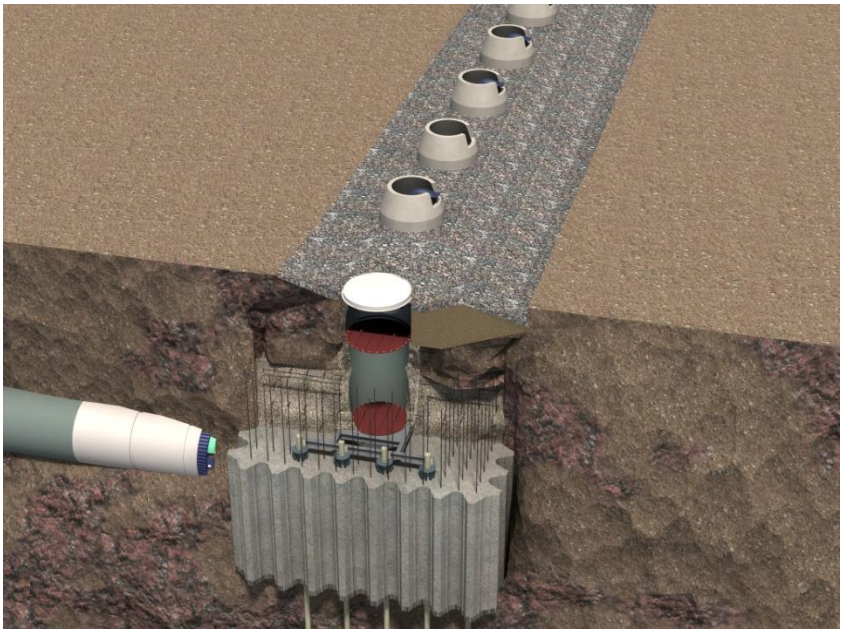
APPENDIX B
GEOTECHNICAL REPORTS

B.1: Geotechnical Data Report

Part K: Appendix H

Annacis Island WWTP New Outfall System

Vancouver Fraser Port Authority
Project and Environmental Review Application



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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

CDM Smith

Golder Associates

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APPENDIX H

Mineralogy and Soil Abrasivity Analyses

PETROGRAPHIC EXAMINATION OF FINE AGGREGATE

CSA A23.2-15A / ASTM C 295

CDM Smith Canada ULC
4720 Kingsway, Suite 1001
Burnaby, BC V5H 4N2

Project Number: 1525-010.3000
April 29, 2017

ATTENTION: Mr. John Newby

PROJECT: Annacis Outfall – Sediment evaluation

Sample:	**BH16-06, Sa. 21 @ 103 – 105 ft**

Date sampled: 2016 **Sampled by:** GAL

ROCK/MINERAL TYPE	PERCENT BY COUNT BY SIEVE SIZE					WEIGHTED TOTAL	MOHS HARDNESS	
	0.250	0.150	0.106	0.075	0.053		Individual	Weighted
Volcanic lithic fragments	21.7	13.4	9.0	6.3	4.4	**14.3**	**5**	**0.72**
Granite - diorite lithic fragments	22.4	15.3	17.0	15.1	12.7	**17.1**	**6**	**1.03**
Undifferentiated lithic fragments	3.2	2.8	4.2	2.0	2.5	**3.0**	**4**	**0.12**
Quartzite/chert	1.1	1.0	--	--	--	**0.9**	**7**	**0.06**
Quartz	32.5	42.1	41.5	47.8	53.5	**40.3**	**7**	**2.82**
Feldspar	13.7	11.4	12.9	14.1	11.4	**12.4**	**6**	**0.74**
Pyroxene/Amphibole	1.1	8.0	9.3	6.8	9.8	**6.6**	**6**	**0.40**
Epidote	0.7	2.1	2.1	2.4	1.6	**1.7**	**6.5**	**0.11**
Oxides	0.3	1.3	1.7	2.5	1.9	**1.1**	**6**	**0.07**
Calcite	1.1	1.3	0.6	0.5	--	**1.0**	**3**	**0.03**
Mica	1.4	1.3	1.7	2.5	2.2	**1.4**	**2.5**	**0.04**
Silt/clay lumps	0.4	--	--	--	--	**0.1**	**1**	**--**
Organic material	0.4	--	--	--	--	**0.1**	**1**	**--**
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**6.14**
Roundness	**0.5**	**0.45**	**0.4**	**0.3**	**0.3**	**0.43**		
Sphericity	**0.7**	**0.7**	**0.7**	**0.7**	**0.75**	**0.7**		

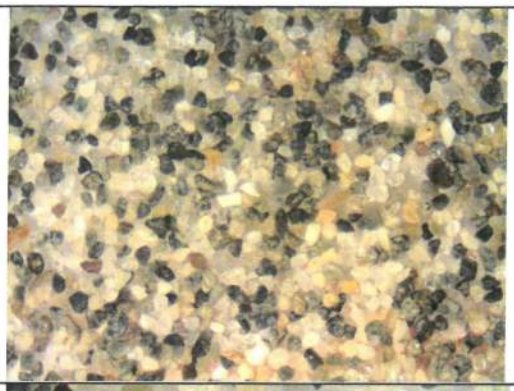
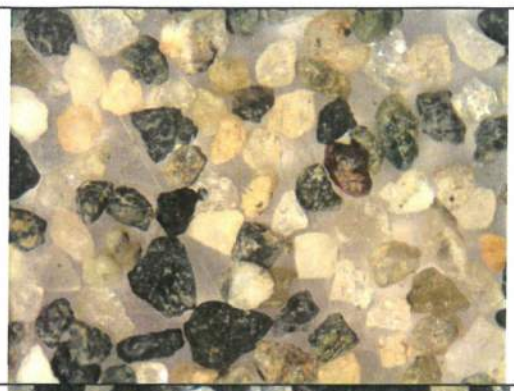
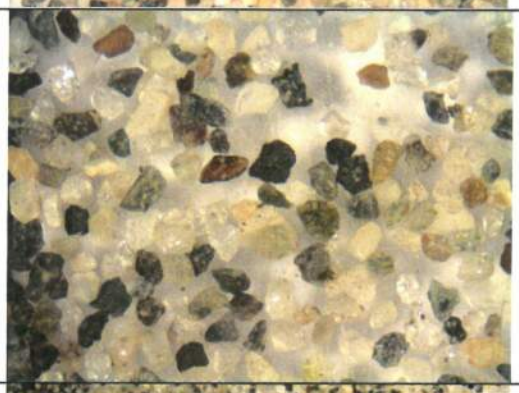
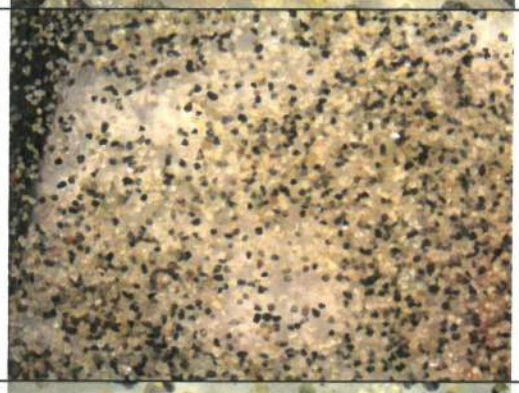
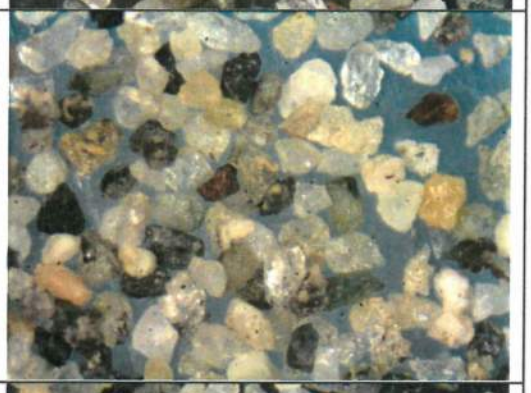
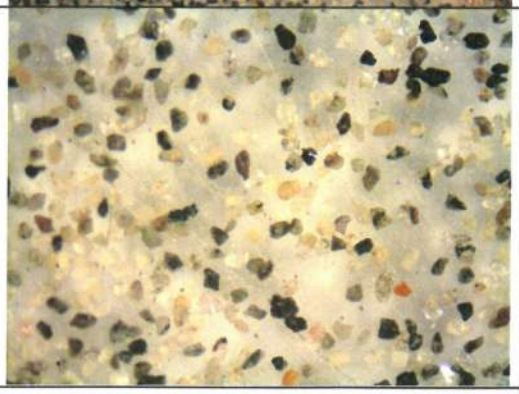
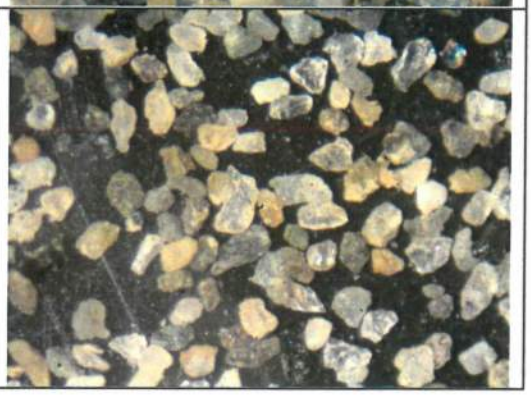
Note: 1. All identifications done using a binocular microscope, and standard physical index tests. No thin-sections were used.

PETROGRAPHER: _____
F. Shrimer, P. Geo.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA F. H. SHRIMER

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other locations/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

Photographs

0.250 mm retained fraction left view: 10x magnification right view: 30x magnification		
0.150 mm retained fraction left view: 30x magnification right view: 40x magnification		
0.106 mm retained fraction left view: 10x magnification right view: 60x magnification		
0.075 mm retained fraction left view: 40x magnification right view: 70x magnification		

PETROGRAPHIC EXAMINATION OF FINE AGGREGATE

CSA A23.2-15A / ASTM C295

CDM Smith Canada ULC
4720 Kingsway, Suite 1001
Burnaby, BC V5H 4N2

Project Number: 1525-010.3000
April 29, 2017

ATTENTION: Mr. John Newby

PROJECT: Annacis Outfall – Sediment evaluation

Sample:	**BH16-07, Sa. 21 @ 108 – 110 ft**

Date sampled: 2016 **Sampled by:** GAL

ROCK/MINERAL TYPE	PERCENT BY COUNT BY SIEVE SIZE (mm)					WEIGHTED TOTAL	MOHS HARDNESS	
	0.25, 0.15	0.106	0.075	0.063	0.053		Individual	Weighted
Volcanic lithic fragments	1.6	5.4	--	--	--	**1.3**	**5**	**0.07**
Granite - diorite lithic fragments	11.2	8.2	11.0	3.6	0.9	**8.3**	**6**	**0.50**
Undifferentiated lithic fragments	5.2	6.6	--	--	--	**1.8**	**4**	**0.07**
Quartz	37.7	52.3	55.5	62.6	64.5	**55.6**	**7**	**--**
Feldspar	10.2	11.5	17.5	16.9	17.5	**15.6**	**6**	**3.89**
Pyroxene/Amphibole	1.0	4.5	8.8	8.3	10.0	**7.5**	**6**	**0.94**
Epidote	--	--	0.7	1.1	1.4	**0.7**	**6.5**	**0.45**
Calcite	1.6	3.7	3.1	1.4	--	**2.6**	**3**	**0.08**
Oxides	0.7	--	2.7	1.8	2.3	**1.7**	**6**	**0.10**
Mica	23.9	7.8	0.7	4.3	3.4	**4.5**	**2.5**	**0.11**
Organic material	6.9	--	--	--	--	**0.4**	**1**	**--**
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**6.26**
Roundness	**0.50**	**0.45**	**0.40**	**0.40**	**0.40**	**0.42**		
Sphericity	**0.50**	**0.55**	**0.70**	**0.75**	**0.80**	**0.67**		

Note: 1. All identifications done using a binocular microscope, and standard physical index tests. No thin-sections were used.

PETROGRAPHER: _____
F. Shrimer, P. Geo.

PROFESSIONAL GEOSCIENTIST — PROVINCE OF BRITISH COLUMBIA — F. H. SHRIMER

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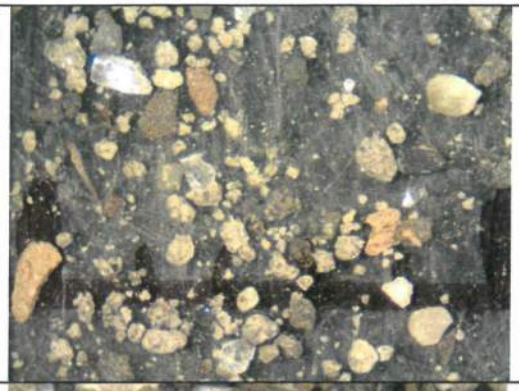
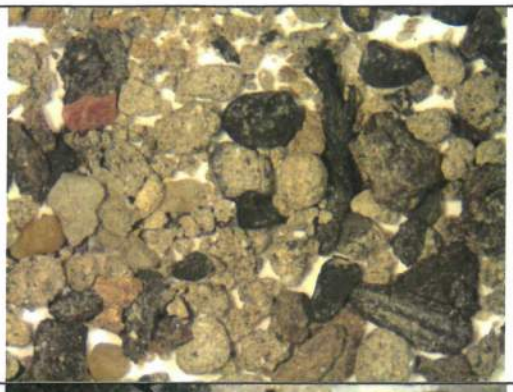
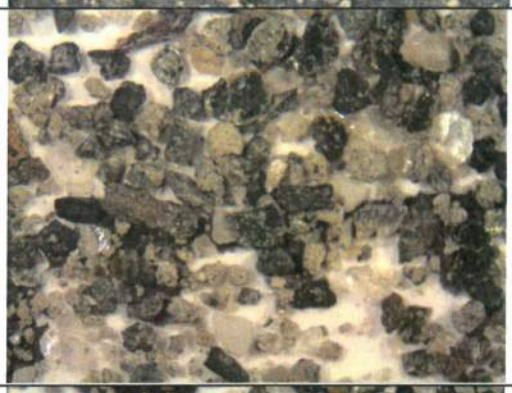
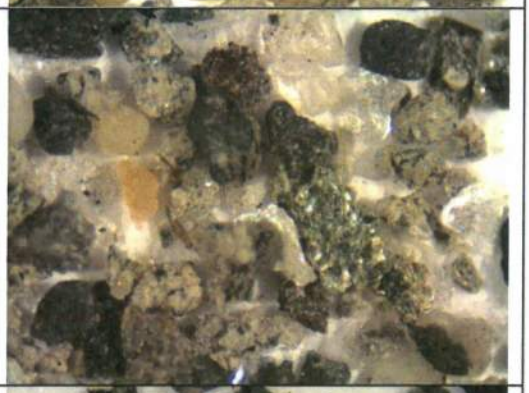
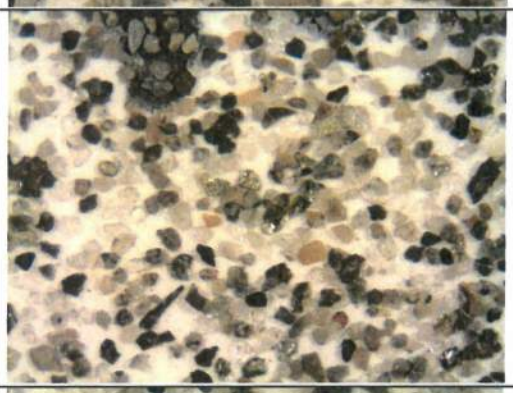
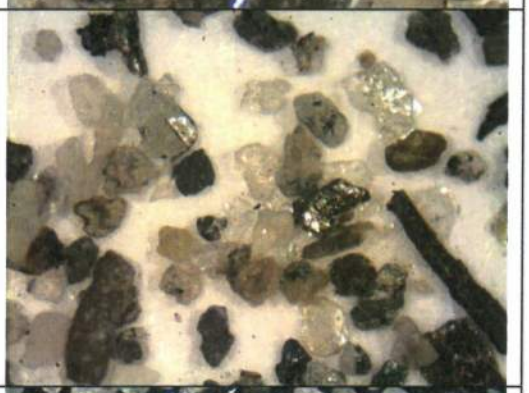
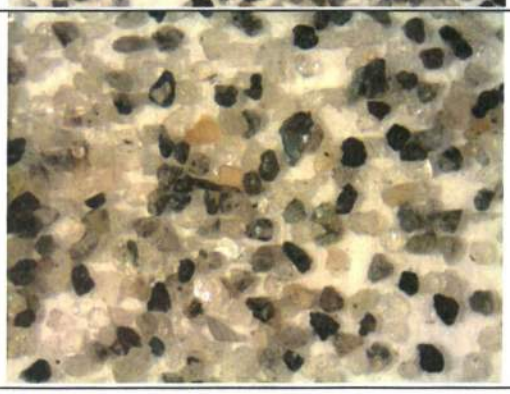
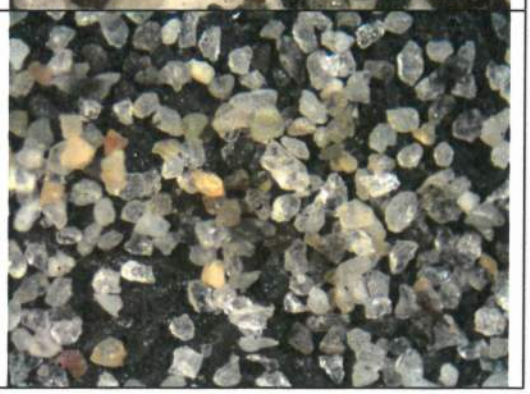
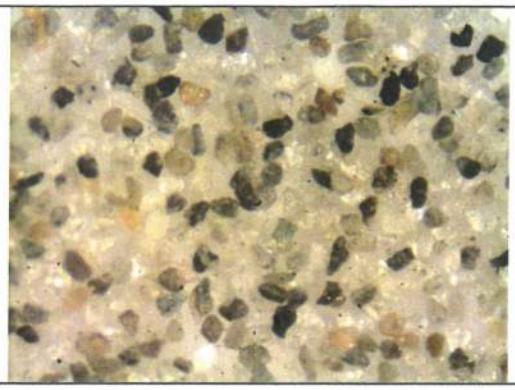
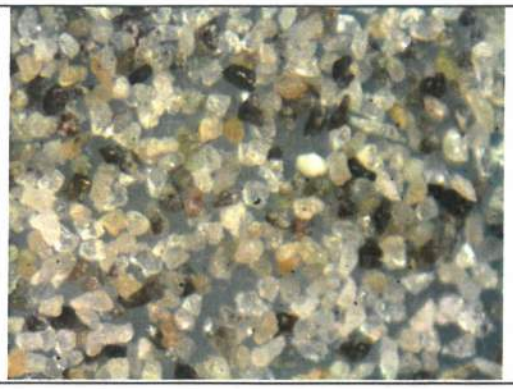
Photographs

0.425 mm retained fraction left view: 10x magnification right view: 15x magnification		
0.250 mm retained fraction left view: 20x magnification right view: 40x magnification		
0.150 mm retained fraction left view: 20x magnification right view: 50x magnification		
Left view: 0.106 mm retained fraction: 40x magnification **Right view: 0.075 mm retained fraction,** 70x magnification		

Left view: 0.063 mm retained fraction: 70x magnification **Right view: 0.053 mm retained fraction,** 70x magnification		

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4720 Kingsway, Suite 1001
Burnaby, BC V5H 4N2

Project Number: 1525-010.3000
April 29, 2017

ATTENTION: Mr. John Newby

PROJECT: Annacis Outfall – Sediment evaluation

Sample:	**SH16-06, Sa. 14 @ 108'6" – 109 ft**

Date sampled: 2016 **Sampled by:** GAL

ROCK/MINERAL TYPE	PERCENT BY COUNT BY SIEVE SIZE (mm)					WEIGHTED TOTAL	MOHS HARDNESS	
	0.85, 0.425	0.250	0.150	0.106	0.075		Individual	Weighted
Volcanic lithic fragments	17.5	17.9	12.5	6.7	5.1	**14.0**	**5**	**0.70**
Granite - diorite lithic fragments	36.8	36.1	19.4	5.4	10.6	**24.6**	**6**	**1.48**
Undifferentiated lithic fragments	5.0	4.0	3.2	1.0	1.7	**3.3**	**4**	**0.13**
Quartzite, Chert	3.3	2.3	1.2	0.7	--	**1.6**	**7**	**0.11**
Quartz	12.4	20.5	36.3	53.8	51.5	**31.8**	**7**	**2.23**
Feldspar	11.2	12.2	16.1	18.9	17.9	**14.9**	**6**	**0.89**
Pyroxene/Amphibole	0.8	2.3	4.9	7.4	6.0	**3.9**	**6**	**0.23**
Epidote	--	--	0.8	1.7	2.6	**0.6**	**6.5**	**0.04**
Garnet	--	--	0.4	0.7	0.8	**0.3**	**7**	**0.02**
Calcite	--	0.7	1.2	--	0.7	**1.0**	**3**	**0.03**
Oxides	0.8	2.3	2.0	1.7	3.0	**2.0**	**6**	**0.12**
Mica	6.6	1.0	1.6	1.3	0.8	**1.4**	**2.5**	**0.04**
Silt/clay lumps	5.8	0.7	0.4	--	--	**0.6**	**1**	**0.01**
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**6.03**
Roundness	**0.5**	**0.4**	**0.35**	**0.3**	**0.25**	**0.39**		
Sphericity	**0.6**	**0.7**	**0.75**	**0.8**	**0.8**	**0.75**		

Note: 1. All identifications done using a binocular microscope, and standard physical index tests. No thin-sections were used.

PETROGRAPHER: _____
F. Shrimer, P. Geo.

PROFESSIONAL GEOSCIENTIST — PROVINCE OF BRITISH COLUMBIA — F. SHRIMER

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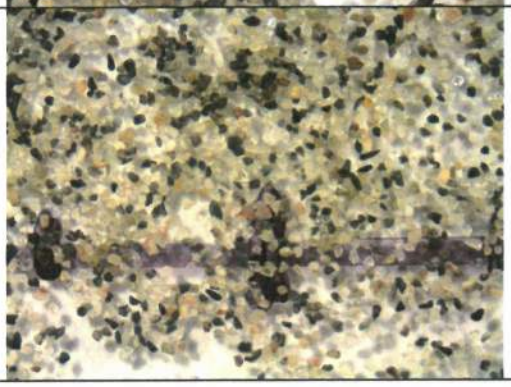
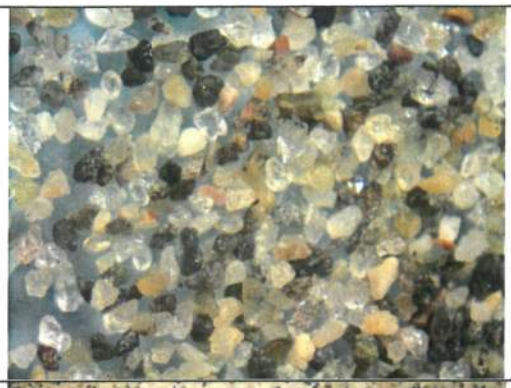
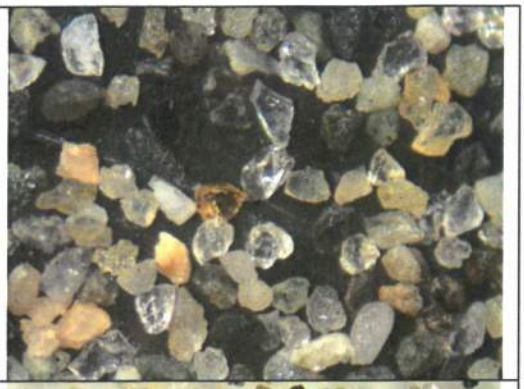
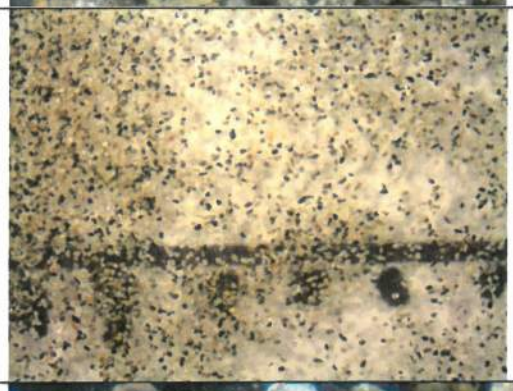
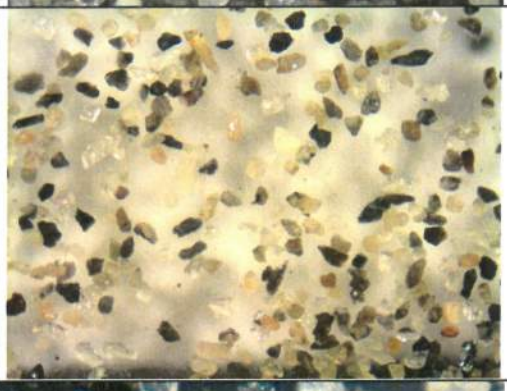
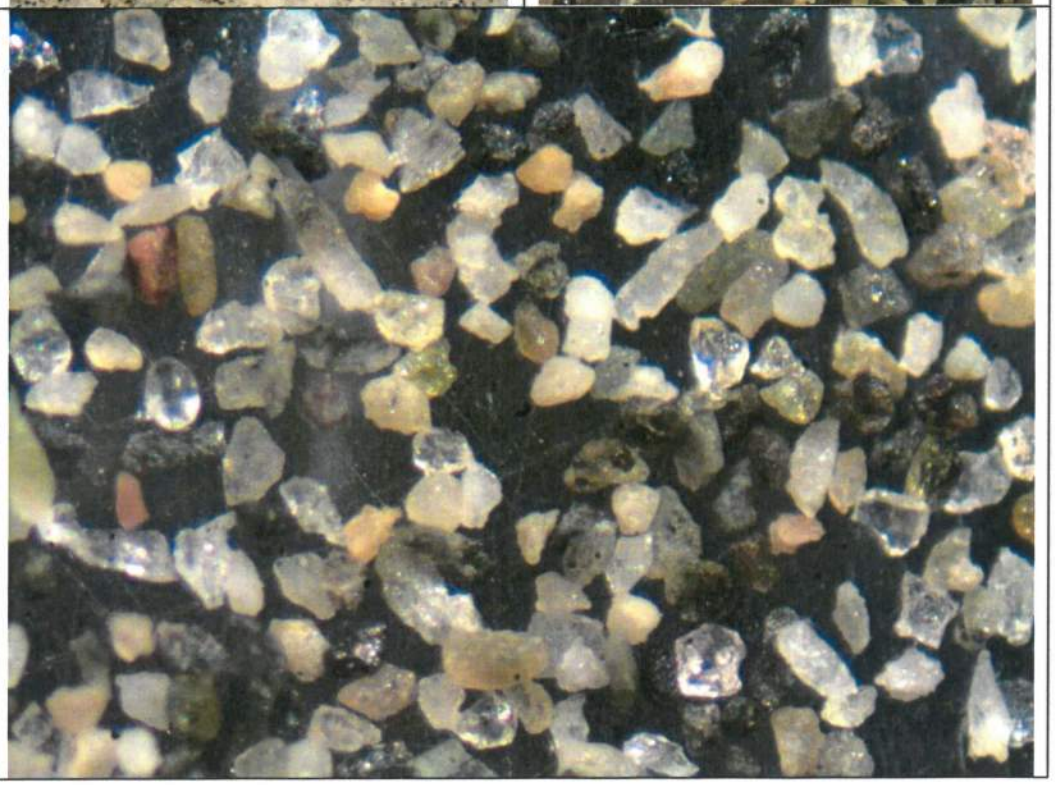
Photographs

Left view: 0.85 mm retained fraction,10x magnification **right view: 0.425 mm retained fraction**, 25x magnification		
0.250 mm retained fraction left view: 10x magnification right view: 30x magnification		
0.150 mm retained fraction left view: 10x magnification right view: 50x magnification		

0.106 mm retained fraction. **left view**: 40x magnification **Right view:** 60x magnification		
0.075 mm retained fraction. **Left view**: 10x magnification **Right view:** 40x magnification		
0.075 mm retained fraction, 60x magnification.		

PETROGRAPHIC EXAMINATION OF FINE AGGREGATE

CSA A23.2-15A / ASTM C 295

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Project Number: 1525-010.3000
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PROJECT: Annacis Outfall – Sediment evaluation

Sample:	**SH16-07, Sa. 14 @ 108'6" – 109 ft**

Date sampled: 2016 **Sampled by:** GAL

ROCK/MINERAL TYPE	PERCENT BY COUNT BY SIEVE SIZE (mm)				WEIGHTED TOTAL	MOHS HARDNESS	
	2.5 - 0.425	0.250	0.150	0.106		Individual	Weighted
Volcanic lithic fragments	30.2	20.9	16.8	7.2	**18.2**	**5**	**0.91**
Granite - diorite lithic fragments	19.0	17.5	14.9	21.1	**16.6**	**6**	**1.00**
Undifferentiated lithic fragments	4.9	3.0	2.3	--	**2.5**	**4**	**0.10**
Quartzite - Chert	2.6	--	--	--	**0.1**	**7**	**0.01**
Quartz	23.1	32.9	38.1	33.6	**35.0**	**7**	**2.45**
Feldspar	11.9	14.2	16.8	22.0	**16.0**	**6**	**0.96**
Pyroxene/Amphibole	3.0	6.7	6.7	8.5	**6.7**	**6**	**0.40**
Epidote	--	0.7	1.1	3.0	**1.1**	**6.5**	**0.07**
Calcite	--	0.7	0.7	0.3	**0.6**	**3**	**0.02**
Oxides	0.8	1.5	1.5	3.3	**1.6**	**6**	**0.10**
Mica	1.1	1.9	1.1	1.0	**1.4**	**2.5**	**0.04**
Silt/clay lumps	3.4	--	--	--	**0.2**	**1**	**--**
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**6.06**
Roundness	**0.5**	**0.4**	**0.35**	**0.3**	**0.37**		
Sphericity	**0.75**	**0.7**	**0.6**	**0.5**	**0.63**		

Note: 1. All identifications done using a binocular microscope, and standard physical index tests. No thin-sections were used.

PETROGRAPHER: _____
F. Shrimer, P. Geo.

PROFESSIONAL GEOSCIENTIST — PROVINCE OF BRITISH COLUMBIA — F. H. SHRIMER

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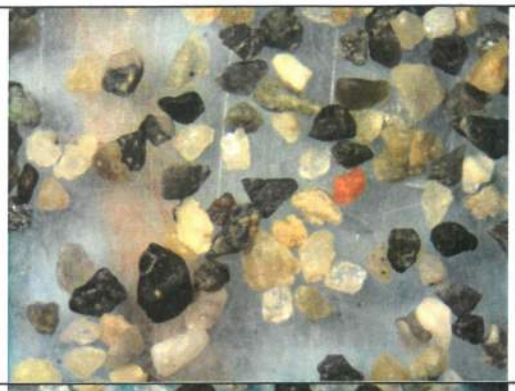
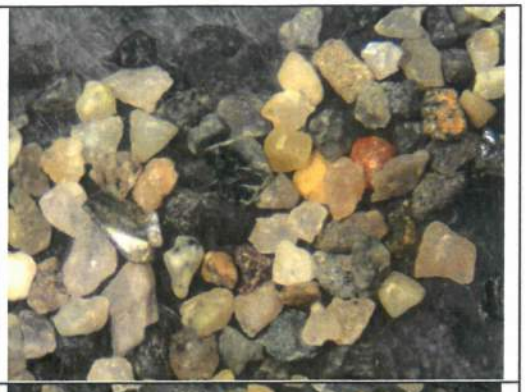
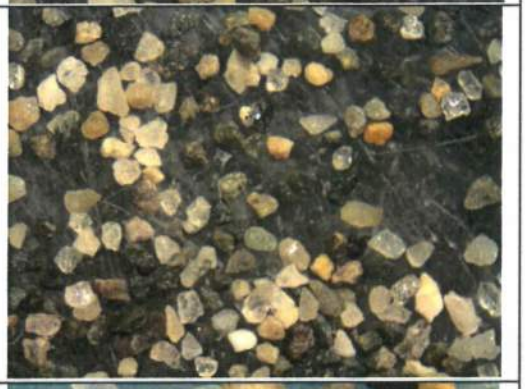
Photographs

0.425 mm retained fraction left view: 15x magnification right view: 20x magnification		
0.250 mm retained fraction left view: 25x magnification right view: 10x magnification		
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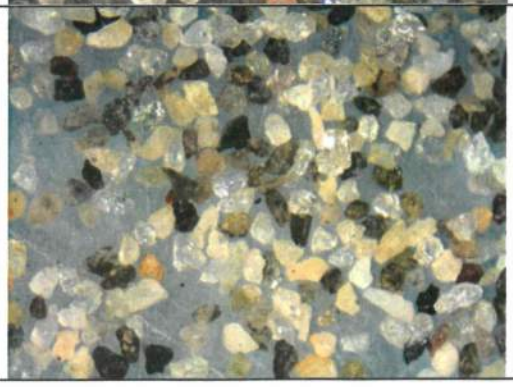
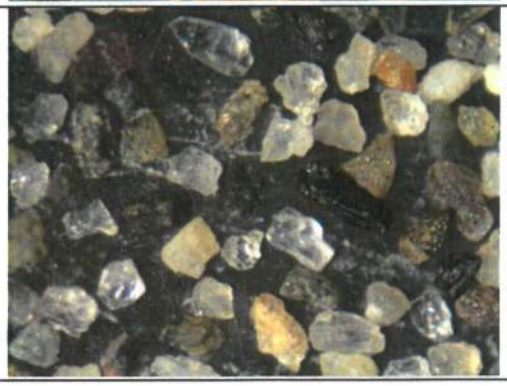
0.106 mm retained fraction left view: 40x magnification right view: 70x magnification		

QUANTITATIVE PHASE ANALYSIS OF 4 POWDER SAMPLES USING THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.

Project: 1525-010.2120

Fred Shrimer, P.Geo.,LG/LEG (WA)
Golder Associates Ltd.
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May 3, 2017

EXPERIMENTAL METHOD

The four samples of **Project 1525-010.2120** were reduced to the optimum grain-size range for quantitative X-ray analysis (<10 μm) by grinding under ethanol in a vibratory McCrone Micronising Mill for 10 minutes. Step-scan X-ray powder-diffraction data were collected over a range 3-80°2θ with CoKα radiation on a Bruker D8 Advance Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a LynxEye-XE detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

RESULTS

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 and Search-Match software by Bruker. X-ray powder-diffraction data of the samples were refined with Rietveld program Topas 4.2 (Bruker AXS). The results of quantitative phase analysis by Rietveld refinements are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots are shown in Figures 1-4.

The samples in Figures 1 and 2 contain a small amount of unknown clay minerals, likely interstratified chlorite-smectite which could not be analyzed (see small humps fitted with calculated peaks at about 7º2θ on the corresponding Figures).

Table 1. Results of quantitative phase analysis (wt.%) – Project 1525-010.2120

Mineral	**Ideal Formula**	**#1** **BH16-06 Sa21 103'-105'**	**#2** **BH16-07 Sa21 108'-110'**	**#3** **SH16-01 Sa47 108'3"-109'9"**	**#4** **SH16-07 Sa14 108'6"-109'**
Actinolite	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$	1.9	2.4	2.1	1.7
Ankerite-Dolomite	$Ca(Fe^{2+},Mg,Mn)(CO_3)_2/CaMg(CO_3)_2$	0.9	2.5	1.9	0.9
Calcite	$CaCO_3 – (Ca,Mg)CO_3$	1.2	3.2	1.8	1.1
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	3.6	4.3	4.1	3.8
Hematite ?	α-Fe_2O_3				0.2
Illite/Muscovite 1M1	$KAl_2AlSi_3O_{10}(OH)_2$ / $K_{0.65}Al_{2.0}Al_{0.65}Si_{3.35}O_{10}(OH)_2$	2.4			2.2
Illite/Muscovite 2M1	$KAl_2AlSi_3O_{10}(OH)_2$ / $K_{0.65}Al_{2.0}Al_{0.65}Si_{3.35}O_{10}(OH)_2$	4.5	6.5	6.7	4.1
K-feldspar	$KAlSi_3O_8$	4.7	5.4	5.4	5.2
Laumontite	$Ca_4[Al_8Si_{16}O_{48}]_{18}H_2O$		1.0	0.9	
Magnetite	Fe_3O_4	0.4	0.4	0.4	0.3
Plagioclase	$NaAlSi_3O_8 – CaAl_2Si_2O_8$	30.0	27.4	28.0	30.1
Quartz	SiO_2	50.0	46.9	48.6	50.5
Siderite, calcian ?	$(Fe,Ca)CO_3$	0.4			
Total		100.0	100.0	100.0	100.0

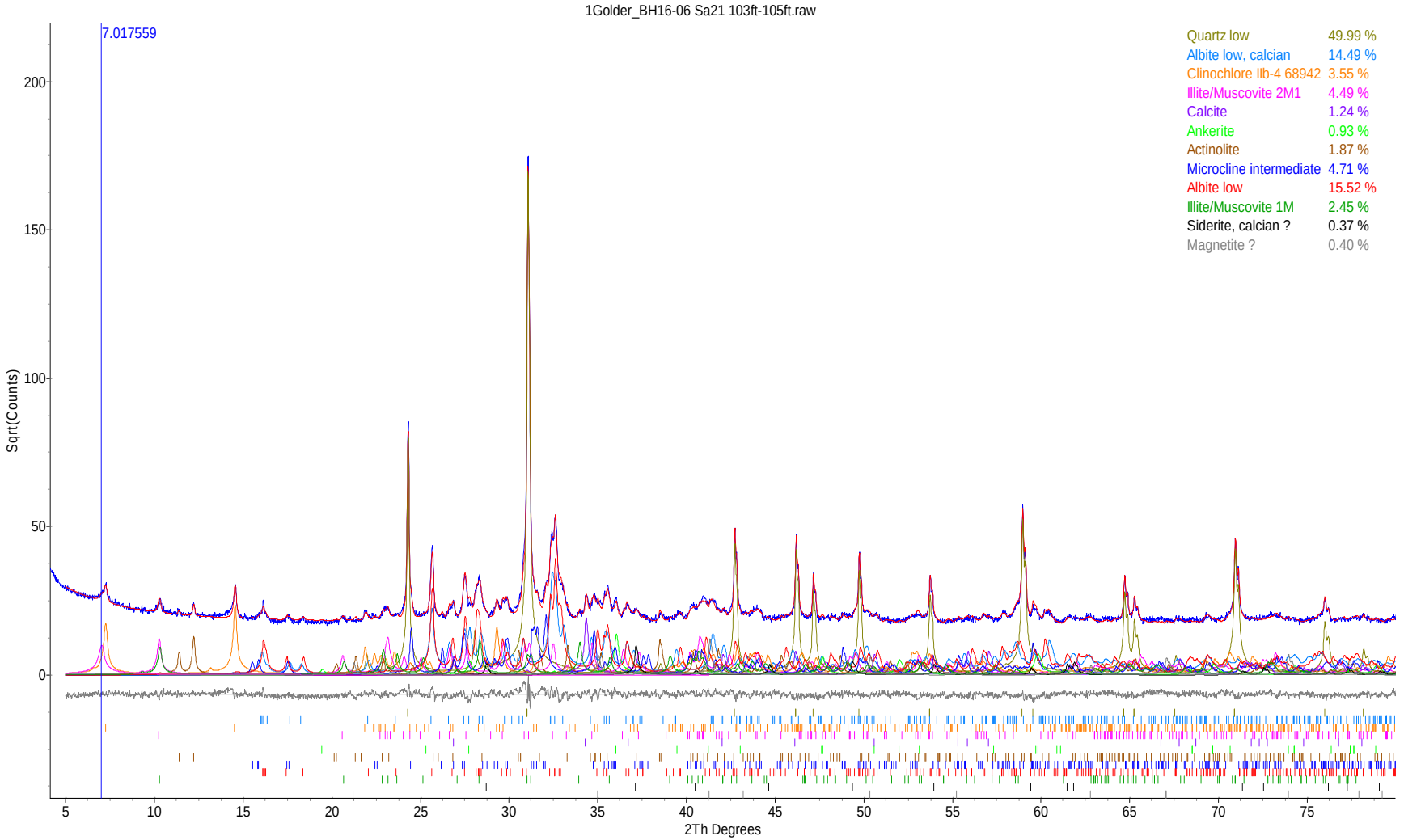

Figure 1. Rietveld refinement plot of sample **Golder Associates BH16-06 Sa21 103'-105'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

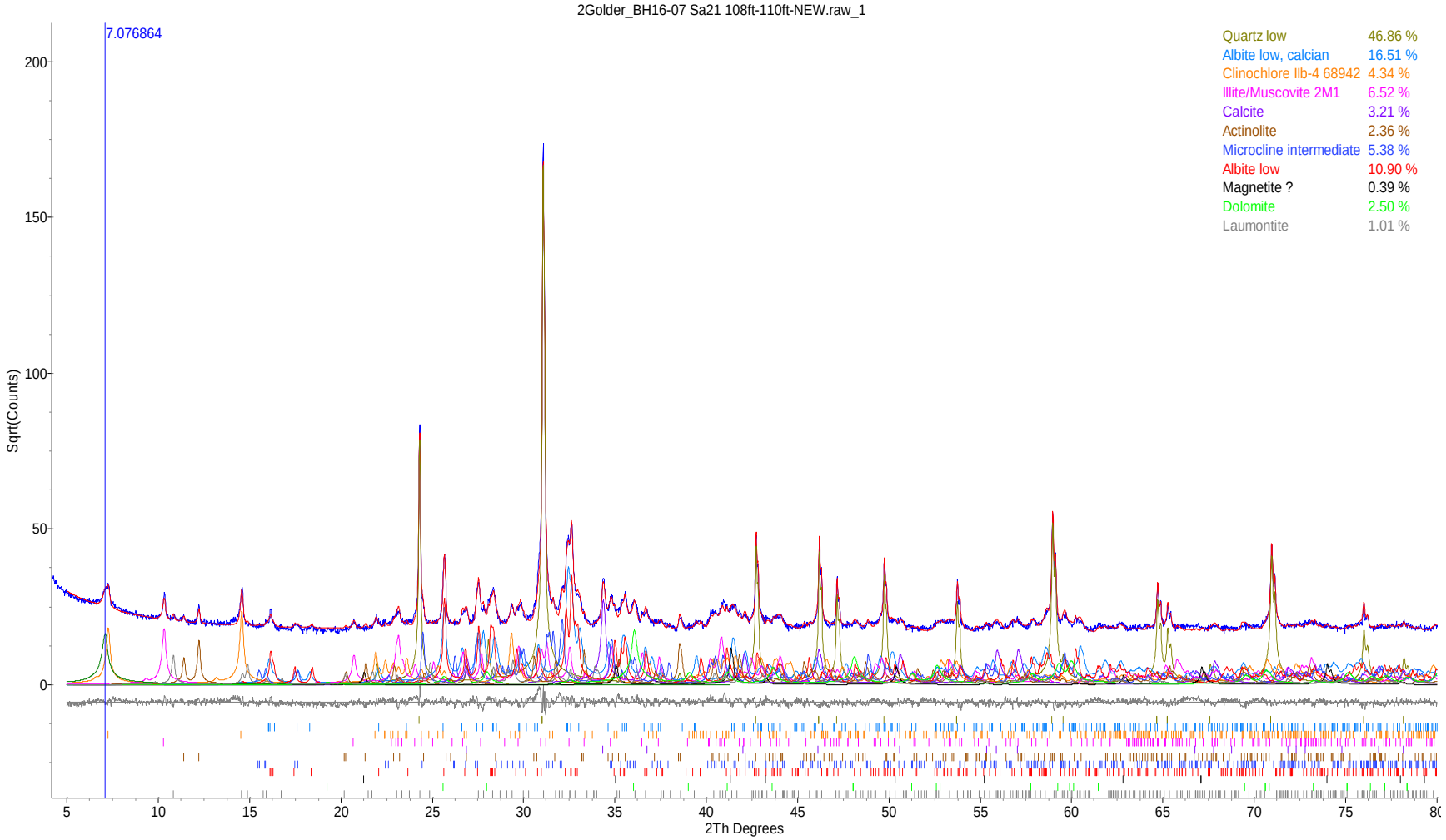

Figure 2. Rietveld refinement plot of sample **Golder Associates BH16-07 Sa21 108'-110'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

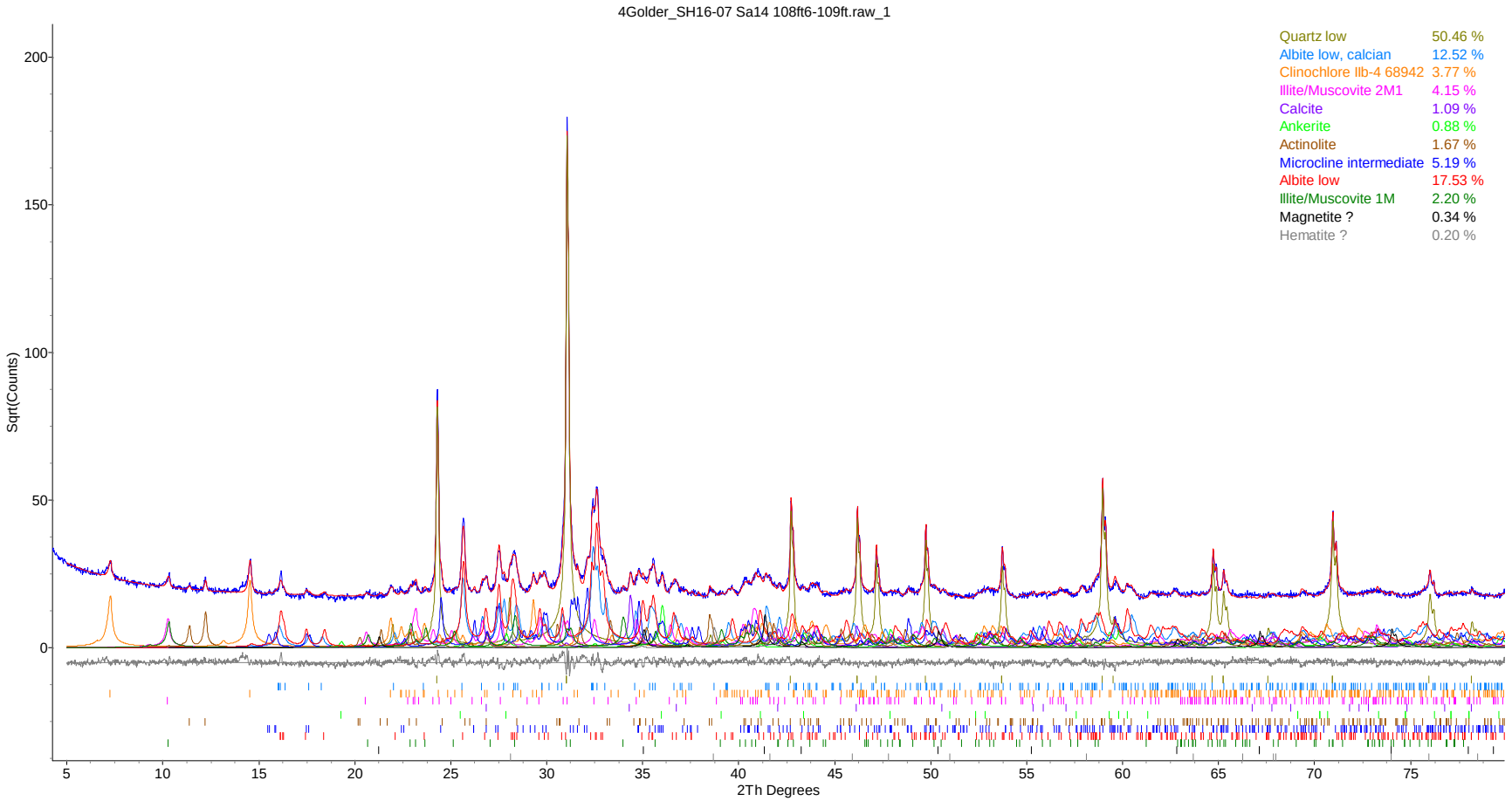

Figure 3. Rietveld refinement plot of sample **Golder Associates SH16-01 Sa47 108'3"-109'9"** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

Figure 4. Rietveld refinement plot of sample **Golder Associates SH16-07 Sa14 108'6"-109'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

SINTEF

17041IG - Restricted

Test report

Soil Abrasion Test™

Determination of abrasivity of soil samples from the Annacis Island Outfall Project

Author
Daniel Voll

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2017-03-27

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NTNU
Samarbeidende laboratorium

KEYWORDS
Abrasivity
Soil Testing

Test report

Soil Abrasion Test™

Determination of abrasivity of soil samples from the Annacis Island Outfall Project

VERSION
1

DATE
2017-03-27

AUTHOR
Daniel Voll

CLIENT
Golder Associates Ltd, Canada

CLIENT'S REF.
Yannick Wittwer

PROJECT NO.
102015289-4

NUMBER OF PAGES/APPENDICES
10

TEST OBJECT
4 Soil samples

TEST OBJECT RECEIVED
2017-03-13

TEST PROGRAM
SAT™

TEST LOCATION
Geological Engineering Laboratory

DATE OF TESTING
From 2017-03-20
To 2017-03-24

ABSTRACT
The samples were analysed in order to determine soil abrasivity by the Soil Abrasion Test™ (SAT™).

The trademarked acronyms Soil Abrasion Test™ and SAT™ are unique for test results and calculated indices originating from the NTNU/SINTEF laboratory and can only be obtained by testing samples at our reference laboratory.

Soil Abrasion Test™ is performed in accordance with: *Nilsen, B., Dahl, F., Holzhäuser, J. and Raleigh, P. (2007): "New test methodology for estimating the abrasiveness of soils for TBM tunnelling", RETC Proceedings, 104 - 116.*

The test results relate only to the items tested

PREPARED BY
Daniel Voll

SIGNATURE


APPROVED BY
Filip Dahl

SIGNATURE


REPORT NO.
17041IG

CLASSIFICATION
Restricted

SINTEF

Table of contents

1 Table of soil samples received for testing

(Given by the Client)

Sample No.[1)]	Borehole	Sample #	Depth				Lab Test	Sample Size
			From (m)	To (m)	From (ft)	To (ft)		(kg)
1.	SH16-07	40	32	32.5	105.0	106.6	SAT	2
2.	SH16-05	39	32	32.5	105.0	106.6	SAT	2
3.	SH16-06	40	32.5	33	106.6	108.3	SAT	2
4.	SH16-01	45	33	33.5	108.3	109.9	SAT	2

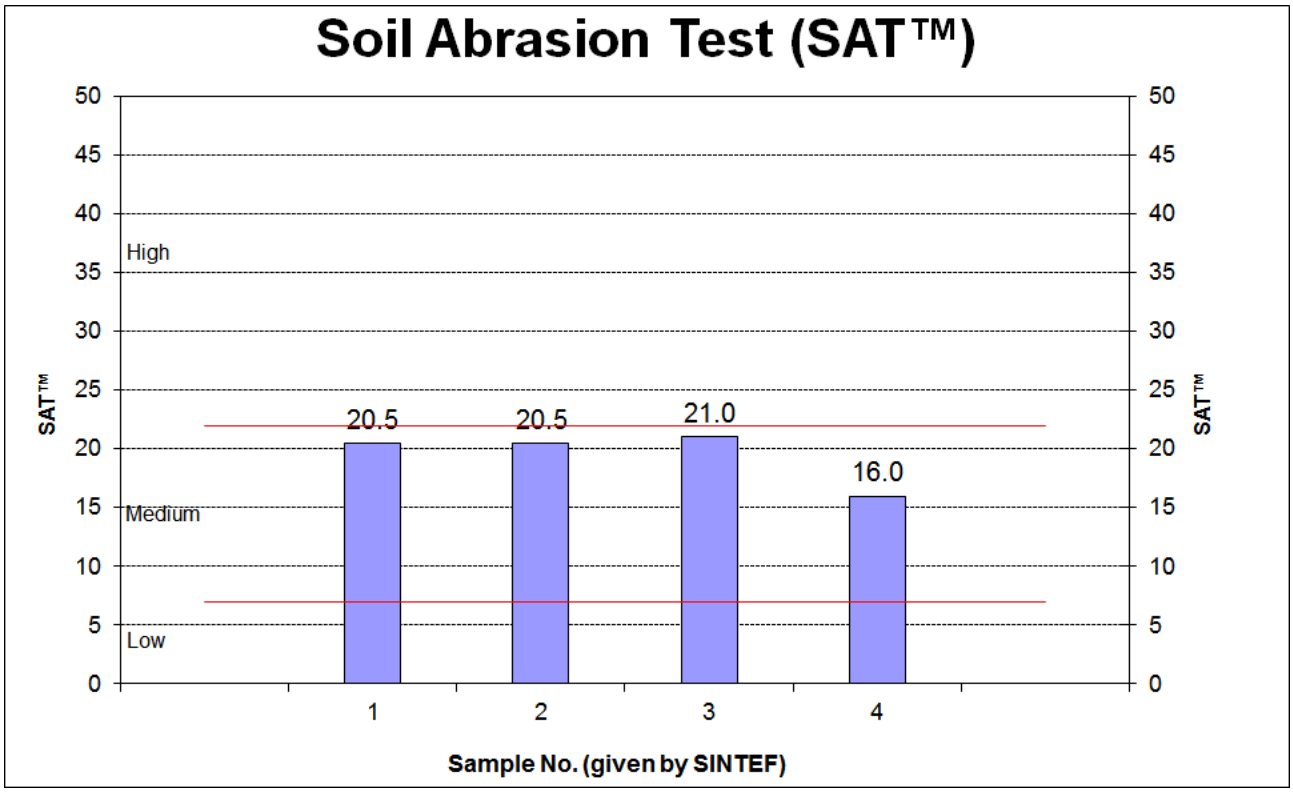
[1)] *Given by SINTEF*

2 Test results SAT™

TEST RESULTS

Sample No. (given by SINTEF)	1	2	3	4
Sample ID (given by the Client)	SH16-07, SA#40 105'-106'6"	SH16-05, SA#39 105'-106'6"	SH16-06, SA#40 106'6"-108'3"	SH16-01, SA#45 108'3"-109'9"
SAT™ test 1 SAT™ test 1	21 20	21 20	20 22	17 15
SAT™ mean [mg]	**20.5**	**20.5**	**21.0**	**16.0**
Percentage of the total sample < 4.0 mm after preparation	100 %	100 %	98 %	100 %
Percentage of the total sample < 1.0 mm after preparation	100 %	100 %	94 %	100 %

3 SAT™ results presented as bar graph



4 Classification of SAT™

Table 1. Classification of soil abrasivity according to Drevland Jakobsen. P., et al. "Review and assessment of the NTNU/SINTEF Soil Abrasion Test (SAT™) for determination of abrasiveness of soil and soft ground". TUST 37 (2013), 107 -114.

Category – Cutter steel abrasion	SAT™ [weight loss mg]
Low	≤ 7.0
Medium	7.1 – 21.9
High	≥ 22

5 Comments and remarks on SAT™ testing and test results

The percentages of sample material < 4.0 mm and < 1.0 mm, which are given in the tables on page 4, are subsequent to preparation according to the procedure. The percentages provide information on the properties of the prepared abrasion powder, but they should not be regarded as representative grain size distribution for the received sample material.

The samples were tested on the sieved portion < 4.0 mm by use of SAT™ pieces *(see Figure 5).*

The tested samples have all a portion of particles < 4.0 mm after preparation, which constitutes > 75 % of the received sample volume. The SAT™ value for the samples can hence be regarded as representative for the in-situ material.

The SAT™ is based on the Abrasion Value Cutter Steel (AVS) test, which is used to determine the abrasiveness of rock. The classification *(see Table 2)* based on the so far 1747 recorded test results from this test is hence useful also for describing/evaluating the abrasiveness of soils.

Table 2. Classification of rock abrasivity or the ability to induce wear on cutter ring steel according to Dahl. F., et al. TUST 28 (2012) 150 -158.

Category – cutter steel abrasion	AVS [weight loss mg]	Cumulative percentage
Extremely low	≤ 1.0	0 – 5 %
Very low	1.1 – 3.9	5 – 15 %
Low	4.0 – 12.9	15 – 35 %
Medium	13.0 – 25.9	35 – 65 %
High	26.0 – 35.9	65 – 85 %
Very high	36.0 – 43.9	85 – 95 %
Extremely high	≥ 44.0	95 – 100 %

A summary of rock samples tested by use of AVS and soil samples tested by use of SAT™ is shown in Figure 1.

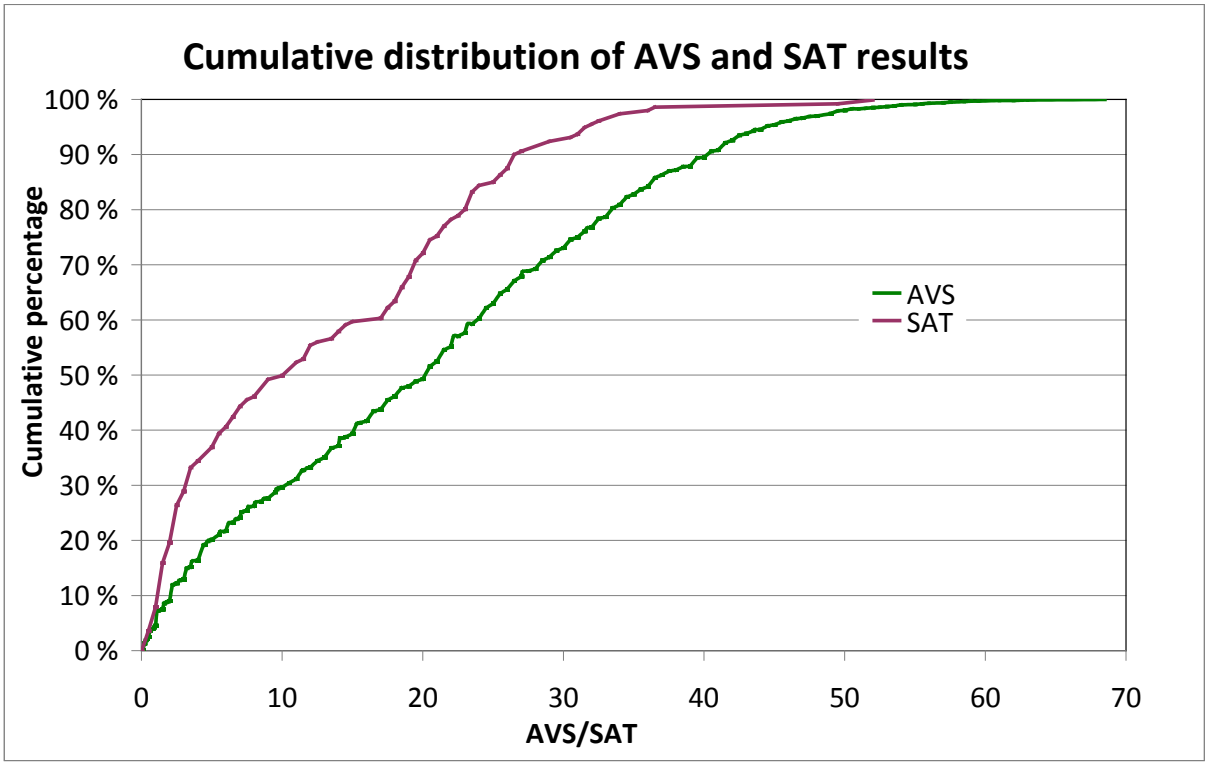


Figure 1. Cumulative distribution of AVS and SAT™ results.

Based on rock testing, the content of quartz and other hard minerals like garnet and epidote have a major impact on the abrasion on the test pieces, but grain shape, grain size and grain binding may also contribute substantially.

In Table 3, AVS results for some sedimentary rocks tested at SINTEF are shown, illustrating that there is a considerable difference in AVS values between the softest (i.e. limestone) and hardest (i.e. quartzite) rocks. As also shown, the AVS value may vary significantly within one type of rock.

Table 3. AVS values for some sedimentary rock samples tested at SINTEF

Rock type	**Number of samples**	**AVS [weight loss mg]**
Limestone	17	0.2 – 1.4
Shale	17	0.4 – 10
Siltstone	4	0.4 – 44
Sandstone	36	0.4 – 52
Quartzite	20	17 – 63

6 Principle description and photos of the SAT™ test method, equipment and methodology

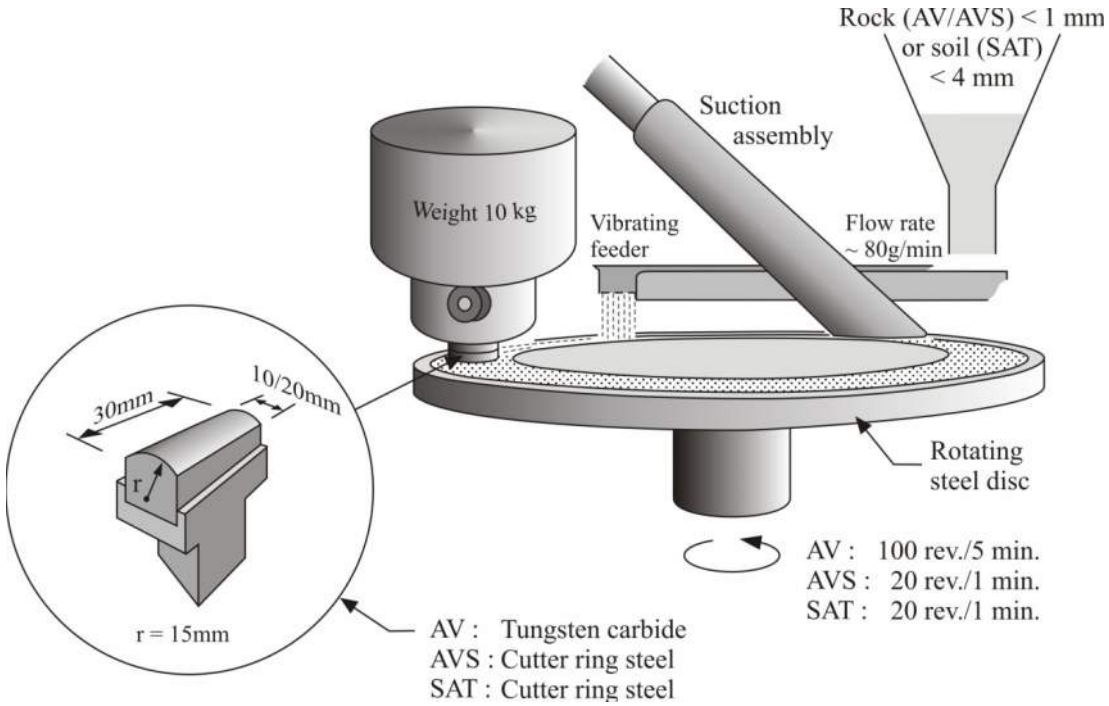


Figure 2. Principle drawing of the SINTEF/NTNU abrasion tests.

Figure 3. Photos of test equipment used to determine soil abrasivity by the Soil Abrasion Test (SAT™).

Figure 4. Photo showing a part of a cutter ring, a 10 mm slice taken from the same ring, and two prepared AVS test pieces which are cut out of the center of the slice.

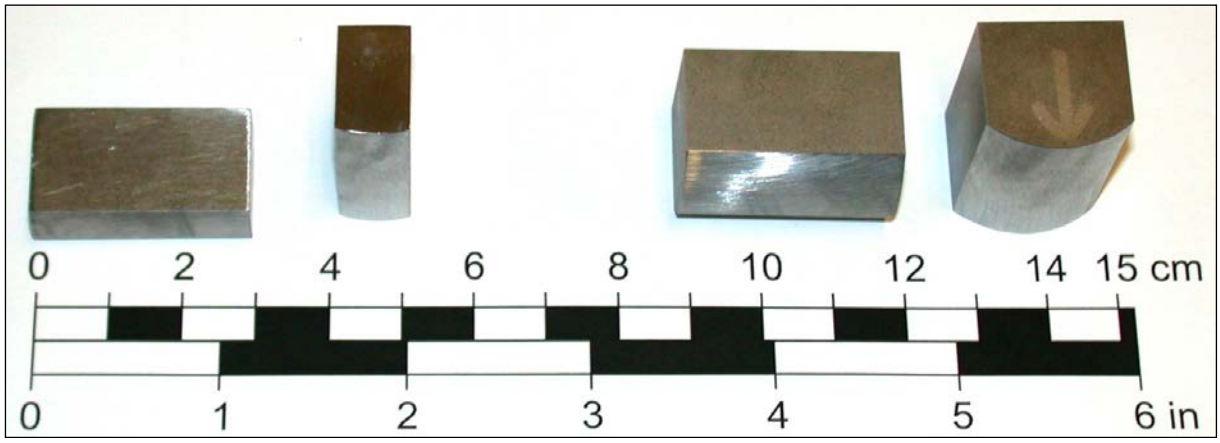


Figure 5. Photo showing two AVS (to the left) and two SAT™ test pieces (to the right).

7 Photographs of the received soil samples prior to preparation

Sample No. 1, "SH16-07, SA#40 105'-106'6". The SAT™ powder was prepared by sieving with steel balls. Of the total sample volume, 100 % was < 1.0 mm after preparation.

Sample No. 2, " SH16-05, SA#39 105'-106'6". The SAT™ powder was prepared by sieving with steel balls. Of the total sample volume, 100 % was < 1.0 mm after preparation.

Sample No. 3, "SH16-06, SA#40 106'6"-108'3". The SAT™ powder was prepared by sieving with steel balls. Of the total sample volume, 98 % was < 4.0 mm and 94 % was < 1.0 mm after preparation.

Sample No. 4, "SH16-01, SA#45 108'3"-109'9". The SAT™ powder was prepared by sieving with steel balls. Of the total sample volume, 100 % was < 1.0 mm after preparation.

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March 30, 2017

Miller Number Report
For
Golder Associates

Test Number	Test Date	Slurry Description	Solids Concentration
2167	3/22/2017	SH16-01 SA#46 108'3-109'9	50% by Mass - 150g Solids - 150g Deionized Water
2168	3/23/2017	SH16-06 SA#41 106'6-108'3	50% by Mass - 150g Solids - 150g Deionized Water
2169	3/28/2017	SH16-07 SA#41 105-106'6	50% by Mass - 150g Solids - 150g Deionized Water
2170	3/29/2017	SH17-05 SA#40 105-106'6	50% by Mass - 150g Solids - 150g Deionized Water

Testing and Report prepared by Brant D. Miller
E-mail: bmiller@wres.us
Phone (214) 348-3001 Fax (469) 327-2643

WRES, Inc.

6 Horizon Point
Frisco, TX 75034-6840
(Dallas Metroplex Area)

Miller Number Determination by ASTM G75-01
For
Golder Associates

Golder Associates submitted four core samples for determination of slurry abrasivity by ASTM G75 Miller Number Test Procedure. Each sample was run per the ASTM G75 standard by mixing slurry batches of 150 grams of solids and 150 grams of water for a 50% by mass concentration. A Calcium Hydroxide [$Ca(OH)_2$] corrosion inhibited slurry test was also performed as part of the standard Miller Number Test Procedure.

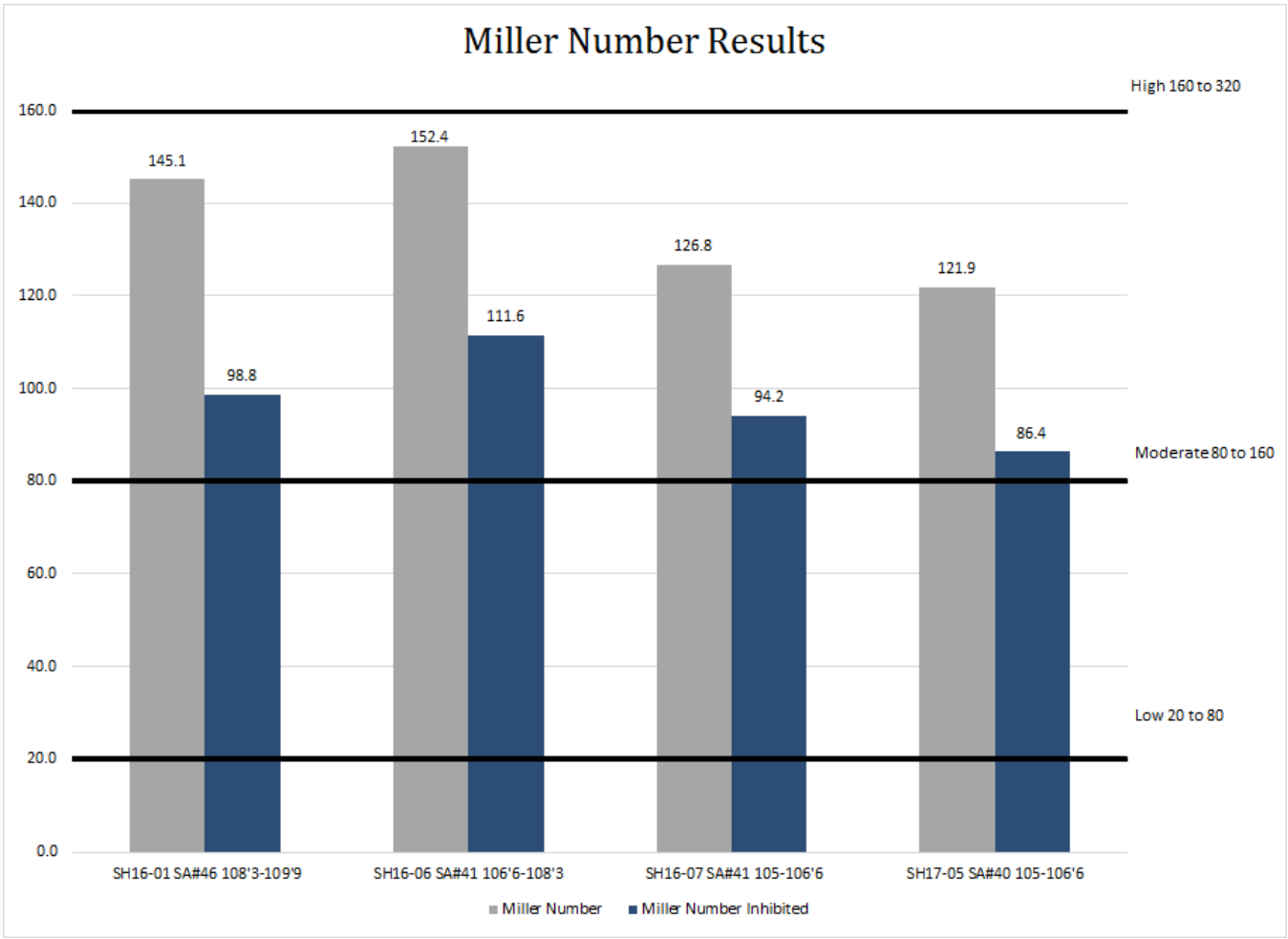
The Miller Number abrasivity values for the samples run as a slurry ranged from 122 to 152 which is moderately abrasive. Standard AFS 50/70 sand has a Miller Number of 120. Sample SH16-06 SA#41 106'6-108'3 was the most abrasive of the submitted samples.

Attrition values of –1 to –5 of the Miller Number indicate how the abrasivity is changing with time during the test. Attrition values of the Miller Number point out that the slurry abrasivity changes with time because of usual particle attrition. The negative values indicates the samples are becoming slightly less abrasive with time.

A sieve analysis was performed on the solids to determine the particle size distribution. Results and Photo Micrographs of the material are displayed on following pages.

E1441 Results

Test Information				Miller/SAR Number					Miller Number ~1mg Ca(OH)2 Inhibited						
Test Number	Test Date	Slurry Description	Solids Concentration	Block 1 Loss	Block 2 Loss	Average Loss	Miller Number	Thickness Loss mm	Block 3 Loss	Block 4 Loss	Average Loss Inhibited	Miller Number Inhibited	Thickness Loss mm Inhibited	pH High Inhibited	pH Low Inhibited
2167	3/22/2017	SH16-01 SA#46 108'3-109'9	50% by Mass - 150g Solids - 150g Deionized Water	48.8	46.6	47.7	145.1	0.01950	32.6	32.9	32.7	98.8	0.01339	13.8	13.0
2168	3/23/2017	SH16-06 SA#41 106'6-108'3	50% by Mass - 150g Solids - 150g Deionized Water	50.5	49.4	50.0	152.4	0.02044	37.0	36.3	36.6	111.6	0.01498	13.9	13.1
2169	3/28/2017	SH16-07 SA#41 105-106'6	50% by Mass - 150g Solids - 150g Deionized Water	42.3	41.0	41.7	126.8	0.01705	32.2	30.0	31.1	94.2	0.01272	13.9	13.2
2170	3/29/2017	SH17-05 SA#40 105-106'6	50% by Mass - 150g Solids - 150g Deionized Water	40.5	39.7	40.1	121.9	0.01640	28.5	28.5	28.5	86.4	0.01166	13.9	13.1



General Discussion

Slurry abrasivity is a complex relationship between chemical and mechanical action on a wear block or wear specimen. The Miller Number abrasivity is a relative rate of wear index of the combined effects of both corrosion and mechanical erosion on a 27% Chrome Iron Wear Block. The Gold Number abrasivity is a relative rate of wear index of the mechanical erosion on a 24K Gold Wear Block. The Gold Number scaled to the Miller Number provides an accurate low abrasivity index. The SAR Number (Slurry Abrasion Response) is a relative rate of volume loss of any solid wearing specimen in given slurry. There is also the potential for synergism to occur between the erosion and corrosion (chemical action) processes that result in higher material loss than is obtained by either process by itself. A standard part of conducting the Miller Number is to conduct a test with corrosion-inhibited slurry using Calcium Hydroxide to raise the pH to 12 + to reduce or eliminate corrosion. Miller Number abrasivity with the inhibited slurry is usually the result of mechanical erosion only. The Miller Number abrasivity difference between the regular slurry and the inhibited slurry is the result of corrosion or the synergistic effect of corrosion and mechanical wear. Oil based slurries will result in a lower Miller, Gold, or SAR Number because of fluid lubricity and reduced potential for corrosion.

Mechanical wear relates to the properties of the solids and fluid as well as the solid concentration and load applied to the wear block or wear specimen. Particle mineral composition, hardness, size, shape, and friability are the main contributing wear factors for the solid components of the slurry. Hardness of minerals as measured by Mohs scale is identified numerically by standard minerals, from 1 (softest) to 10 (hardest):

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

A mineral of a given hardness will scratch or wear a mineral of a lower number. Miller Number abrasivity (rate of wear) correlates with the Mohs Hardness for a particular mineral tested. Rate of wear increases as hardness of the particle tested increases. The size of the particles in the slurry has a major affect on the degree of wear, similar to the action of sandpaper of different grits. Hence, the larger the grains on the sandpaper the more wear seen, smaller less wear. Particle shapes ranging from spherical to sharp and angular determine the degree wear. Beach sand worn to a rounded shape by wave action for eons of time is much less abrasive than newly fractured quartz of the same general size. Rounded material has a ball bearing effect creating less wear, where as sharp angular solids will gouge the wear block or wear specimen and therefore create more wear.

Mechanical wear directly relates to the concentration of the solids at the wear interface and the load applied. Increasing the concentration of the solids increases the rate of material loss from the wear block or wear specimen until the wear interface is saturated. Further increase in concentration after saturation has little effect on rate of wear. Saturation occurs in fast settling slurries at approximately 20% by mass solids concentration.

Wear Block (Miller Number) or Specimen (SAR Number) Hardness

The Miller Number Test procedure evaluates the relative abrasivity (rate of wear) of particular slurry on a 27% Chrome Iron or 24K Gold Wear Block. The Gold Wear Block is used to evaluate slurries with Miller Numbers less the 20. Gold Number standard 24K Gold Wear Block Hardness is 79-80 Re. The purpose of the Gold Wear block is to lose a significant quantity of material from the wear block in low abrasion slurries. The Gold Number is calculated based on the mass loss of the Gold Wear Block assuming it is a 27% Chrome Iron Wear Block. A factor based on prior silica sand test results is used to scale the Gold Number to approximate the Miller Number Scale. When the hardness of the slurry solids is below the 27% Chrome Iron hardness a lower abrasivity valve is obtained relative to the valve obtained with a 24K Gold Wear Specimen. Higher abrasivity values that may be observed with the 24K Gold Wear Specimens are valid for that particular environment.

Wear Specimen Slurry Abrasion Response (SAR) evaluates abrasion and corrosion response of materials that handle slurries. Hardness of these materials has a correlation to the mechanical abrasion component of the test. However, harder materials may not provide the best slurry abrasion resistance because of corrosion.

Corrosion (Chemical Reaction)

Normally the abrasivity represents the combination and often times synergistic effects from corrosion (chemical reaction) and mechanical abrasion. The Gold Number represents the mechanical abrasion caused by the solids since Gold Wear Blocks are corrosion resistant. Oxidation of the 27% Chrome Iron can occur from Oxygen, Chlorides, or Sulfides. Sulfide scales tend to crack and spall more readily than oxidation products by oxygen or chlorides and result in a higher abrasivity. The Gold Number does not take into account the potential for corrosion in the actual slurry application because of the corrosion resistance of Gold. Corrosion must be considered in addition to the abrasivity value as determined by the Gold Number because corrosion may be present in the actual metallic slurry handling equipment. The SAR Numbers for the metal and Elastomer wear specimens are the combination of the mechanical wear and corrosion of the metal wear specimens and chemical action on the Elastomer wear specimens.

ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2167
- Date : 22-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH16-01 SA#46 108'3-109'9
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with Fillers)

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

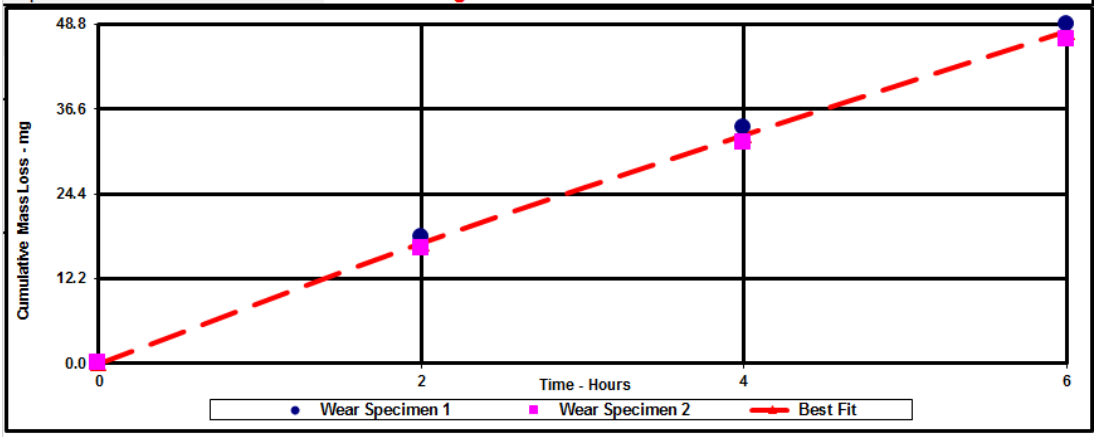
Tray	1			2			
Wear Specimen	2013-120			2013-121			
Hardness	64.7 Rc			66.1 Rc			
Scale Factor	1.081			1.132			
	pH	Mass g	Loss mg	pH	Mass g	Loss mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**8.6**	**14.1100**	0.0	**8.6**	**14.0652**	0.0	
Weight After 2 Hours	**8.8**	**14.0904**	19.6	**8.7**	**14.0465**	18.6	
Weight After 4 Hours	**8.8**	**14.0734**	17.0	**8.8**	**14.0292**	17.3	
Weight After 6 Hours	**8.8**	**14.0572**	16.1	**8.8**	**14.0125**	16.8	Actual
Weight Total Loss			52.7			52.7	105.5
Weight Final Dry (Elastomer Only)							
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-1			L-2			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	C mg	D mg	Ave mg	*Best Fit mg	Error mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	18.1	16.5	17.3	17.3	0.000	
Weight After 4 Hours	4	33.8	31.7	32.8	32.8	0.001	
Weight After 6 Hours	6	48.8	46.6	47.7	47.7	0.000	Inc
	Cumm	Chart	Max	48.8		0.000	12.2

Click Here to Solve Curve Fit

Results

Best Fit Mass Loss	=	9.12 * Hours^ 0.923	
Miller Number	145.12	Relative Rate of Mass/Volume loss at 2 hours	
Departure	-4%	Relative Rate of Change in Mass/Volume loss at 2 hours	
Lap Mass Loss	0.00	mg	



ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2167 ~ 1mg Ca(OH)2 Inhibited
- Date : 22-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH16-01 SA#46 108'3-109'9
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
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Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

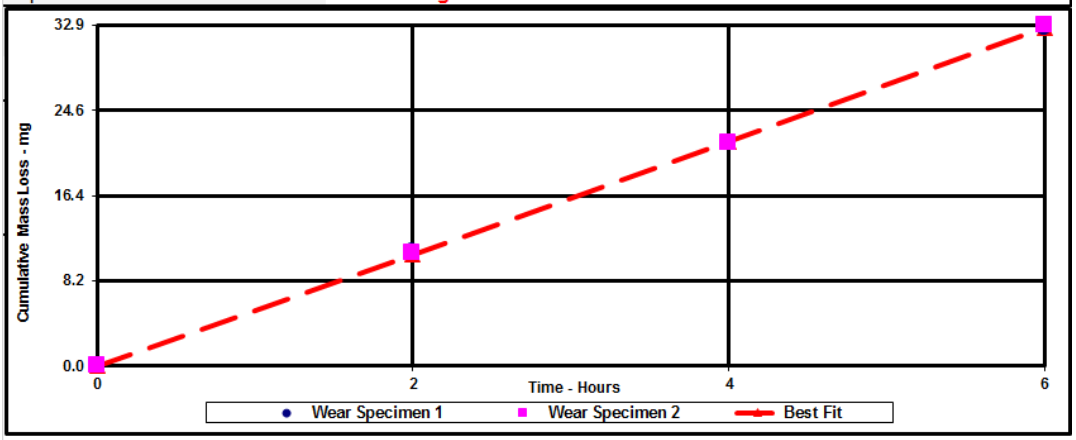
Tray	3			4			
Wear Specimen	2013-122			2013-123			
Hardness	64.7 Rc			66.1 Rc			
Scale Factor	1.143			1.152			
	pH	Mass	Loss	pH	Mass	Loss	
		g	mg		g	mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**13.8**	**14.1386**	0.0	**13.8**	**14.1174**	0.0	
Weight After 2 Hours	**13.7**	**14.1261**	12.5	**13.7**	**14.1050**	12.5	
Weight After 4 Hours	**13.5**	**14.1141**	12.0	**13.3**	**14.0927**	12.3	
Weight After 6 Hours	**13.1**	**14.1013**	12.7	**13.0**	**14.0796**	13.1	Actual
Weight Total Loss			37.3			37.9	75.1
Weight Final Dry (Elastomer Only)			0.0			0.0	
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-3			L-4			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	2013-122	2013-123	Ave	*Best Fit	Error	
		mg	mg	mg	mg	mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	11.0	10.8	10.9	10.8	0.143	
Weight After 4 Hours	4	21.5	21.5	21.5	21.7	-0.192	
Weight After 6 Hours	6	32.6	32.9	32.7	32.7	0.080	Inc
	Cumm	Chart	Max	32.9		0.064	8.2

Click Here to Solve Curve Fit

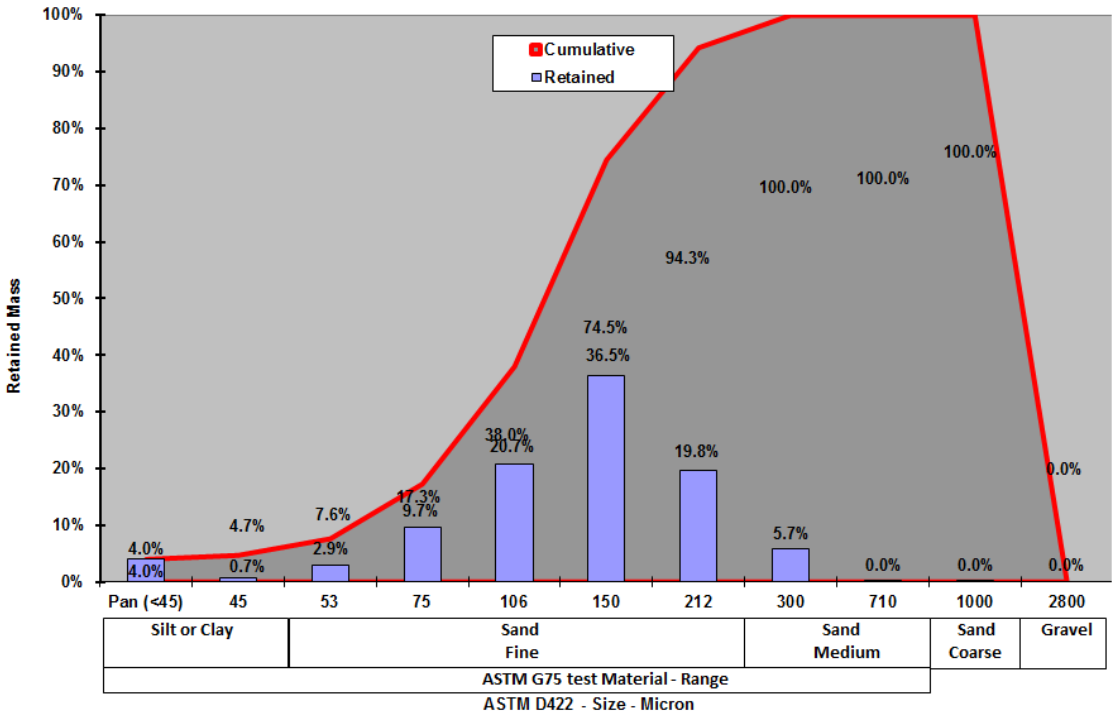
Results

Best Fit Mass Loss	=	5.33 * Hours^ 1.011	
Miller Number	98.82	Relative Rate of Mass/Volume loss at 2 hours	
Departure	1%	Relative Rate of Change in Mass/Volume loss at 2 hours	
Lap Mass Loss	0.00	mg	

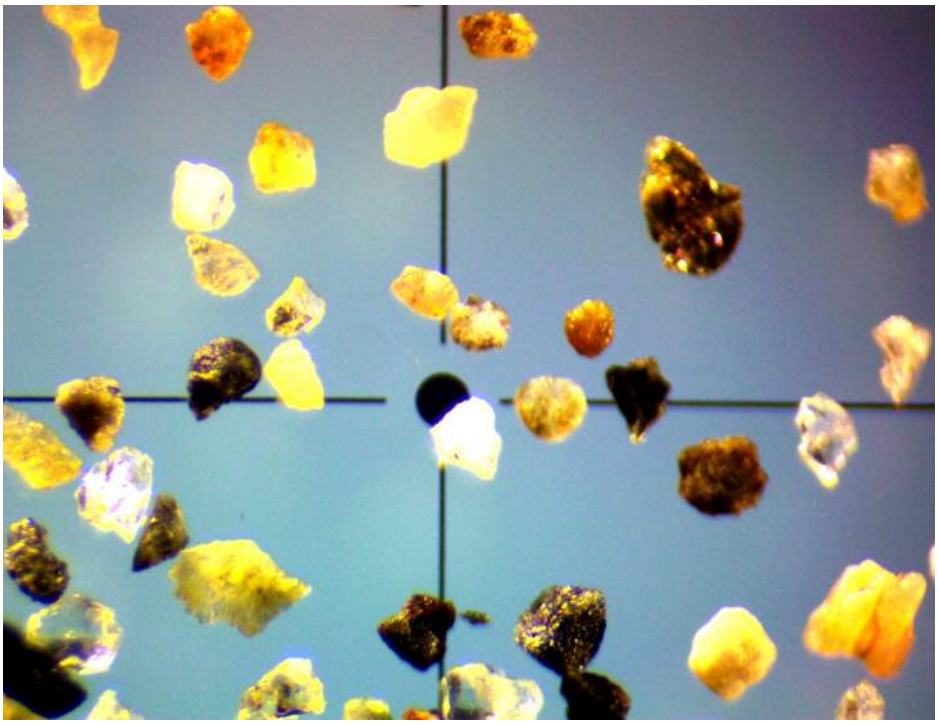


SH16-01 SA#46 108'3-109'9

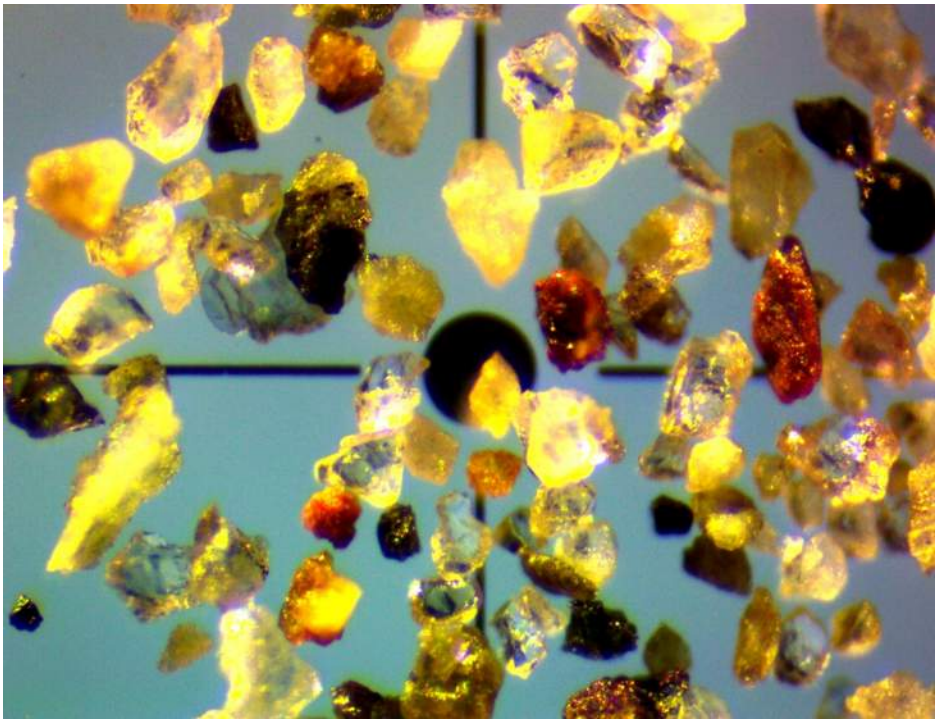
Solids Particle Distribution (Micron)



SH16-01 SA#46 108'3-109'9



Particles > 150 Micron with 200µ Grid Photo Micrograph



Particles < 150 Micron with 200µ Grid Photo Micrograph

ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2168
- Date : 23-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH16-06 SA#41 106'6-108'3
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with Fillers)

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

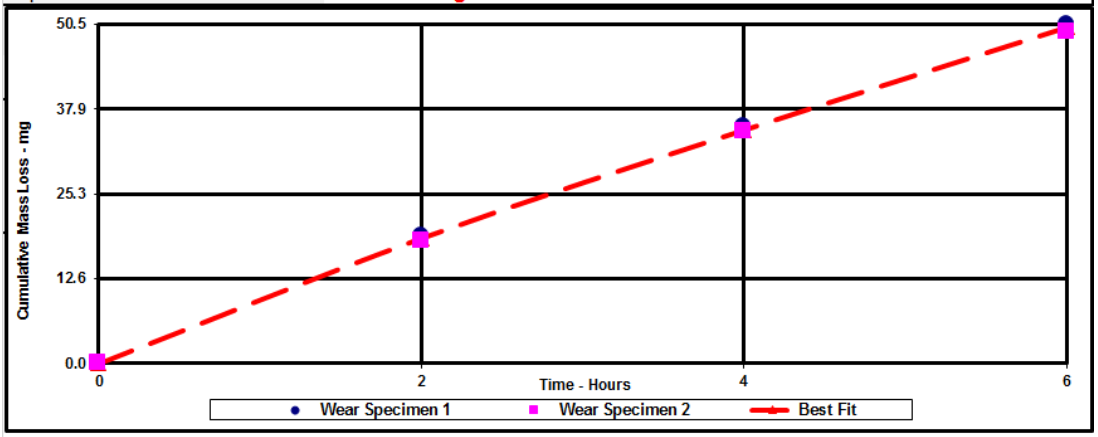
Tray	1			2			
Wear Specimen	2013-120			2013-121			
Hardness	64.7 Rc			66.1 Rc			
Scale Factor	1.081			1.132			
	pH	Mass g	Loss mg	pH	Mass g	Loss mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**8.6**	**14.0055**	0.0	**8.6**	**13.9660**	0.0	
Weight After 2 Hours	**8.6**	**13.9850**	20.4	**8.6**	**13.9454**	20.6	
Weight After 4 Hours	**8.7**	**13.9672**	17.8	**8.7**	**13.9268**	18.6	
Weight After 6 Hours	**8.7**	**13.9509**	16.4	**8.6**	**13.9100**	16.8	Actual
Weight Total Loss			54.6			55.9	110.6
Weight Final Dry (Elastomer Only)							
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-1			L-2			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	C mg	D mg	Ave mg	*Best Fit mg	Error mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	18.9	18.2	18.5	18.7	-0.135	
Weight After 4 Hours	4	35.4	34.6	35.0	34.8	0.196	
Weight After 6 Hours	6	50.5	49.4	50.0	50.1	-0.086	Inc
	Cumm	Chart	Max	50.5		0.064	12.6

Click Here to Solve Curve Fit

Results

Best Fit Mass Loss	:	=	10.02 * Hours^ 0.898
Miller Number	:	152.37	Relative Rate of Mass/Volume loss at 2 hours
Departure	:	-5%	Relative Rate of Change in Mass/Volume loss at 2 hours
Lap Mass Loss	:	0.00	mg



ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2168 ~ 1mg Ca(OH)2 Inhibited
- Date : 23-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH16-06 SA#41 106'6-108'3
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

Tray	3			4			
Wear Specimen	**2013-122**			**2013-123**			
Hardness	**64.7 Rc**			**66.1 Rc**			
Scale Factor	**1.143**			**1.152**			
	pH	Mass	Loss	pH	Mass	Loss	
		g	mg		g	mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**13.9**	**14.0791**	0.0	**13.9**	**14.0364**	0.0	
Weight After 2 Hours	**13.8**	**14.0642**	14.9	**13.8**	**14.0214**	15.0	
Weight After 4 Hours	**13.6**	**14.0501**	14.1	**13.7**	**14.0076**	13.8	
Weight After 6 Hours	**13.1**	**14.0368**	13.3	**13.2**	**13.9945**	13.0	Actual
Weight Total Loss			42.2			41.8	84.1
Weight Final Dry (Elastomer Only)			0.0			0.0	
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-3			L-4			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	2013-122	2013-123	Ave	*Best Fit	Error	
		mg	mg	mg	mg	mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	13.0	13.0	13.0	13.1	-0.069	
Weight After 4 Hours	4	25.3	25.0	25.2	25.1	0.097	
Weight After 6 Hours	6	37.0	36.3	36.6	36.7	-0.042	Inc
	Cumm	Chart	Max	37.0		0.016	9.2

Click Here to Solve Curve Fit

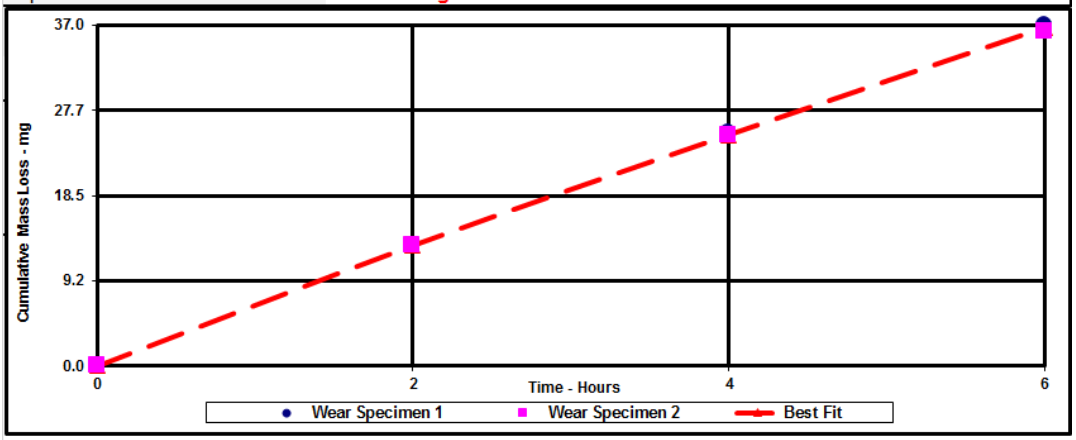
Results

Best Fit Mass Loss : = 6.82 * Hours^ 0.939

Miller Number : 111.59 Relative Rate of Mass/Volume loss at 2 hours

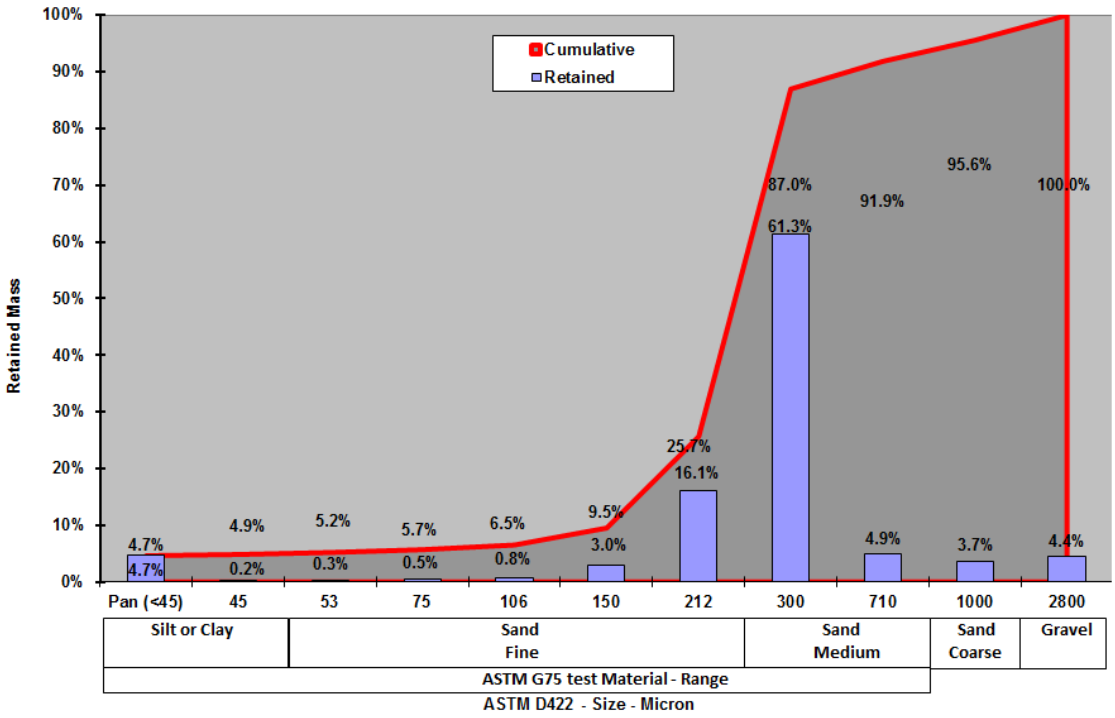
Departure : -3% Relative Rate of Change in Mass/Volume loss at 2 hours

Lap Mass Loss : 0.00 mg

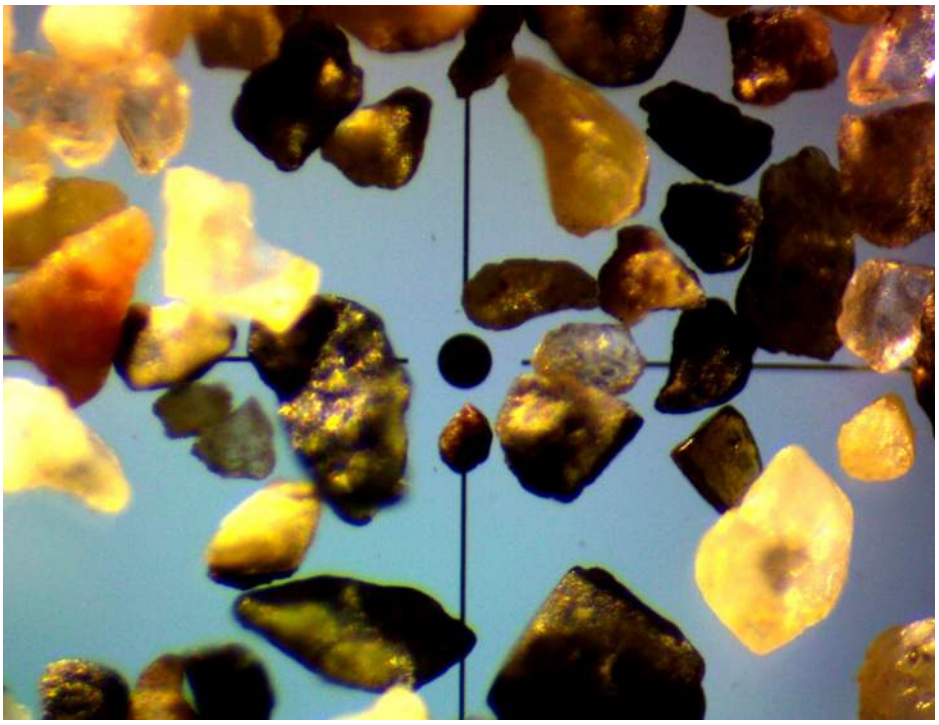


SH16-06 SA#41 106'6-108'3

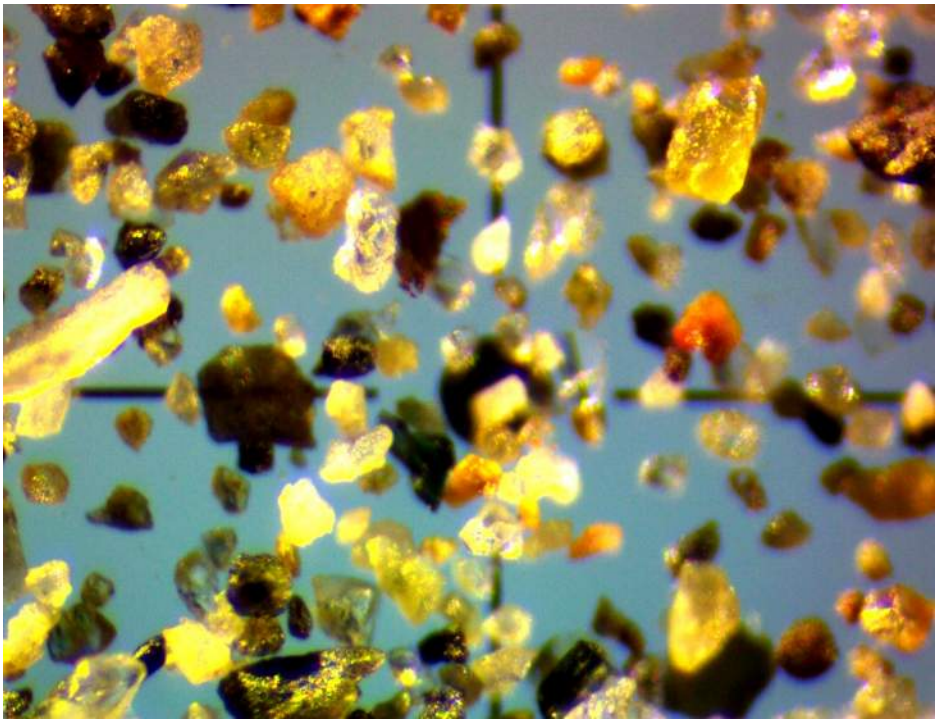
Solids Particle Distribution (Micron)



SH16-06 SA#41 106'6-108'3



Particles > 150 Micron with 200µ Grid Photo Micrograph



Particles < 150 Micron with 200µ Grid Photo Micrograph

ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2169
- Date : 28-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH16-07 SA#41 105-106'6
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with Fillers)

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

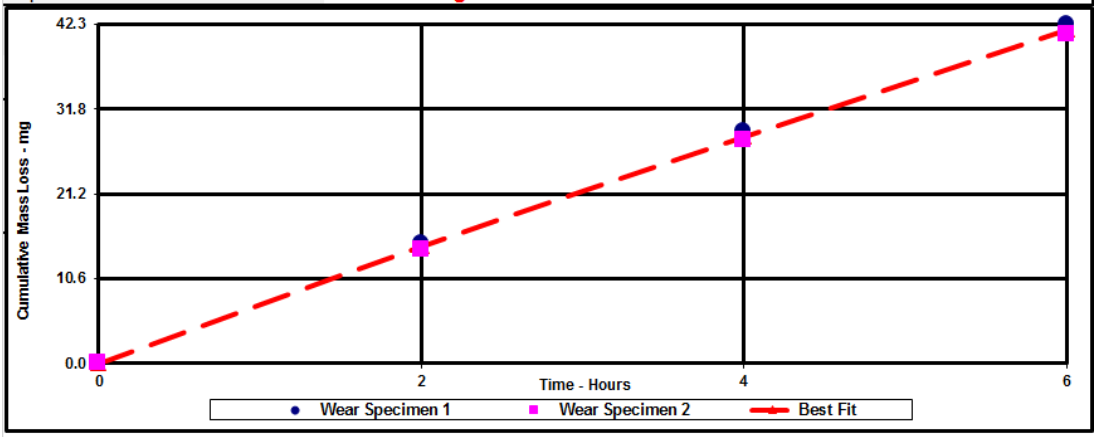
Tray	1			2			
Wear Specimen	2013-120			2013-121			
Hardness	64.9 Rc			64.6 Rc			
Scale Factor	1.081			1.132			
	pH	Mass	Loss	pH	Mass	Loss	
		g	mg		g	mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**8.1**	**13.8449**	0.0	**8.1**	**13.8063**	0.0	
Weight After 2 Hours	**8.6**	**13.8287**	16.2	**8.6**	**13.7902**	16.1	
Weight After 4 Hours	**8.8**	**13.8136**	15.1	**8.8**	**13.7747**	15.4	
Weight After 6 Hours	**8.8**	**13.7991**	14.5	**8.8**	**13.7598**	14.9	Actual
Weight Total Loss			45.8			46.4	92.2
Weight Final Dry (Elastomer Only)							
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-1			L-2			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	C	D	Ave	*Best Fit	Error	
		mg	mg	mg	mg	mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	15.0	14.2	14.6	14.6	-0.040	
Weight After 4 Hours	4	28.9	27.9	28.4	28.3	0.056	
Weight After 6 Hours	6	42.3	41.0	41.7	41.7	-0.024	Inc
	Cumm	Chart	Max	42.3		0.005	10.6

Click Here to Solve Curve Fit

Results

Best Fit Mass Loss	:	=	7.57 * Hours^ 0.953
Miller Number	:	126.82	Relative Rate of Mass/Volume loss at 2 hours
Departure	:	-2%	Relative Rate of Change in Mass/Volume loss at 2 hours
Lap Mass Loss	:	0.00	mg



ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2169 ~ 1mg Ca(OH)2 Inhibited
- Date : 28-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH16-07 SA#41 105-106'6
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

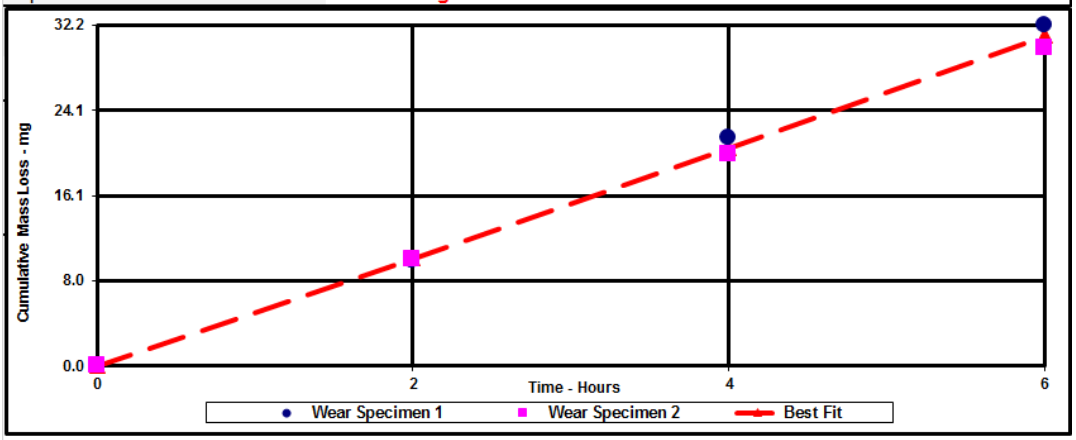
Tray	3			4			
Wear Specimen	2013-122			2013-123			
Hardness	64.7 Rc			66.1 Rc			
Scale Factor	1.143			1.152			
	pH	Mass	Loss	pH	Mass	Loss	
		g	mg		g	mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**13.9**	**13.9235**	0.0	**13.9**	**13.8620**	0.0	
Weight After 2 Hours	**13.7**	**13.9121**	11.4	**13.8**	**13.8504**	11.5	
Weight After 4 Hours	**13.4**	**13.8989**	13.3	**13.5**	**13.8389**	11.5	
Weight After 6 Hours	**13.2**	**13.8868**	12.1	**13.3**	**13.8274**	11.5	Actual
Weight Total Loss			36.8			34.6	71.4
Weight Final Dry (Elastomer Only)			0.0			0.0	
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-3			L-4			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	2013-122	2013-123	Ave	*Best Fit	Error	
		mg	mg	mg	mg	mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	10.0	10.0	10.0	10.1	-0.152	
Weight After 4 Hours	4	21.6	20.0	20.8	20.6	0.202	
Weight After 6 Hours	6	32.2	30.0	31.1	31.2	-0.084	Inc
	Cumm	Chart	Max	32.2		0.071	8.0

Click Here to Solve Curve Fit

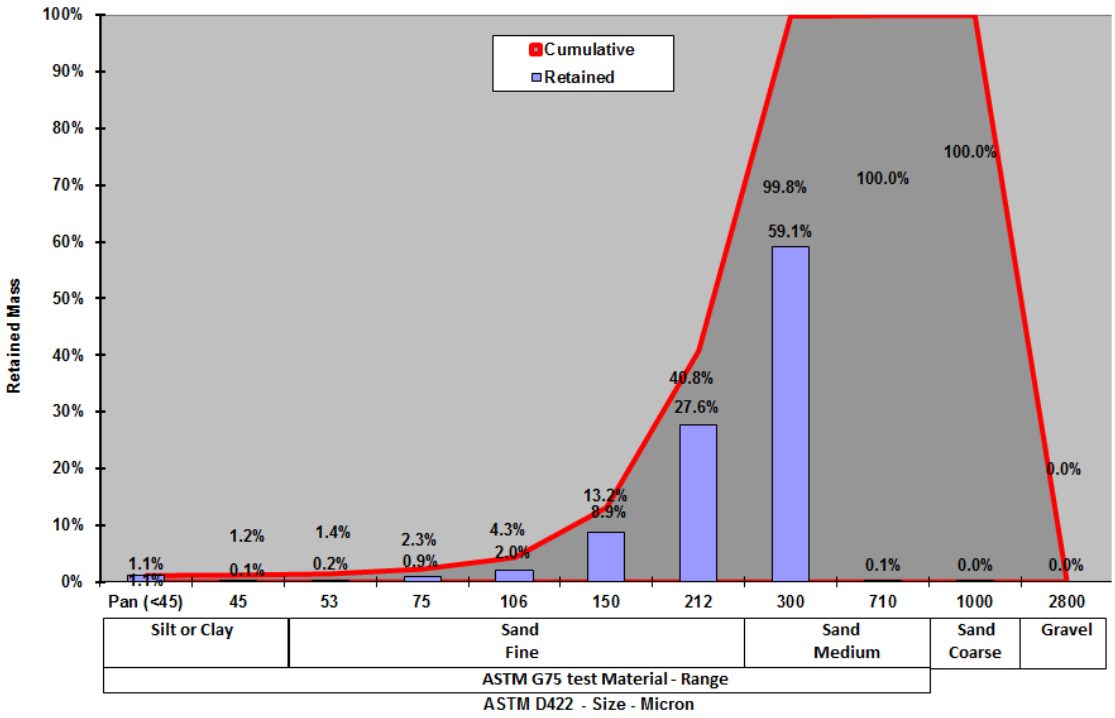
Results

Best Fit Mass Loss	=	5.00 * Hours^ 1.022	
Miller Number	94.24	Relative Rate of Mass/Volume loss at 2 hours	
Departure	1%	Relative Rate of Change in Mass/Volume loss at 2 hours	
Lap Mass Loss	0.00	mg	

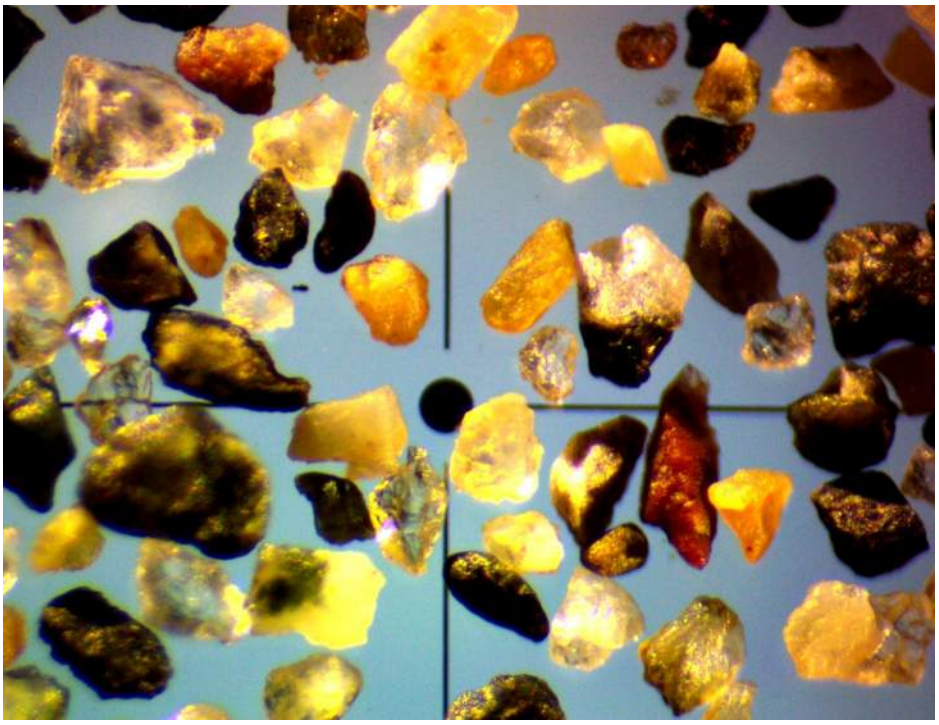


SH16-07 SA#41 105-106'6

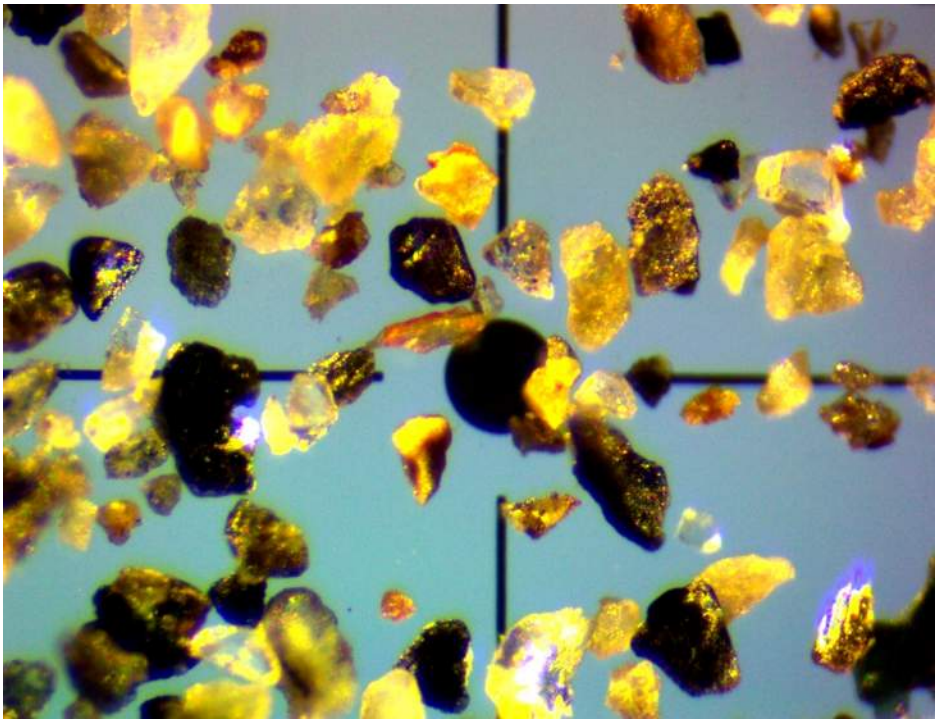
Solids Particle Distribution (Micron)



SH16-07 SA#41 105-106'6



Particles > 150 Micron with 200µ Grid Photo Micrograph



Particles < 150 Micron with 200µ Grid Photo Micrograph

ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2170
- Date : 29-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH17-05 SA#40 105-106'6
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with Fillers)

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

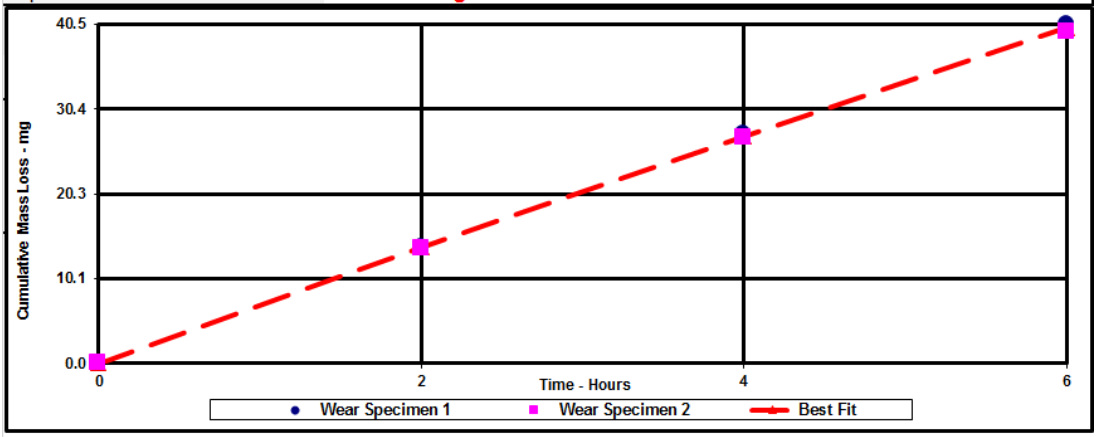
Tray	1			2			
Wear Specimen	2013-120			2013-121			
Hardness	64.7 Rc			66.1 Rc			
Scale Factor	1.081			1.132			
	pH	Mass g	Loss mg	pH	Mass g	Loss mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**8.4**	**13.7959**	0.0	**8.4**	**13.7578**	0.0	
Weight After 2 Hours	**8.7**	**13.7808**	15.1	**8.7**	**13.7423**	15.5	
Weight After 4 Hours	**8.8**	**13.7662**	14.6	**8.7**	**13.7273**	15.0	
Weight After 6 Hours	**8.9**	**13.7521**	14.1	**8.9**	**13.7129**	14.4	Actual
Weight Total Loss			43.8			44.9	88.7
Weight Final Dry (Elastomer Only)							
Dry Loss Factor			1.00			1.00	
LAP Serial Number	L-1			L-2			
Initial Wt							
Final Wt			-			-	

Best Fit Analysis	Adjusted Chart Data						
	Hours	C mg	D mg	Ave mg	*Best Fit mg	Error mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	14.0	13.7	13.8	13.9	-0.064	
Weight After 4 Hours	4	27.5	26.9	27.2	27.1	0.088	
Weight After 6 Hours	6	40.5	39.7	40.1	40.1	-0.037	Inc
	Cumm	Chart	Max	40.5		0.013	10.1

Click Here to Solve Curve Fit

Results

Best Fit Mass Loss	:	=	7.11 * Hours^ 0.966
Miller Number	:	121.94	Relative Rate of Mass/Volume loss at 2 hours
Departure	:	-2%	Relative Rate of Change in Mass/Volume loss at 2 hours
Lap Mass Loss	:	0.00	mg



ASTM G75 Slurry Abrasivity Determination
By Miller Number System

Test
- Type : Miller Number
- Number : M-2170 ~ 1mg Ca(OH)2 Inhibited
- Date : 29-Mar-2017

Project
- Description : E1441 Golder Associates

Slurry
- Description : SH17-05 SA#40 105-106'6
- AFS Test Sand Factor : 1.0000
- Concentration : 50% by Mass - 150g Solids - 150g Deionized Water
- Temperature : Ambient

Wear Specimen
- Description : 27% Chrome Iron
- Specific Gravity : 7.58

Arm Load
- Force : 5.00 lbs-f (22.24 Newton) for Miller, Gold, & SAR Number (Metal, Rubber, Epoxy with

Lap Material
- Description : Neoprene
- Hardness : 78-82 Shore A
- Wear Factor : 1.000

Tray		**3**			**4**		
Wear Specimen		**2013-122**			**2013-123**		
Hardness		**64.7 Rc**			**66.1 Rc**		
Scale Factor		**1.143**			**1.152**		
	pH	Mass	Loss	pH	Mass	Loss	
		g	mg		g	mg	
Weight Initial Dry (Elastomer Only)							
Weight Initial Wet or Dry	**13.9**	**13.8843**	0.0	**13.9**	**13.8267**	0.0	
Weight After 2 Hours	**13.9**	**13.8734**	10.9	**13.9**	**13.8154**	11.3	
Weight After 4 Hours	**13.5**	**13.8626**	10.8	**13.7**	**13.8048**	10.6	
Weight After 6 Hours	**13.1**	**13.8517**	10.9	**13.1**	**13.7938**	10.9	Actual
Weight Total Loss			32.6			32.9	65.4
Weight Final Dry (Elastomer Only)			0.0			0.0	
Dry Loss Factor			1.00			1.00	
LAP Serial Number		L-3			L-4		
Initial Wt							
Final Wt			-			-	

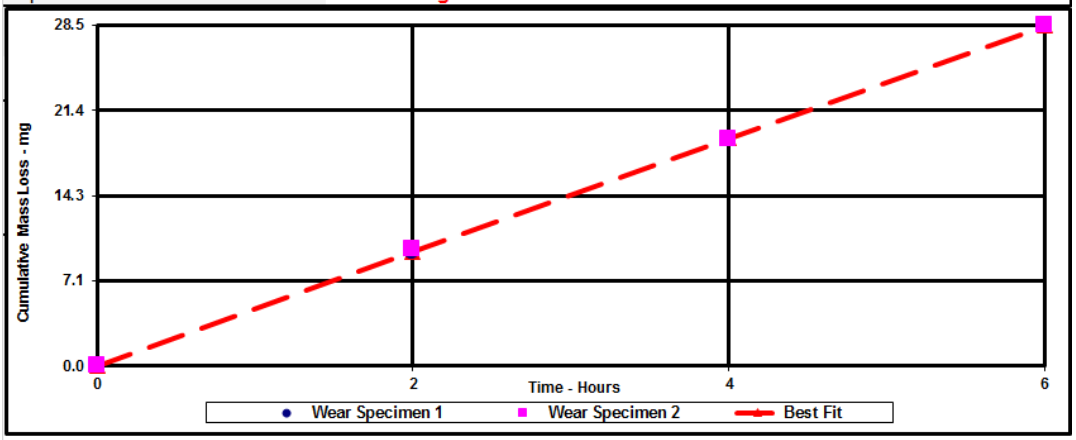
Best Fit Analysis — Adjusted Chart Data

	Hours	2013-122	2013-123	Ave	*Best Fit	Error	
		mg	mg	mg	mg	mg	
Weight Initial Wet or Dry	0	0.0	0.0	0.0	0.0	0.000	
Weight After 2 Hours	2	9.5	9.8	9.7	9.6	0.051	
Weight After 4 Hours	4	19.0	19.0	19.0	19.1	-0.070	
Weight After 6 Hours	6	28.5	28.5	28.5	28.5	0.030	Inc
	Cumm	Chart	Max	28.5		0.008	7.1

Click Here to Solve Curve Fit

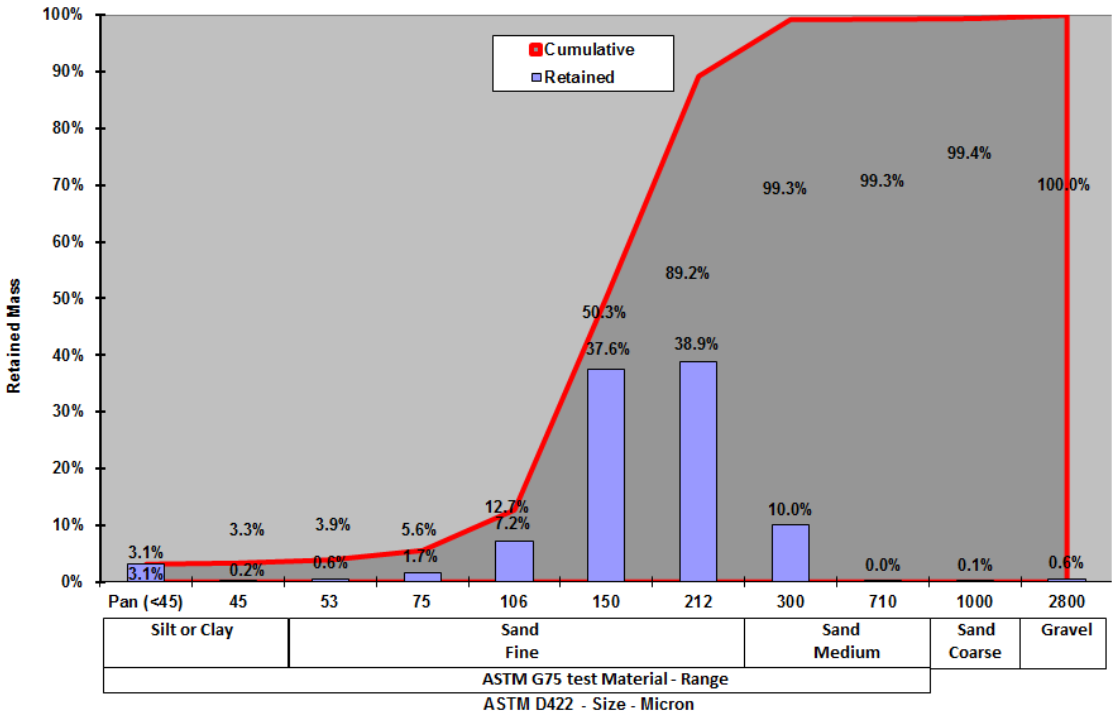
Results

Best Fit Mass Loss	=	4.84 * Hours^ 0.989	
Miller Number	86.38	Relative Rate of Mass/Volume loss at 2 hours	
Departure	-1%	Relative Rate of Change in Mass/Volume loss at 2 hours	
Lap Mass Loss	0.00	mg	

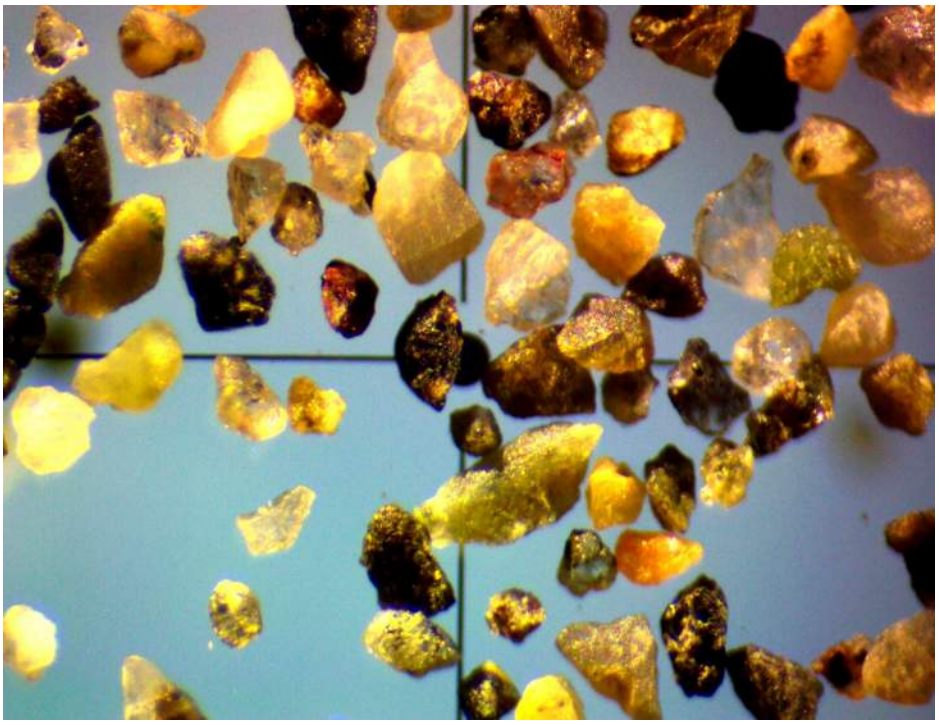


SH17-05 SA#40 105-106'6

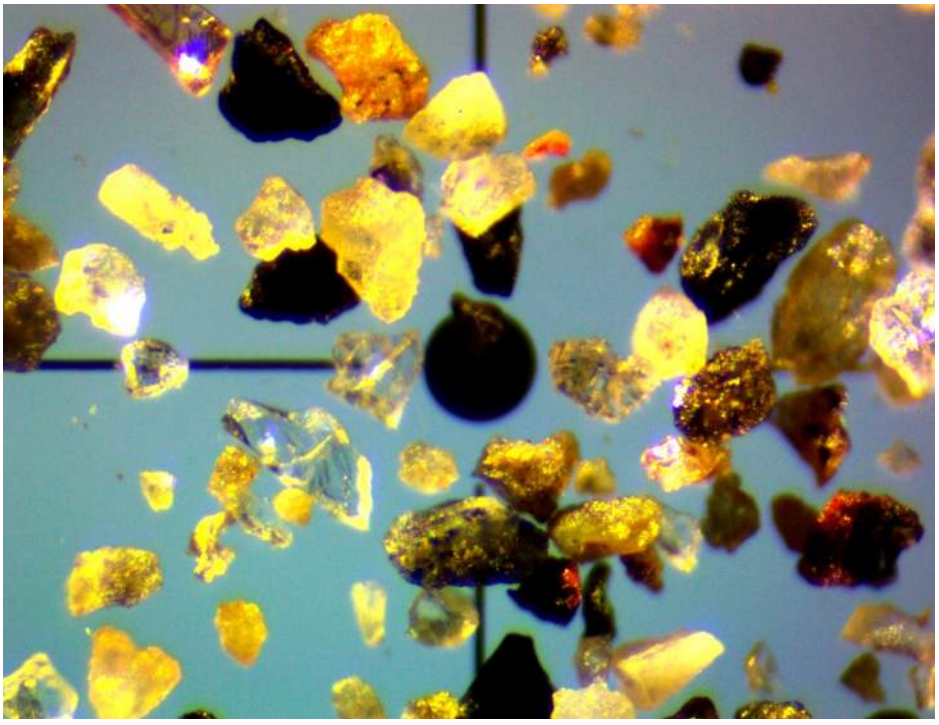
Solids Particle Distribution (Micron)



SH17-05 SA#40 105-106'6



Particles > 150 Micron with 200µ Grid Photo Micrograph



Particles < 150 Micron with 200µ Grid Photo Micrograph

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