Klohn Crippen Berger

Resolution Copper Mining LLC

Resolution Copper Project

Near West Tailings Storage Facility

Geotechnical Site Characterization Report

Volume 3 of 4 – Appendices III, IV, V, VI and VIII

M09441A18.730

October 2017

APPENDIX III

Geotechnical Laboratory Testing Results

Appendix III-A

ATL Laboratory Results

Moisture Content
Atterberg Limits
Particle Size Analysis
Proctor Compaction
Specific Gravity
Total Soluble Salt Content
Unconfined Compressive Strength
LA Abrasion Tests

Moisture Content

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer: Resolution Copper Mining

Lab No.:

Project Name: Resolution Near West Site Inv.

Project No.: 506

Material Type: Drill Holes

Test Method: ASTM X AASHTO

Material Source: Various, see below

Date: 12/21/2016

Sample Location: Various, see below

Tested By: MC

Material Source and location	Percent moisture
DH16-06 / S1 / 12-1-12.3 ft.	4.6%
DH16-06 / S2 / 29.0-29.1 ft.	5.7%
DH16-06 / S3 / 31.6-31.7 ft.	5.2%
DH16-06 / S4 / 43.0-43.2ft.	5.2%
DH16-06 / S5 / 47.9-48.1 ft.	8.5%
DH16-06 / S6 / 67.5-67.7 ft.	6.2%
DH16-06 / S7 / 72.5-72.7 ft.	4.6%
DH16-06 / S8 / 92.5-92.7 ft.	3.1%
DH16-06 / S9 / 104.8-105.0 ft.	4.2%
DH16-07 / S1 / 19.6-19.8 ft.	4.5%
DH16-07 / S2 / 25.8-28.6 ft.	2.1%
DH16-07 / S4 / 57.8-57.9 ft.	3.5%
DH16-07 / S5 / 64.7-64.9 ft.	5.7%
DH16-07 / S6 / 73.6-73.8 ft.	2.3%
DH16-07 / S7 / 88.6-88.7 ft.	4.6%
DH16-07 / S8 / 99.3-99.4 ft.	2.2%
DH16-07 / S18 / 197.5-197.6 ft.	21.6%
DH16-08 / S1 / 6.0-6.6 ft.	11.3%
DH16-08 / S2 / 17.1-17.3 ft.	3.5%

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer:	Resolution Copper Mining	Lab No.:	
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Drill Holes	Test Method:	ASTM X AASHTO
Material Source:	Various, see below	Date:	12/21/2016
Sample Location:	Various, see below	Tested By:	MC

Material Source and location	**Percent moisture**
DH16-08 / S3 / 28.6-28.8 ft.	5.4%
DH16-08 / S4 / 31.8-32.0 ft.	5.6%
DH16-08 / S5 / 31.9-39.3 ft.	3.8%
DH16-08 / S6 / 48.8-49.0 ft.	5.6%
DH16-08 / S7 / 59.1-59.3 ft.	4.9%
DH16-08 / S8 / 69.1-69.3 ft.	2.6%
DH16-08 / S9 / 75.4-75.6 ft.	3.7%
DH16-08 / S10 / 90.4-90.6 ft.	4.9%
DH16-08 / S11 / 94.5-94.8 ft.	2.4%
DH16-08 / S12 / 104.1-104.3 ft.	2.2%
DH16-11 / S1 / 6.0-7.5 ft.	9.5%
DH16-12 / S1 / 43.8-47.0 ft.	6.5%
DH16-12 / S2 / 48.5-48.7 ft.	8.5%
DH16-12 / S3 / 63.4-63.6 ft.	4.4%
DH16-12 / S4 / 68.0-68.2 ft.	5.1%
DH16-12 / S5 / 78.8-78.9 ft.	5.7%
DH16-12 / S6 / 84.6-84.8 ft.	5.1%
DH16-12 / S7 / 108.8-109.0 ft.	7.7%
DH16-13 / S1 / 26.3-26.5 ft.	6.1%

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer: Resolution Copper Mining
Lab No.:
Project Name: Resolution Near West Site Inv.
Project No.: 506
Material Type: Drill Holes
Test Method: ASTM X AASHTO
Material Source: Various, see below
Date: 12/21/2016
Sample Location: Various, see below
Tested By: MC

Material Source and location	Percent moisture
DH16-13 / S2 / 32.8-33.0 ft.	9.7%
DH16-13 / S3 / 48.8-49.0 ft.	5.8%
DH16-13 / S4 / 57.0-57.3 ft.	6.6%
DH16-13 / S5 / 65.9-66.1 ft.	5.1%
DH16-13 / S6 / 78.8-79.0 ft.	7.3%
DH16-13 / S7 / 94.1-94.3 ft.	9.9%
DH16-13 / S8 / 103.6-103.8 ft.	4.9%
TP16-01 / MB-01 / 0-2.0 ft.	13.3%
TP16-01 / MB-02 / 2.0-4.0 ft.	14.9%
TP16-01 / MB-03 / 4.0-6.0 ft.	7.3%
TP16-01 / MB-04 / 6.0-8.0 ft.	10.3%
TP16-02 / MB-02 / 2.0-4.0 ft.	9.2%
TP16-02 / MB-03 / 4.0-6.0 ft.	5.9%
TP16-03 / MB-02 / 2.0-4.0 ft.	3.5%
TP16-03 / MB-03 / 4.0-6.0 ft.	3.6%
TP16-04 / MB-02 / 2.0-4.0 ft.	8.4%
TP16-05 / MB-01 / 0-1.0 ft.	9.8%
TP16-05 / MB-05 / 1.0-4.0 ft.	5.3%
TP16-07 / MB-02 / 1.54.0 ft.	3.1%

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer:	Resolution Copper Mining	Lab No.:	11457
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Drill Holes	Test Method:	ASTM X AASHTO
Material Source:	Various, see below	Date:	2/22/2017
Sample Location:	Various, see below	Tested By:	MC

Material Source and location	Percent moisture
DH16-14 / S1 / 36.9'-37.5'	3.6%
DH16-14 / S2 / 54.1'-54.6'	8.2%
DH16-15 / S1 / 14.4'- 14.8'	6.0%
DH16-15 / S2 / 31.3'-31.5'	3.6%
DH16-15 / S3 / 43.2'- 43.5'	4.0%
DH16-15 / S4 / 57.8'-58.1'	9.6%
DH16-15 / S5 / 86.3'-86.5'	5.5%
DH16-16 / S1 / 39.7'-40.0'	9.6%
DH16-18 / S1 / 11.0'-12.2'	8.5%
DH16-21 / S2 / 1.0'-1.4'	13.4%
DH16-22 / S1 / 31.8'-32.0'	7.7%
DH17-26 / S1 / 10.5'-10.8'	7.0%
DH17-26 / S2 / 30.5'-30.8'	6.1%

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer:	Resolution Copper Mining	Lab No.:	11457
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Drill Holes	Test Method:	ASTM X AASHTO
Material Source:	Various, see below	Date:	2/22/2017
Sample Location:	Various, see below	Tested By:	MC

Material Source and location	Percent moisture
DH17-26 / S3 / 50.2'-50.4'	6.3%
DH17-26 / S11 / 72.6'-72.8'	7.3%
DH17-26 / S12 / 91.4'-91.9'	15.2%
DH17-28 / S1 / 20.8'-21.0'	4.7%
DH17-28 / S4 / 51.7'-51.9'	5.5%
DH17-28 / S5 / 58.8'-59.0'	9.0%
DH17-28 / S6 / 72.2'-72.5'	9.3%
Dh17-28 / S7 / 81.9'-89.2'	7.8%
DH17-28 / S8 / 91.1'-91.4'	4.4%
DH17-30 / S1 / 14.0'-14.3'	6.6%
DH17-30 / S3 / 15.4'-15.7'	5.6%
DH17-30 / S4 / 23.5'-23.9'	6.6%

Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer:	Resolution Copper Mining	Lab No.:	11457
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Drill Holes	Test Method:	ASTM X AASHTO
Material Source:	Various, see below	Date:	2/22/2017
Sample Location:	Various, see below	Tested By:	MC

Material Source and location	Percent moisture
DH17-30 / S5 / 41.1'-41.4'	6.0%
DH17-30 / S6 / 51.0'-51.3'	5.5%
DH17-30 / S7 / 73.3'-73.6'	6.2%
DH17-30 / S8 / 93.5'-93.7'	8.0%

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer:	Resolution Copper Mining	Lab No.:	12133
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Cores	Test Method:	ASTM X AASHTO
Material Source:	Various, see below	Date:	3/14/2017
Sample Location:	Various, see below	Tested By:	MC

Material Source and location	Percent moisture
DH17-33 / S6 / 5.8'	13.9%
DH17-33 / S7 / 11.4'	10.9%
DH17-33 / S8 18.2'	9.7%
DH17-33 / S9 / 33'	13.5%
DH17-33 / S10 / 56'	8.9%
DH17-34 / S6 / 15'	6.1%
DH17-34 / S7 / 32'	7.8%
DH17-34 / S8 / 52.9'	6.2%
DH17-34 / S9 / 65'	10.6%
DH17-37 / S5 / 16'	5.8%
DH17-37 / S6 / 23'	6.9%
DH17-37 / S7 / 29'	5.0%
DH17-37 / S8 / 37'	5.9%
DH17-38 / S1 / 11.1-11.3'	7.3%
DH17-38 / S4 / 15.5-15.7'	6.8%

Remarks:

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Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM D2216 or AASHTO T255/265

Customer: Resolution Copper Mining

Lab No.:

Project Name: Resolution Near West Site Inv.

Project No.: 506

Material Type: Drill Holes

Test Method: ASTM X AASHTO

Material Source: Various, see below

Date: 12/21/2016

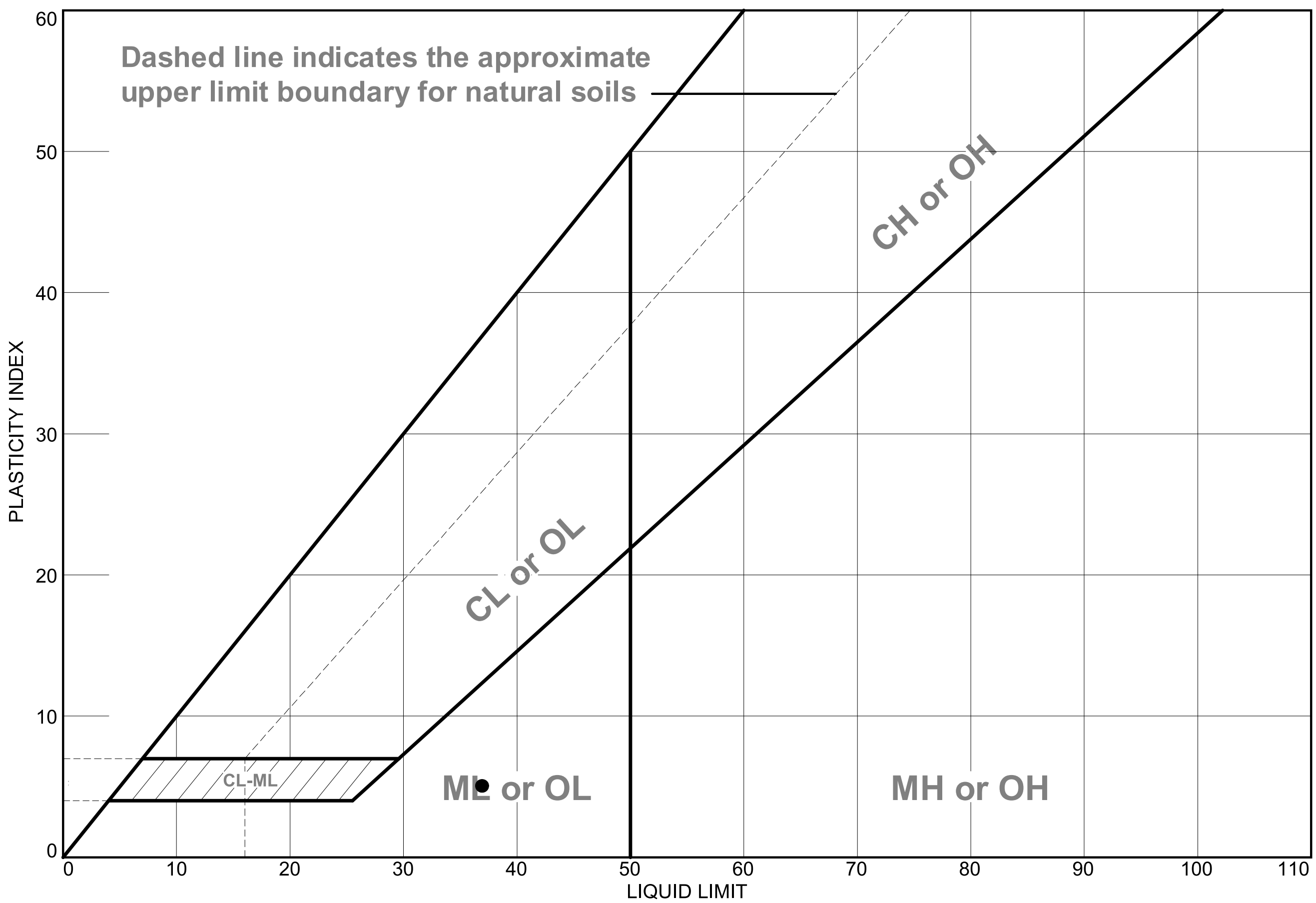
Sample Location: Various, see below

Tested By: MC

Material Source and location	Percent moisture
TP16-06 / MB-02 / 2.0-4.0 ft.	3.2%
TP16-05 / MB-03 / 4.0-6.0 ft.	3.3%
TP16-07 / MB-03 / 4.0-6.0 ft.	2.9%
TP16-08 / MB-01 / 0-3.0 ft.	4.1%
TP16-08 / MB-03 / 5.0-7.0 ft.	2.2%
TP16-09 / MB-01 / 0-1.0 ft.	2.9%
TP16-09 / MB-02 / 1.0-4.0 ft.	3.3%
TP16-09 / MB-03 / 4.0-7.0 ft.	4.4%
TP16-10 / MB-02 / 1.5-5.0 ft.	1.3%
TP16-10 / MB-03 / 5.0-8.0 ft.	1.7%
TP16-11 / MB-02 / 2.0-5.0 ft.	2.8%
TP16-11 / MB-03 / 5.0-7.0 ft.	1.60%
TP16-12 / MB-02 / 2.0-4.0 ft.	2.9%
TP16-12 / MB-03 / 4.0-6.0 ft.	1.0%
TP16-13 / MB-02 / 1.5-6.0 ft.	4.2%
TP16-14 / MB-02 / 2.0-4.5 ft.	4.8%
TP16-14 / MB-03 / 4.5-6.0 ft.	1.9%

Atterberg Limits

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		37	32	5			

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

● **Source:** DH16-13 S9 **Depth:** 20.9-21.0 **Sample No.:** DH16-13 S9

Remarks:

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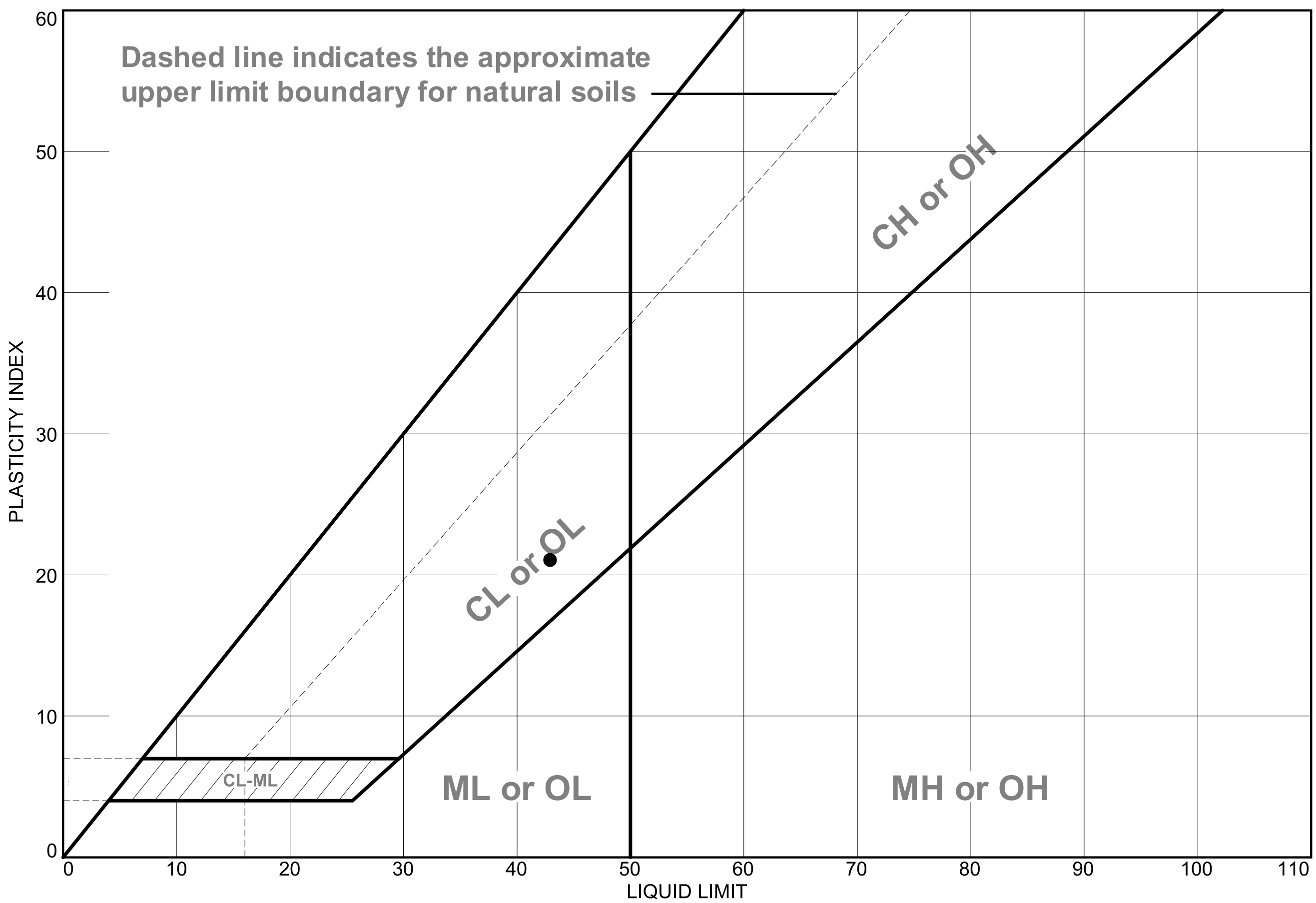
Figure

Tested By: MC

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY	43	22	21	86.5	75.9	CL

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

● **Source:** TP16-01 BK-01 **Depth:** 0-2.0 **Sample No.:** TP16-01 BK-01

Remarks:

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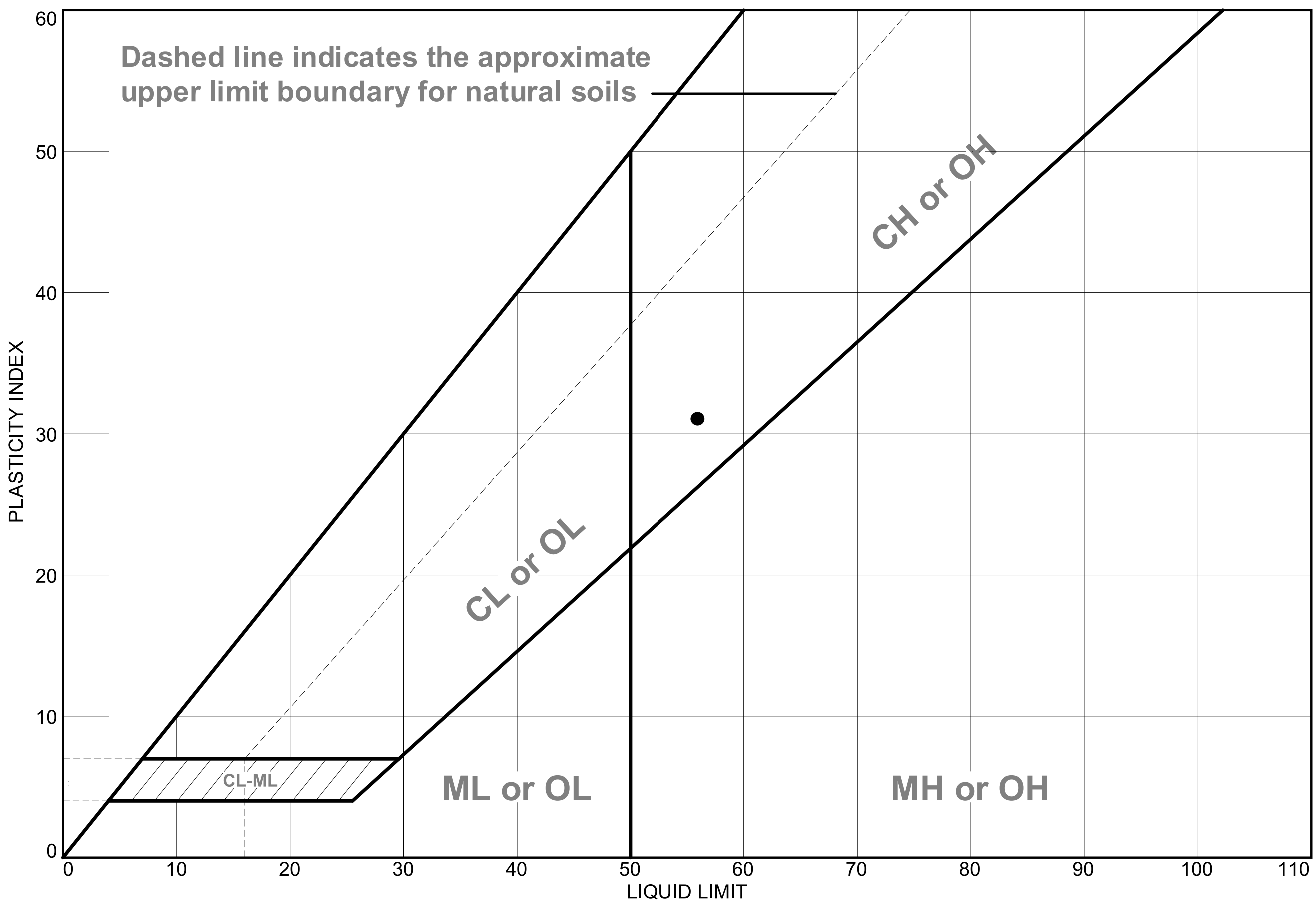
Figure

Tested By: MC

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAYEY SAND WITH GRAVEL	56	25	31	61.3	45.0	SC

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

● **Source:** TP16-05 BK-01 **Depth:** 0-1.0 **Sample No.:** TP16-05 BK-01

Remarks:

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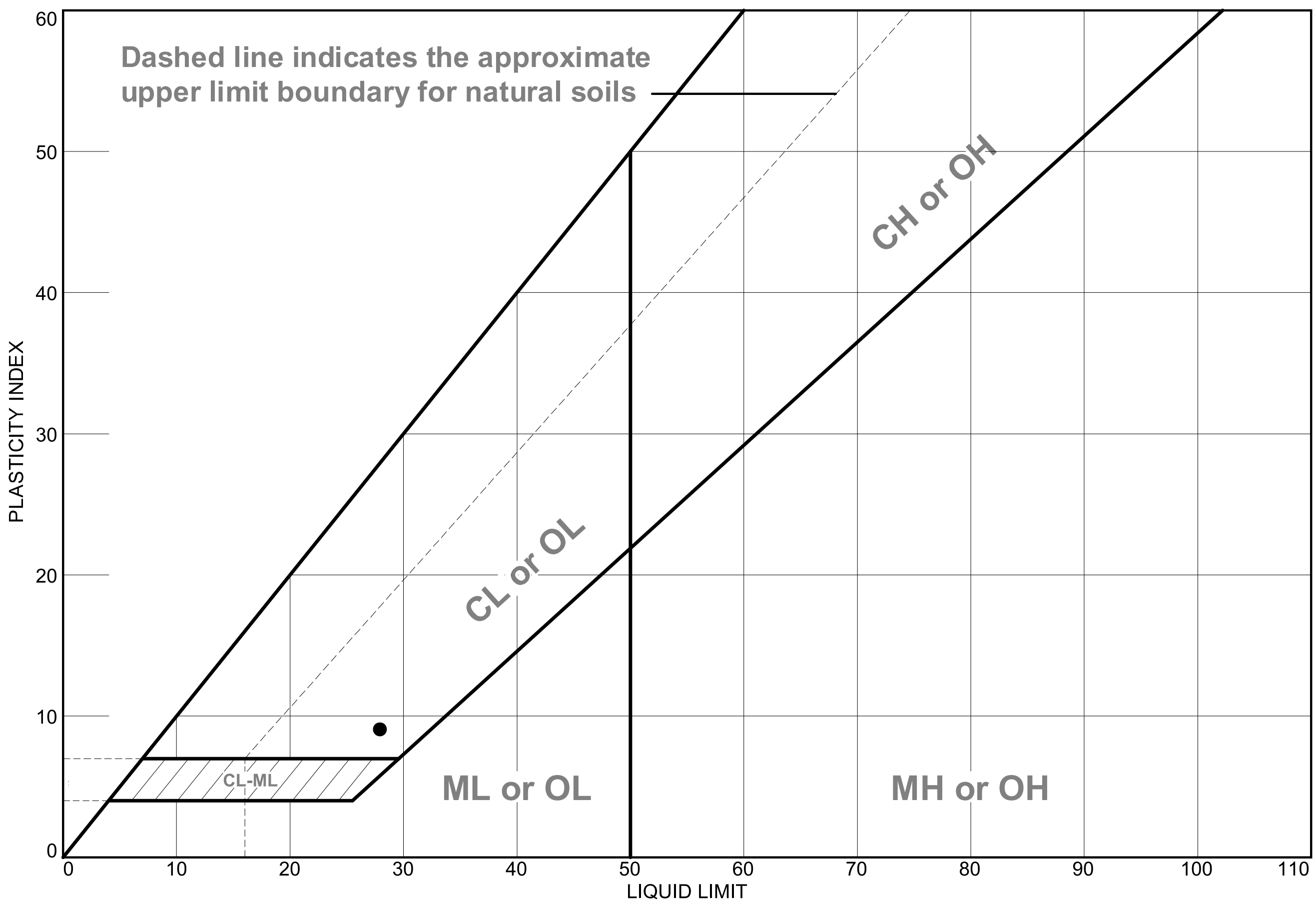
Figure

Tested By: MC

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		28	19	9	38.4	28.3	GC

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

● **Source:** TP16-09 BK-01 **Depth:** 0-1.0 **Sample No.:** TP16-09 BK-01

Remarks:

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Figure

Tested By: MC

Particle Size Analysis

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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer:	Resolution Copper Mining	Lab No.:	10632
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Various	Test Method:	ASTM X AASHTO
Material Source:	DH16-06 S17	Date:	1/9/2017
Sample Location:	25.0-26.0 ft.	Tested By:	MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
		0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	11.4	3.1%	3.1%	96.9%	
1/2"	19.2	5.3%	8.4%	91.6%	
3/8"	27.8	7.7%	16.1%	83.9%	
4	107.2	29.5%	45.6%	54.4%	
8	66.5	18.3%	64.0%	36.0%	
10	19.5	5.4%	74.1%	25.9%	
Sum +#10	251.6	69.3%	74.1%	25.9%	
16	14.6	4.0%	78.2%	21.8%	
30	25.3	7.0%	85.1%	14.9%	
40	12.9	3.6%	88.7%	11.3%	
50	12.0	3.3%	92.0%	8.0%	
100	19.4	5.3%	97.3%	2.7%	
200	7.5	2.1%	99.4%	0.6%	
- 200 S.O.	2.0	0.6%	100.0%	0.0%	
Sum - #10	93.7	25.8%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	7:40	68	1017
5	7:45	68	1016
15	8:00	69	1014
30	8:15	69	1013
60	8:40	69	1013
250	11:40	69	1009
1440	7:40	68	1009

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	20.70	-
Hydroscopic "Wet" Weight	32.90	12.20
Dry Weight	32.40	11.70
% Moisture	4.3	-

Total Sample	
Plus #10 Weight	251.6
Minus #10 Weight	111.3
Total	362.9

Remarks:

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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer:	Resolution Copper Mining	Lab No.:	10632
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Various	Test Method:	ASTM X AASHTO
Material Source:	DH16-07 S14	Date:	1/9/2017
Sample Location:	25.0-26.0 ft.	Tested By:	MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
		0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	0.0	0.0%	0.0%	100.0%	
4	0.0	0.0%	0.0%	100.0%	
8	0.0	0.0%	0.0%	100.0%	
10	0.0	0.0%	0.0%	100.0%	
Sum +#10	0.0	0.0%	0.0%	100.0%	

16	25.0	24.9%	24.9%	75.1%	
30	30.9	30.7%	55.6%	44.4%	
40	9.9	9.8%	65.4%	34.6%	
50	7.2	7.2%	72.6%	27.4%	
100	11.2	11.1%	83.7%	16.3%	
200	7.4	7.4%	91.1%	8.9%	
- 200 S.O.	9.0	8.9%	100.0%	0.0%	
Sum - #10	100.6	100.0%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	9:08	70	1011
5	9:13	70	1010
15	9:25	70	1008
30	9:35	70	1008
60	10:08	70	1008
250	1:10	70	1007
1440	7:00	70	1006

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	21.00	-
Hydroscopic "Wet" Weight	39.39	18.39
Dry Weight	38.94	17.94
% Moisture	2.5	-

Total Sample	
Plus #10 Weight	0.0
Minus #10 Weight	100.6
Total	100.6

Remarks:

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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer:	Resolution Copper Mining	Lab No.:	10632
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Various	Test Method:	ASTM X AASHTO
Material Source:	DH16-07 S14	Date:	1/9/2017
Sample Location:	20.0-20.5 ft.	Tested By:	MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
		0.0%	0.0%	100.0%	
1"	48.1	10.4%	10.4%	89.6%	
3/4"	15.6	3.4%	13.8%	86.2%	
1/2"	19.3	4.2%	18.0%	82.0%	
3/8"	29.8	6.5%	24.5%	75.5%	
4	105.5	22.9%	47.3%	52.7%	
8	95.6	20.7%	68.0%	32.0%	
10	28.1	6.1%	74.1%	25.9%	
Sum +#10	342.0	74.1%	74.1%	25.9%	

16	23.0	5.0%	79.1%	20.9%	
30	27.6	6.0%	85.1%	14.9%	
40	11.1	2.4%	87.5%	12.5%	
50	10.7	2.3%	89.8%	10.2%	
100	14.7	3.2%	93.0%	7.0%	
200	10.5	2.3%	95.3%	4.7%	
- 200 S.O.	21.7	4.7%	100.0%	0.0%	
Sum - #10	119.3	25.9%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	7:50	69	1011
5	7:55	69	1010
15	8:10	69	1009
30	8:20	69	1008
60	8:50	69	1008
250	11:11	69	1007
1440	7:50	68	1006

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	21.00	-
Hydroscopic "Wet" Weight	31.11	10.11
Dry Weight	30.71	9.71
% Moisture	4.1	-

Total Sample	
Plus #10 Weight	342.0
Minus #10 Weight	119.3
Total	461.3

Remarks:

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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer: Resolution Copper Mining
Lab No.: 10632
Project Name: Resolution Near West Site Inv.
Project No.: 506
Material Type: Various
Test Method: ASTM X AASHTO
Material Source: DH16-07 S18
Date: 1/9/2017
Sample Location: 197.5-197.6 ft.
Tested By: MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
		0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	0.0	0.0%	0.0%	100.0%	
4	29.9	17.0%	17.0%	83.0%	
8	46.8	26.7%	43.7%	56.3%	
10	9.4	5.4%	49.1%	50.9%	
Sum +#10	86.1	49.1%	49.1%	50.9%	

16	3.9	2.2%	51.3%	48.7%	
30	22.4	12.8%	64.1%	35.9%	
40	19.6	11.2%	75.3%	24.7%	
50	13.4	7.6%	82.9%	17.1%	
100	15.2	8.7%	91.6%	8.4%	
200	7.6	4.3%	95.9%	4.1%	
- 200 S.O.	7.2	4.1%	100.0%	0.0%	
Sum - #10	89.3	50.9%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	8:35	70	1011
5	8:40	70	1010
15	8:50	70	1009
30	9:05	70	1008
60	9:35	70	1008
250	12:35	71	1007
1440	8:35	68	1006

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	20.79	-
Hydroscopic "Wet" Weight	31.12	10.33
Dry Weight	29.99	9.20
% Moisture	12.3	-

Total Sample	
Plus #10 Weight	86.1
Minus #10 Weight	89.3
Total	175.4

Remarks:

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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer: Resolution Copper Mining

Lab No.: 10632

Project Name: Resolution Near West Site Inv.

Project No.: 506

Material Type: Various

Test Method: ASTM X AASHTO

Material Source: DH16-08 S17

Date: 1/9/2017

Sample Location: 37.4-38.2 ft.

Tested By: MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
	0.0	0.0%	0.0%	100.0%	
1"	49.8	11.3%	11.3%	88.7%	
3/4"	6.0	1.4%	12.6%	87.4%	
1/2"	42.6	9.6%	22.3%	77.7%	
3/8"	38.7	8.8%	31.0%	69.0%	
4	117.1	26.5%	57.6%	42.4%	
8	67.1	15.2%	72.7%	27.3%	
10	23.8	5.4%	78.1%	21.9%	
Sum +#10	345.1	78.1%	78.1%	21.9%	

16	20.6	4.7%	82.8%	17.2%	
30	26.6	6.0%	88.8%	11.2%	
40	12.4	2.8%	91.6%	8.4%	
50	10.5	2.4%	94.0%	6.0%	
100	12.2	2.8%	96.8%	3.2%	
200	6.5	1.5%	98.2%	1.8%	
- 200 S.O.	7.8	1.8%	100.0%	0.0%	
Sum - #10	96.6	21.9%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	8:35	70	1011
5	8:40	70	1010
15	8:50	70	1009
30	9:05	70	1008
60	9:35	70	1008
250	12:35	71	1007
1440	8:35	68	1006

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	20.76	-
Hydroscopic "Wet" Weight	35.53	14.77
Dry Weight	35.20	14.44
% Moisture	2.3	-

Total Sample	
Plus #10 Weight	345.1
Minus #10 Weight	96.6
Total	441.7

Remarks:

ATL-CMT
Geotechnical • Environmental • Civil • Inspections

Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer:	Resolution Copper Mining	Lab No.:	10632
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Various	Test Method:	ASTM X AASHTO
Material Source:	DH16-12 S11	Date:	1/9/2017
Sample Location:	36.7-37.5 ft.	Tested By:	MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
	0.0	0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	9.8	3.8%	3.8%	96.2%	
4	76.9	29.5%	33.3%	66.7%	
8	53.7	20.6%	53.9%	46.1%	
10	16.0	6.1%	60.1%	39.9%	
Sum +#10	156.4	60.1%	60.1%	39.9%	
16	10.6	4.1%	64.1%	35.9%	
30	27.3	10.5%	74.6%	25.4%	
40	12.4	4.8%	79.4%	20.6%	
50	12.0	4.6%	84.0%	16.0%	
100	16.0	6.1%	90.1%	9.9%	
200	10.6	4.1%	94.2%	5.8%	
- 200 S.O.	15.1	5.8%	100.0%	0.0%	
Sum - #10	104.0	39.9%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	8:35	70	1011
5	8:40	70	1010
15	8:50	70	1009
30	9:05	70	1008
60	9:35	70	1008
250	12:35	71	1007
1440	8:35	68	1006

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	20.76	-
Hydroscopic "Wet" Weight	35.53	14.77
Dry Weight	35.20	14.44
% Moisture	2.3	-

Total Sample	
Plus #10 Weight	156.4
Minus #10 Weight	104.0
Total	260.4

Remarks:

ATL-CMT
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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer: Resolution Copper Mining
Lab No.: 10632
Project Name: Resolution Near West Site Inv.
Project No.: 506
Material Type: Various
Test Method: ASTM X AASHTO
Material Source: DH16-13 S9
Date: 1/9/2017
Sample Location: 20.4-21.0 ft.
Tested By: MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
	0.0	0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	2.8	1.3%	1.3%	98.7%	
4	42.6	19.3%	20.6%	79.4%	
8	59.3	26.9%	47.5%	52.5%	
10	17.6	8.0%	55.4%	44.6%	
Sum +#10	122.3	55.4%	55.4%	44.6%	

16	14.0	6.3%	61.8%	38.2%	
30	25.0	11.3%	73.1%	26.9%	
40	10.9	4.9%	78.1%	21.9%	
50	11.0	5.0%	83.0%	17.0%	
100	14.5	6.6%	89.6%	10.4%	
200	10.2	4.6%	94.2%	5.8%	
- 200 S.O.	12.7	5.8%	100.0%	0.0%	
Sum - #10	98.3	44.6%	100.0%	0.0%	

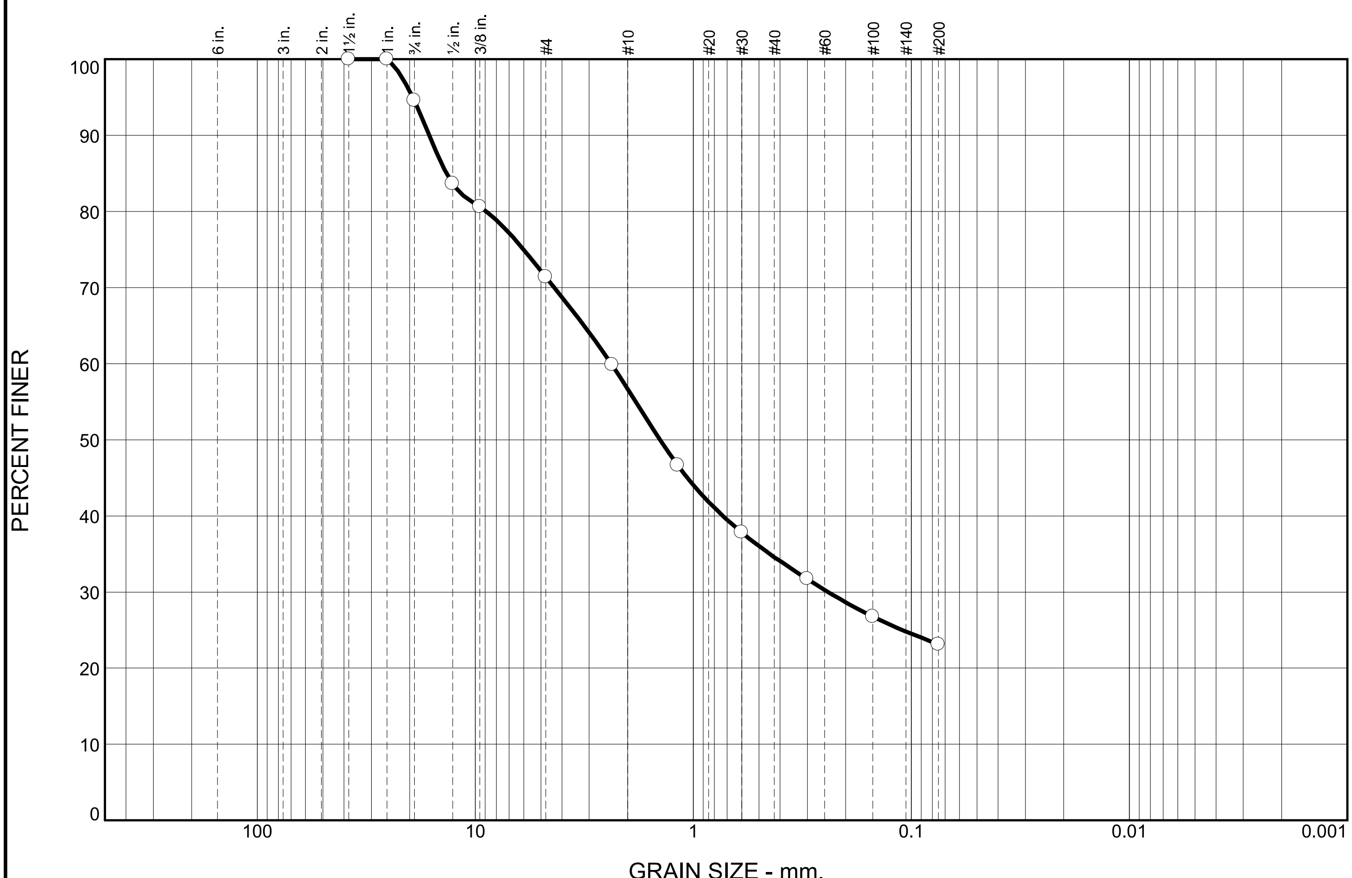
Elapsed Time (min)	Time	Temp	Reading
2	9:34	70	1014
5	9:39	70	1013
15	9:50	70	1011
30	10:05	70	1010
60	10:34	70	1009
250	1:35	70	1008
1440	7:00	70	1007

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	28.13	-
Hydroscopic "Wet" Weight	42.01	13.88
Dry Weight	41.53	13.40
% Moisture	3.6	-

Total Sample	
Plus #10 Weight	122.3
Minus #10 Weight	98.3
Total	220.6

Remarks:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	5.4	23.2	14.7	22.1	11.5	23.1	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			13.5636	2.3809	1.4217	0.2407				

Material Description	USCS	AASHTO
○ SANDY GRAVEL (GS)		

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○ **Source of Sample:** DH16-08 S1 **Depth:** 6.0-6.6 **Sample Number:** DH16-08 S1

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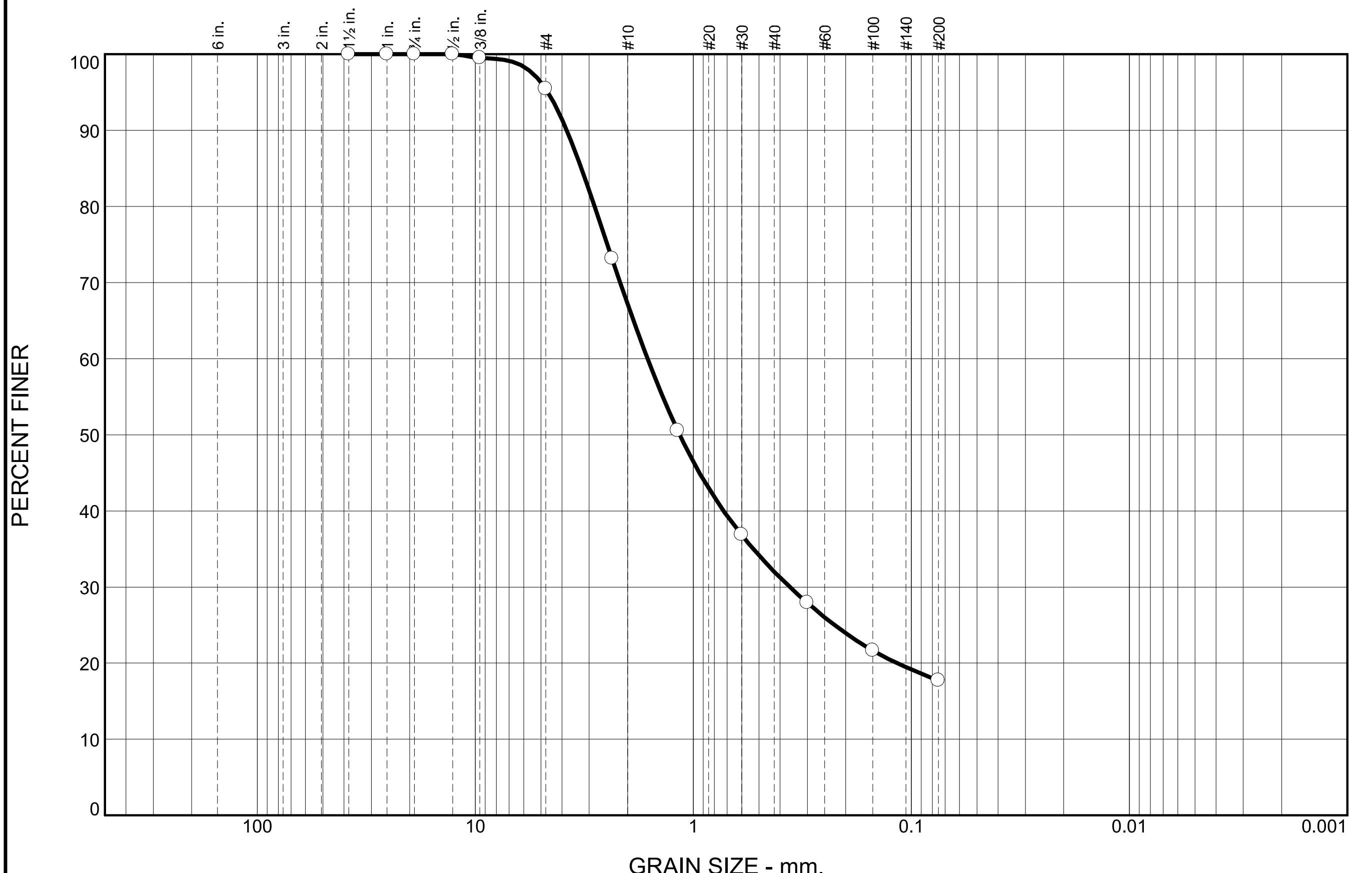
Remarks:
○unable to make exact classification without ASTM D4318 (Atterburg) test.

Figure

Tested By: MC

Particle Size Distribution Report



% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
0.0	0.0	4.6	28.3	35.1	14.3	17.7	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		3.2620	1.6221	1.1554	0.3607				

Material Description	USCS	AASHTO
SAND WITH FINES (SW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

Source of Sample: DH16-11 S1 **Depth:** 6.0-7.5 **Sample Number:** DH16-11 S1

Remarks:
unable to make exact classification without ASTM D4318 (Atterburg) testing.

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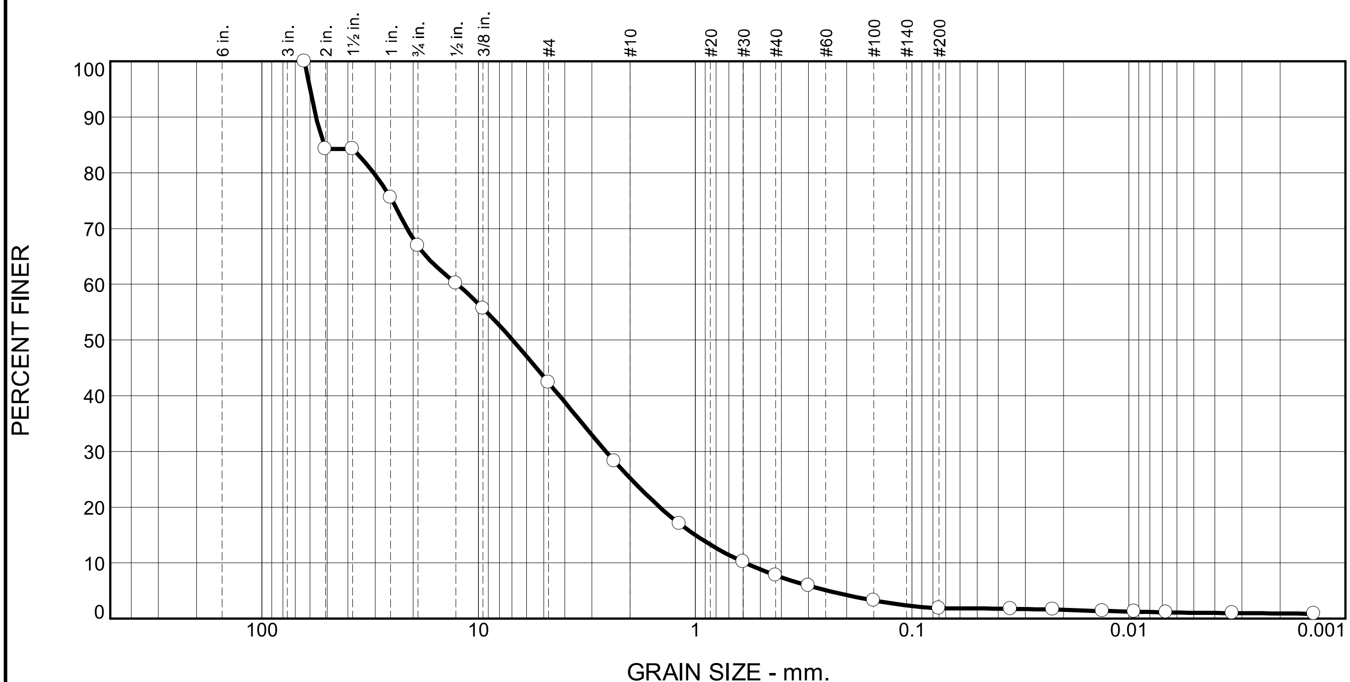
Figure

Tested By: MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	33	25	17	17	6	1	1

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.5"	100		
2"	84		
1.5"	84		
1"	76		
3/4"	67		
1/2"	60		
3/8"	56		
#4	42		
#8	28		
#16	17		
#30	10		
#40	8		
#50	6		
#100	3		
#200	1.8		
0.0350 mm.	1.7		
0.0224 mm.	1.6		
0.0132 mm.	1.4		
0.0094 mm.	1.2		
0.0067 mm.	1.1		
0.0033 mm.	1.0		
0.0014 mm.	0.9		

* (no specification provided)

Material Description

Poorly Graded Gravel With Sand (GP)

Atterberg Limits (ASTM D 4318)

PL= 18 **LL=** 24 **PI=** 6

Classification

USCS (D 2487)= GP **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 56.2673 D_{85}= 51.7183 D_{60}= 12.5390
D_{50}= 6.9672 D_{30}= 2.5854 D_{15}= 0.9982
D_{10}= 0.5859 C_u= 21.40 C_c= 0.91

Remarks

Date Received: 2-22-17 **Date Tested:** 3-3-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-14 S1 **Depth:** 36.9-37.5' **Date Sampled:** 1-21-17
Sample Number: DH16-14 S1

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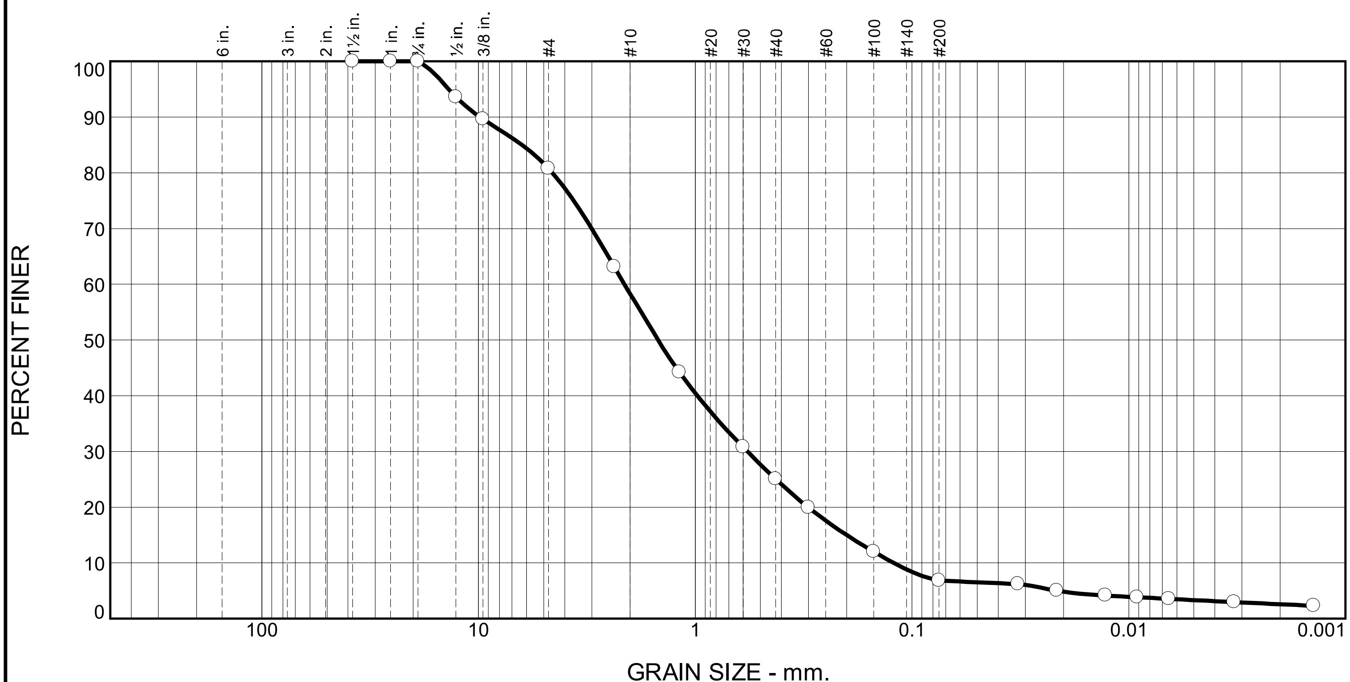
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	19	23	33	18	4	3

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	94		
3/8"	90		
#4	81		
#8	63		
#16	44		
#30	31		
#40	25		
#50	20		
#100	12		
#200	6.8		
0.0324 mm.	6.2		
0.0214 mm.	5.0		
0.0128 mm.	4.1		
0.0091 mm.	3.8		
0.0065 mm.	3.5		
0.0033 mm.	3.0		
0.0014 mm.	2.3		

* (no specification provided)

Material Description

Well Graded Sand With Silty Clay and Gravel (SW-SC)

Atterberg Limits (ASTM D 4318)

PL= 17 **LL=** 24 **PI=** 7

Classification

USCS (D 2487)= SW-SC **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 9.8315 D_{85}= 6.2915 D_{60}= 2.1186
D_{50}= 1.4832 D_{30}= 0.5736 D_{15}= 0.1999
D_{10}= 0.1215 C_u= 17.44 C_c= 1.28

Remarks

Date Received: 2-22-17 **Date Tested:** 3-3-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-14 S2 **Depth:** 54.1-54.6' **Date Sampled:** 1-21-17
Sample Number: DH16-14 S2

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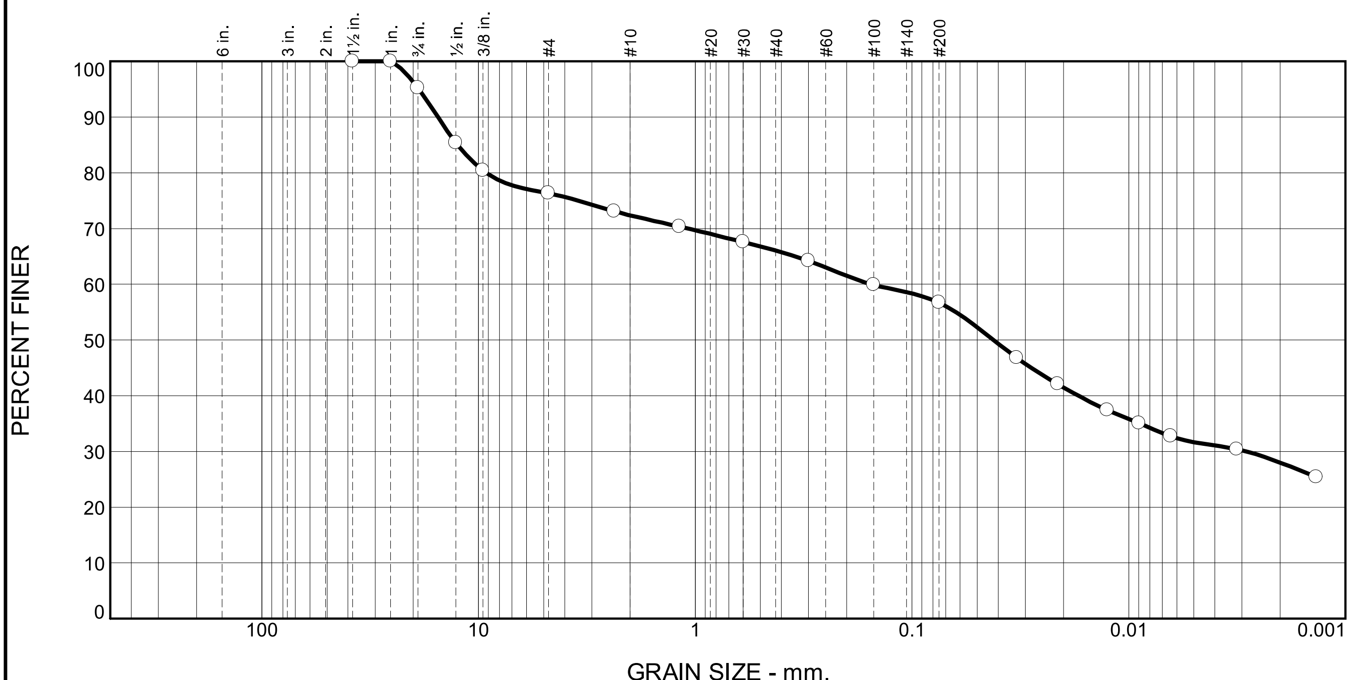
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	5	19	4	6	9	25	32

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	95		
1/2"	85		
3/8"	80		
#4	76		
#8	73		
#16	70		
#30	68		
#50	64		
#100	60		
#200	57		
0.0328 mm.	47		
0.0212 mm.	42		
0.0125 mm.	37		
0.0089 mm.	35		
0.0064 mm.	33		
0.0032 mm.	30		
0.0014 mm.	25		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 15.3832 D_{85}= 12.4752 D_{60}= 0.1535
D_{50}= 0.0421 D_{30}= 0.0029 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-10-17 **Date Tested:** 2-22-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-17 S1 **Depth:** 26.0'-27.0' **Date Sampled:**
Sample Number: DH16-17 S1

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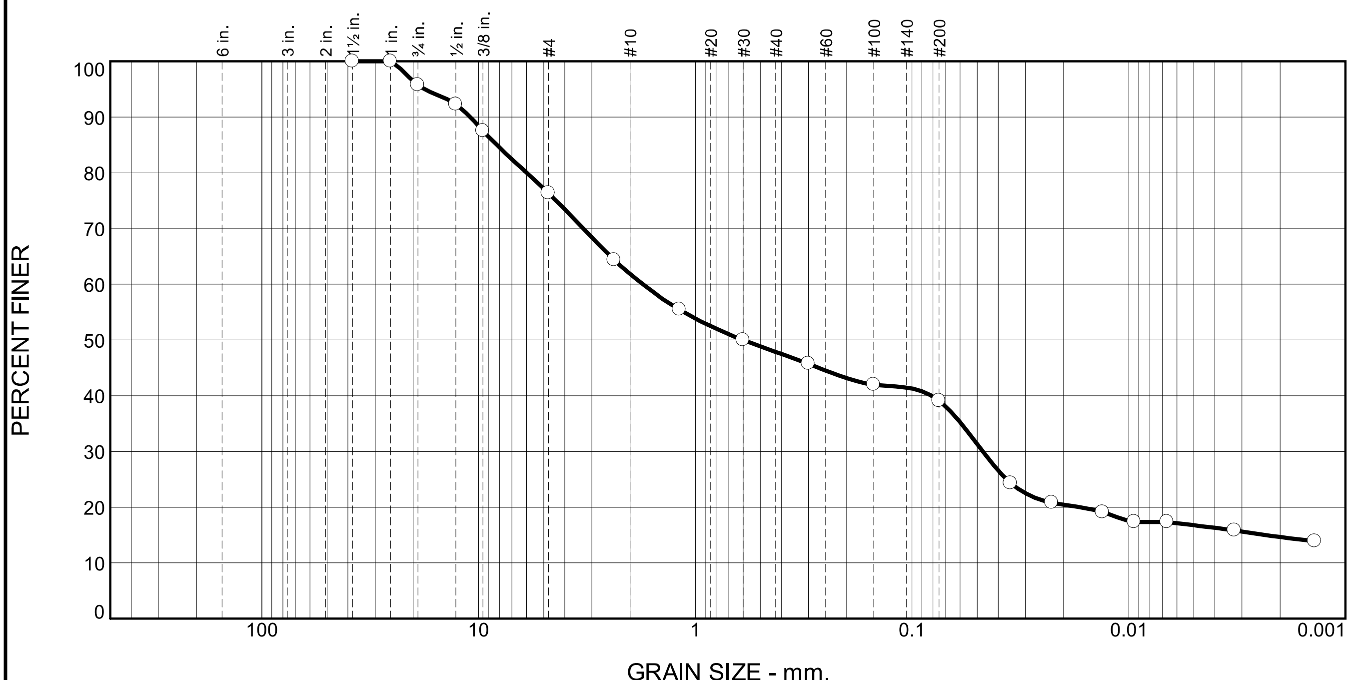
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	4	20	14	14	9	22	17

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	96		
1/2"	92		
3/8"	88		
#4	76		
#8	64		
#16	55		
#30	50		
#50	46		
#100	42		
#200	39		
0.0350 mm.	24		
0.0226 mm.	21		
0.0132 mm.	19		
0.0094 mm.	17		
0.0066 mm.	17		
0.0032 mm.	16		
0.0014 mm.	14		

* (no specification provided)

Material Description

Silty Sand With Gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 10.9289 D_{85}= 8.2296 D_{60}= 1.7460
D_{50}= 0.6006 D_{30}= 0.0471 D_{15}= 0.0024
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-18 S1 new **Depth:** 11-12.2' **Date Sampled:** 1-20-17
Sample Number: DH16-18 S1

ATL - CMT
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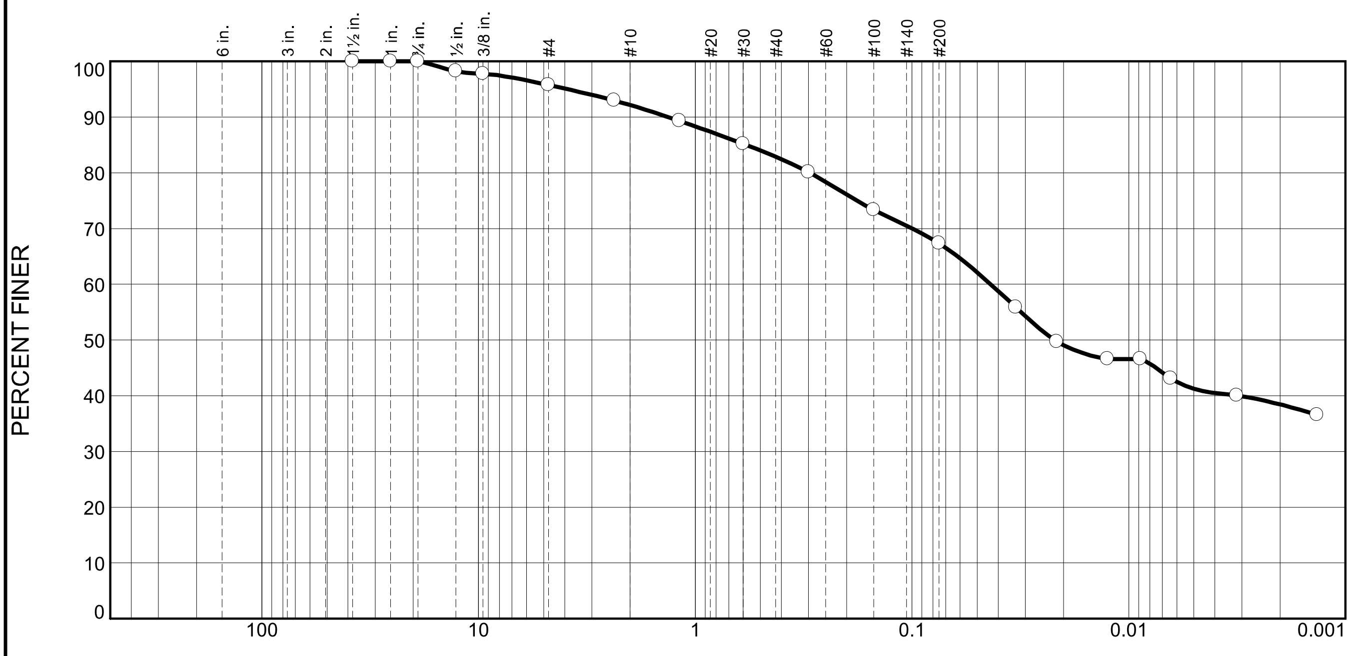
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	4	4	9	16	26	41

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	98		
3/8"	98		
#4	96		
#8	93		
#16	89		
#30	85		
#50	80		
#100	73		
#200	67		
0.0331 mm.	56		
0.0214 mm.	50		
0.0125 mm.	47		
0.0088 mm.	47		
0.0064 mm.	43		
0.0032 mm.	40		
0.0013 mm.	37		

* (no specification provided)

Material Description

Sandy Lean Clay (CL)

Atterberg Limits (ASTM D 4318)

PL= 20 **LL=** 49 **PI=** 29

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(18)

Coefficients

D_{90}= 1.3305 D_{85}= 0.5824 D_{60}= 0.0433
D_{50}= 0.0220 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-21 S1 new **Depth:** 0.5-1.5' **Date Sampled:** 1-21-17
Sample Number: DH16-21 S1

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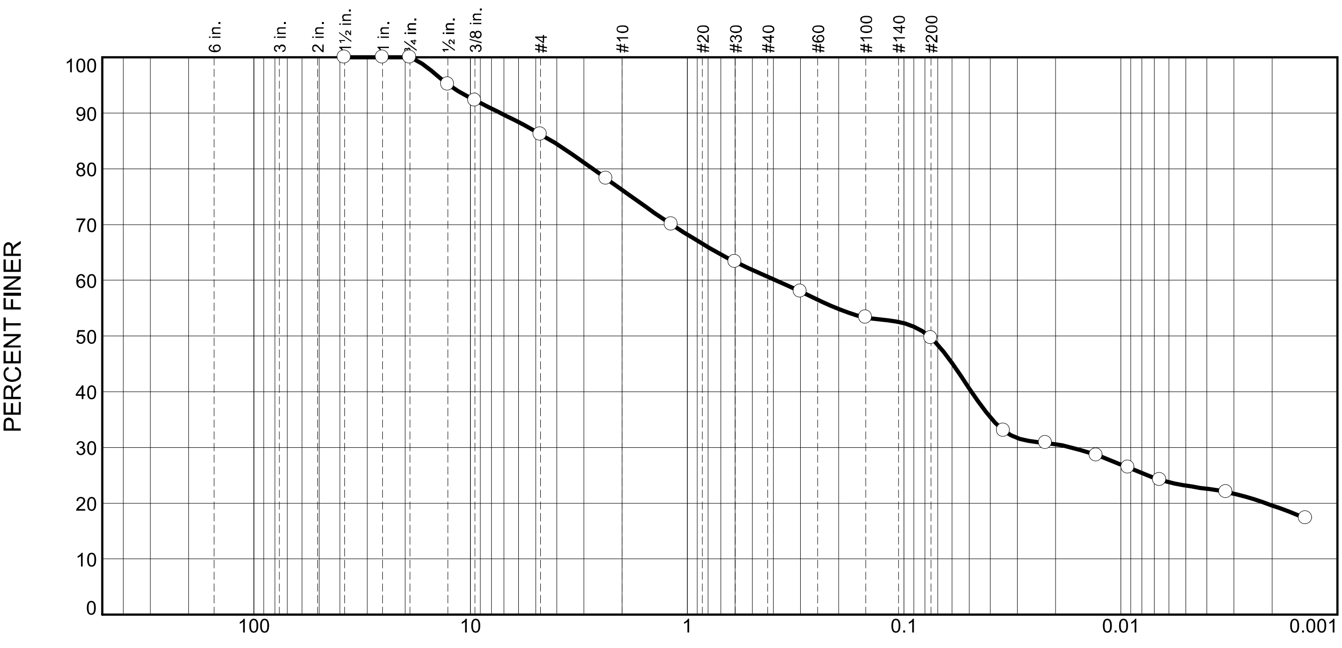
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	14	10	15	11	27	23

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	95		
3/8"	92		
#4	86		
#8	78		
#16	70		
#30	63		
#50	58		
#100	53		
#200	50		
0.0346 mm.	33		
0.0221 mm.	31		
0.0129 mm.	29		
0.0092 mm.	26		
0.0066 mm.	24		
0.0033 mm.	22		
0.0014 mm.	17		

* (no specification provided)

Material Description

Sandy Silt (ML)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 7.2634 D_{85}= 4.2212 D_{60}= 0.3909
D_{50}= 0.0769 D_{30}= 0.0170 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-22 S1 new **Depth:** 31.8-32.0' **Date Sampled:** 1-21-17
Sample Number: DH16-22 S1

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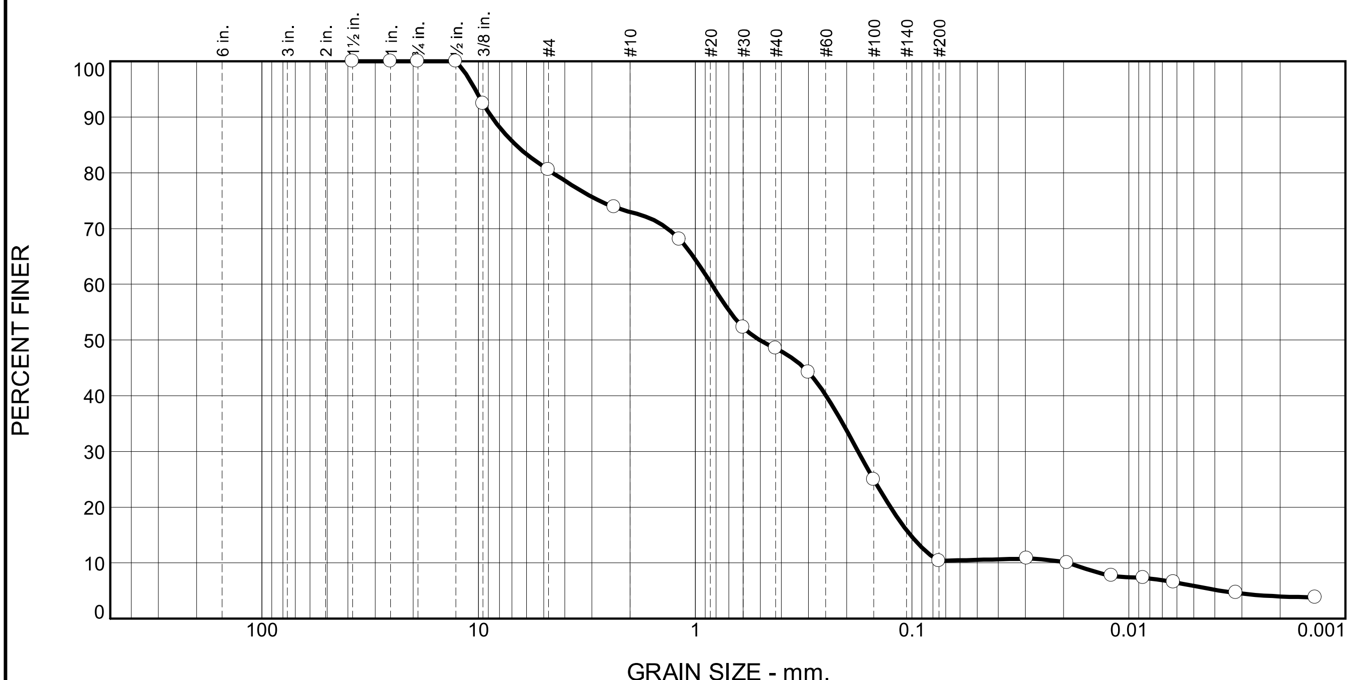
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	19	8	24	39	4	6

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	100		
3/8"	92		
#4	81		
#8	74		
#16	68		
#30	52		
#40	49		
#50	44		
#100	25		
#200	10		
0.0295 mm.	11		
0.0192 mm.	10		
0.0120 mm.	7.7		
0.0086 mm.	7.3		
0.0062 mm.	6.5		
0.0032 mm.	4.6		
0.0014 mm.	3.8		

* (no specification provided)

Material Description

Well Graded Sand With Silt And Gravel (SW-SM)

Atterberg Limits (ASTM D 4318)

PL= 38 **LL=** 57 **PI=** 19

Classification

USCS (D 2487)= SW-SM **AASHTO (M 145)=** A-2-7(0)

Coefficients

D_{90}= 8.6826 D_{85}= 6.7236 D_{60}= 0.8406
D_{50}= 0.5038 D_{30}= 0.1771 D_{15}= 0.1016
D_{10}= 0.0191 C_u= 43.90 C_c= 1.95

Remarks

Date Received: 2-22-17 **Date Tested:** 2-28-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH17-26 S4 **Depth:** 9.0-9.3' **Date Sampled:** 1-20-17
Sample Number: DH17-26 S4

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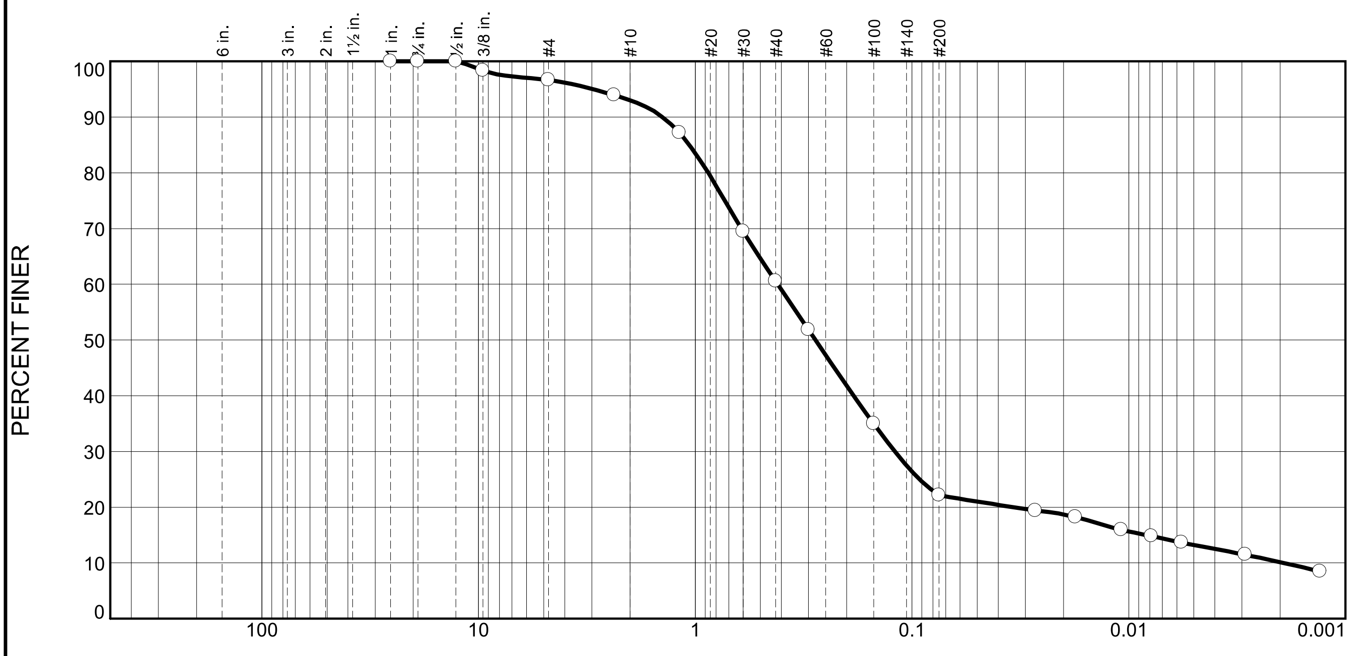
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	3	4	32	39	9	13

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100		
3/4"	100		
1/2"	100		
3/8"	98		
#4	97		
#8	94		
#16	87		
#30	69		
#40	61		
#50	52		
#100	35		
#200	22		
0.0269 mm.	19		
0.0176 mm.	18		
0.0108 mm.	16		
0.0078 mm.	15		
0.0057 mm.	14		
0.0029 mm.	11		
0.0013 mm.	8.5		

* (no specification provided)

Material Description

Silty Sand (SM)

Atterberg Limits (ASTM D 4318)

PL= 32 **LL=** 57 **PI=** 25

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-7(1)

Coefficients

D_{90}= 1.4131 D_{85}= 1.0628 D_{60}= 0.4156
D_{50}= 0.2789 D_{30}= 0.1200 D_{15}= 0.0083
D_{10}= 0.0019 C_u= 214.39 C_c= 17.89

Remarks

Date Received: 2-22-17 **Date Tested:** 3-3-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH17-26 S5 **Depth:** 11.0-11.3' **Date Sampled:** 1-21-17
Sample Number: DH17-26 S5

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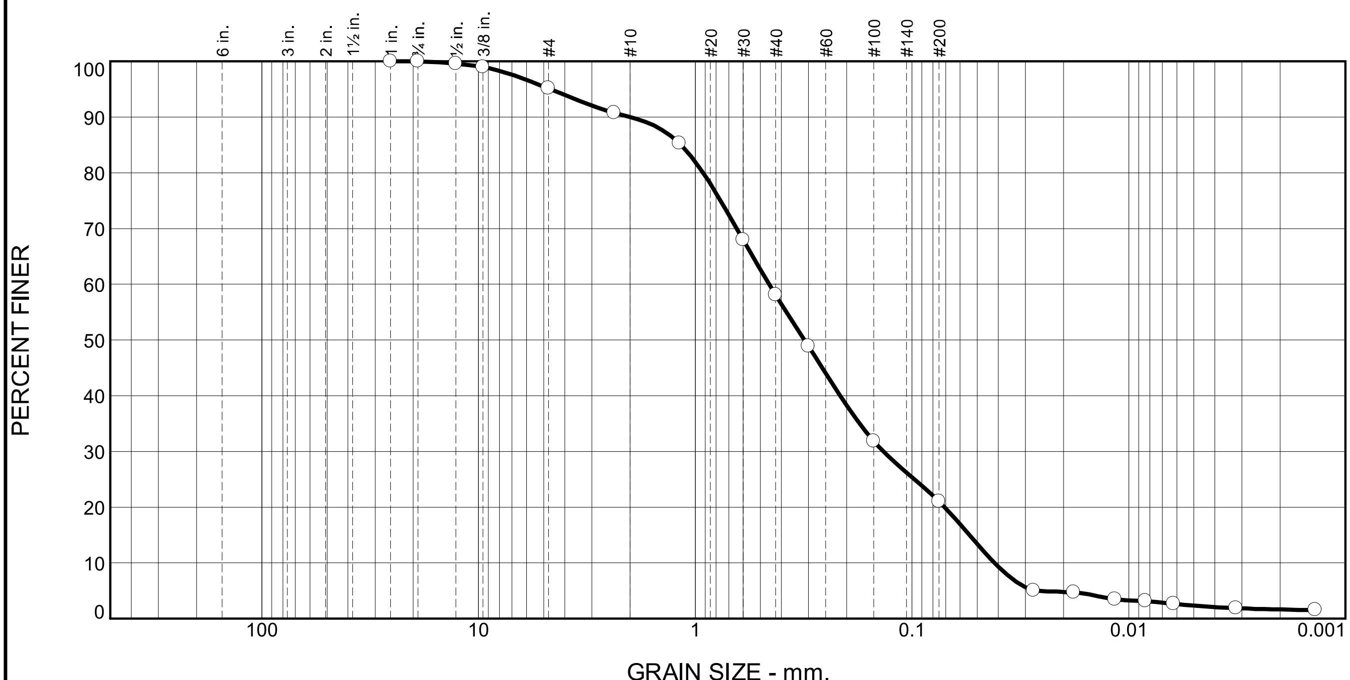
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	5	5	32	37	19	2

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100		
3/4"	100		
1/2"	100		
3/8"	99		
#4	95		
#8	91		
#16	85		
#30	68		
#40	58		
#50	49		
#100	32		
#200	21		
0.0275 mm.	5.0		
0.0179 mm.	4.7		
0.0115 mm.	3.5		
0.0084 mm.	3.1		
0.0062 mm.	2.7		
0.0032 mm.	1.9		
0.0014 mm.	1.5		

* (no specification provided)

Material Description

Silty Sand (SM)

Atterberg Limits (ASTM D 4318)

PL= 36 **LL=** 53 **PI=** 17

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-7(0)

Coefficients

D_{90}= 2.0013 D_{85}= 1.1618 D_{60}= 0.4553
D_{50}= 0.3133 D_{30}= 0.1355 D_{15}= 0.0544
D_{10}= 0.0416 C_u= 10.94 C_c= 0.97

Remarks

Date Received: 2-22-17 **Date Tested:** 3-6-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH17-26 S6 **Depth:** 16.9-17.9' **Date Sampled:** 1-21-17
Sample Number: DH17-26 S6

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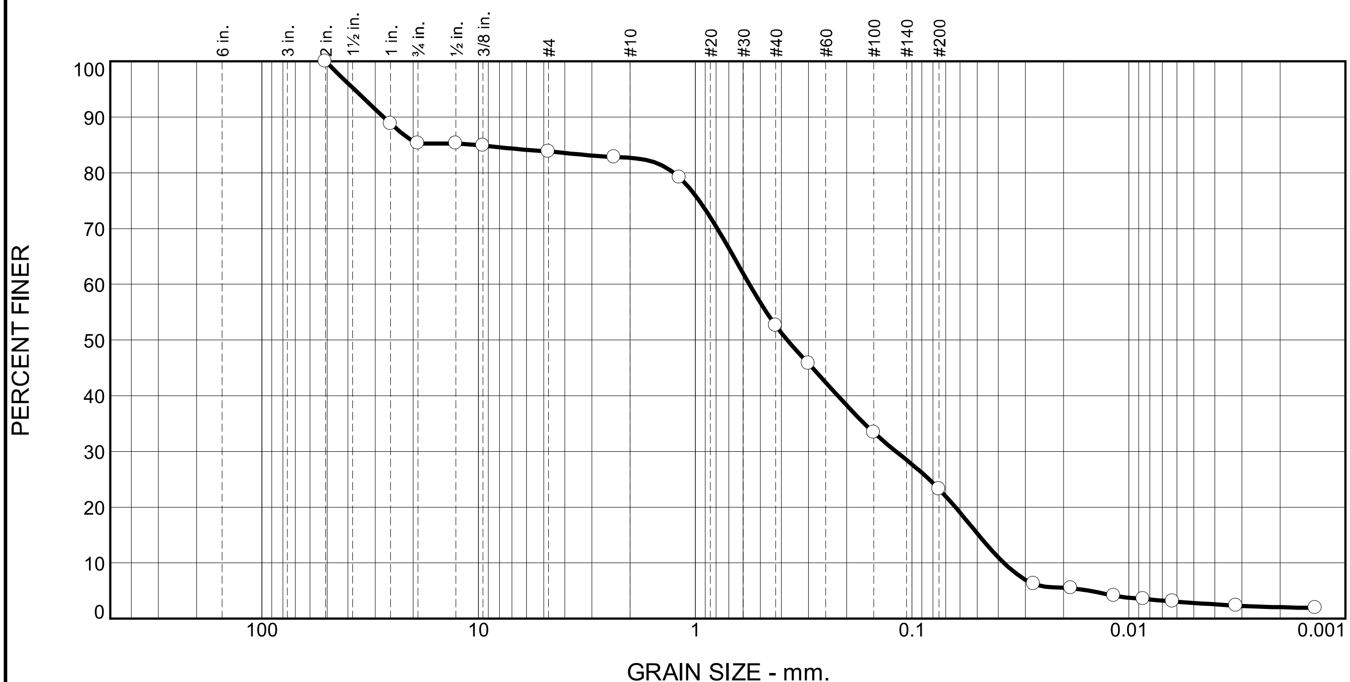
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	15	1	1	30	30	20	3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2"	100		
1"	89		
3/4"	85		
1/2"	85		
3/8"	85		
#4	84		
#8	83		
#16	79		
#40	53		
#50	46		
#100	33		
#200	23		
0.0275 mm.	6.3		
0.0185 mm.	5.5		
0.0117 mm.	4.1		
0.0086 mm.	3.5		
0.0063 mm.	3.1		
0.0032 mm.	2.3		
0.0014 mm.	1.9		

* (no specification provided)

Material Description

Silty Sand With Gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= 32 **LL=** 45 **PI=** 13

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-7(0)

Coefficients

D_{90}= 27.4361 D_{85}= 10.2350 D_{60}= 0.5618
D_{50}= 0.3762 D_{30}= 0.1184 D_{15}= 0.0493
D_{10}= 0.0377 C_u= 14.92 C_c= 0.66

Remarks

Date Received: 2-22-17 **Date Tested:** 3-6-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH17-26 S12 **Depth:** 91.4-91.9 **Date Sampled:** 1-21-17
Sample Number: DH17-26 S12

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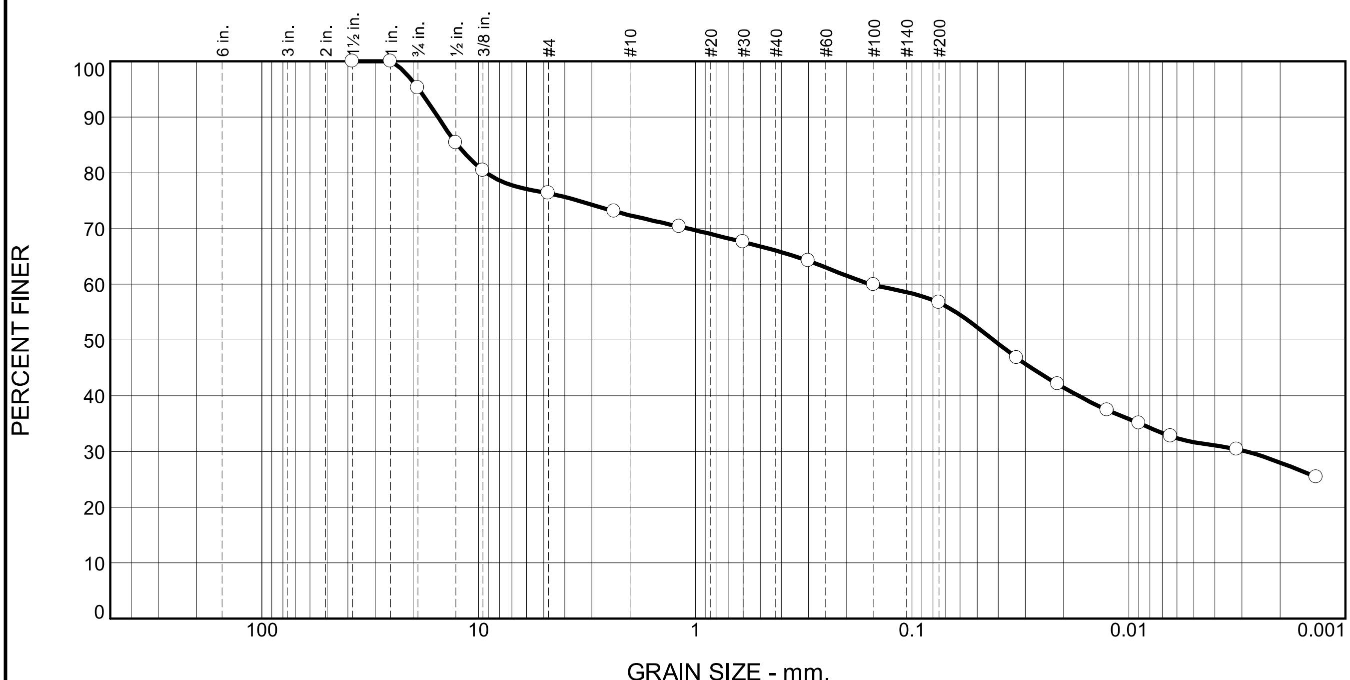
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	5	19	4	6	9	25	32

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	95		
1/2"	85		
3/8"	80		
#4	76		
#8	73		
#16	70		
#30	68		
#50	64		
#100	60		
#200	57		
0.0328 mm.	47		
0.0212 mm.	42		
0.0125 mm.	37		
0.0089 mm.	35		
0.0064 mm.	33		
0.0032 mm.	30		
0.0014 mm.	25		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 15.3832 D_{85}= 12.4752 D_{60}= 0.1535
D_{50}= 0.0421 D_{30}= 0.0029 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-10-17 **Date Tested:** 2-22-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-17 S1 **Depth:** 26.0'-27.0' **Date Sampled:**
Sample Number: DH16-17 S1

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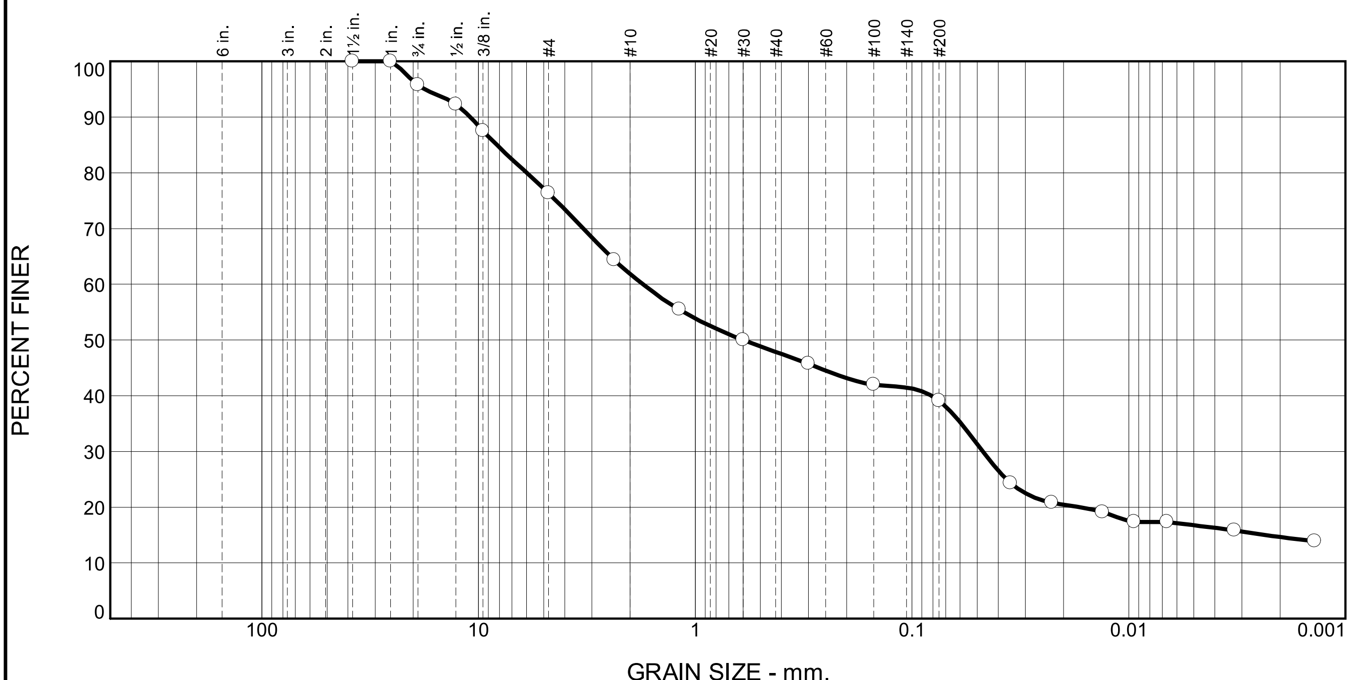
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	4	20	14	14	9	22	17

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	96		
1/2"	92		
3/8"	88		
#4	76		
#8	64		
#16	55		
#30	50		
#50	46		
#100	42		
#200	39		
0.0350 mm.	24		
0.0226 mm.	21		
0.0132 mm.	19		
0.0094 mm.	17		
0.0066 mm.	17		
0.0032 mm.	16		
0.0014 mm.	14		

* (no specification provided)

Material Description

Silty Sand With Gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 10.9289 D_{85}= 8.2296 D_{60}= 1.7460
D_{50}= 0.6006 D_{30}= 0.0471 D_{15}= 0.0024
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-18 S1 new **Depth:** 11-12.2' **Date Sampled:** 1-20-17
Sample Number: DH16-18 S1

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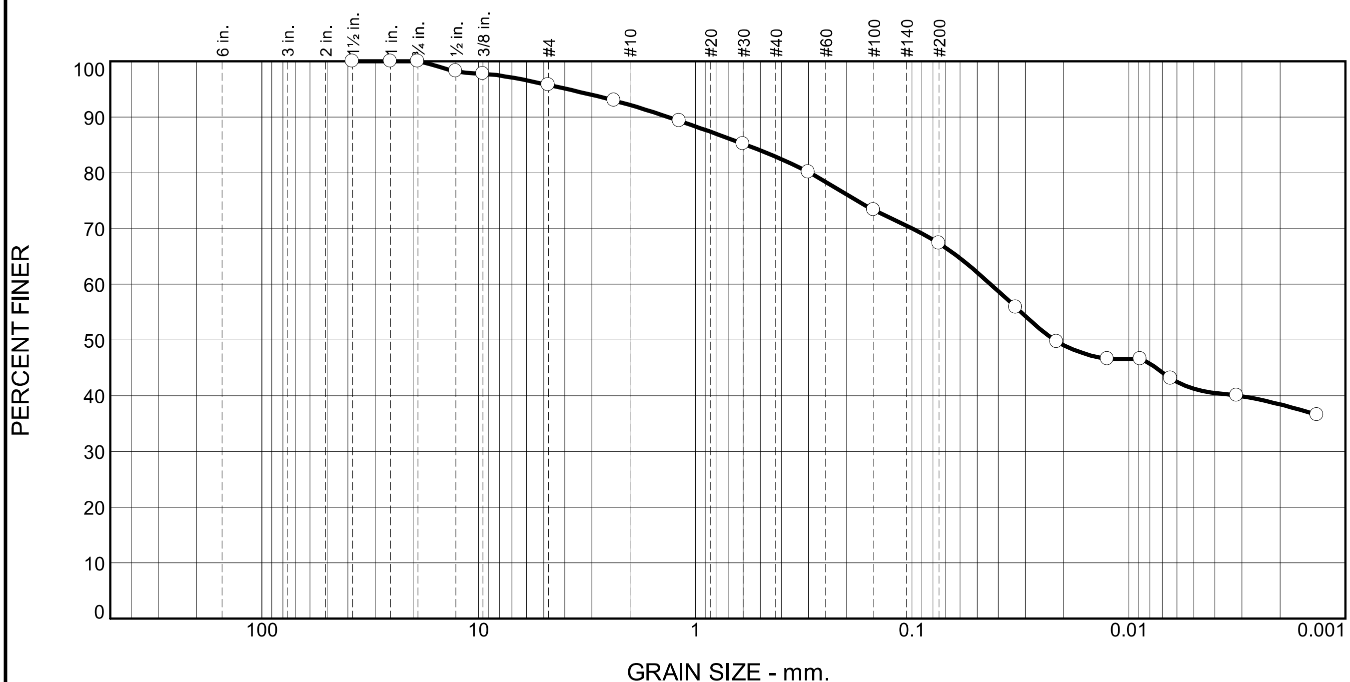
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	4	4	9	16	26	41

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	98		
3/8"	98		
#4	96		
#8	93		
#16	89		
#30	85		
#50	80		
#100	73		
#200	67		
0.0331 mm.	56		
0.0214 mm.	50		
0.0125 mm.	47		
0.0088 mm.	47		
0.0064 mm.	43		
0.0032 mm.	40		
0.0013 mm.	37		

* (no specification provided)

Material Description

Sandy Lean Clay (CL)

Atterberg Limits (ASTM D 4318)

PL= 20 **LL=** 49 **PI=** 29

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(18)

Coefficients

D_{90}= 1.3305 D_{85}= 0.5824 D_{60}= 0.0433
D_{50}= 0.0220 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-21 S1 new **Depth:** 0.5-1.5' **Date Sampled:** 1-21-17
Sample Number: DH16-21 S1

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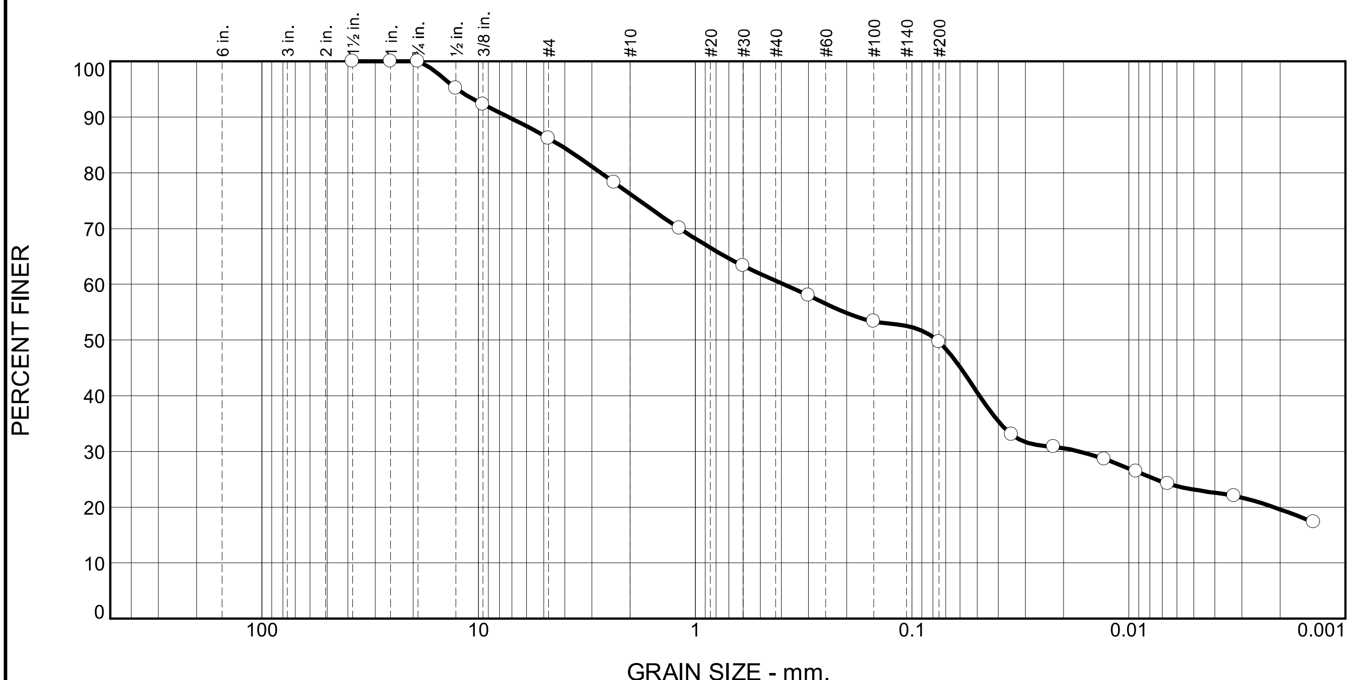
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	14	10	15	11	27	23

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	95		
3/8"	92		
#4	86		
#8	78		
#16	70		
#30	63		
#50	58		
#100	53		
#200	50		
0.0346 mm.	33		
0.0221 mm.	31		
0.0129 mm.	29		
0.0092 mm.	26		
0.0066 mm.	24		
0.0033 mm.	22		
0.0014 mm.	17		

* (no specification provided)

Material Description

Sandy Silt (ML)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 7.2634 D_{85}= 4.2212 D_{60}= 0.3909
D_{50}= 0.0769 D_{30}= 0.0170 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-22 S1 new **Depth:** 31.8-32.0' **Date Sampled:** 1-21-17
Sample Number: DH16-22 S1

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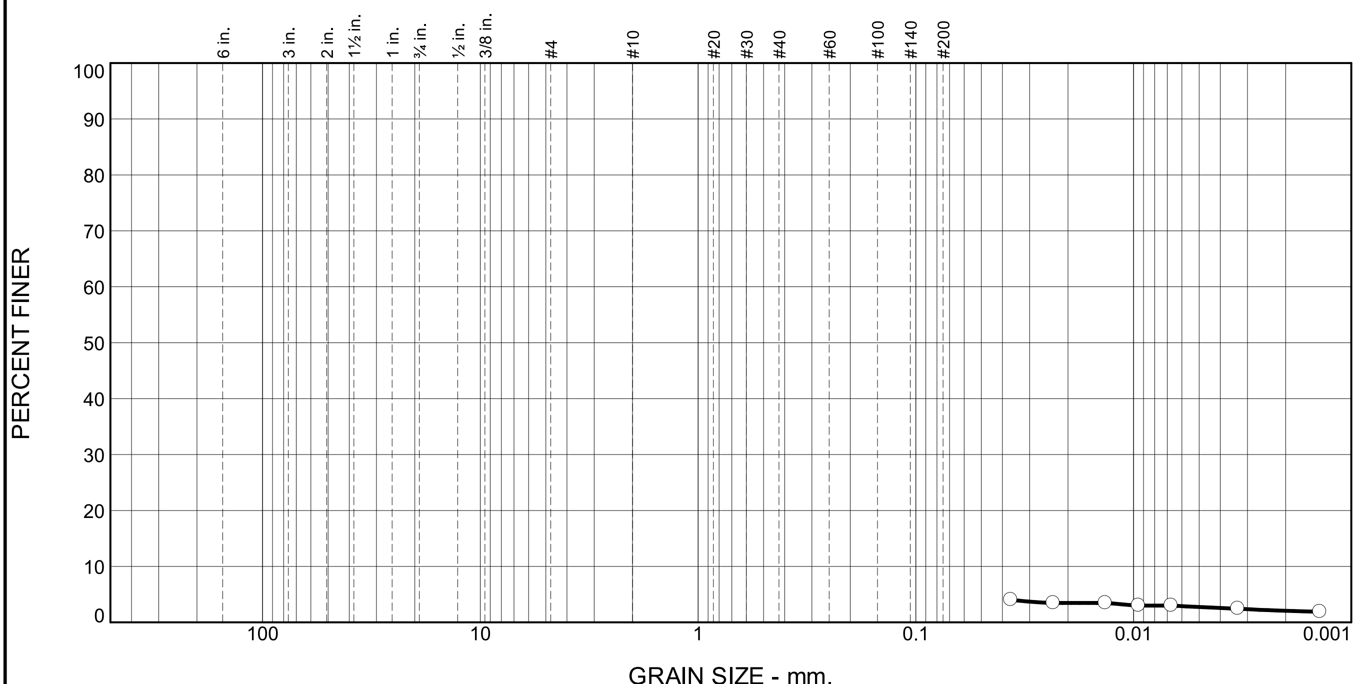
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
							3

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.0365 mm.	4.0		
0.0233 mm.	3.5		
0.0134 mm.	3.5		
0.0095 mm.	3.0		
0.0067 mm.	3.0		
0.0033 mm.	2.4		
0.0014 mm.	1.9		

* (no specification provided)

Material Description

Core

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Test Included only Hydroscopic Moisture (D422) Core was hand crushed to obtain sample.

Date Received: **Date Tested:** 11-10-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-01 /S13 **Depth:** 10.3-10.5' **Date Sampled:**
Sample Number: DH16-01 /S13

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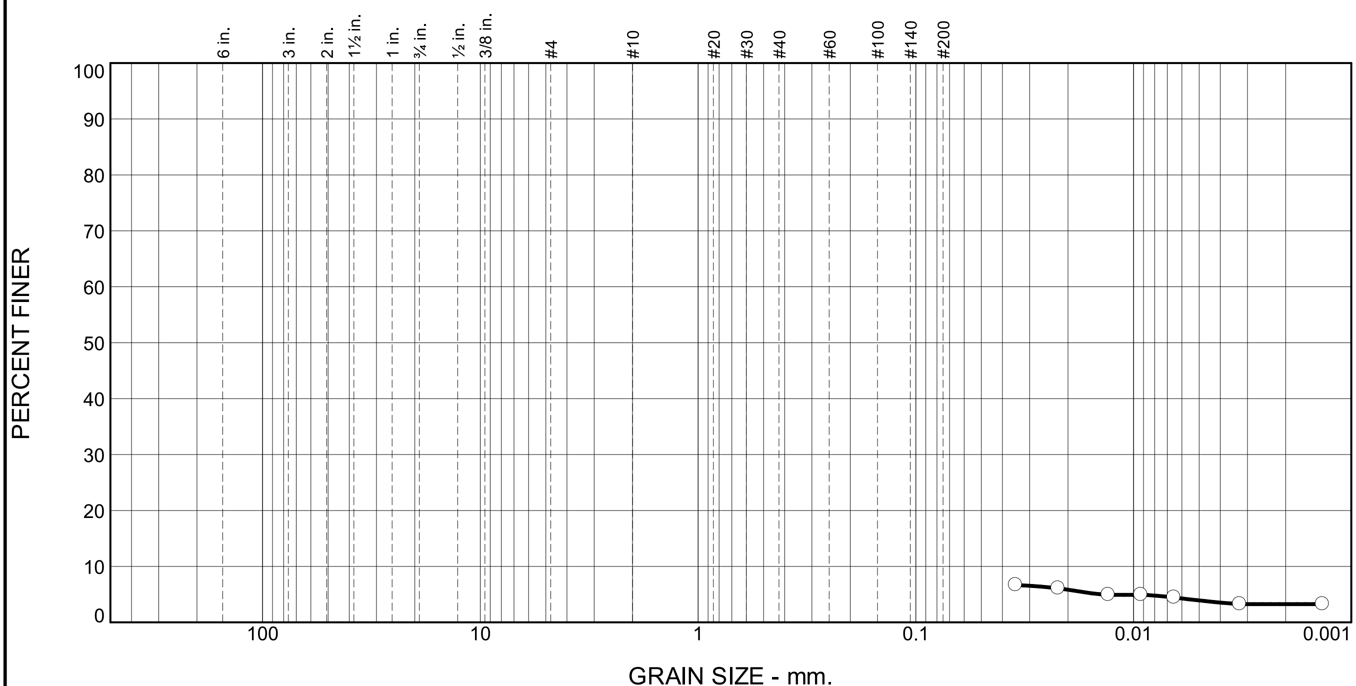
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
							4

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.0347 mm.	6.7		
0.0222 mm.	6.1		
0.0130 mm.	4.9		
0.0092 mm.	4.9		
0.0065 mm.	4.4		
0.0032 mm.	3.3		
0.0014 mm.	3.3		

* (no specification provided)

Material Description

Core

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Test Included only Hydroscopic Moisture (D422) Core was hand crushed to obtain material.

Date Received: **Date Tested:** 11-10-16

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-01 S14 **Depth:** 26.4-26.8' **Date Sampled:**
Sample Number: DH16-01 ?S14

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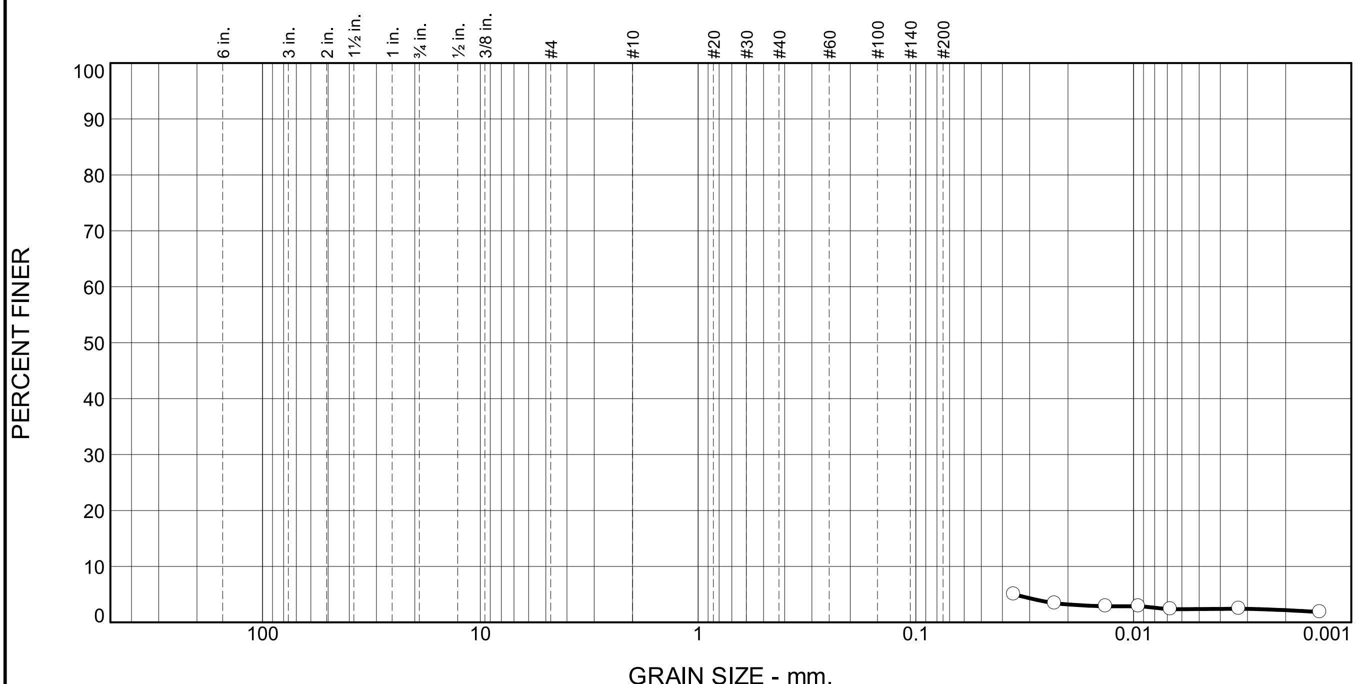
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
							2

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.0354 mm.	5.0		
0.0230 mm.	3.4		
0.0134 mm.	2.9		
0.0095 mm.	2.9		
0.0068 mm.	2.3		
0.0033 mm.	2.4		
0.0014 mm.	1.8		

* (no specification provided)

Material Description

Core

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Test Included only Hydroscopic Moisture (D422). Core was hand crushed to obtain Material.

Date Received: **Date Tested:** 11-10-16

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-03/S15 **Depth:** 6.0-6.4' **Date Sampled:**
Sample Number: DH16-03 / S15

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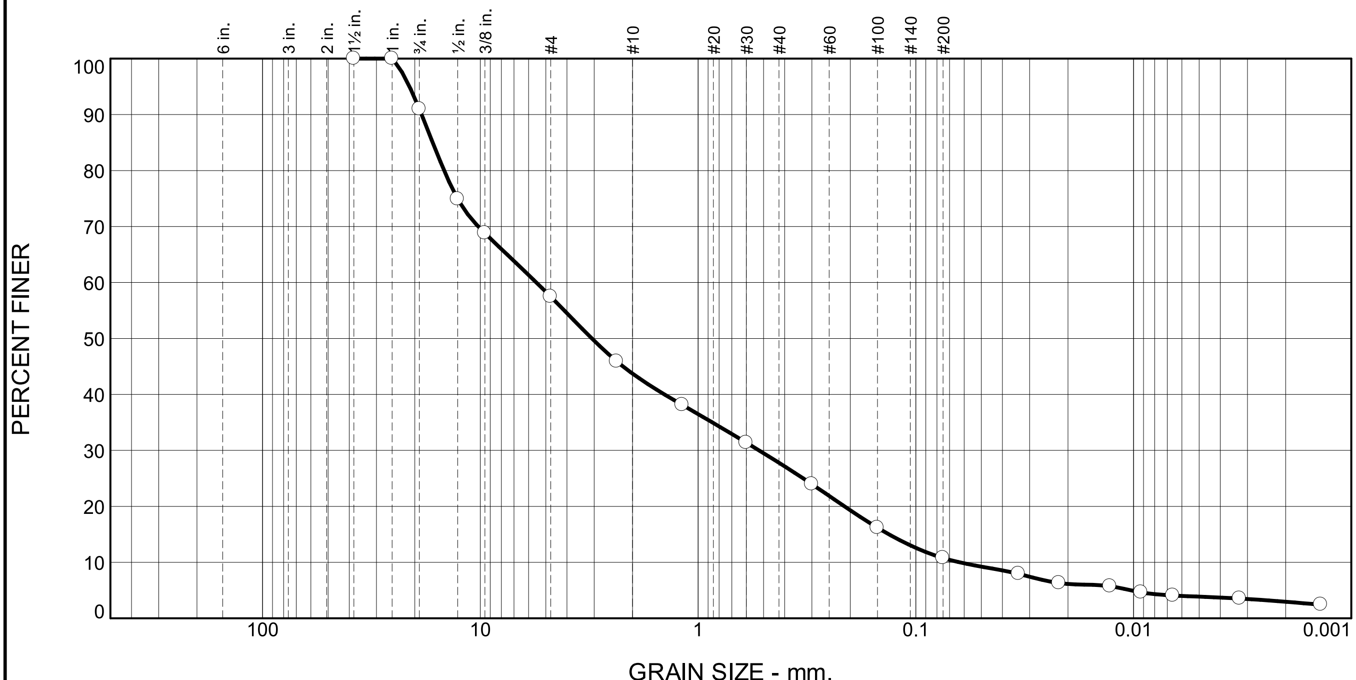
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	9	34	13	16	17	7	4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	91		
1/2"	75		
3/8"	69		
#4	57		
#8	46		
#16	38		
#30	31		
#50	24		
#100	16		
#200	11		
0.0337 mm.	7.9		
0.0220 mm.	6.3		
0.0128 mm.	5.7		
0.0092 mm.	4.6		
0.0066 mm.	4.1		
0.0033 mm.	3.5		
0.0014 mm.	2.4		

* (no specification provided)

Material Description

Core

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 18.5942 D_{85}= 16.5366 D_{60}= 5.5293
D_{50}= 3.0737 D_{30}= 0.5248 D_{15}= 0.1329
D_{10}= 0.0628 C_u= 88.01 C_c= 0.79

Remarks

Date Received: **Date Tested:** 11-10-16

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-05 /S1 **Depth:** 6.0' **Date Sampled:**
Sample Number: DH16-05 / S1

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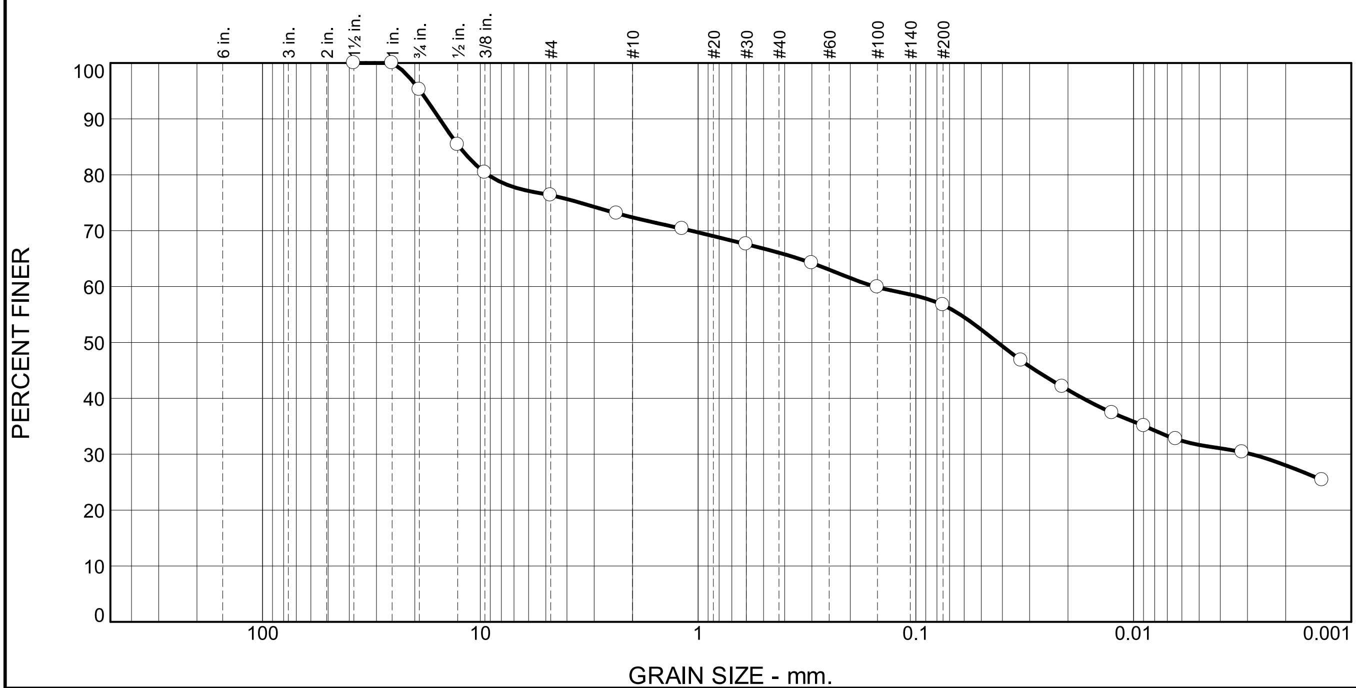
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	5	19	4	6	9	25	32

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	95		
1/2"	85		
3/8"	80		
#4	76		
#8	73		
#16	70		
#30	68		
#50	64		
#100	60		
#200	57		
0.0328 mm.	47		
0.0212 mm.	42		
0.0125 mm.	37		
0.0089 mm.	35		
0.0064 mm.	33		
0.0032 mm.	30		
0.0014 mm.	25		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 15.3832 D_{85}= 12.4752 D_{60}= 0.1535
D_{50}= 0.0421 D_{30}= 0.0029 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-10-17 **Date Tested:** 2-22-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-17 S1 **Depth:** 26.0'-27.0' **Date Sampled:**
Sample Number: DH16-17 S1

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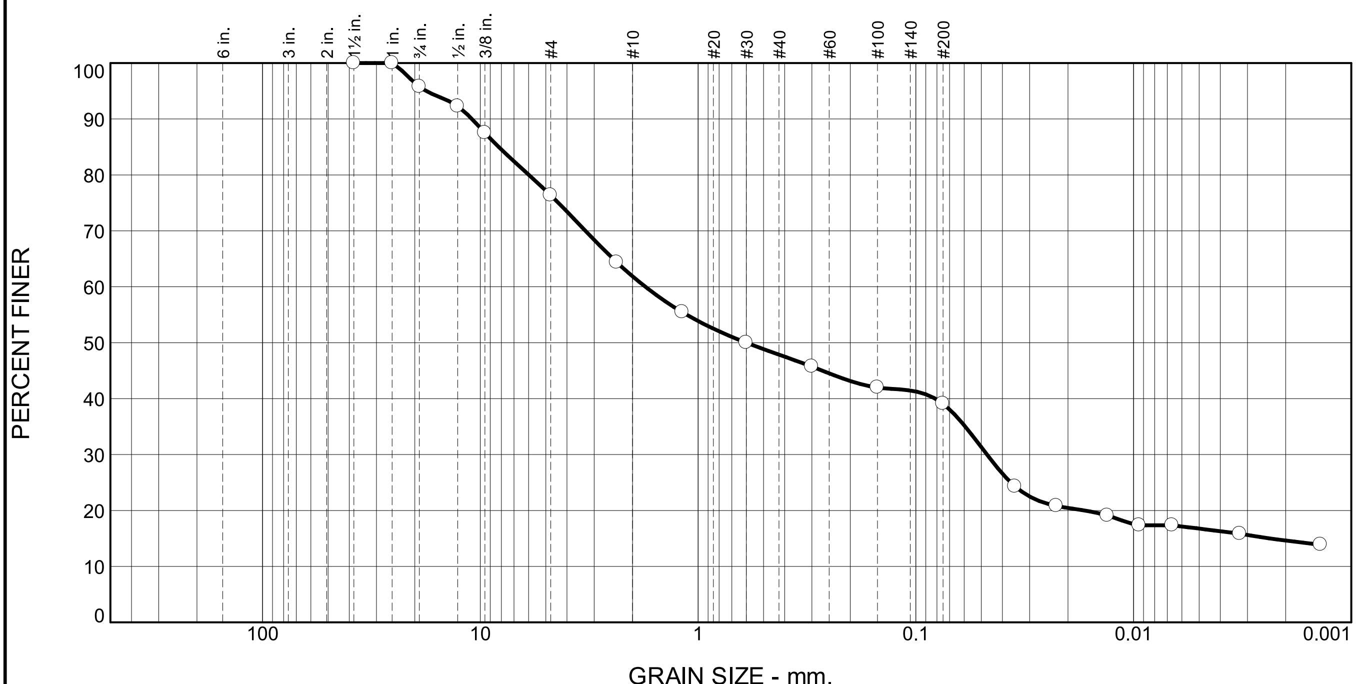
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	4	20	14	14	9	22	17

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	96		
1/2"	92		
3/8"	88		
#4	76		
#8	64		
#16	55		
#30	50		
#50	46		
#100	42		
#200	39		
0.0350 mm.	24		
0.0226 mm.	21		
0.0132 mm.	19		
0.0094 mm.	17		
0.0066 mm.	17		
0.0032 mm.	16		
0.0014 mm.	14		

* (no specification provided)

Material Description

Silty Sand With Gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 10.9289 D_{85}= 8.2296 D_{60}= 1.7460
D_{50}= 0.6006 D_{30}= 0.0471 D_{15}= 0.0024
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17
Tested By: MC
Checked By:
Title:

Source of Sample: DH16-18 S1 new **Depth:** 11-12.2' **Date Sampled:** 1-20-17
Sample Number: DH16-18 S1

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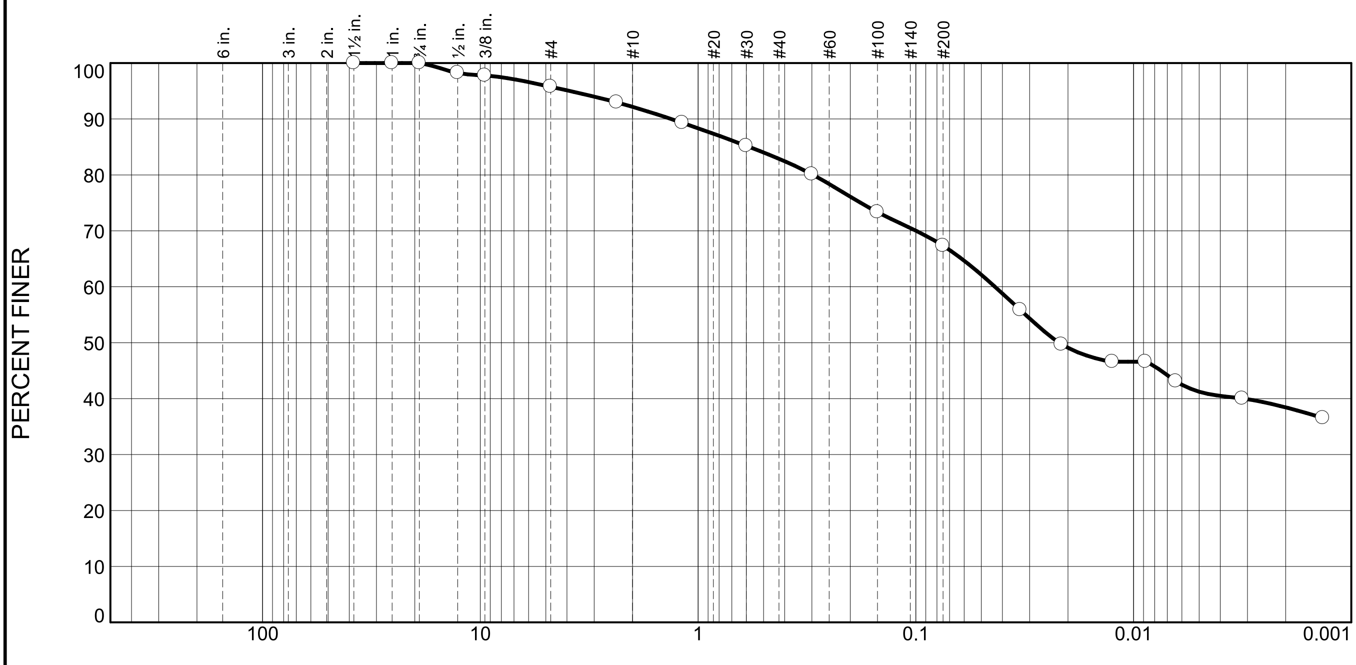
Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	4	4	9	16	26	41

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	98		
3/8"	98		
#4	96		
#8	93		
#16	89		
#30	85		
#50	80		
#100	73		
#200	67		
0.0331 mm.	56		
0.0214 mm.	50		
0.0125 mm.	47		
0.0088 mm.	47		
0.0064 mm.	43		
0.0032 mm.	40		
0.0013 mm.	37		

* (no specification provided)

Material Description

Sandy Lean Clay (CL)

Atterberg Limits (ASTM D 4318)

PL= 20 **LL=** 49 **PI=** 29

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(18)

Coefficients

D_{90}= 1.3305 D_{85}= 0.5824 D_{60}= 0.0433
D_{50}= 0.0220 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-21 S1 new **Depth:** 0.5-1.5' **Date Sampled:** 1-21-17
Sample Number: DH16-21 S1

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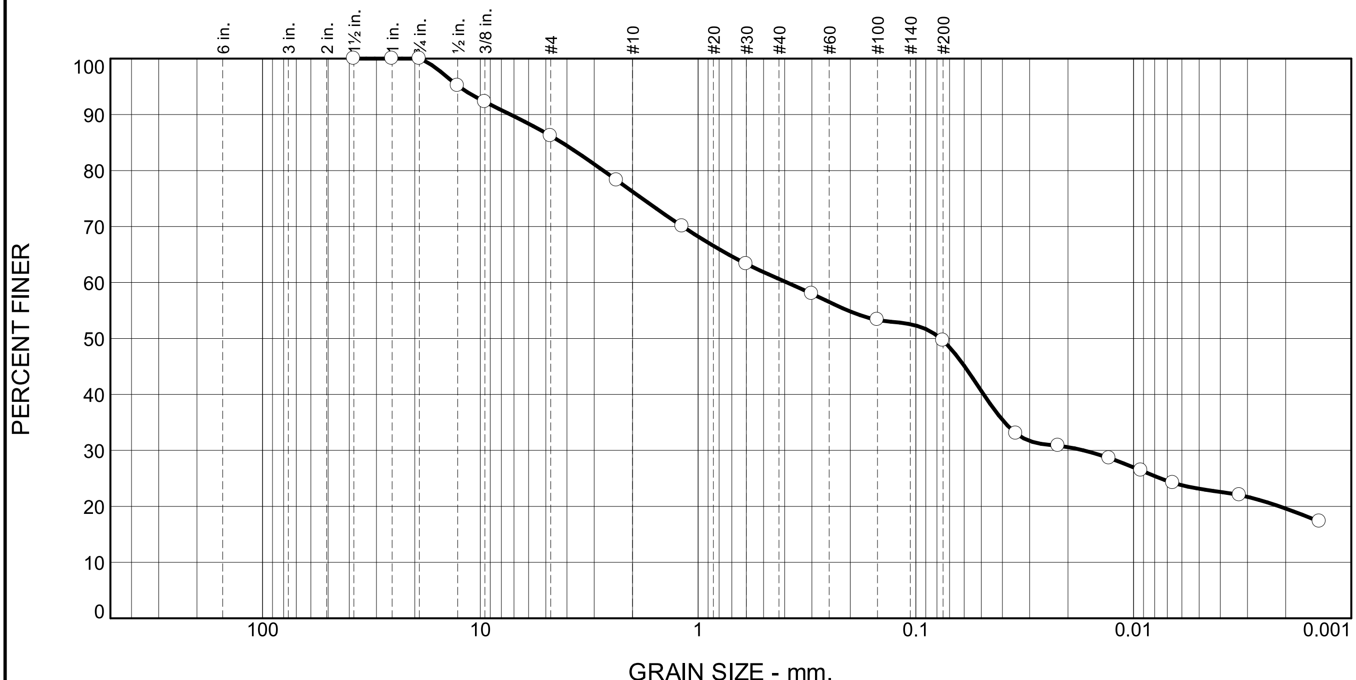
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	14	10	15	11	27	23

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100		
1"	100		
3/4"	100		
1/2"	95		
3/8"	92		
#4	86		
#8	78		
#16	70		
#30	63		
#50	58		
#100	53		
#200	50		
0.0346 mm.	33		
0.0221 mm.	31		
0.0129 mm.	29		
0.0092 mm.	26		
0.0066 mm.	24		
0.0033 mm.	22		
0.0014 mm.	17		

* (no specification provided)

Material Description

Sandy Silt (ML)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 7.2634 D_{85}= 4.2212 D_{60}= 0.3909
D_{50}= 0.0769 D_{30}= 0.0170 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2-22-17 **Date Tested:** 2-22-17

Tested By: MC

Checked By:

Title:

Source of Sample: DH16-22 S1 new **Depth:** 31.8-32.0' **Date Sampled:** 1-21-17
Sample Number: DH16-22 S1

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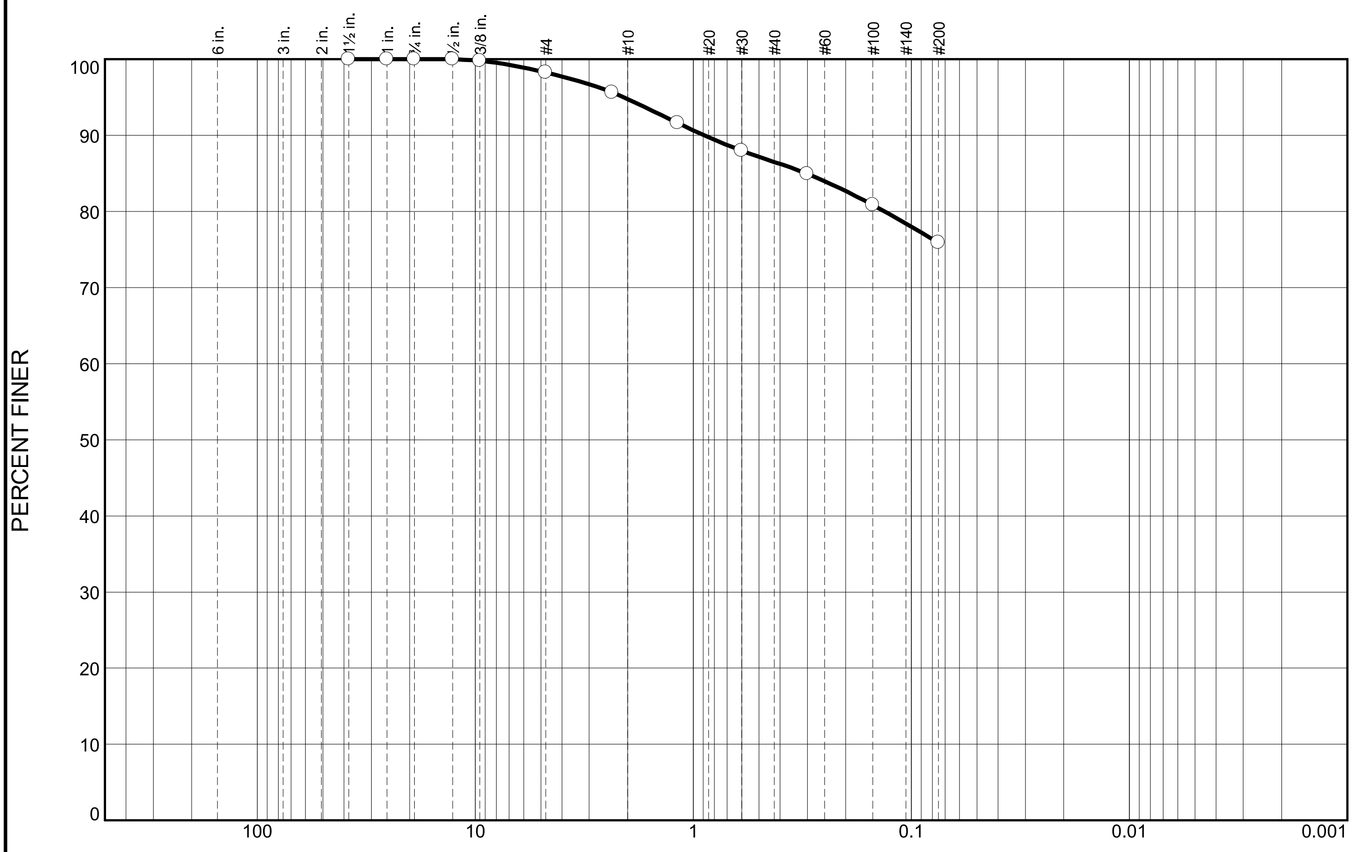
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation
Project No: 506 **Figure**

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	1.8	3.4	8.3	10.6	75.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	43	22	0.3040							

Material Description	USCS	AASHTO
○ CLAY	CL	A-7-6(16)

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-01 BK-01 **Depth:** 0-2.0 **Sample No.:** TP16-01 BK-01

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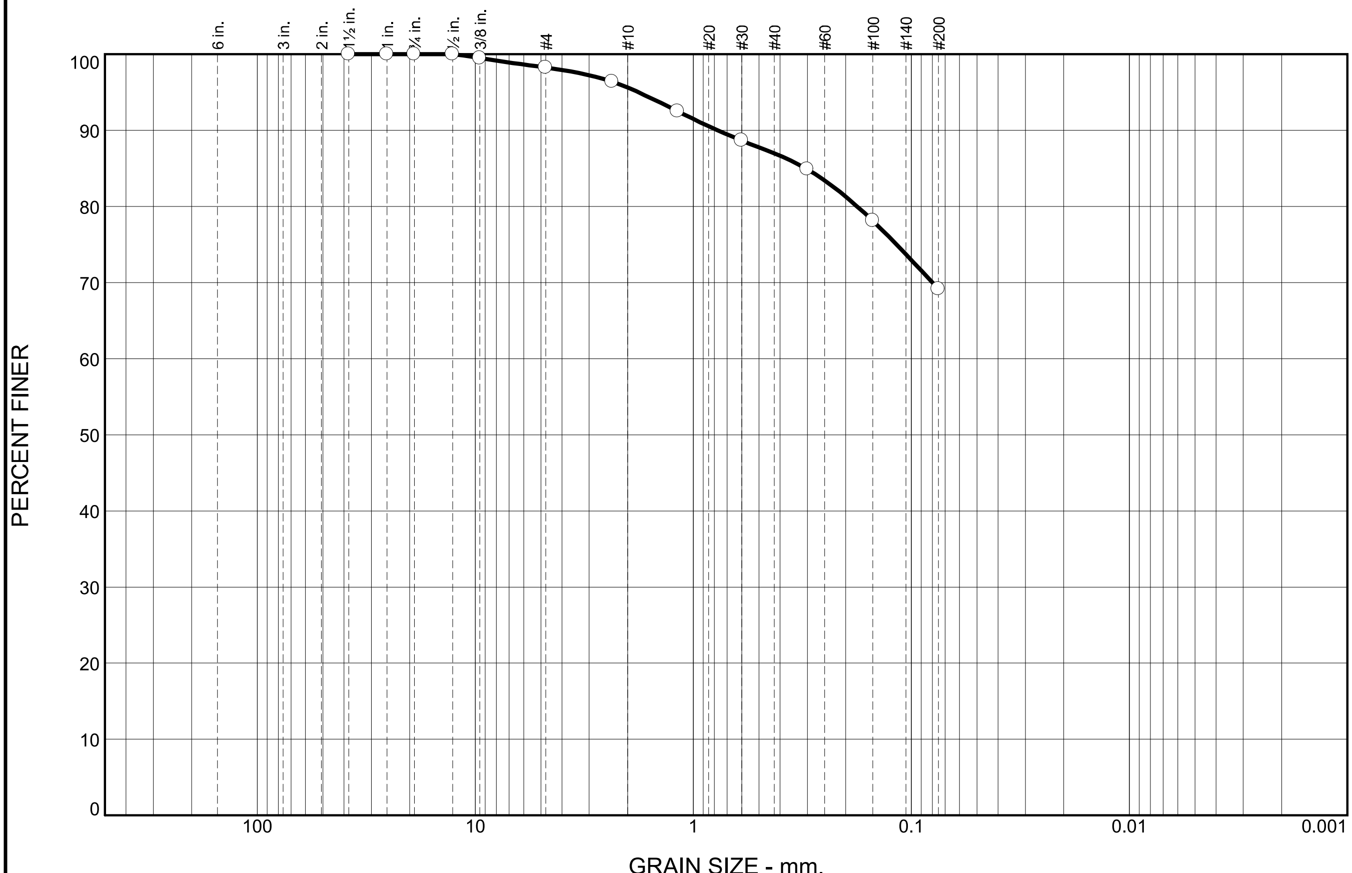
Remarks:

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	1.8	2.6	8.6	17.9	69.1	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.3052							

Material Description	USCS	AASHTO
○ SAND (SW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-01 BK-02 **Depth:** 2.0-4.0 **Sample No.:** TP16-01 BK-02

Remarks:
○unable to make exact classification without ASTM D4318-Atterburg testing.

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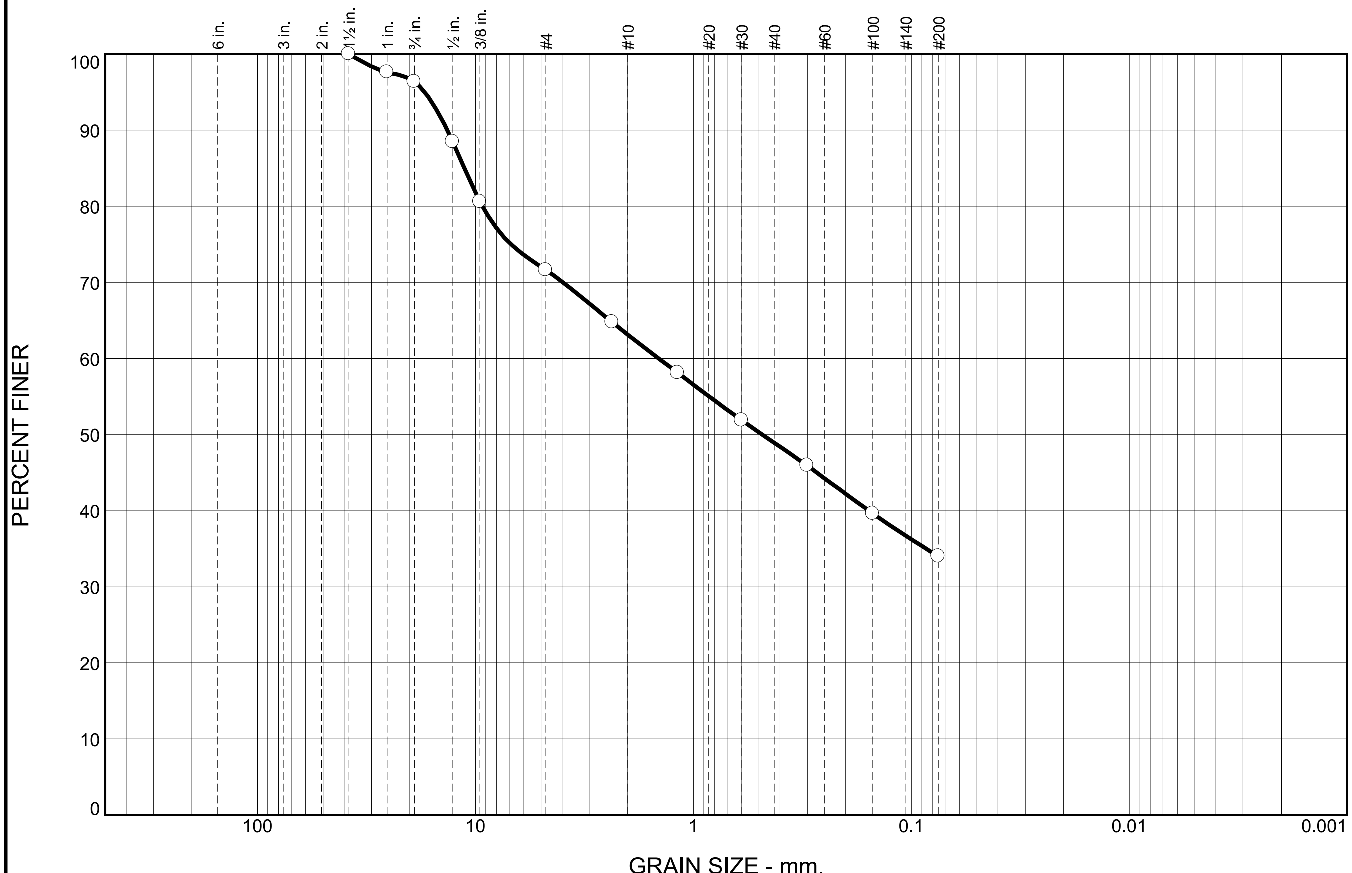
Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	3.7	24.7	8.5	14.2	14.9	34.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			11.2285	1.4433	0.4827					

Material Description	USCS	AASHTO
○ SAND WITH FINES (SW-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-01 BK-03 **Depth:** 4.0-6.0 **Sample No.:** TP16-01 BK-03

Remarks:

○unable to make exact classification without ASTM D4318- Atterburg testing.

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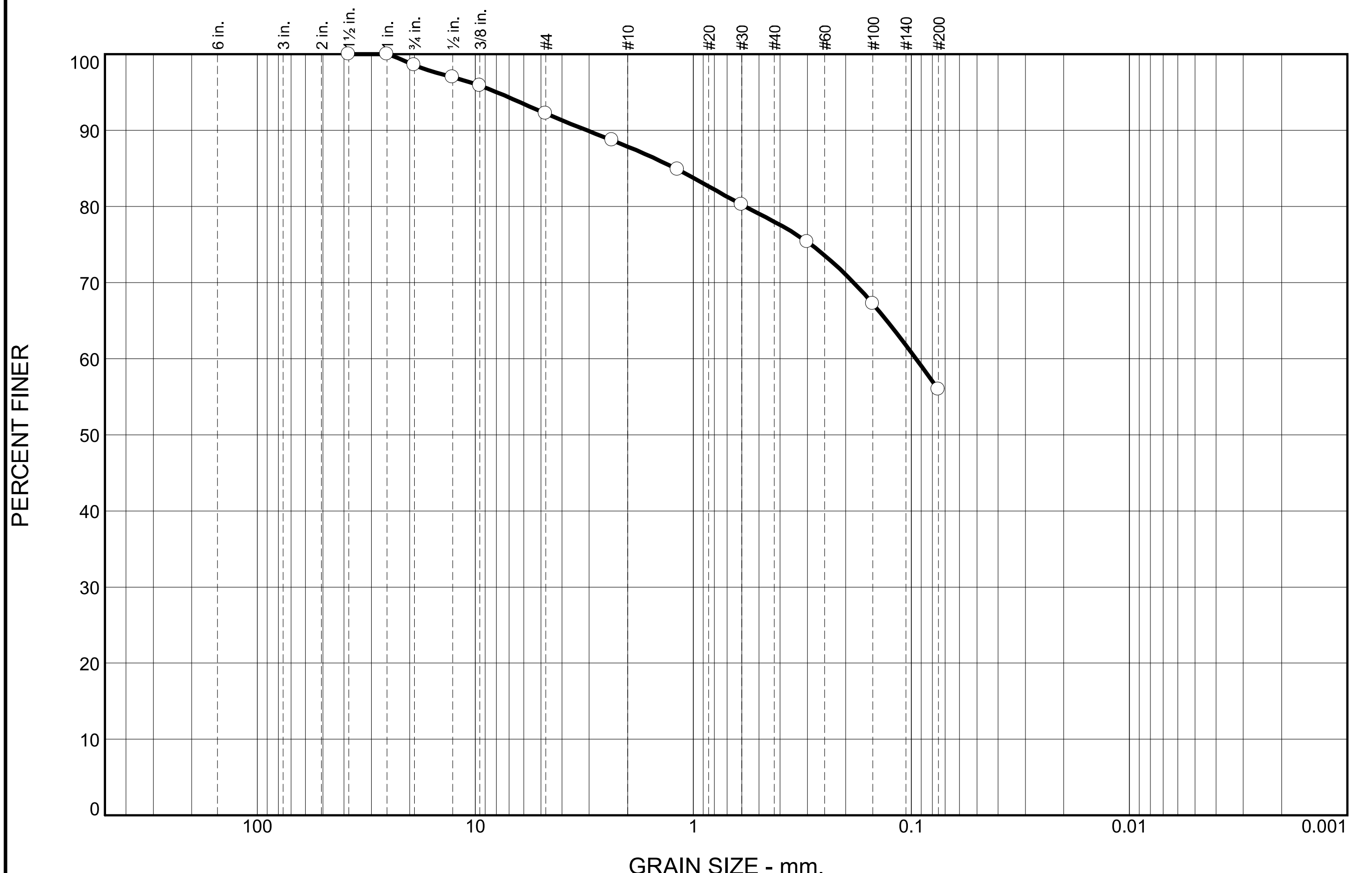
Figure

Tested By: MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.4	6.4	4.3	9.9	22.1	55.9	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		1.2078	0.0952						

Material Description	USCS	AASHTO
SAND WITH FINES (SW-SM)		

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

Source: TP16-01 BK-04 **Depth:** 6.0-8.0 **Sample No.:** TP16-01 BK-04

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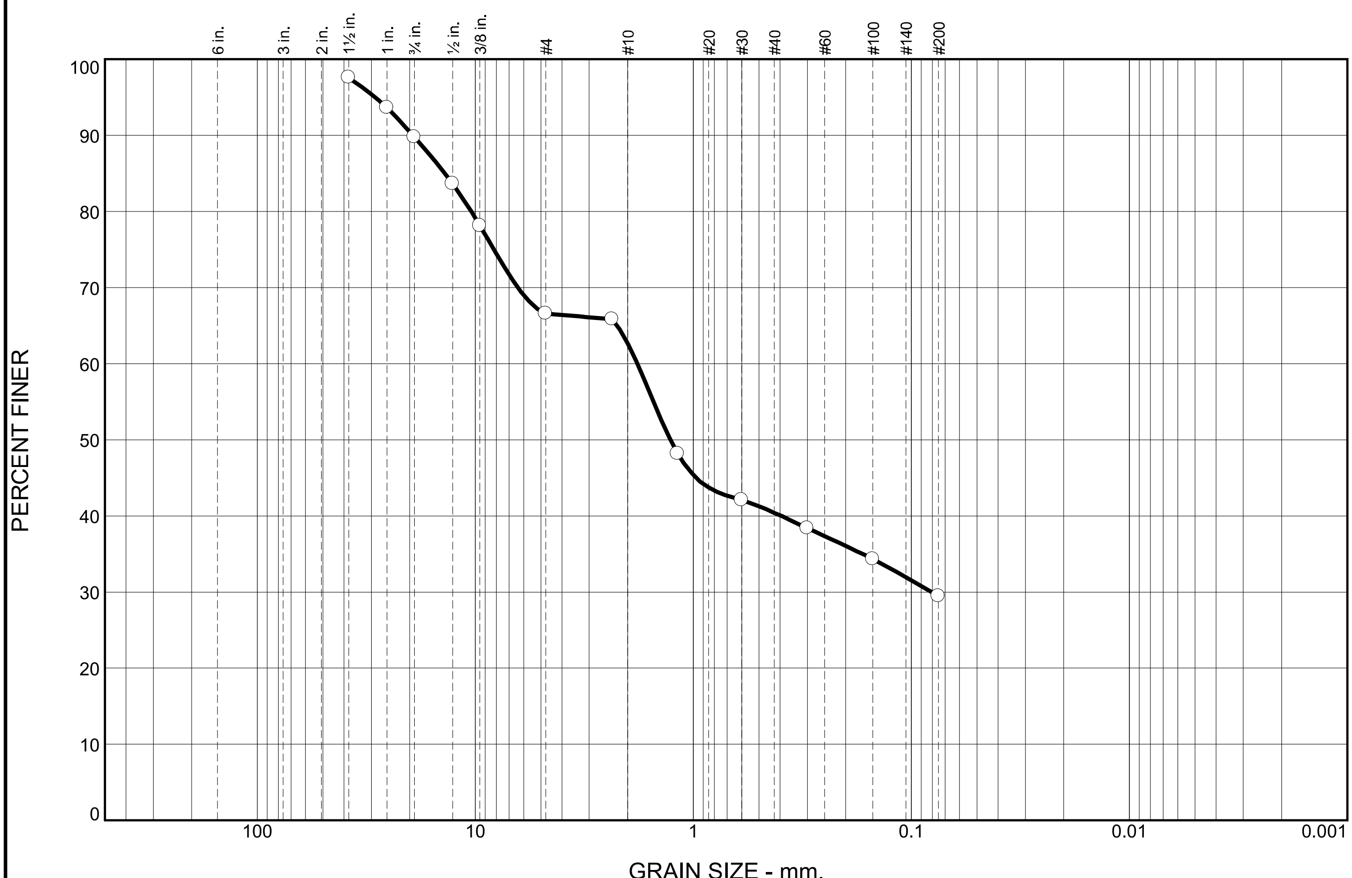
Remarks:
unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○			23.2	3.9	22.3	11.0	29.4	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	NV	NP	13.7863	1.8073	1.2747	0.0808				

Material Description	USCS	AASHTO
○ SANDY GRAVEL	SM	A-2-4(0)

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-02 BK-02 **Depth:** 2.0-4.0 **Sample No.:** TP16-02 BK-02

Remarks:

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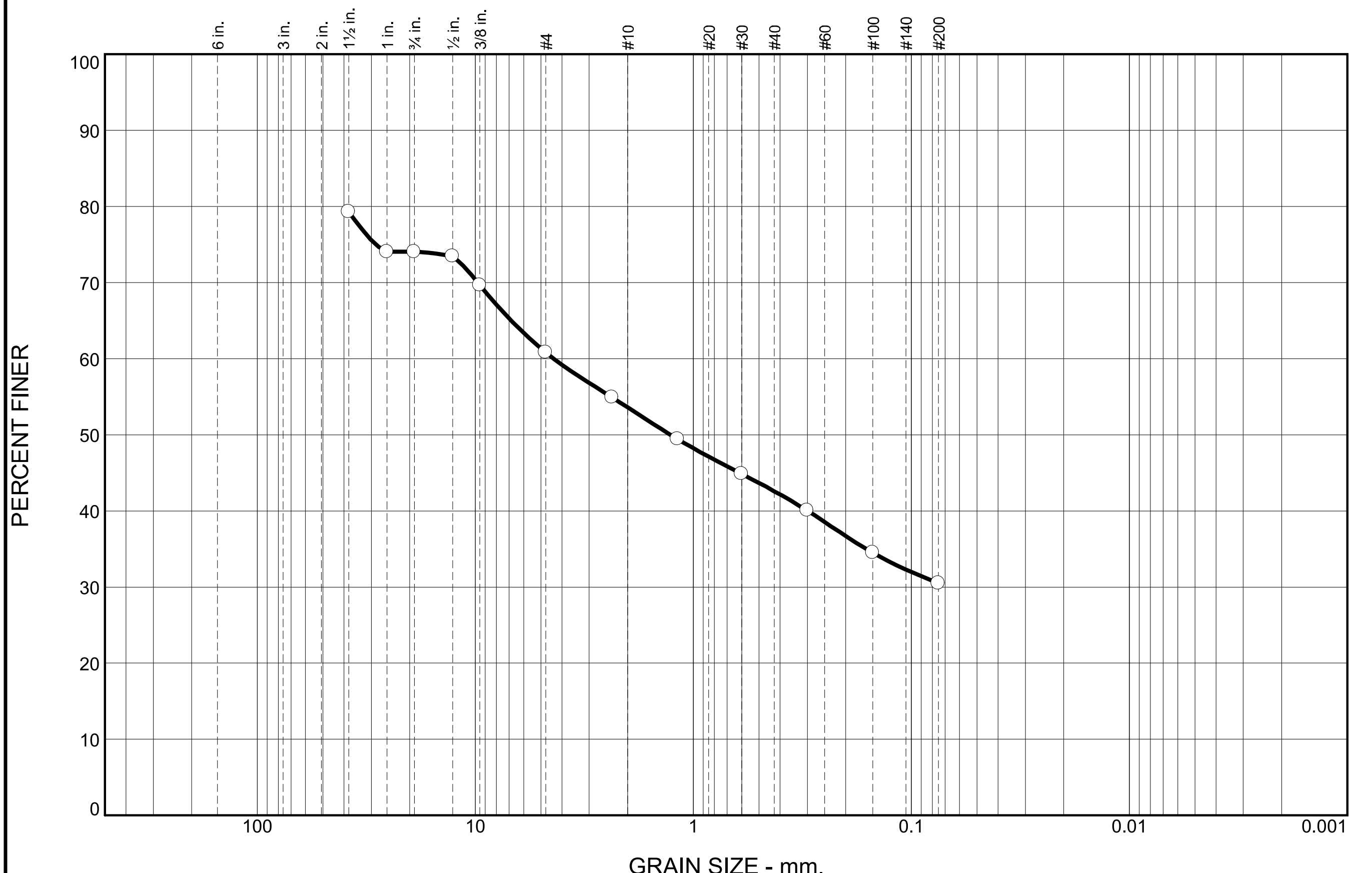
Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○			13.2	7.2	11.0	12.1	30.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○				4.3677	1.2732					

Material Description	USCS	AASHTO
○ SANDY GRAVEL (SM)		

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○ **Source:** TP16-02 BK-03 **Depth:** 4.0-6.0 **Sample No.:** TP16-02 BK-03

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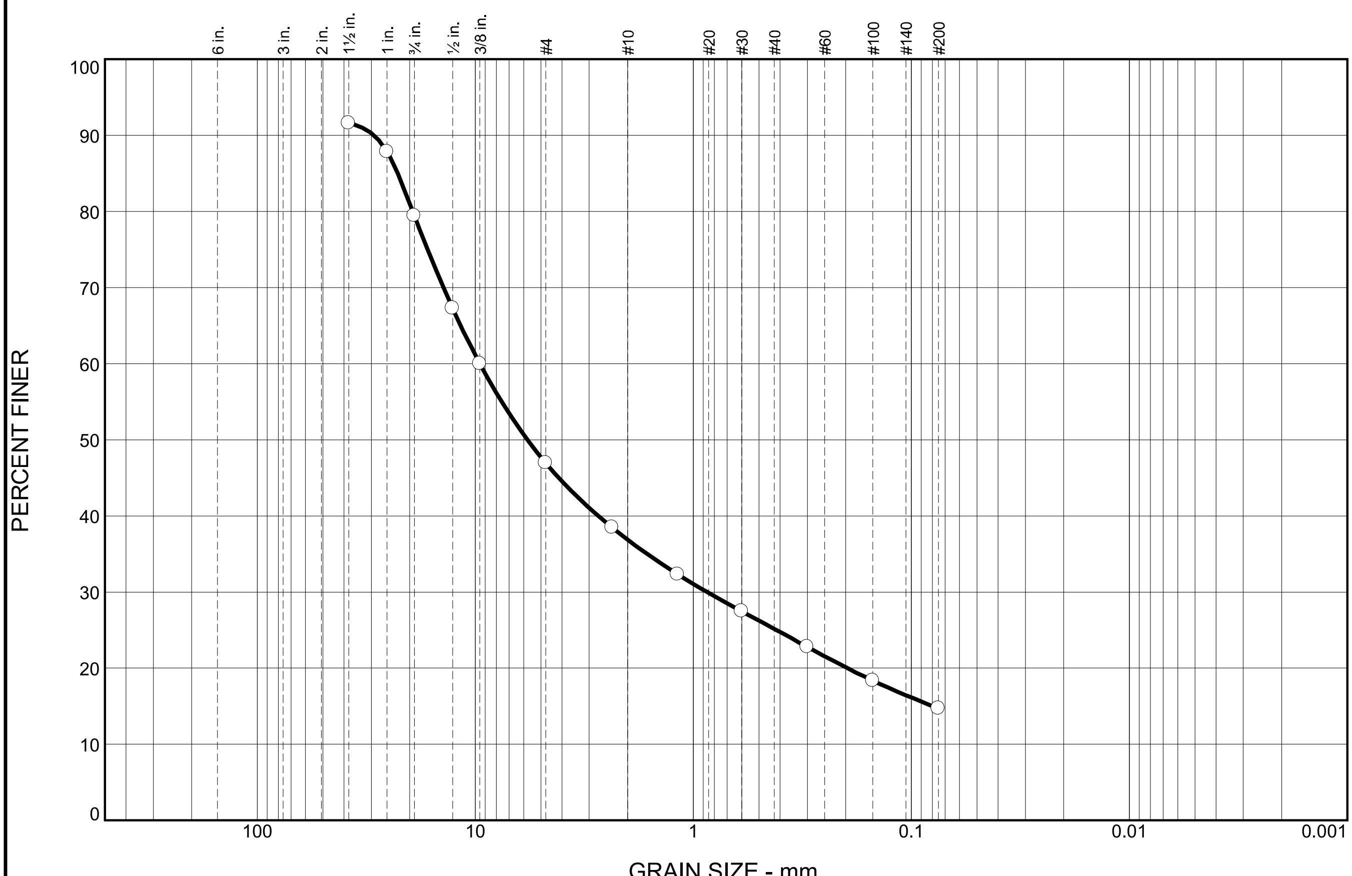
Remarks:
○unable to make exact classification without ASTM D4318-Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○			32.5	10.0	11.8	10.4	14.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			22.7190	9.5279	5.7637	0.8642	0.0797			

Material Description	USCS	AASHTO
○ SAND WITH FINES (GW-SW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-03 BK-02 **Depth:** 2.0-4.0 **Sample No.:** TP16-03 BK-02

Remarks:
○unable to make exact classification without ASTM D4318-Atterberg testing.

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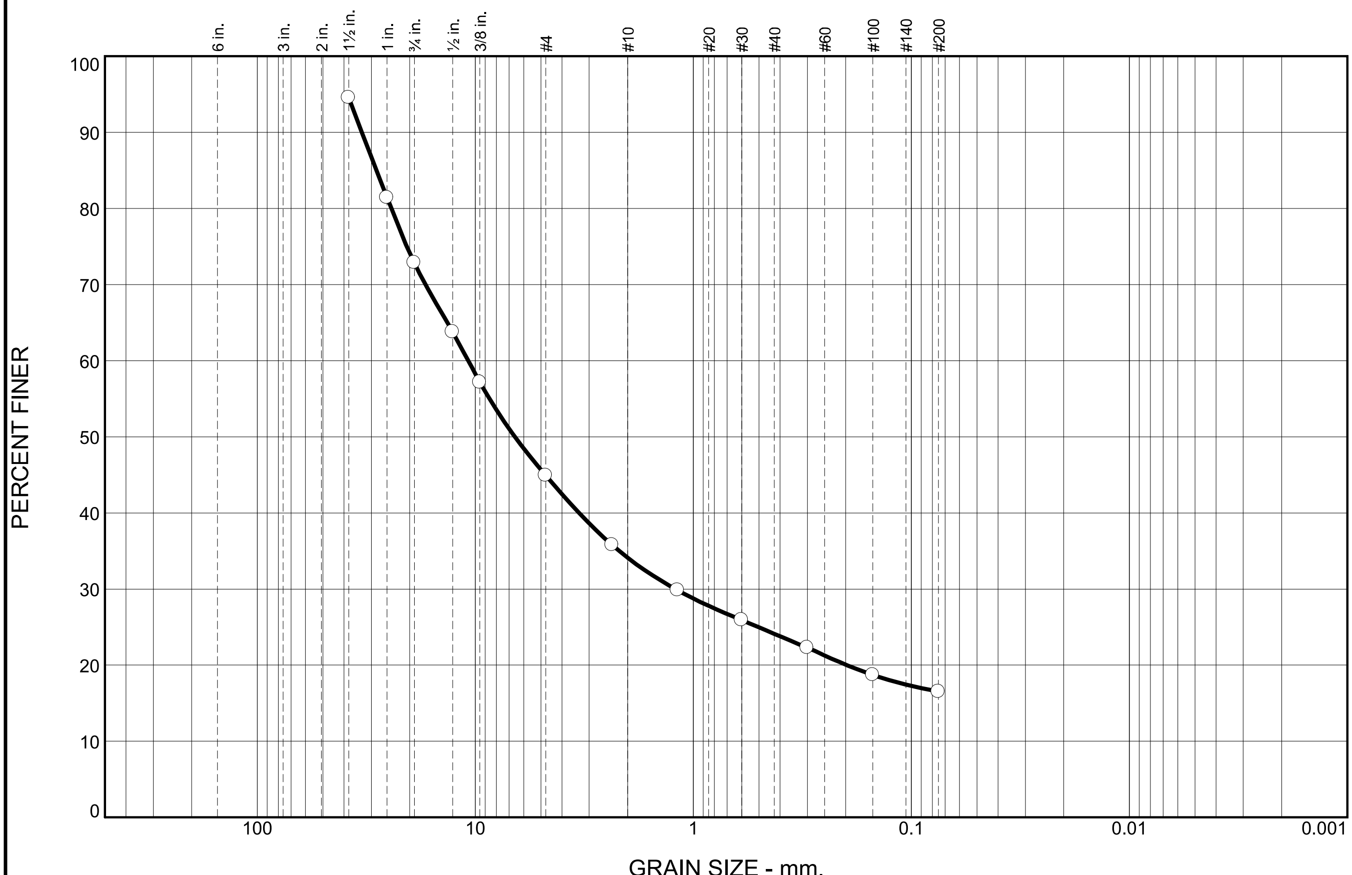
Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○			28.0	10.8	10.0	7.6	16.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			28.3910	10.7839	6.5799	1.2101				

Material Description	USCS	AASHTO
○ GRAVELY SAND WITH FINES (GW-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-03 BK-03 **Depth:** 4.0-6.0 **Sample No.:** TP16-03 BK-03

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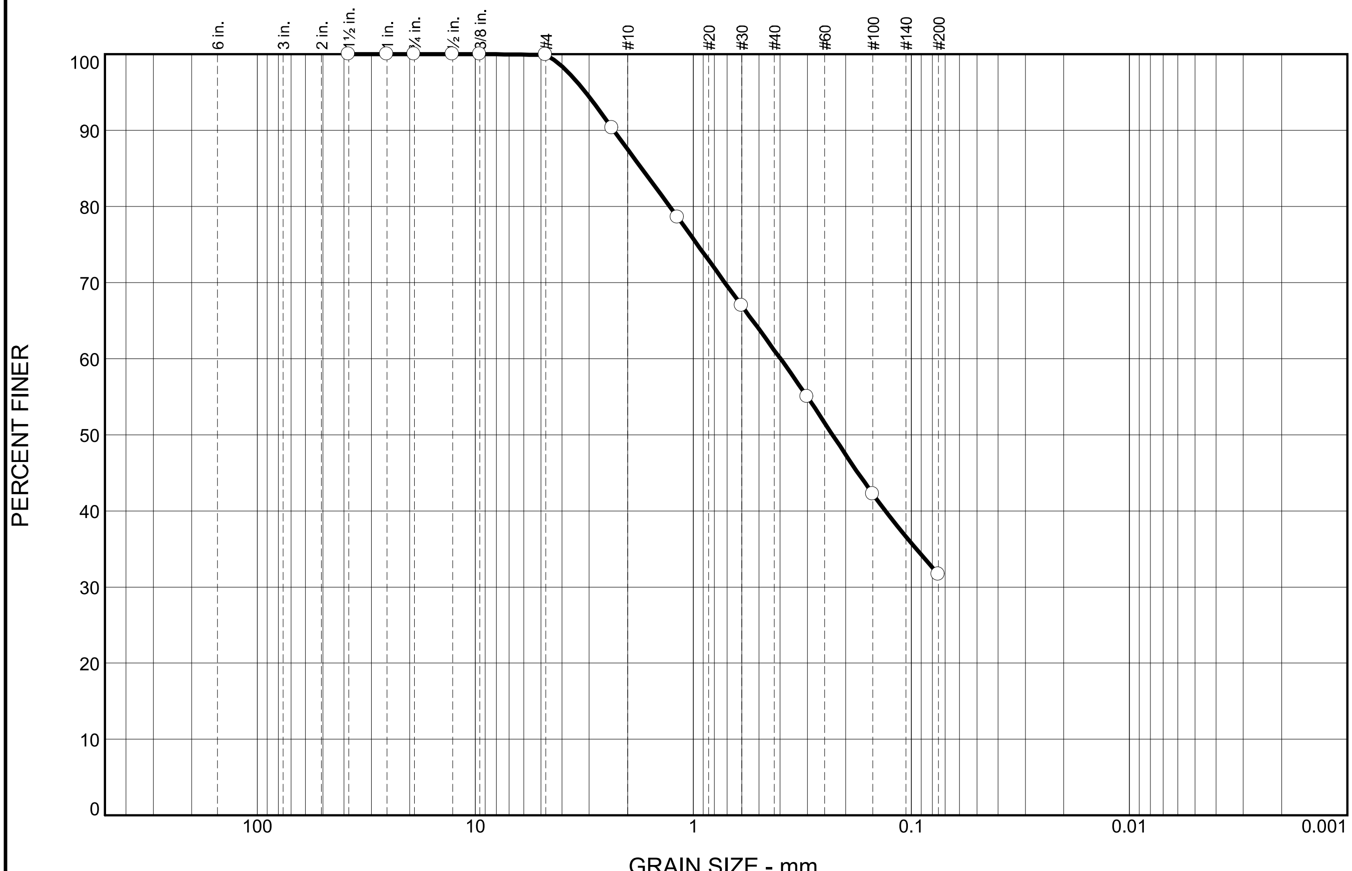
Remarks:

○unable to make exact classification without ASTM D4318-Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.1	12.4	26.4	29.5	31.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			1.7261	0.3985	0.2298					

Material Description	USCS	AASHTO
○ SILTY SAND (SM)		

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○ **Source:** TP16-04 BK-02 **Depth:** 2.0-4.0 **Sample No.:** TP16-04 BK-02

Remarks:
○unable to make exact classification without ASTM D4318-Atterberg testing.

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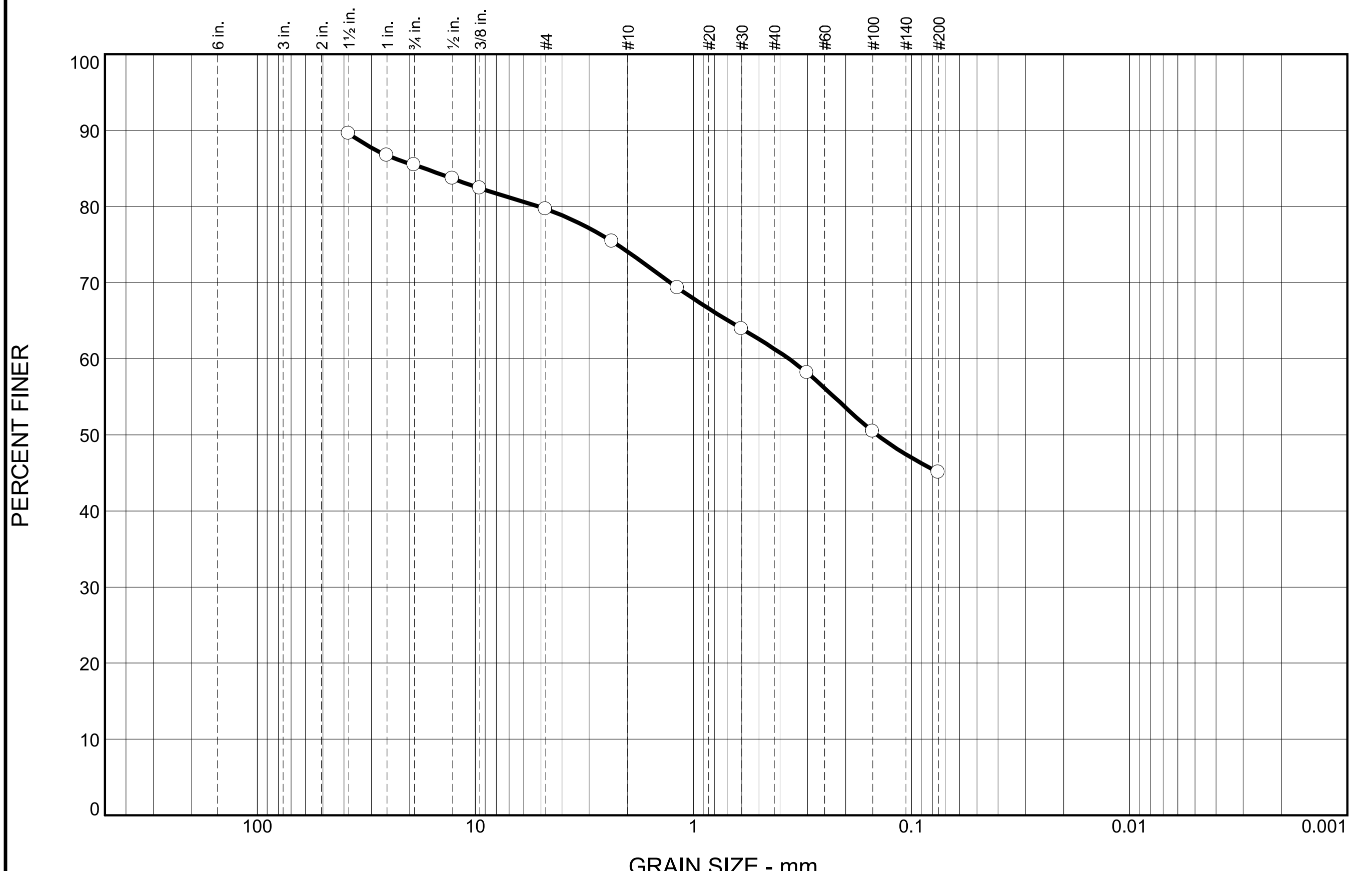
Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○			5.7	5.7	12.7	16.3	45.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	56	25	17.1138	0.3652	0.1435					

Material Description	USCS	AASHTO
○ CLAYEY SAND WITH GRAVEL	SC	A-7-6(9)

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-05 BK-01 **Depth:** 0-1.0 **Sample No.:** TP16-05 BK-01

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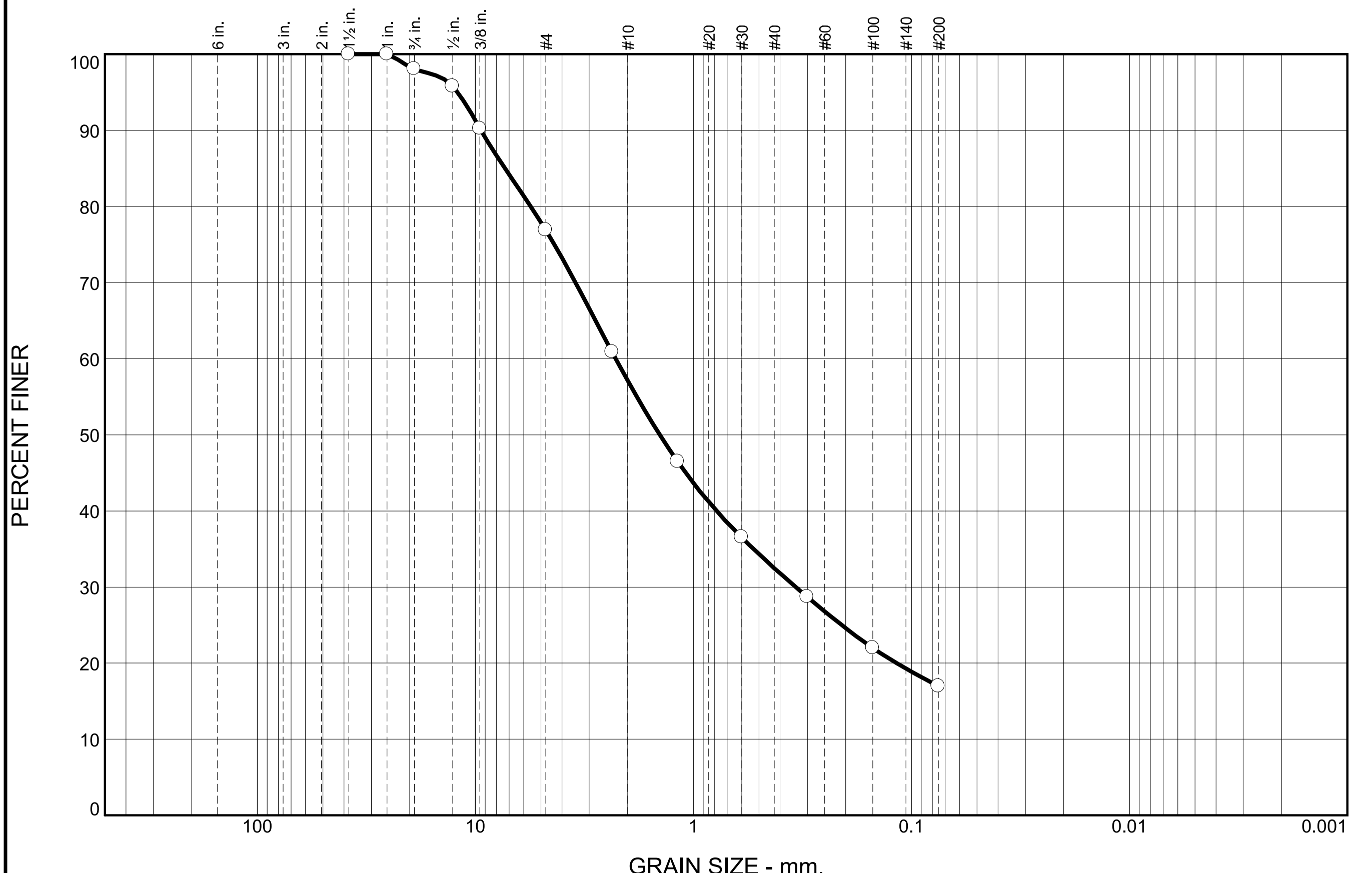
Remarks:

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	1.9	21.2	19.8	24.6	15.5	17.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	NV	NP	7.3021	2.2705	1.4261	0.3391				

Material Description	USCS	AASHTO
○ GRAVELY SAND	SM	A-1-b

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-05 BK-02 **Depth:** 1.0-4.0 **Sample No.:** TP16-05 BK-02

Remarks:

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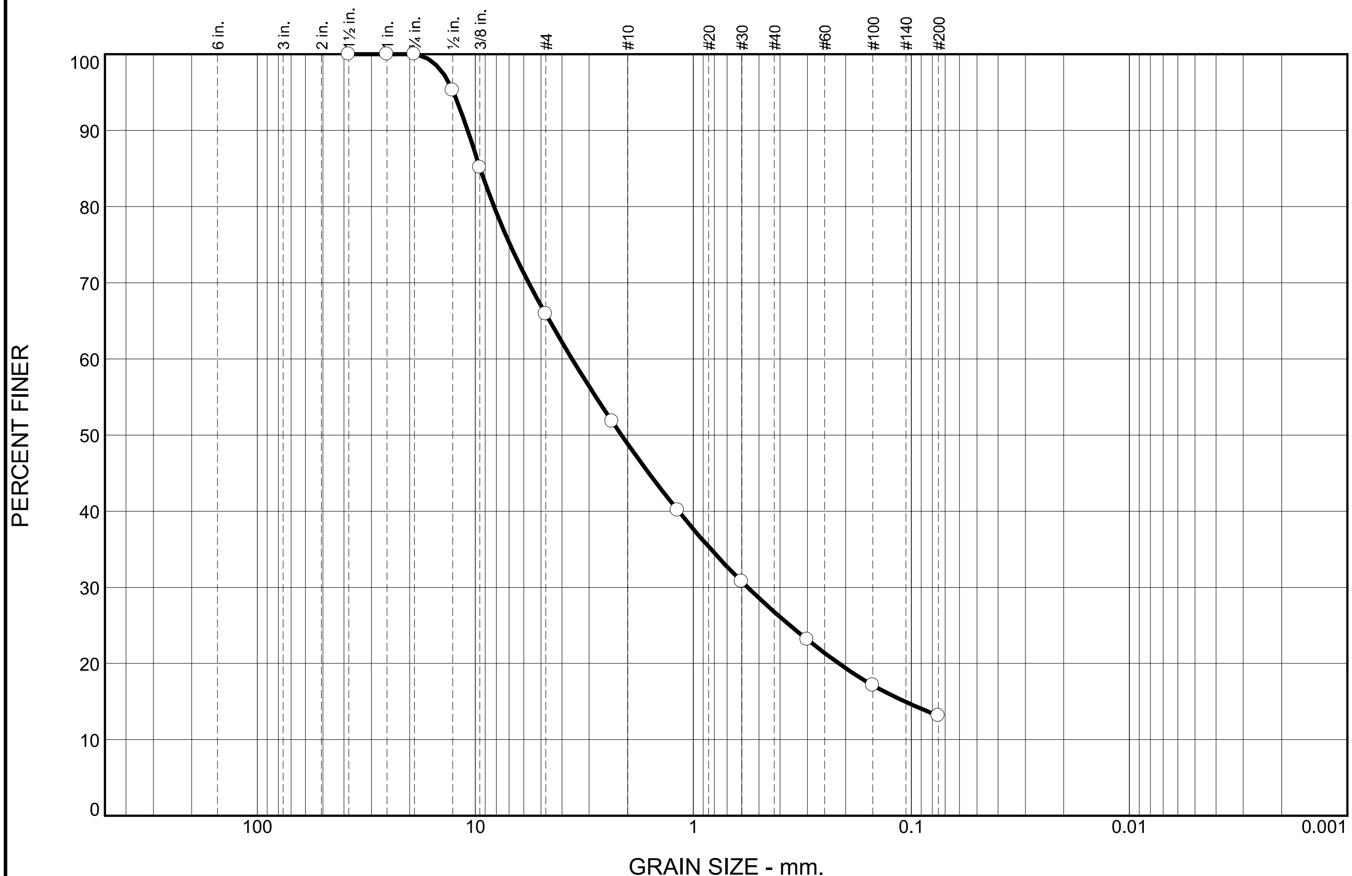
Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	34.1	17.1	22.0	13.7	13.1	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			9.4930	3.6016	2.1373	0.5637	0.1068			

Material Description	USCS	AASHTO
○ SANDY GRAVEL (GW-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source of Sample:** TP16-05 BK-03 **Sample Number:** TP16-05 BK-03

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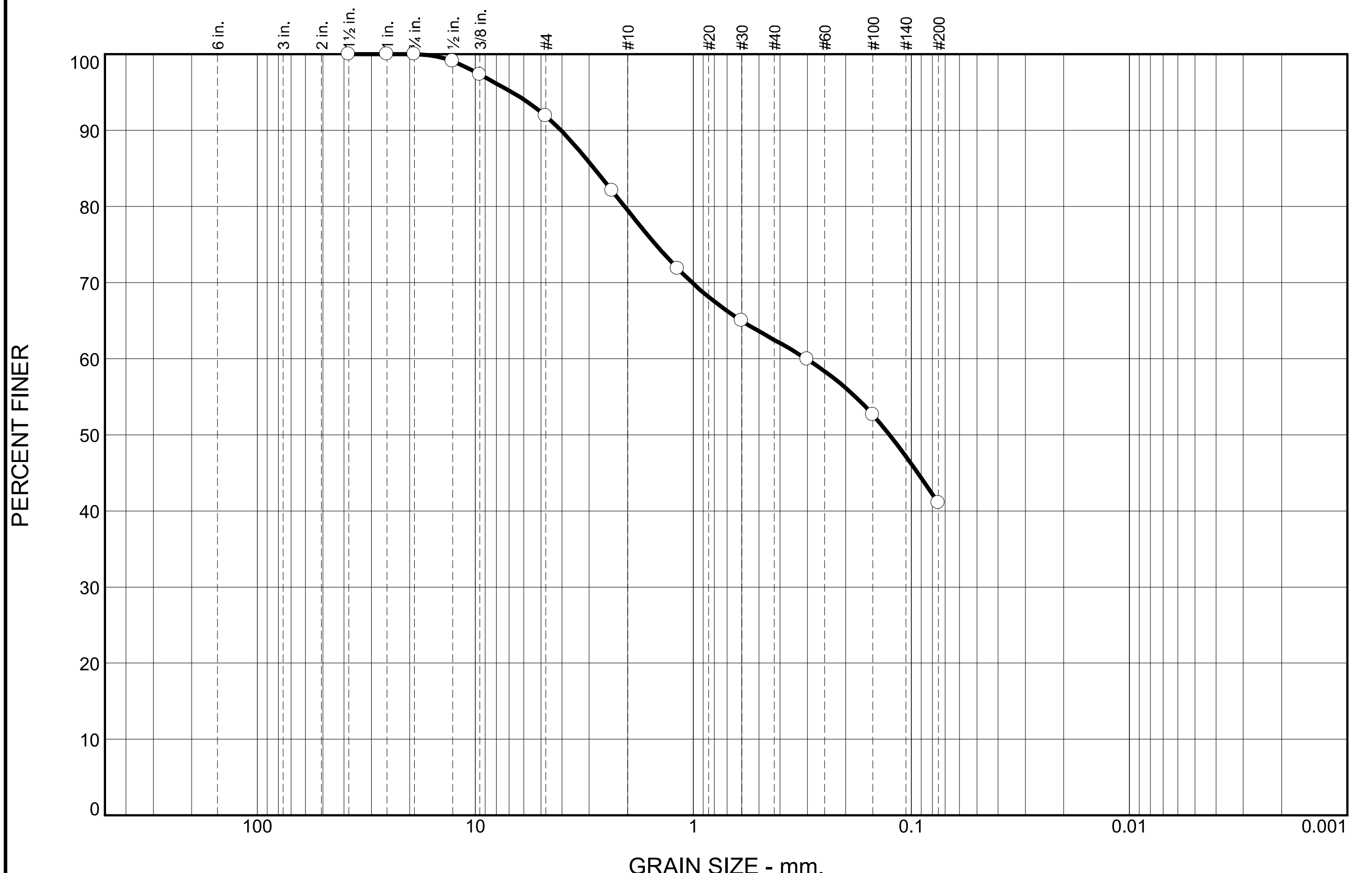
Remarks:

○unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	8.1	12.4	17.0	21.5	41.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			2.8498	0.3033	0.1258					

Material Description	USCS	AASHTO
○ SAND WITH FINES (SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-06 BK-02 **Depth:** 2.0-4.0 **Sample No.:** TP16-06 BK-02

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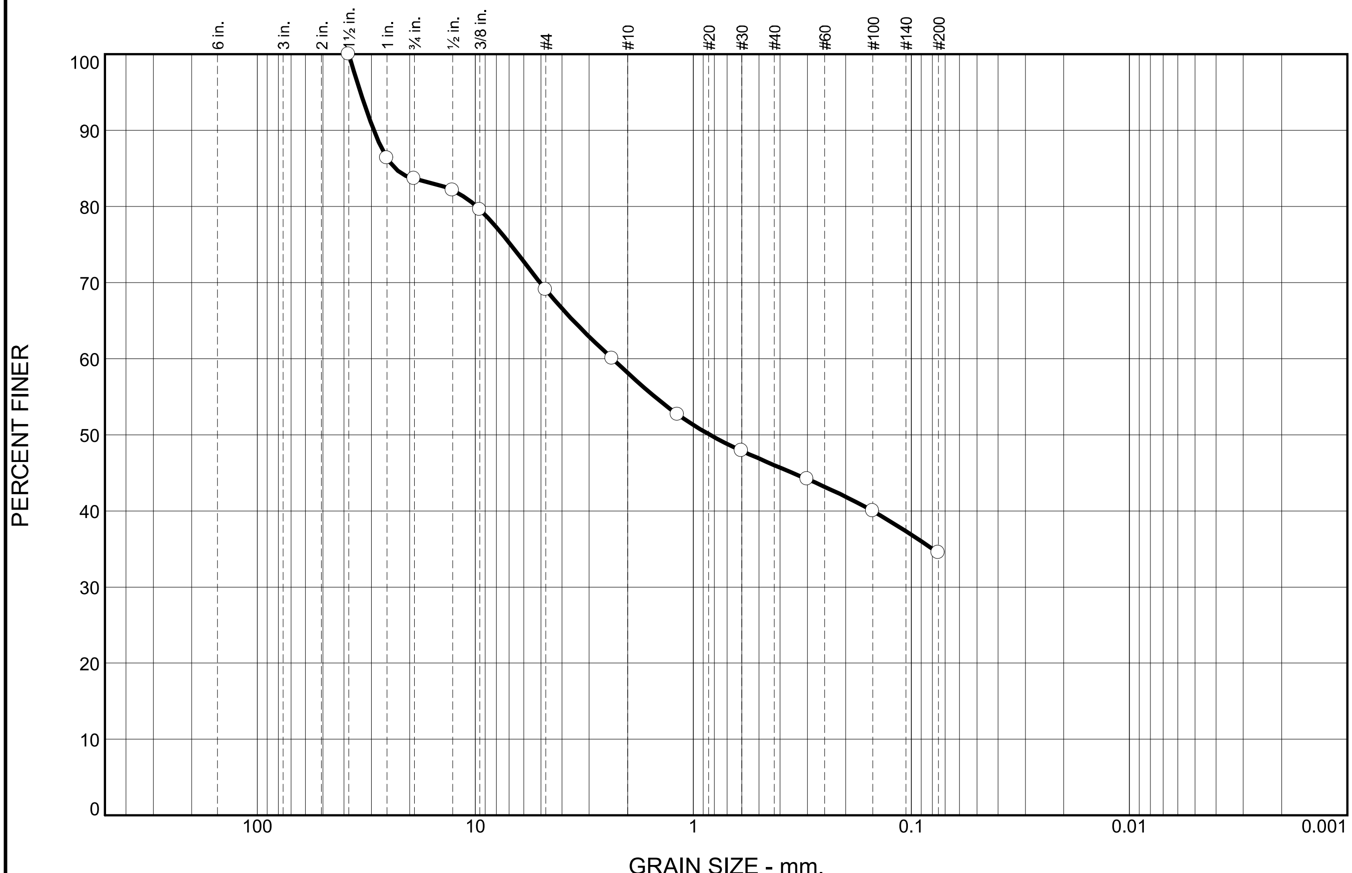
Remarks:

○unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	16.4	14.5	11.0	12.1	11.5	34.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			23.3059	2.3533	0.8395					

Material Description	USCS	AASHTO
○ GRAVEL WITH SAND (GW-SM)		

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○ **Source:** TP16-06 BK-03 **Depth:** 4.0-6.0 **Sample No.:** TP16-06 BK-03

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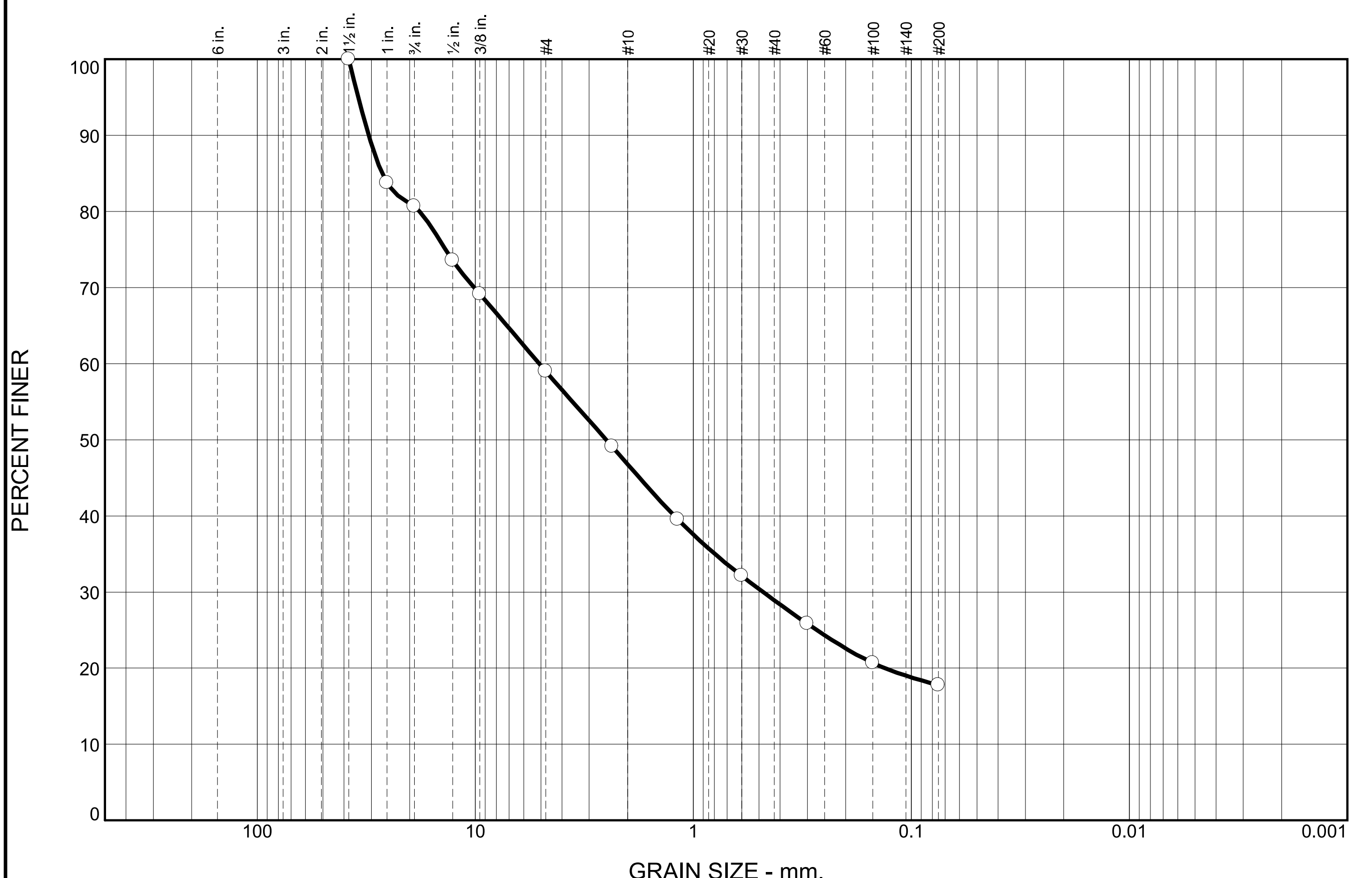
Remarks:
○unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	19.3	21.7	12.2	17.9	11.1	17.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			26.7489	5.0906	2.5108	0.4794				

Material Description	USCS	AASHTO
○ GRAVEL WITH SAND (GW-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-07 BK-02 **Depth:** 1.5-4.0 **Sample No.:** TP16-07 BK-02

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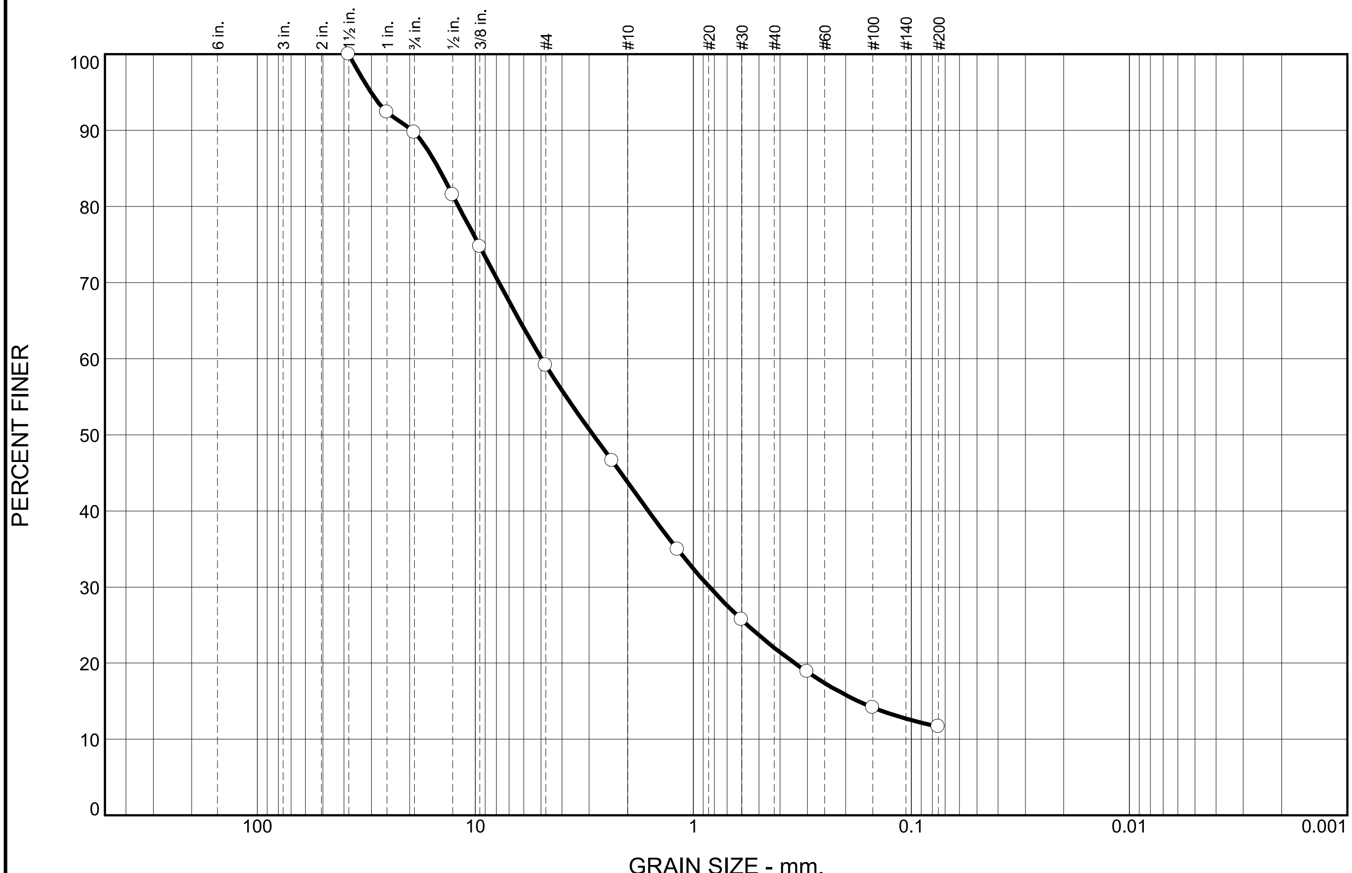
Remarks:

○unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
○	0.0	10.3	30.6	15.4	21.7	10.4	11.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			14.7267	4.9621	2.8824	0.8430	0.1755			

Material Description	USCS	AASHTO
○ SANDY GRAVEL (SM-GW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-07 BK-03 **Depth:** 4.0-6.0 **Sample No.:** TP16-07 BK-03

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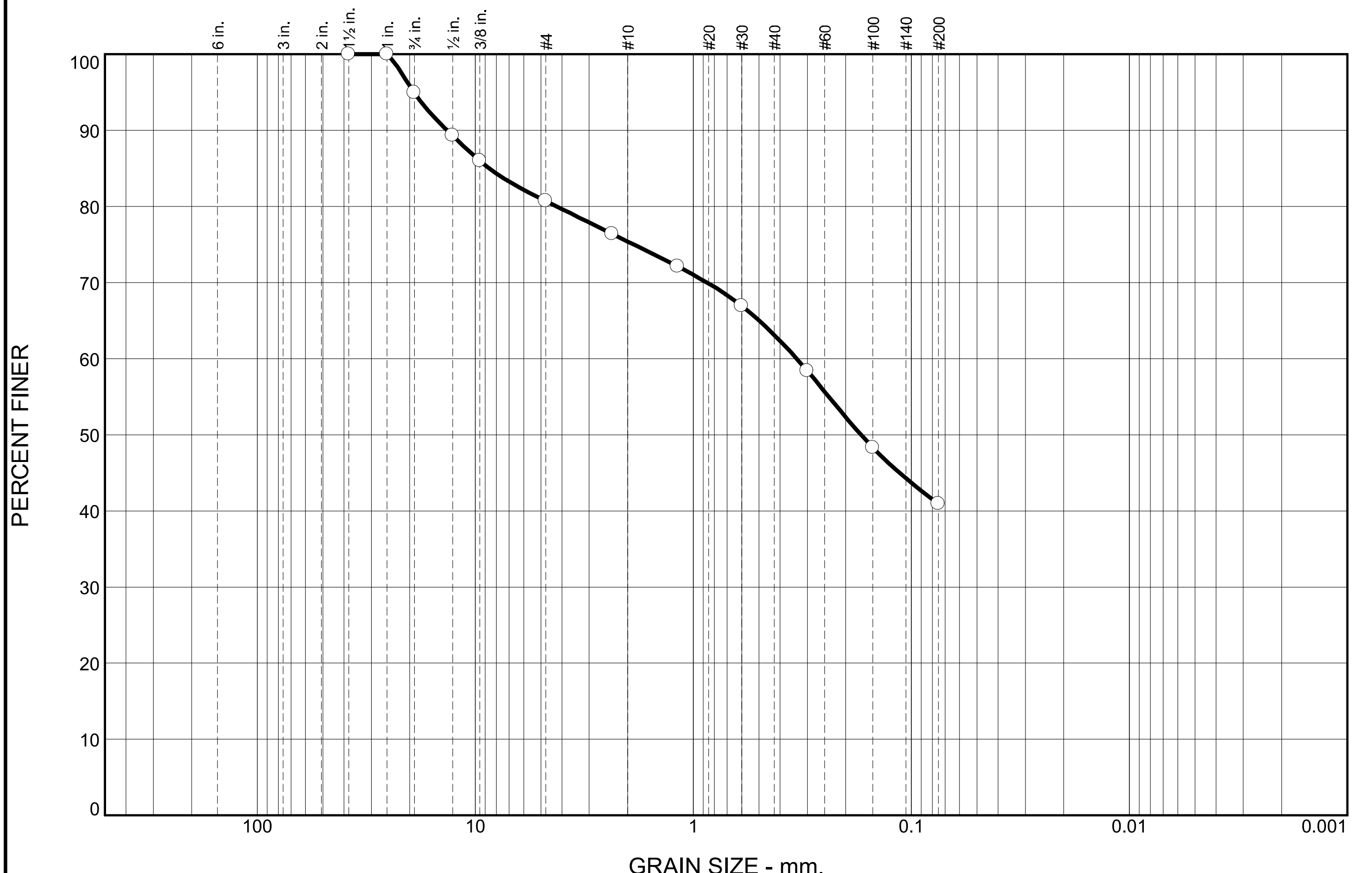
Remarks:

○unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	5.1	14.2	5.3	12.3	22.2	40.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			8.6138	0.3358	0.1702					

Material Description	USCS	AASHTO
○ SAND WITH FINES (SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source of Sample:** TP16-08 BK-01 **Sample Number:** TP16-08 BK-01

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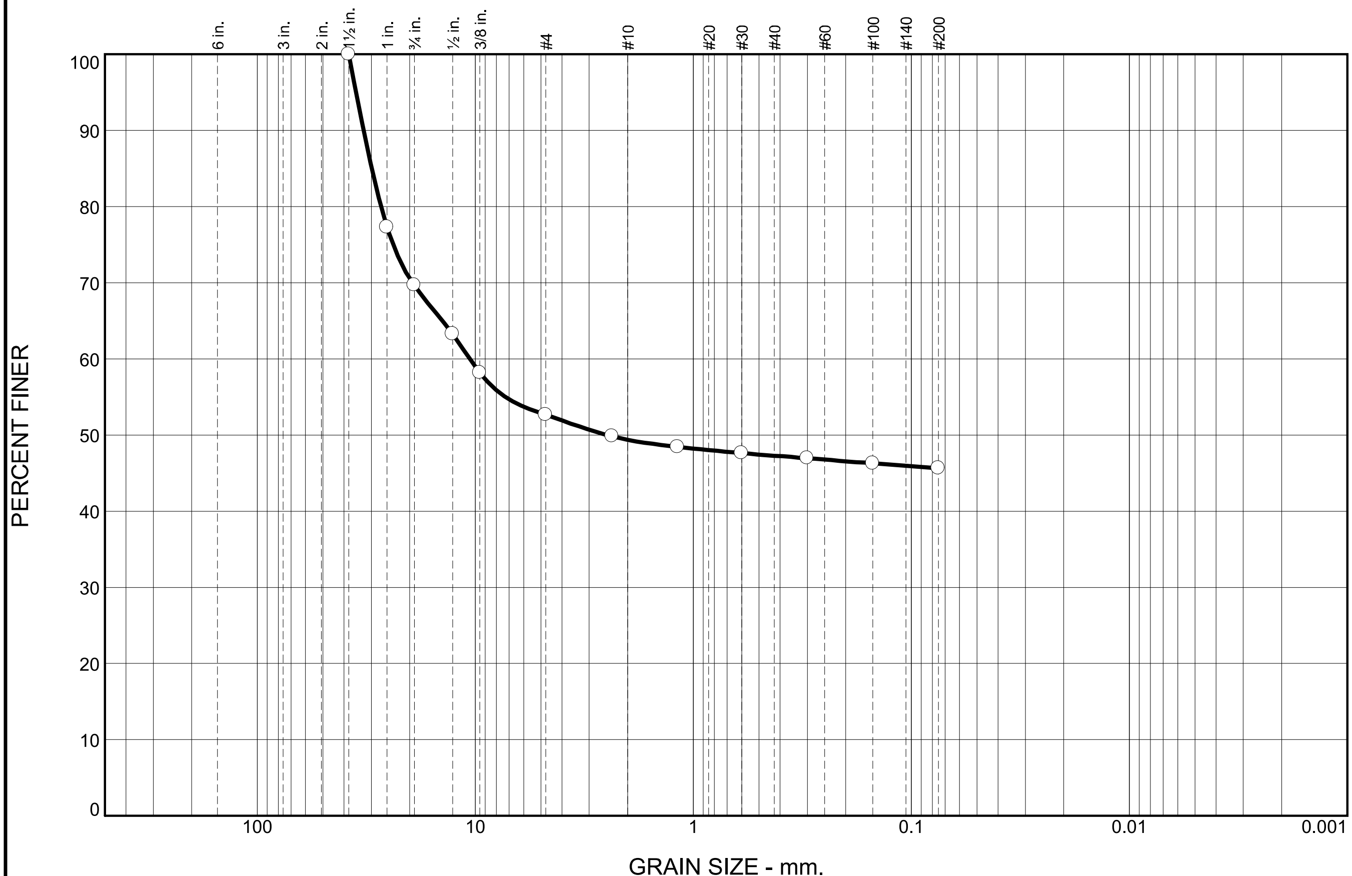
Remarks:

○Unable to make exact classification without ASTM D4318 - Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	30.3	17.0	3.3	2.1	1.7	45.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			29.8350	10.6094	2.4862					

Material Description	USCS	AASHTO
○ SANDY GRAVEL (SM-GW)		

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○ **Source:** TP16-08 BK-03 **Depth:** 5.0-7.0 **Sample No.:** TP16-08 BK-03

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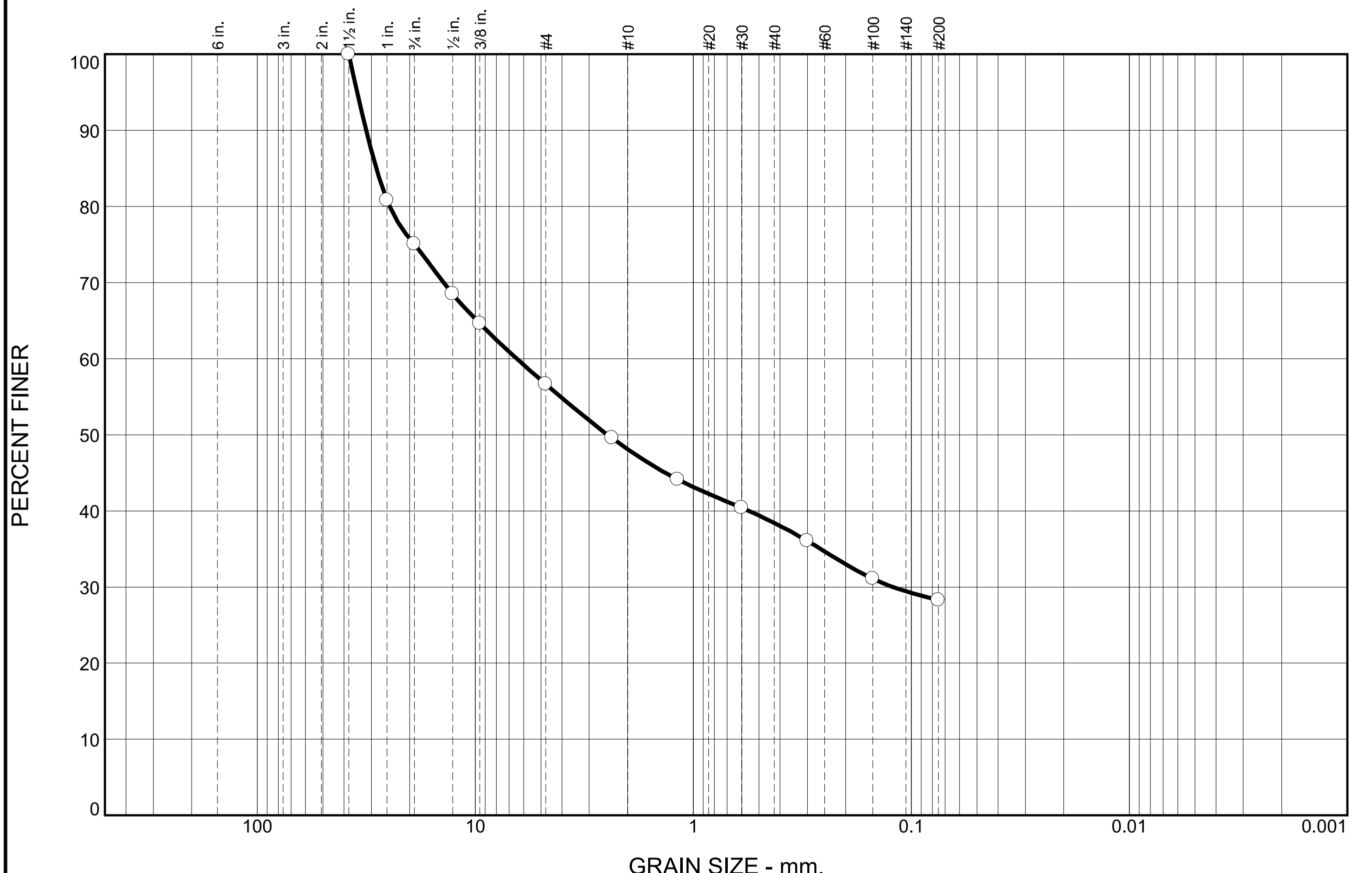
Remarks:
○Unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	24.9	18.4	8.6	9.7	10.1	28.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	28	19	28.4479	6.4480	2.4720	0.1214				

Material Description	USCS	AASHTO
○ GRAVELY SAND	GC	A-2-4(0)

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-09 BK-01 **Depth:** 0-1.0 **Sample No.:** TP16-09 BK-01

ATL-CMT

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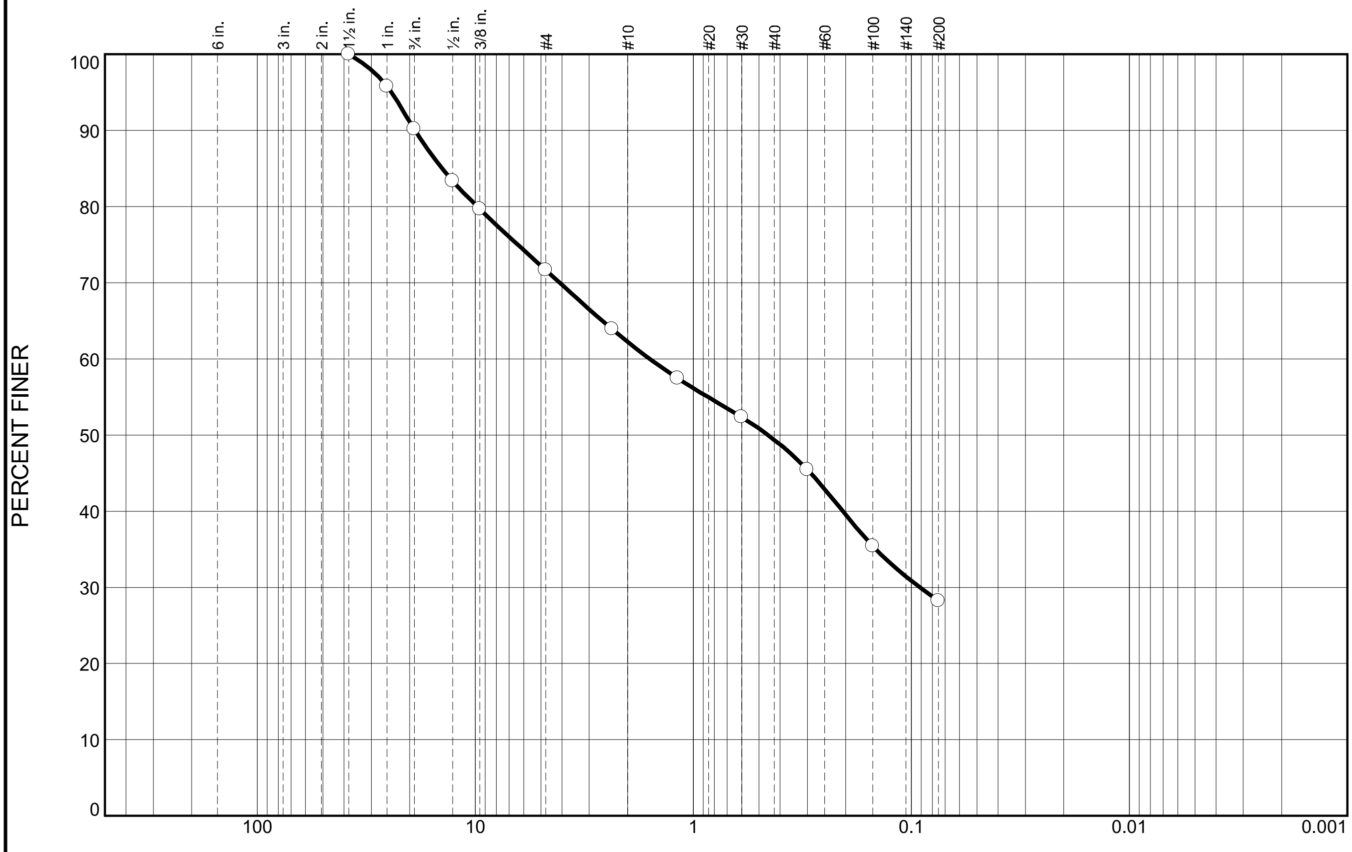
Remarks:

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	9.8	18.5	9.5	12.8	21.2	28.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			14.1868	1.5851	0.4547	0.0912				

Material Description	USCS	AASHTO
○ GRAVELY CLAY (GC)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-09 BK-02 **Depth:** 1.0-4.0 **Sample No.:** TP16-09 BK-02

ATL-CMT

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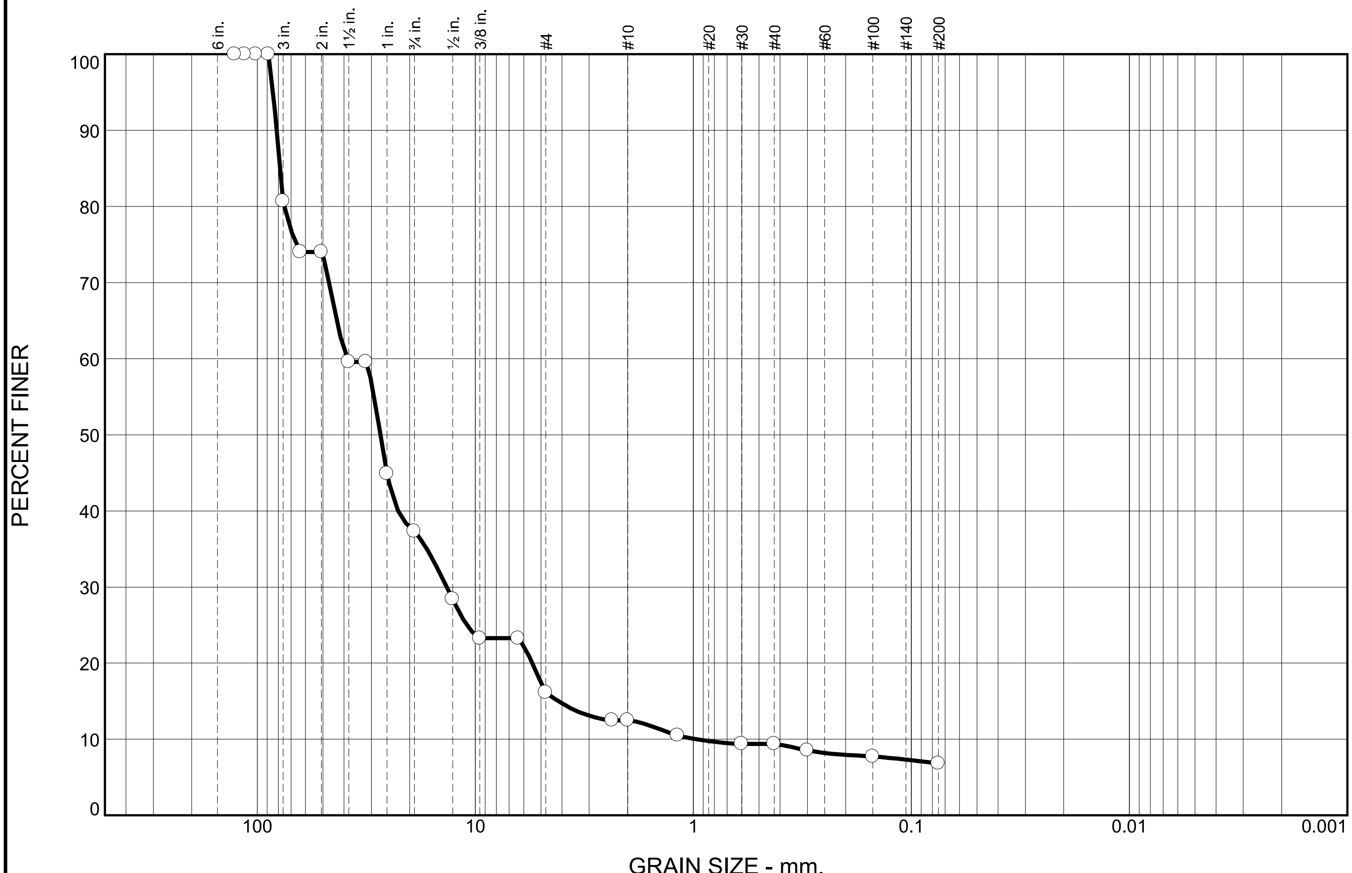
Remarks:

○Unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	19.3	43.4	21.2	3.6	3.1	2.6	6.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			78.8436	38.8941	27.2495	13.5255	4.1678	0.9664	4.87	40.24

Material Description	USCS	AASHTO
○ GRAVEL (GW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-09 BK-03 **Depth:** 4.0-7.0 **Sample No.:** TP16-09 BK-03

ATL-CMT

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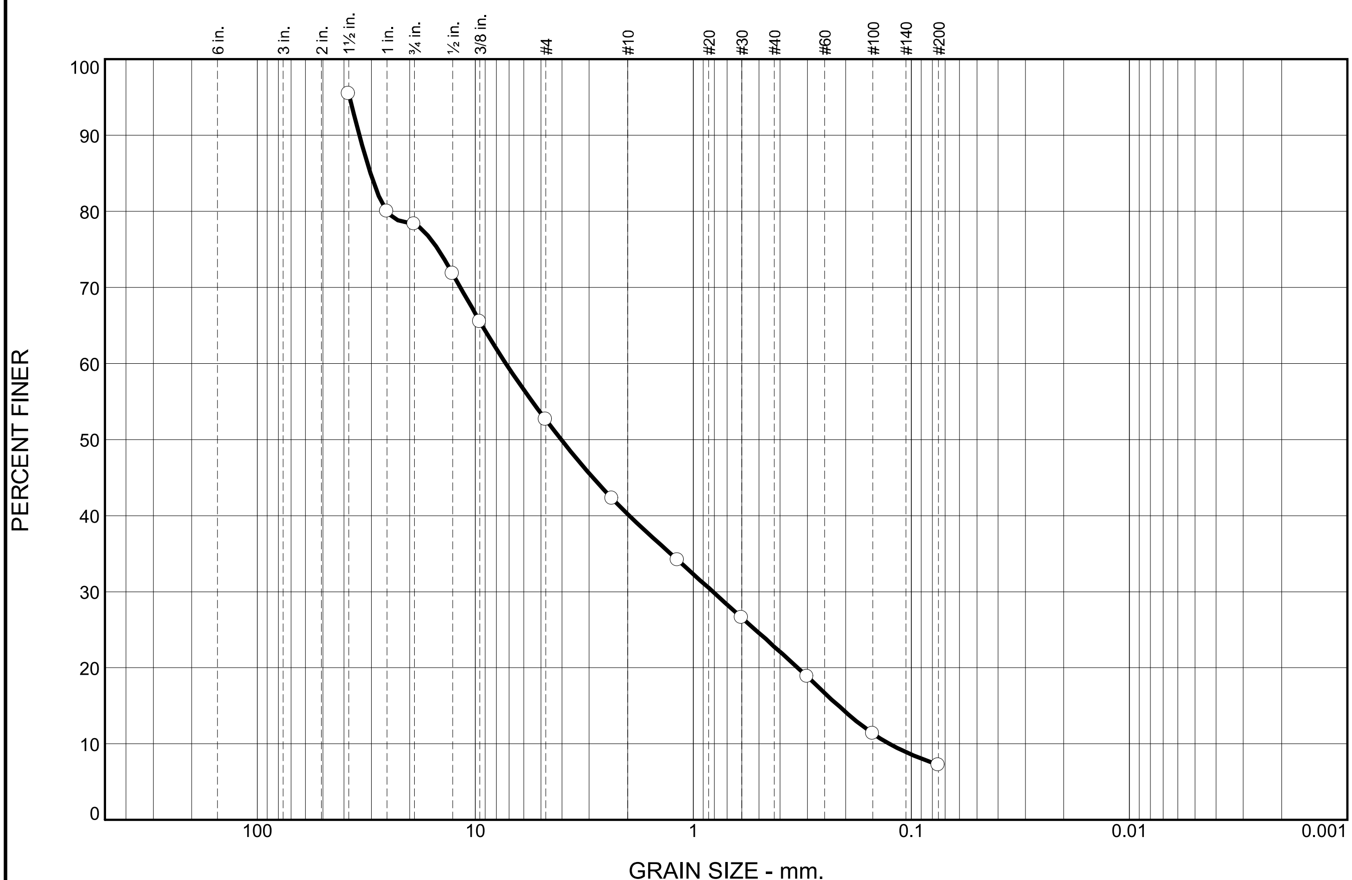
Remarks:

○Unable to make exact classification without ASTM D4318 - Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		25.7	12.4	17.4	15.6	7.2	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		30.2476	7.2412	4.0378	0.8144	0.2157	0.1259	0.73	57.51

Material Description	USCS	AASHTO
○ GRAVEL (GW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-10 BK-02 **Depth:** 1.5-5.0 **Sample No.:** TP16-10 BK-02

ATL-CMT

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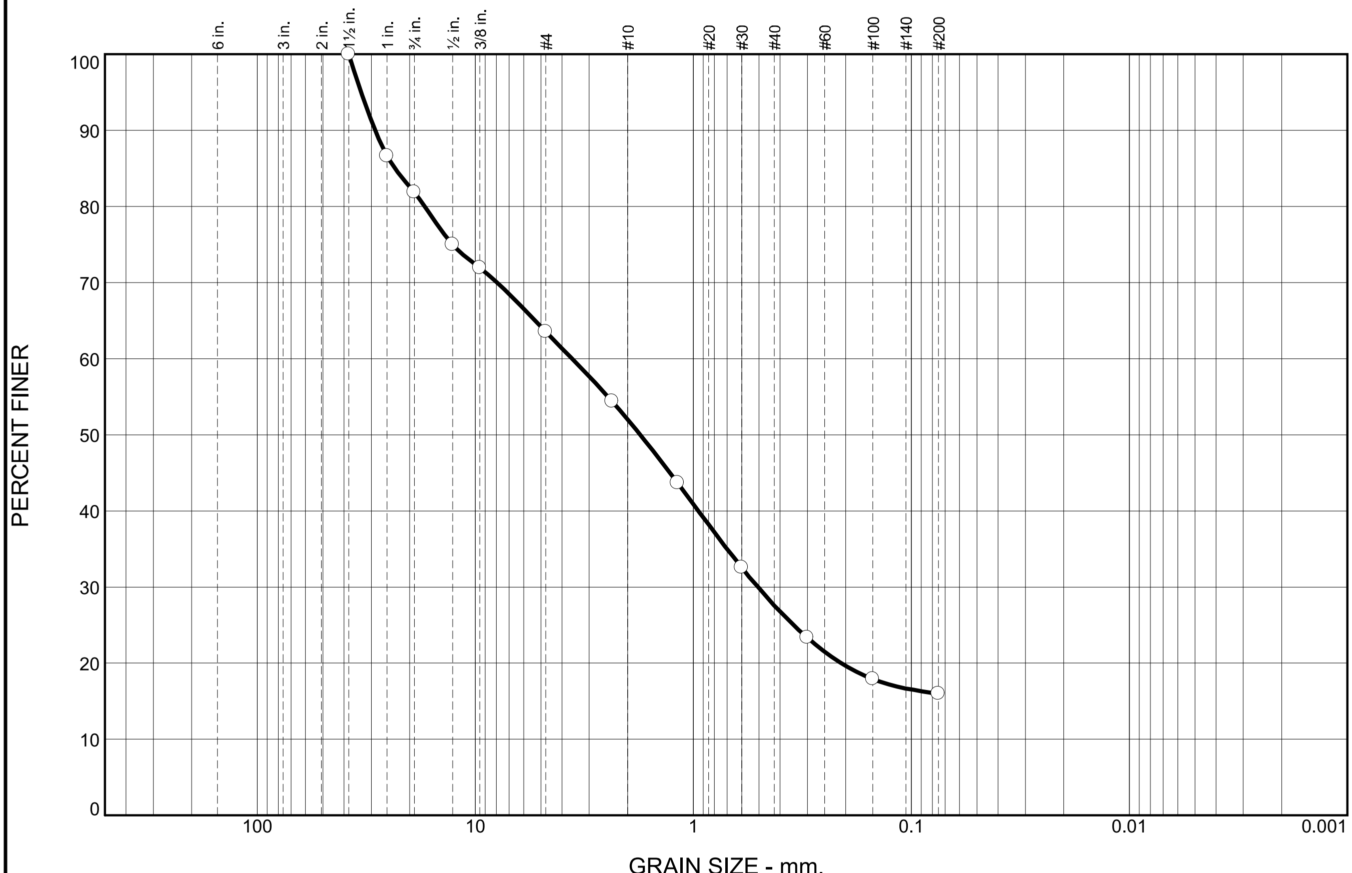
Remarks:

○Unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	18.1	18.4	11.5	24.4	11.6	16.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			23.3911	3.6004	1.7533	0.5058				

Material Description	USCS	AASHTO
○ GRAVEL WITH SAND (GW-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-10 BK-03 **Depth:** 5.0-8.0 **Sample No.:** TP16-10 BK-03

ATL-CMT

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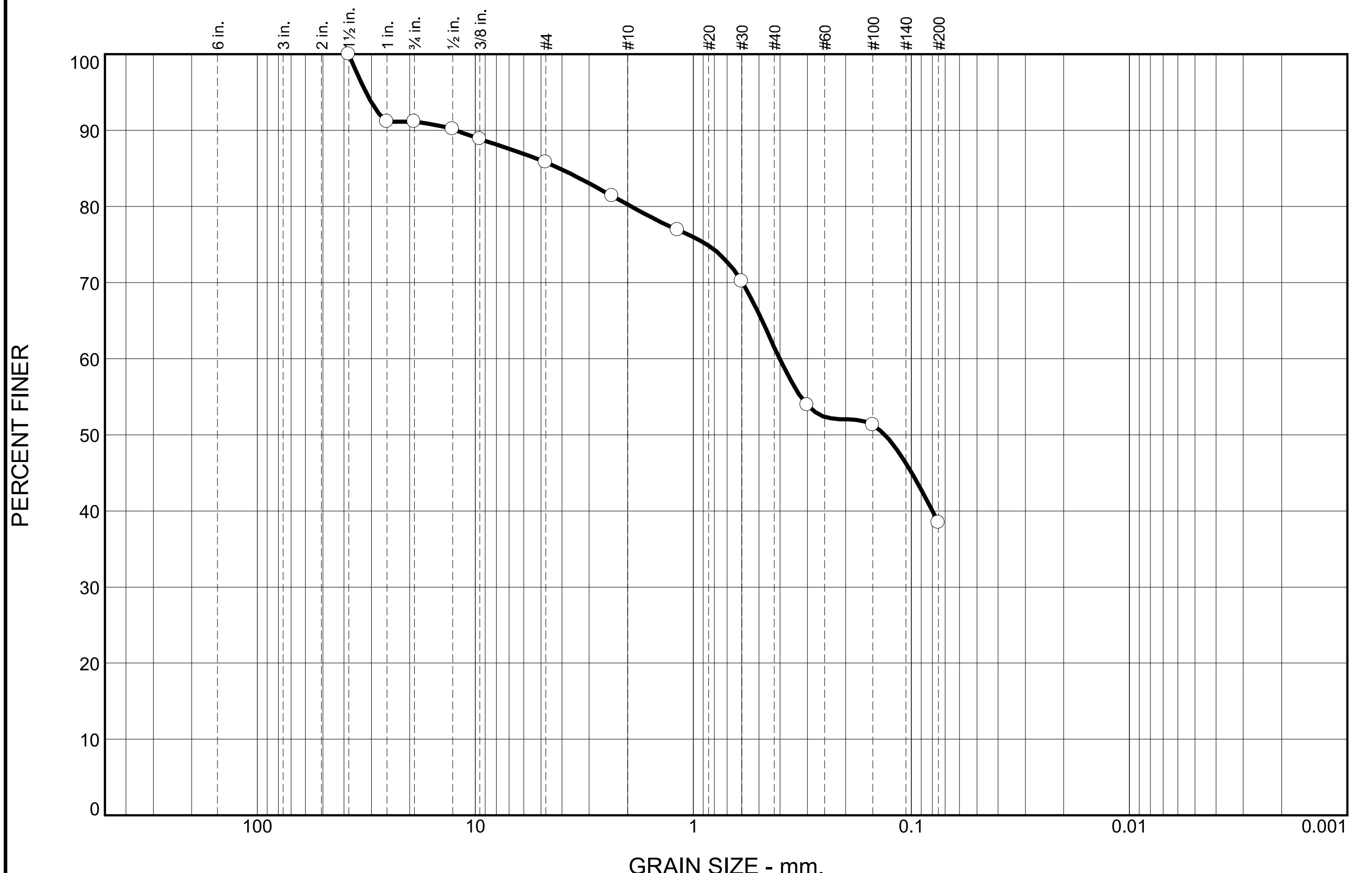
Remarks:

○Unable to make exact classification without ASTM- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	8.9	5.3	5.6	18.7	23.0	38.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			4.1102	0.4015	0.1322					

Material Description	USCS	AASHTO
○ SILTY GRAVEL (GM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-11 BK-02 **Depth:** 2.0-5.0 **Sample No.:** TP16-11 BK-02

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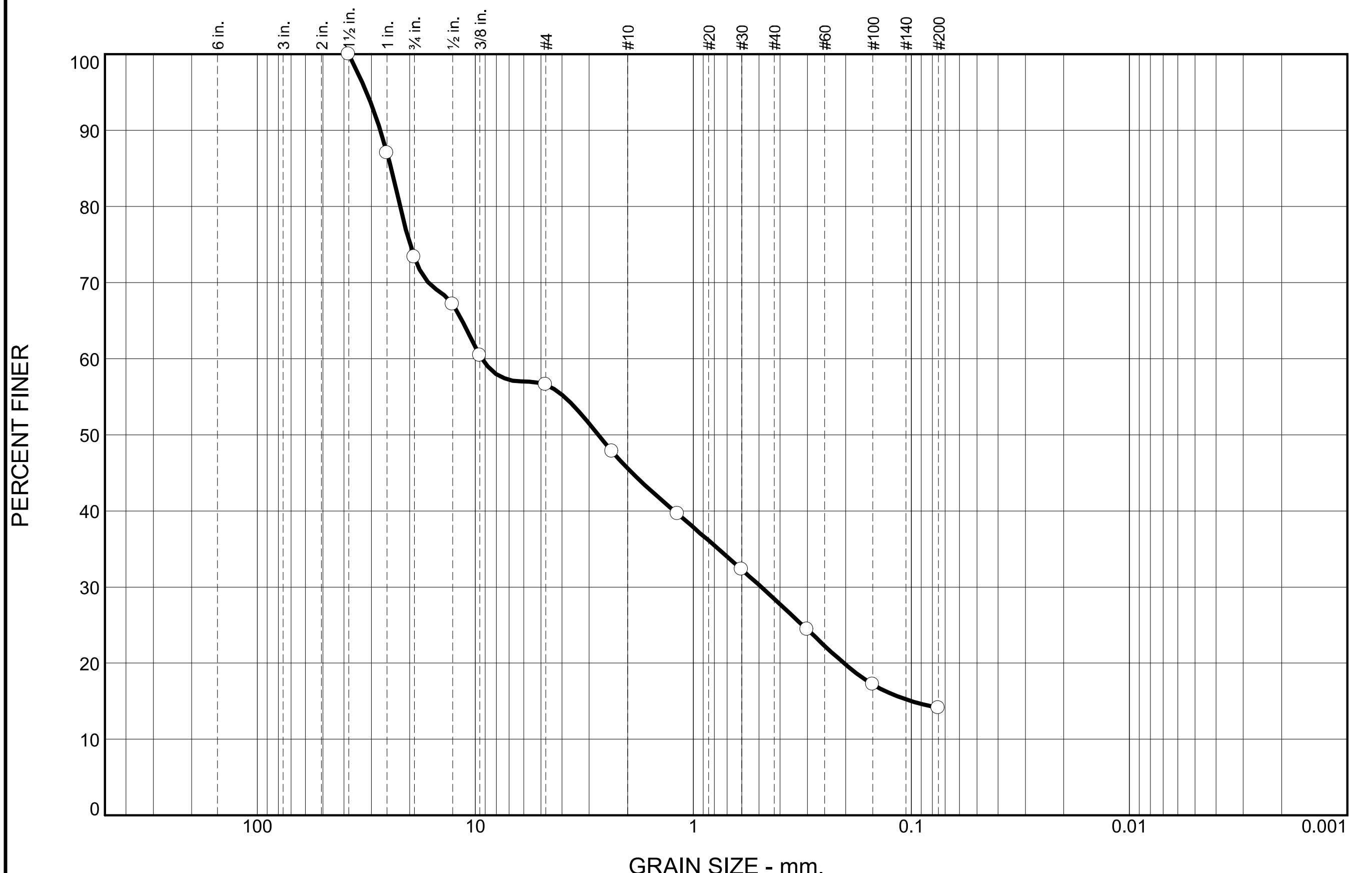
Remarks:

○Unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	26.7	16.7	11.0	17.2	14.3	14.1	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			24.3713	9.3243	2.7313	0.4883	0.0995			

Material Description	USCS	AASHTO
○ SANDY GRAVEL (GM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-11 BK-03 **Depth:** 5.0-7.0 **Sample No.:** TP16-11 BK-03

Remarks:

○Unable to make exact classification without ASTM D4318-Atterberg testing.

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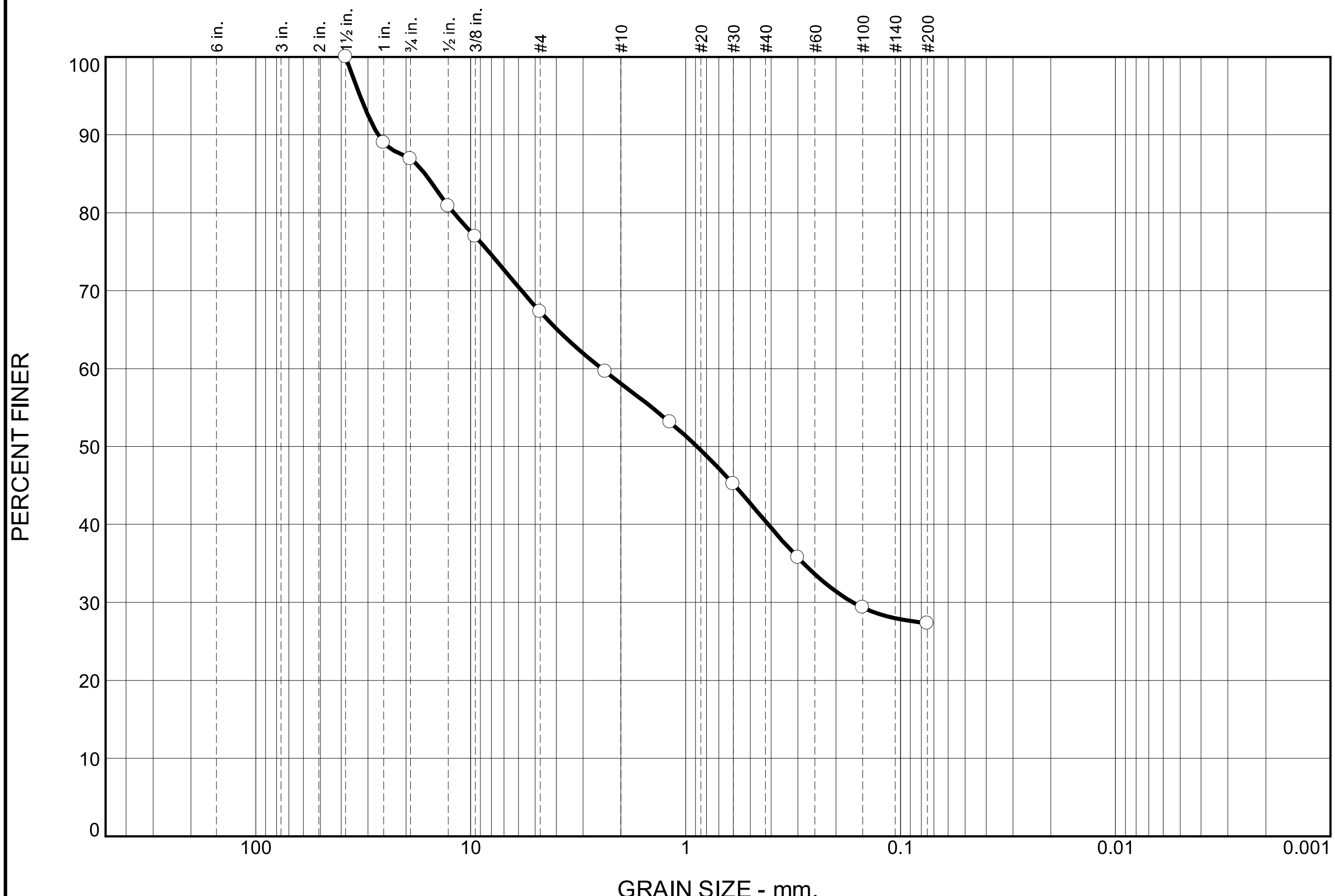
Figure

Tested By: MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	13.1	19.6	9.2	17.7	13.1	27.3	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		16.3110	2.4545	0.8844	0.1668				

Material Description	USCS	AASHTO
SAND WITH GRAVEL AND FINES (GM-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

Source: TP16-12 BK-02 **Depth:** 2.0-4.0 **Sample No.:** TP16-12 BK-02

ATL-CMT

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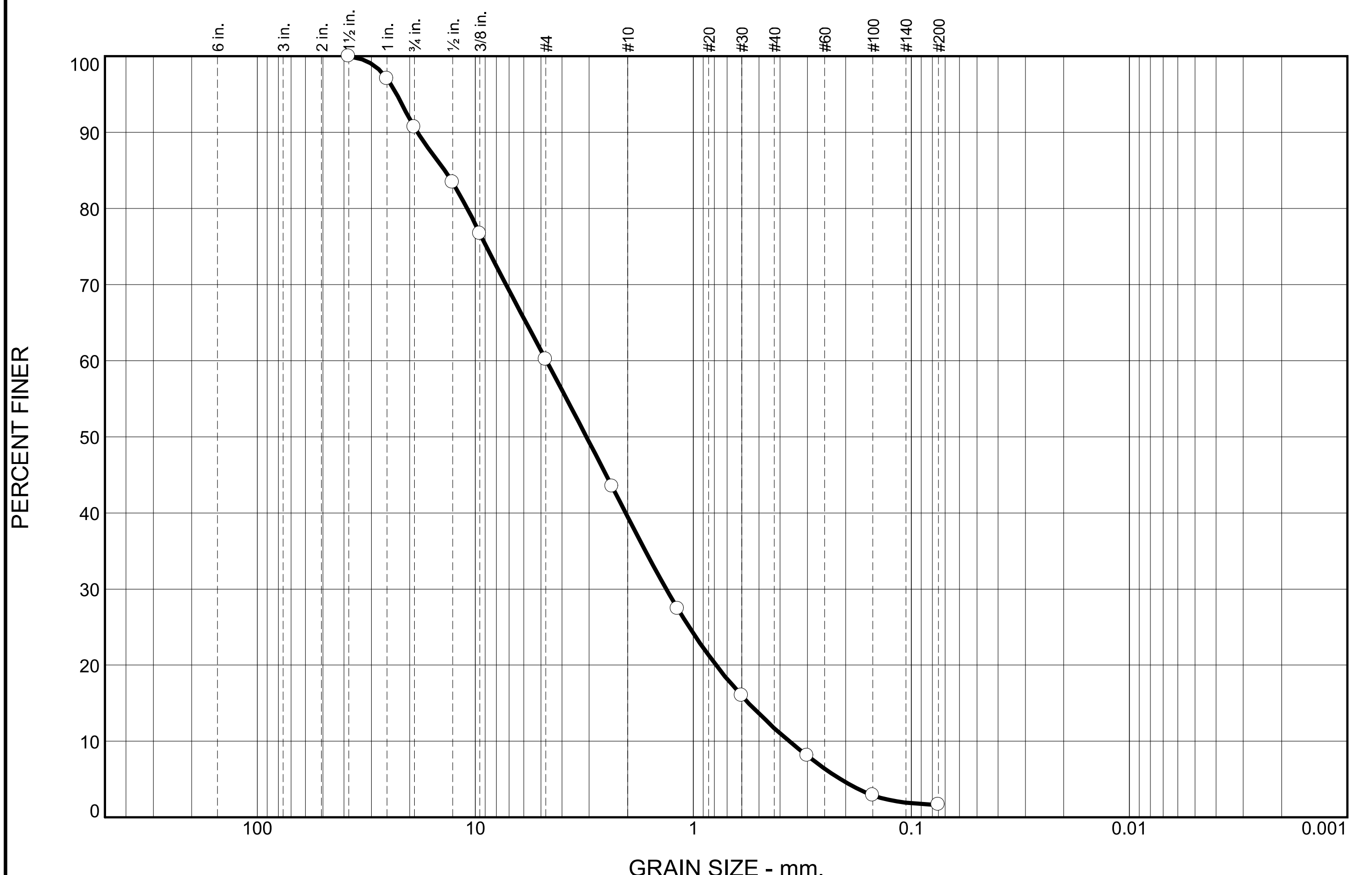
Remarks:

Unable to make exact classification without ASTM D4318 testing.

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	9.3	30.6	20.6	27.8	10.0	1.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			13.8151	4.7206	3.0944	1.3330	0.5570	0.3627	1.04	13.01

	Material Description	USCS	AASHTO
○	GRAVELY SAND	SW	

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-12 BK-03 **Depth:** 4.0-6.0 **Sample No.:** TP16-12 BK-03

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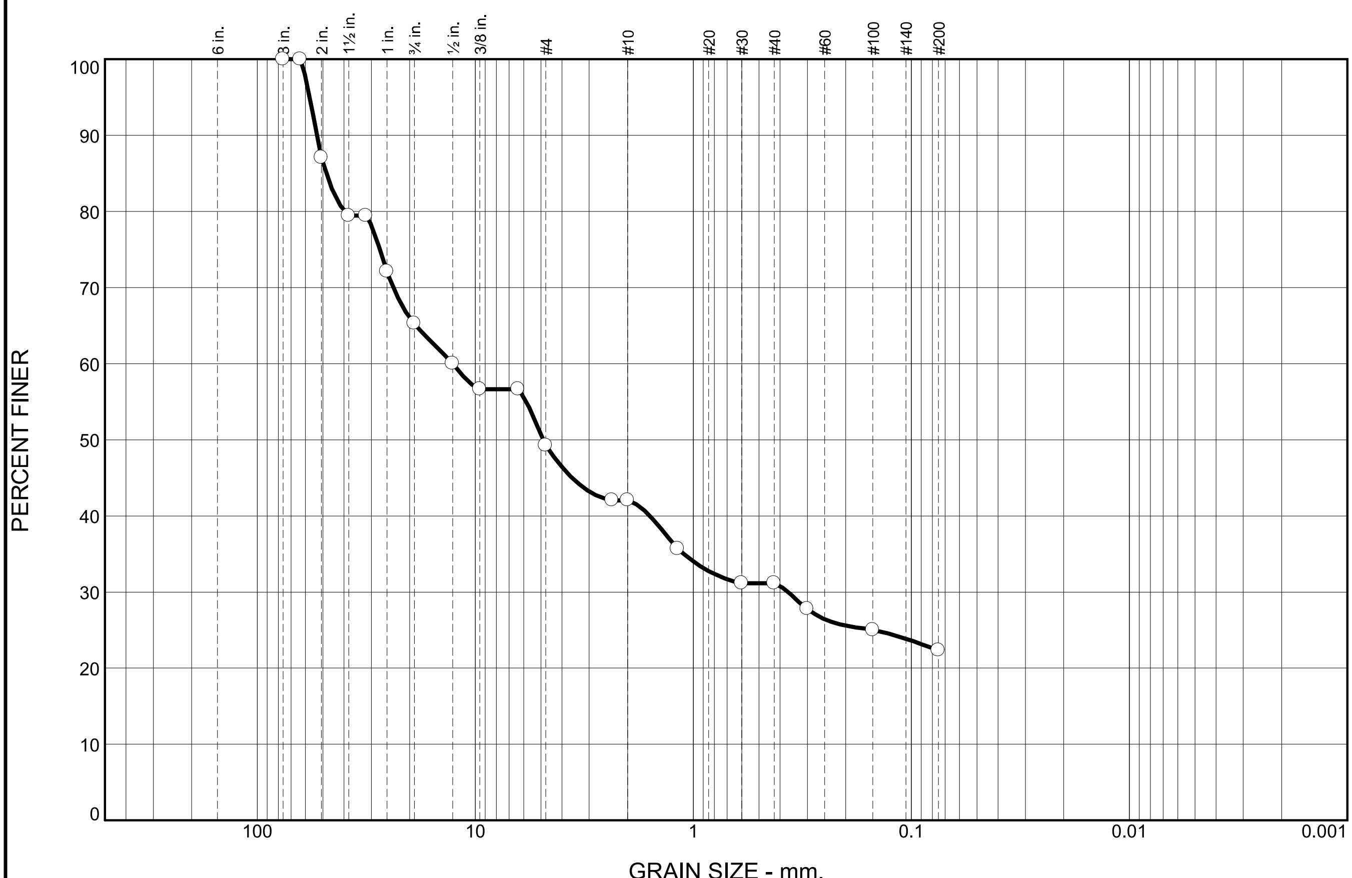
Remarks:

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	34.7	16.1	7.1	10.9	8.9	22.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			48.2043	12.6951	4.8820	0.3682				

Material Description	USCS	AASHTO
○ GRAVEL WITH SAND AND FINES (GM-SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-13 BK-02 **Depth:** 1.5-6.0 **Sample No.:** TP16-13 BK-02

Remarks:
○Unable to make exact classification without ASTM D4318- Atterberg testing.

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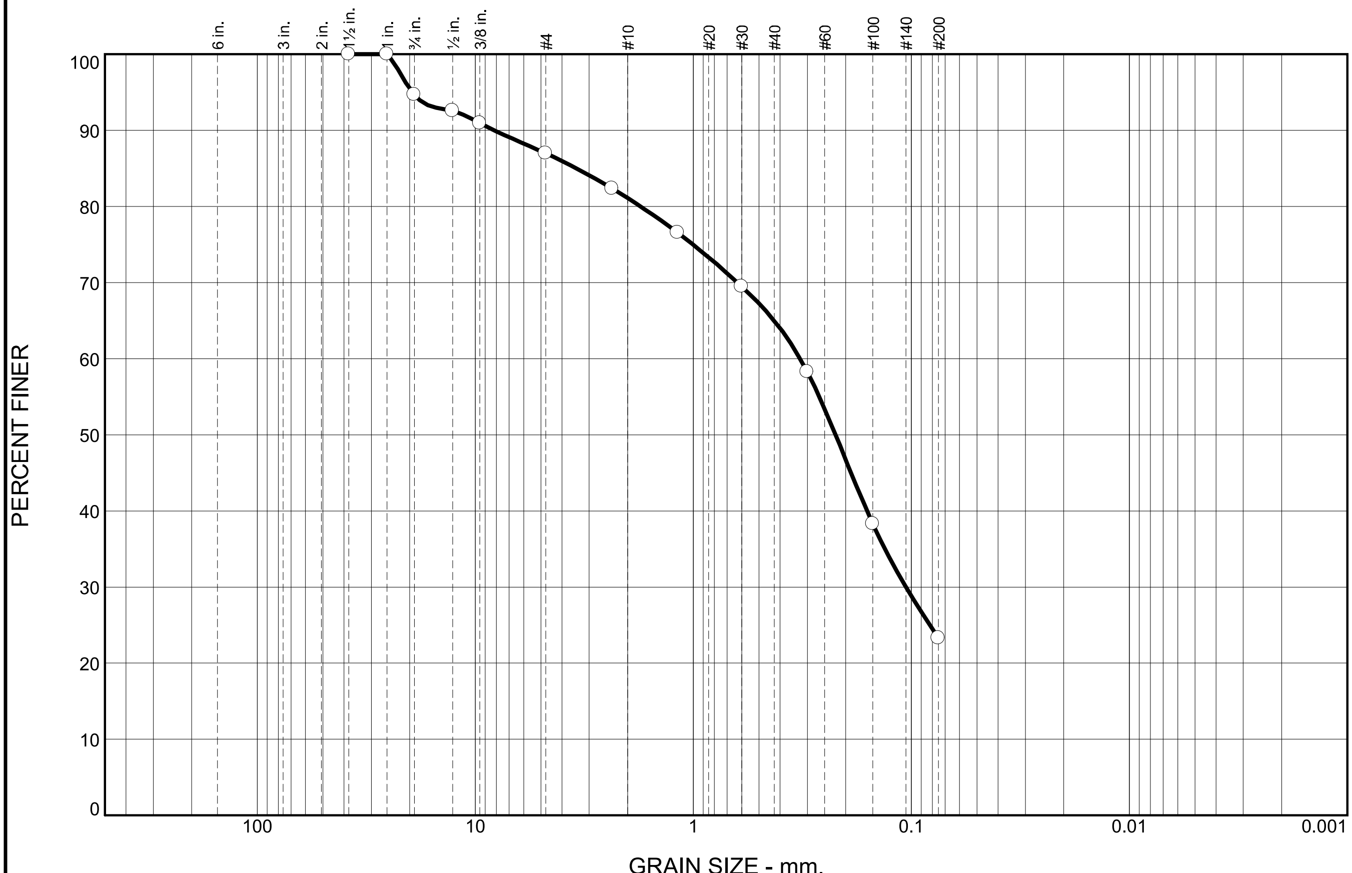
Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	5.3	7.7	5.9	16.1	41.7	23.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			3.4414	0.3238	0.2227	0.1057				

Material Description	USCS	AASHTO
○ SAND WITH FINES (SM)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-14 BK-02 **Depth:** 2.0-4.5 **Sample No.:** TP16-14 BK-02

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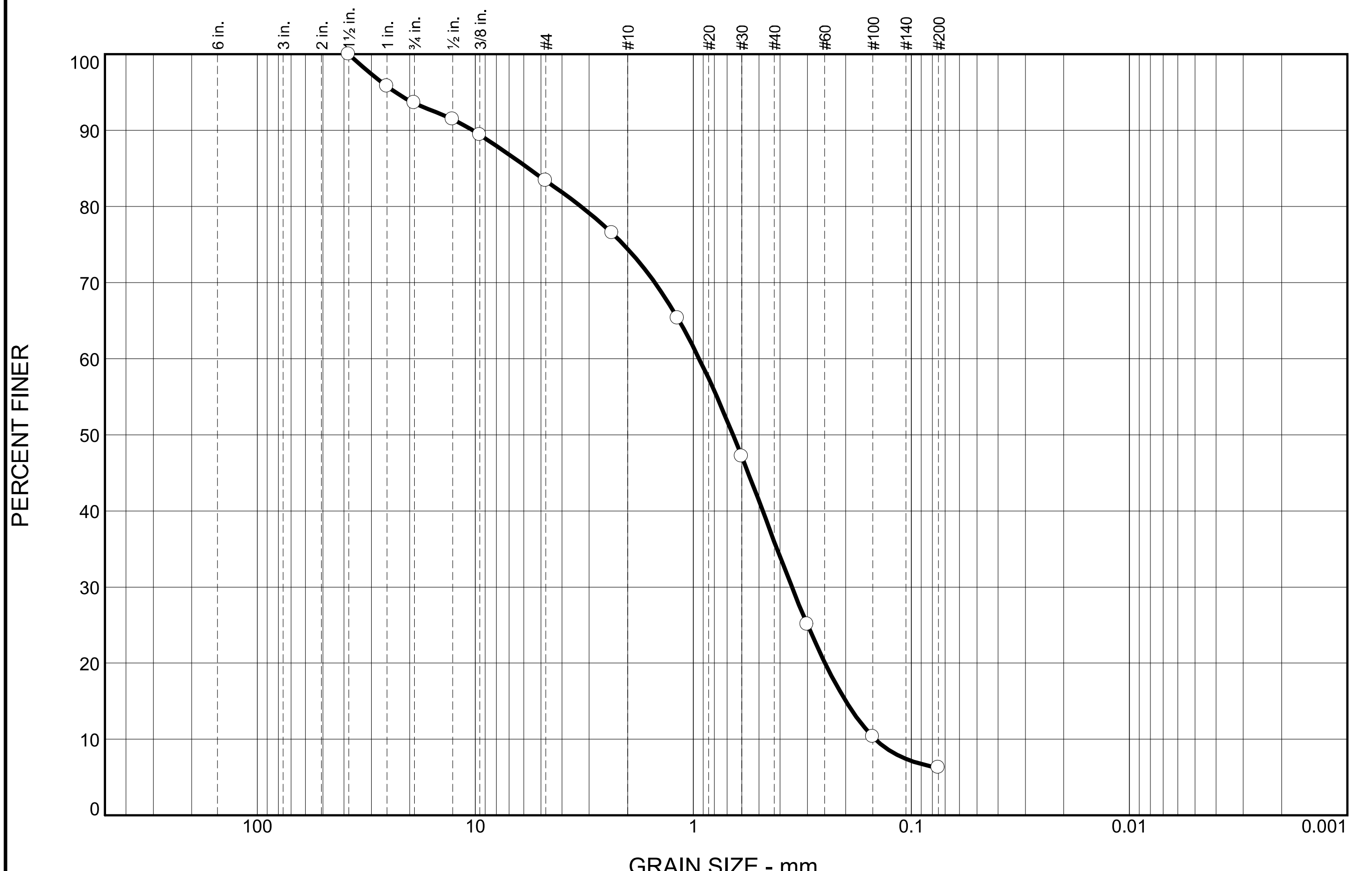
Remarks:

○Unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	6.4	10.2	9.0	38.4	29.8	6.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			5.6955	0.9402	0.6573	0.3531	0.1995	0.1461	0.91	6.44

Material Description	USCS	AASHTO
○ SAND WITH GRAVEL (SM-GW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-14 BK-03 **Depth:** 4.5-6.0 **Sample No.:** TP16-14 BK-03

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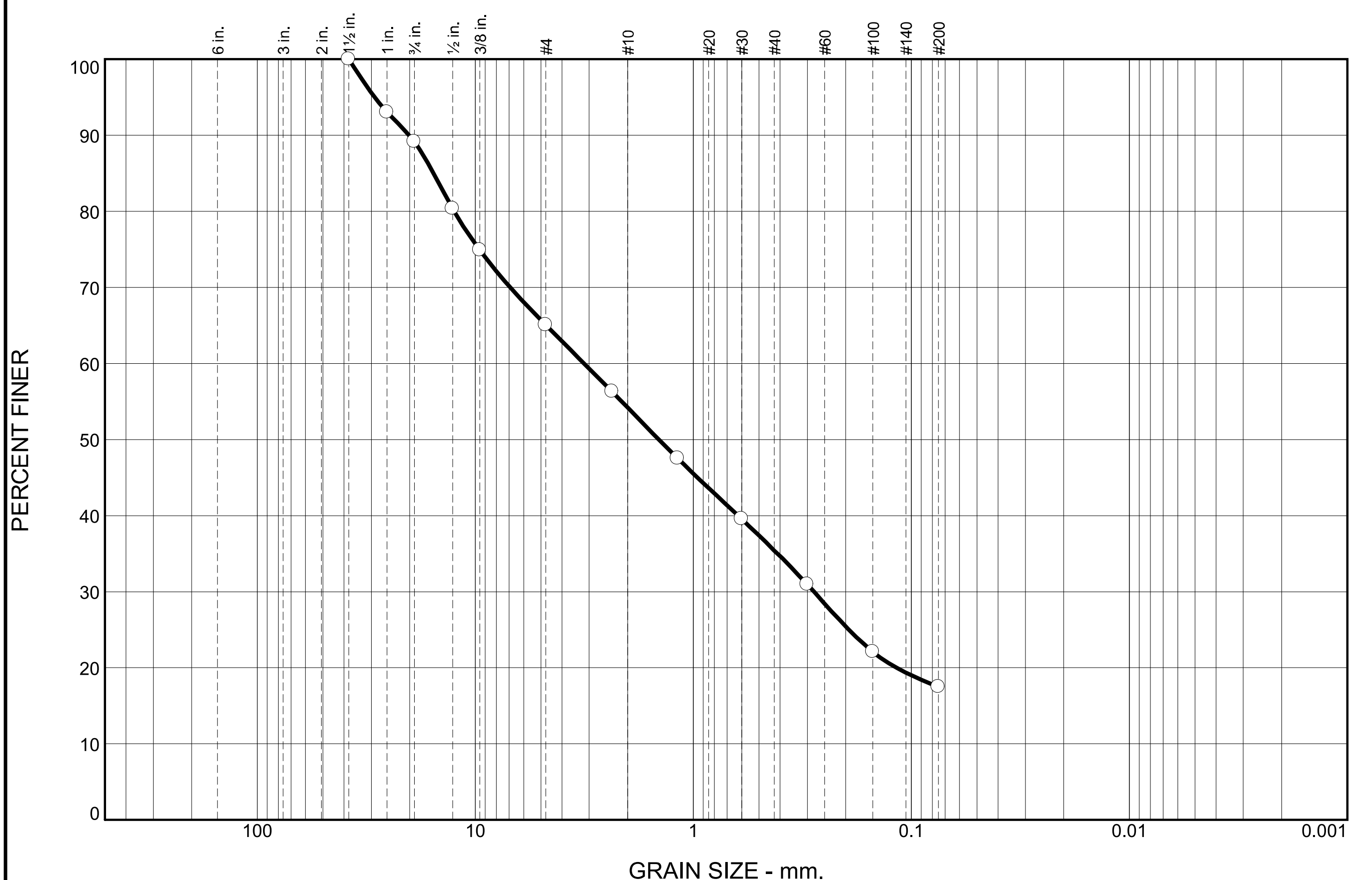
Remarks:

○Unable to make exact classification without ASTM D4318- Atterberg testing.

Figure

Tested By: MC

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	10.8	24.1	10.9	18.8	17.9	17.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			15.5444	3.1716	1.4397	0.2800				

Material Description	USCS	AASHTO
○ SANDY GRAVEL (SM-GW)		

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○ **Source:** TP16-14 BK-04 **Depth:** 6.0-10.0 **Sample No.:** TP16-14 BK-04

ATL-CMT

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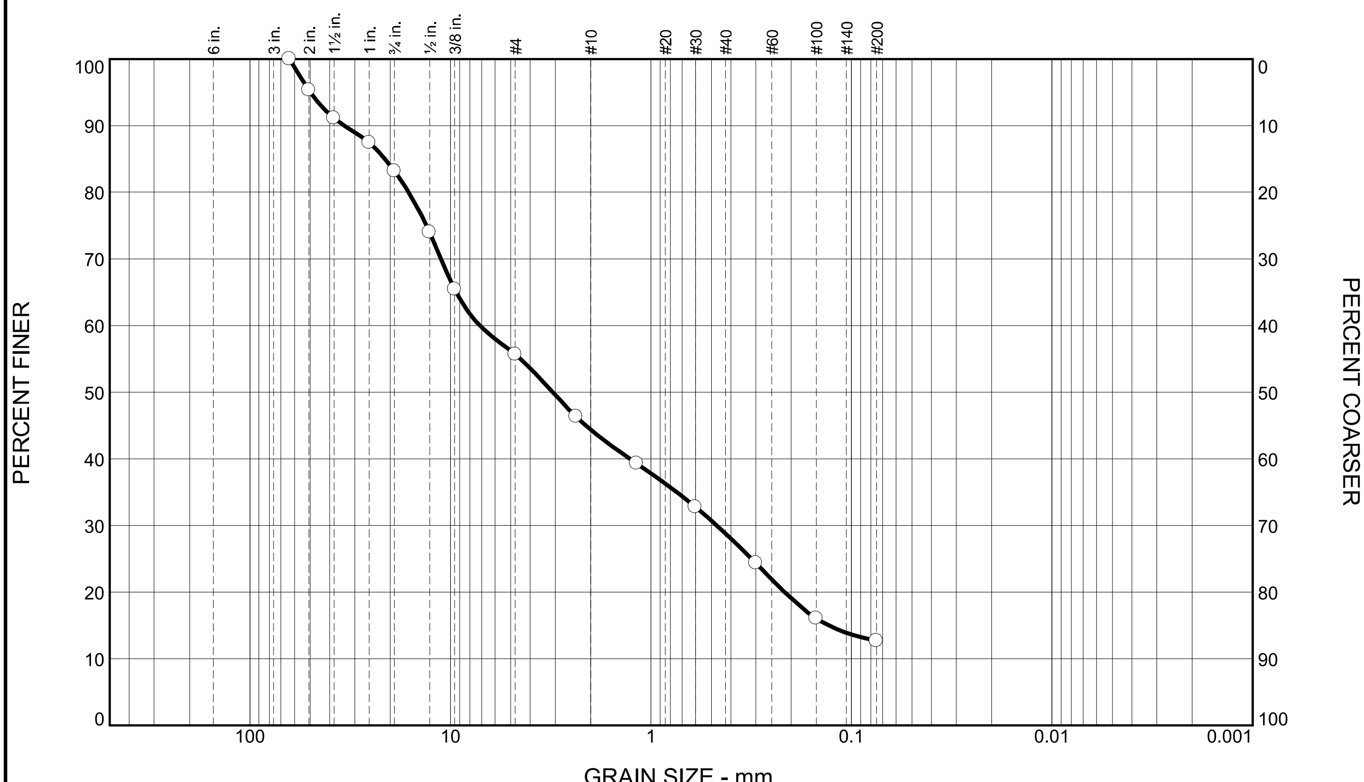
Remarks:

○Unable to make exact classification without ASTM D 4318- Atterberg teting.

Figure

Tested By: MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	16.8	27.5	11.3	15.6	16.1	12.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2.5"	100.0		
2"	95.3		
1.5	91.1		
1	87.4		
3/4"	83.2		
1/2"	74.0		
3/8"	65.4		
#4	55.7		
#8	46.3		
#16	39.3		
#30	32.8		
#50	24.4		
#100	16.1		
#200	12.7		

* (no specification provided)

Material Description

GP-GM

Atterberg Limits

PL= NP LL= NV PI= NP

Classification

USCS= GM AASHTO= A-1-a

Remarks

Source of Sample: TP 16-19 **Depth:** 8'
Sample Number: TP16-19 #4 **Date:** 4-21-17

ATL-CMT
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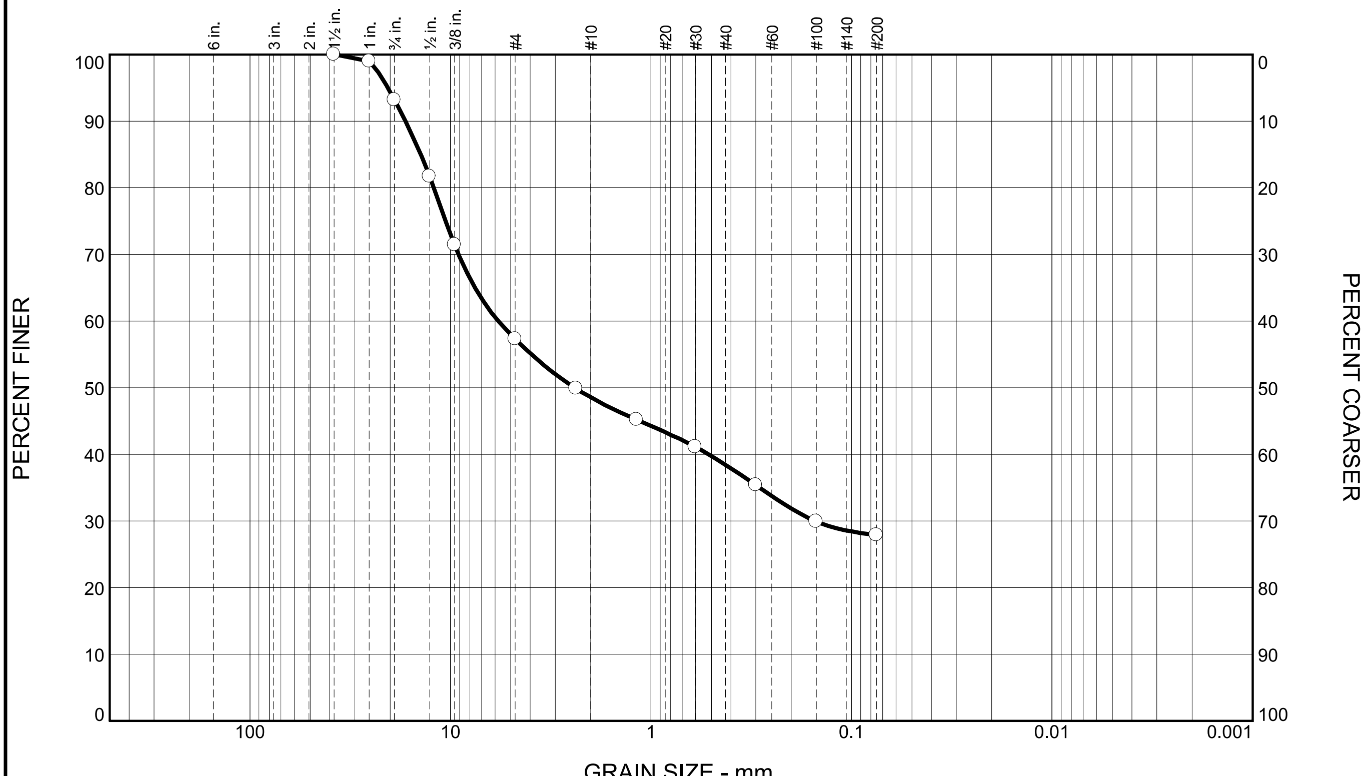
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Tested By: MC / HS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.8	35.9	8.7	10.2	10.5	27.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	99.0		
3/4"	93.2		
1/2"	81.7		
3/8"	71.4		
#4	57.3		
#8	49.9		
#16	45.2		
#30	41.1		
#50	35.4		
#100	29.9		
#200	27.9		

* (no specification provided)

Material Description

GM

Atterberg Limits

PL= NP LL= NV PI= NP

Classification

USCS= GM AASHTO= A-2-4(0)

Remarks

Source of Sample: TP16-22 **Depth:** 8'
Sample Number: TP16-22 #3

Date: 4-21-17

ATL-CMT
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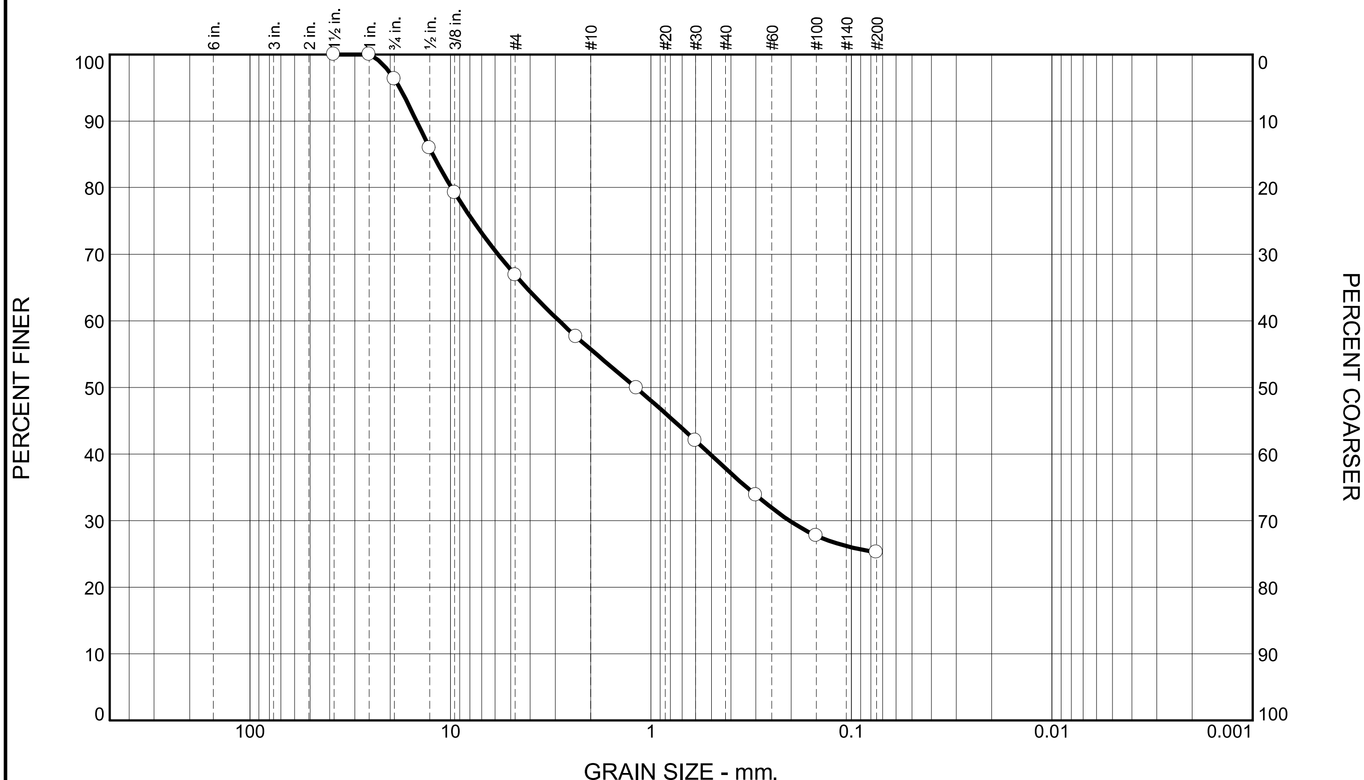
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Tested By: MC / HS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.7	29.4	11.2	17.8	12.7	25.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	100.0		
3/4"	96.3		
1/2"	85.9		
3/8"	79.2		
#4	66.9		
#8	57.6		
#16	49.9		
#30	42.0		
#50	33.8		
#100	27.7		
#200	25.2		

* (no specification provided)

Material Description

GM

Atterberg Limits

PL= NP LL= NV PI= NP

Classification

USCS= SM AASHTO= A-1-b

Remarks

Source of Sample: TP16-23 **Depth:** 4'
Sample Number: TP16-23 #2

Date: 4-21-17

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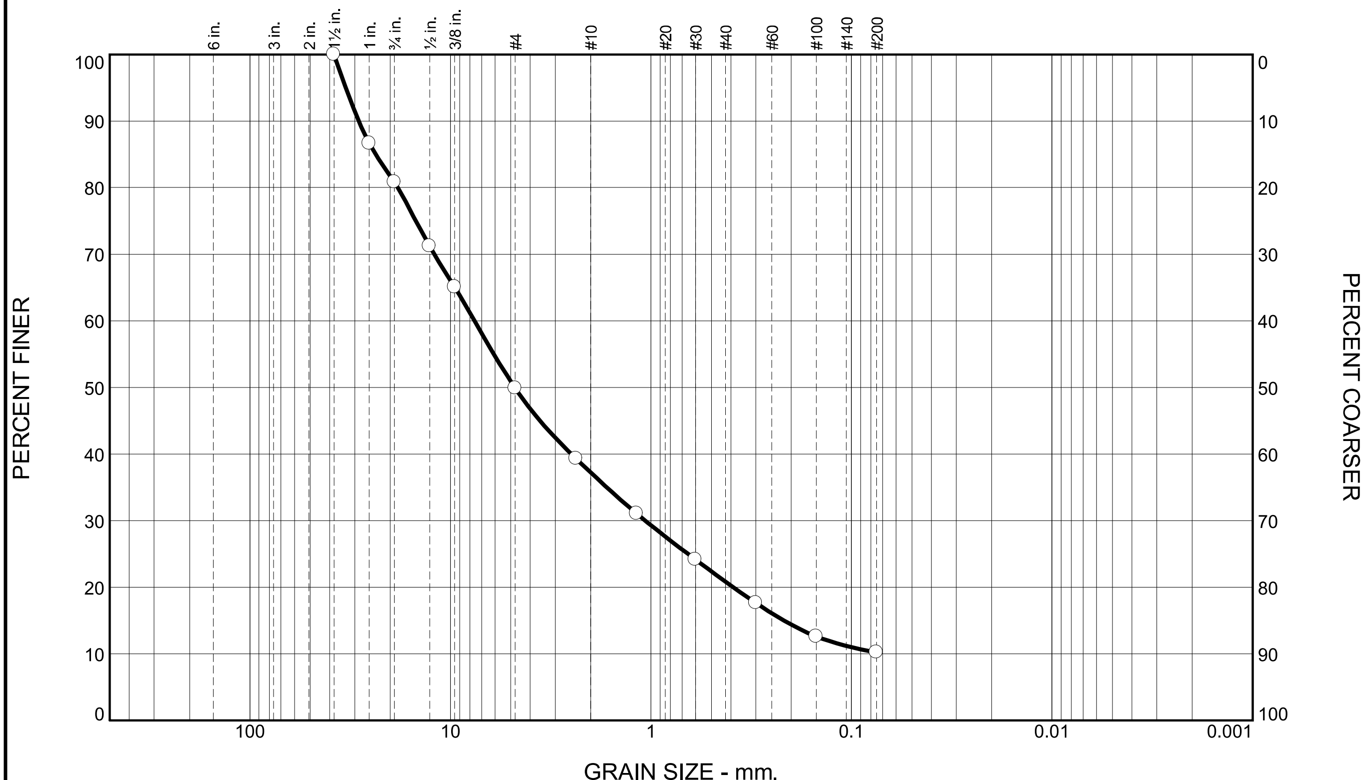
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Tested By: HS / MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	19.2	30.9	12.7	16.4	10.6	10.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	86.6		
3/4"	80.8		
1/2"	71.2		
3/8"	65.1		
#4	49.9		
#8	39.3		
#16	31.1		
#30	24.2		
#50	17.7		
#100	12.6		
#200	10.2		

* (no specification provided)

Material Description

GP-GM

Atterberg Limits

PL= NP LL= NV PI= NP

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Source of Sample: TP16-25 **Depth:** 7'
Sample Number: TP16-25 #3

Date: 4-21-17

ATL-CMT
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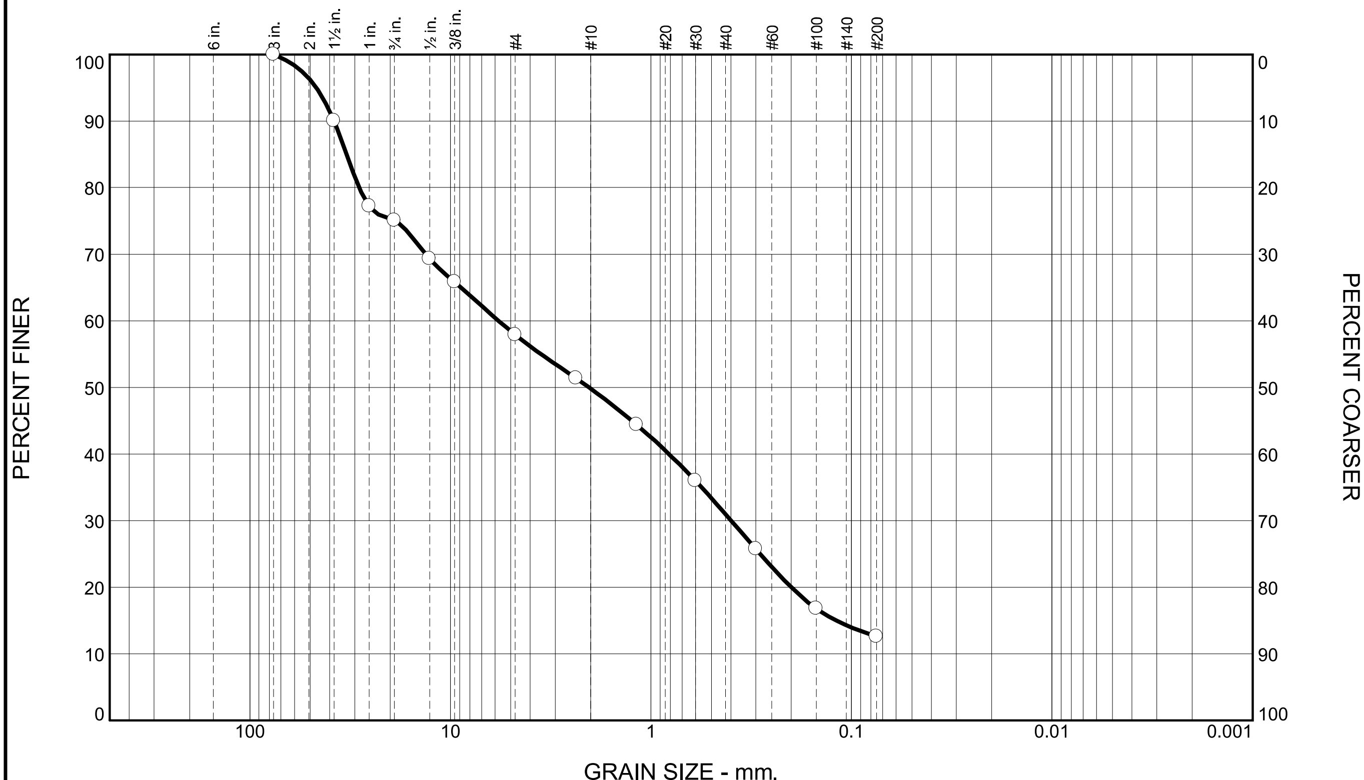
Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Tested By: HS / MC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	24.9	17.2	8.1	18.8	18.4	12.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3"	100.0		
1.5	90.0		
1	77.2		
3/4"	75.1		
1/2"	69.3		
3/8"	65.8		
#4	57.9		
#8	51.4		
#16	44.4		
#30	36.0		
#50	25.7		
#100	16.8		
#200	12.6		

* (no specification provided)

Material Description

GM

Atterberg Limits

PL= NP LL= NV PI= NP

Classification

USCS= SM AASHTO= A-1-b

Remarks

Source of Sample: TP16-27 **Depth:** 5'
Sample Number: TP16-27 #2

Date: 4-21-17

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Client: Resolution Copper Mining
Project: Resolution Near West Site Investigation

Project No: 506 **Figure**

Tested By: HS / MC

ATL - CMT
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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer:	Resolution Copper Mining	Lab No.:	10632
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Various	Test Method:	ASTM X AASHTO
Material Source:	TP16-01 BK-01	Date:	1/9/2017
Sample Location:	0-2.0 ft.	Tested By:	MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
	0.0	0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	0.0	0.0%	0.0%	100.0%	
4	12.1	7.4%	7.4%	92.6%	
8	32.7	20.1%	27.5%	72.5%	
10	17.5	10.7%	38.3%	61.7%	
Sum +#10	62.3	38.3%	38.3%	61.7%	
16	17.4	10.7%	49.0%	51.0%	
30	25.3	15.5%	64.5%	35.5%	
40	7.9	4.9%	69.3%	30.7%	
50	5.3	3.3%	72.6%	27.4%	
100	9.8	6.0%	78.6%	21.4%	
200	8.7	5.3%	84.0%	16.0%	
- 200 S.O.	26.1	16.0%	100.0%	0.0%	
Sum - #10	100.5	61.7%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	9:20	69	1033
5	9:25	70	1031
15	9:35	70	1028
30	10:05	70	1026
60	10:20	70	1025
250	1:20	70	1023
1440	7:00	70	1018

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	20.90	-
Hydroscopic "Wet" Weight	38.16	17.26
Dry Weight	37.41	16.51
% Moisture	4.5	-

Total Sample	
Plus #10 Weight	62.3
Minus #10 Weight	100.5
Total	162.8

Remarks:

ATL - CMT

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Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer:	Resolution Copper Mining	Lab No.:	10632
Project Name:	Resolution Near West Site Inv.	Project No.:	506
Material Type:	Various	Test Method:	ASTM X AASHTO
Material Source:	TP16-05 BK-01	Date:	1/9/2017
Sample Location:	0-1.0 ft.	Tested By:	MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
	0.0	0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	0.0	0.0%	0.0%	100.0%	
4	0.4	0.4%	0.4%	99.6%	
8	32.2	30.1%	30.5%	69.5%	
10	25.8	24.2%	54.7%	45.3%	
Sum +#10	58.4	54.7%	54.7%	45.3%	

16	8.5	8.0%	62.6%	37.4%	
30	16.6	15.5%	78.2%	21.8%	
40	5.3	5.0%	83.1%	16.9%	
50	3.0	2.8%	86.0%	14.0%	
100	4.3	4.0%	90.0%	10.0%	
200	3.7	3.5%	93.4%	6.6%	
- 200 S.O.	7.0	6.6%	100.0%	0.0%	
Sum - #10	48.4	45.3%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	8:15	71	1033
5	8:20	71	1031
15	8:35	70	1028
30	8:45	70	1026
60	9:15	70	1025
250	12:15	71	1023
1440	8:15	68	1018

Hydroscopic Moisture		W/O Pan
Pan Tare Weight	20.75	-
Hydroscopic "Wet" Weight	34.51	13.76
Dry Weight	33.99	13.24
% Moisture	3.9	-

Total Sample	
Plus #10 Weight	58.4
Minus #10 Weight	48.4
Total	106.8

Remarks:

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Geotechnical • Environmental • Civil • Inspections

Particle-Size Analysis of Soils, ASTM D422 or AASHTO T88

Customer: Resolution Copper Mining
Lab No.: 10632
Project Name: Resolution Near West Site Inv.
Project No.: 506
Material Type: Various
Test Method: ASTM X AASHTO
Material Source: TP16-09 BK-01
Date: 1/9/2017
Sample Location: 0-1.0 ft.
Tested By: MC

Sieve Size	Mass Retained	Individual % Ret	Cumulative % Ret	Cumulative % Pass	Spec. % Pass
		0.0%	0.0%	100.0%	
	0.0	0.0%	0.0%	100.0%	
1"	0.0	0.0%	0.0%	100.0%	
3/4"	0.0	0.0%	0.0%	100.0%	
1/2"	0.0	0.0%	0.0%	100.0%	
3/8"	0.0	0.0%	0.0%	100.0%	
4	0.0	0.0%	0.0%	100.0%	
8	58.4	30.2%	30.2%	69.8%	
10	28.5	14.8%	45.0%	55.0%	
Sum +#10	86.9	45.0%	45.0%	55.0%	

16	24.1	12.5%	57.5%	42.5%	
30	25.5	13.2%	70.7%	29.3%	
40	14.4	7.5%	78.1%	21.9%	
50	9.8	5.1%	83.2%	16.8%	
100	15.4	8.0%	91.1%	8.9%	
200	8.0	4.1%	95.3%	4.7%	
- 200 S.O.	9.1	4.7%	100.0%	0.0%	
Sum - #10	106.3	55.0%	100.0%	0.0%	

Elapsed Time (min)	Time	Temp	Reading
2	9:24	70	1033
5	9:29	70	1031
15	9:45	70	1028
30	9:55	70	1026
60	10:30	70	1025
250	1:25	70	1023
1440	7:00	70	1018

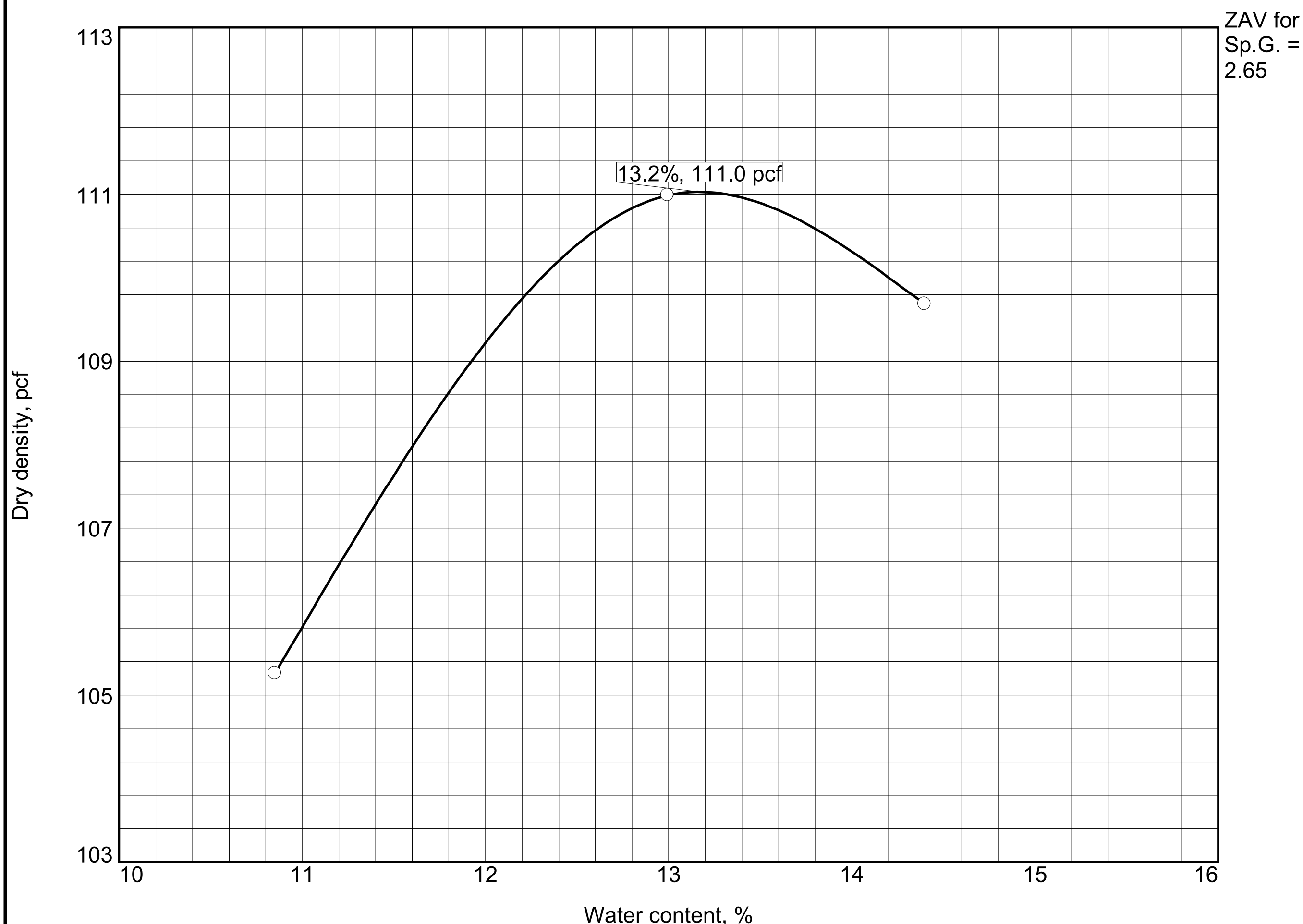
Hydroscopic Moisture		W/O Pan
Pan Tare Weight	21.17	-
Hydroscopic "Wet" Weight	38.72	17.55
Dry Weight	38.29	17.12
% Moisture	2.5	-

Total Sample	
Plus #10 Weight	86.9
Minus #10 Weight	106.3
Total	193.2

Remarks:

Proctor Compaction

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
2.0-4.0	SM	A-2-4(0)	9.2	2.65	NV	NP	33.4	29.4

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 111.0 pcf Optimum moisture = 13.2 %	SANDY GRAVEL

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○**Source of Sample:** TP16-02 BK-02 **Sample Number:** TP16-02 BK-02

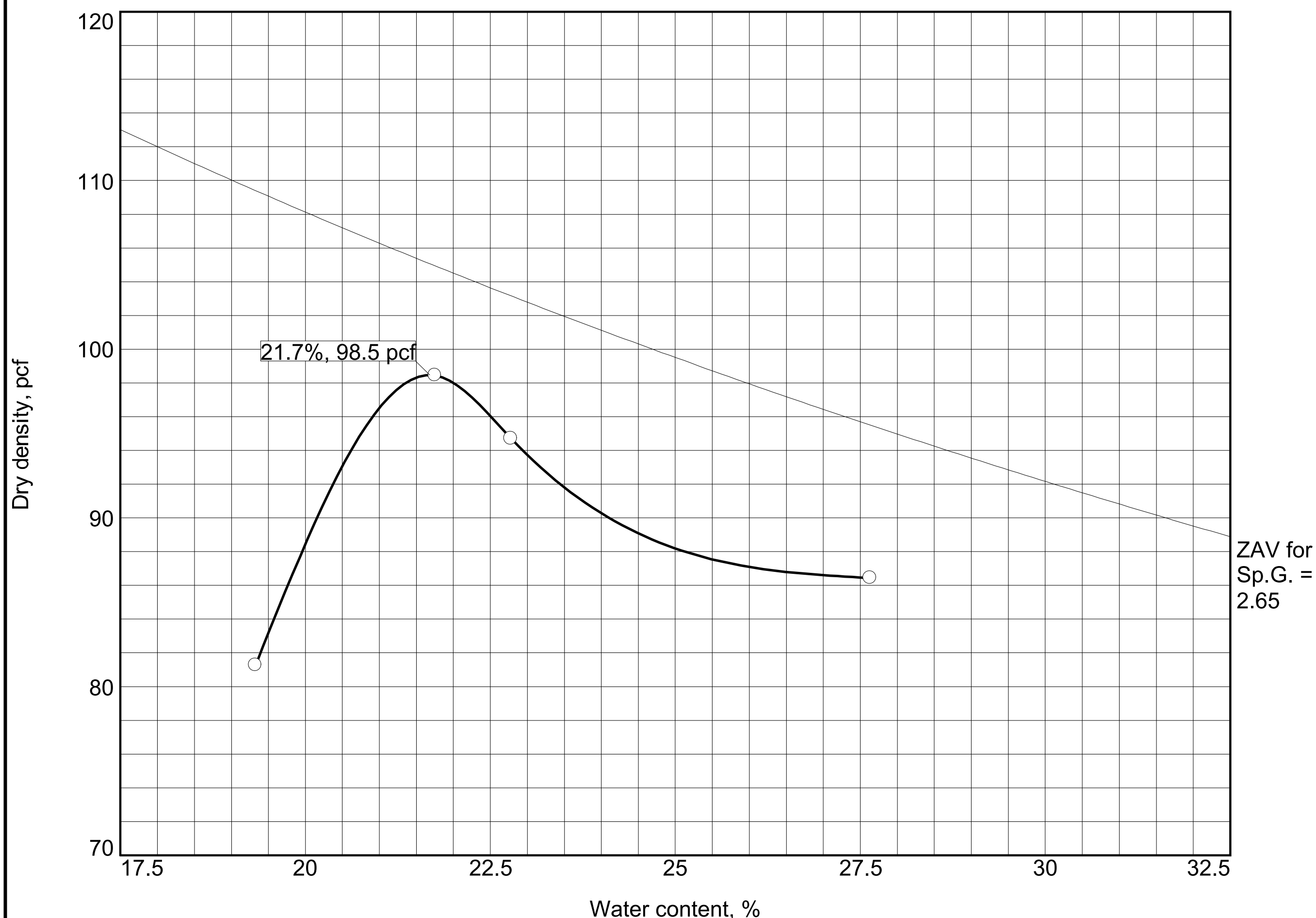
ATL-CMT
Geotechnical • Environmental • Civil • Inspections

Remarks:

Figure

Tested By: TM

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
2.0-4.0			8.4	2.65			0.1	31.6

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 98.5 pcf Optimum moisture = 21.7 %	SILTY SAND (SM)

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○**Source of Sample:** TP16-04 BK-02 **Sample Number:** TP16-04 BK-02

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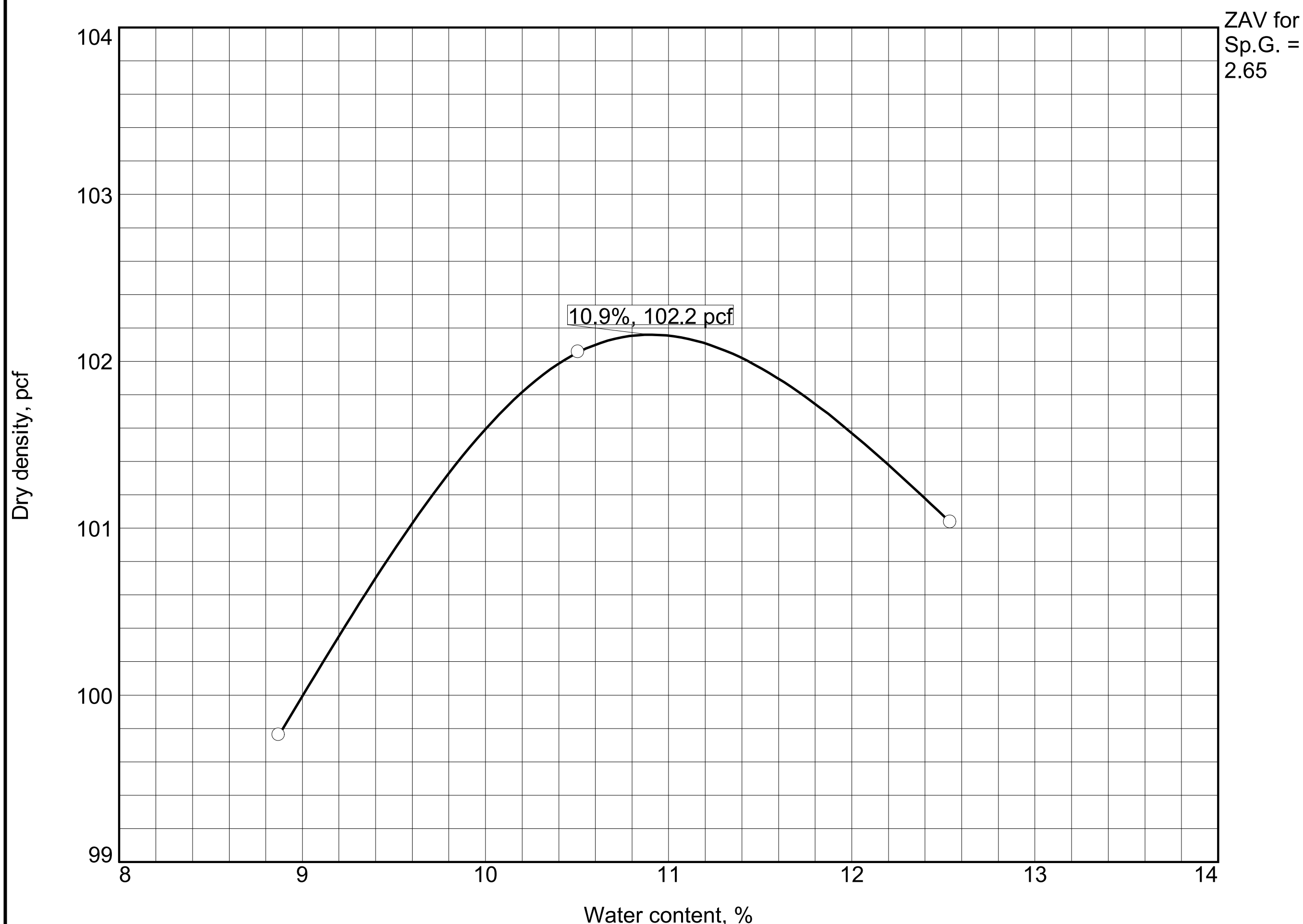
Remarks:

Figure

Tested By: TM

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
1.0-4.0	SM	A-1-b	5.3	2.65	NV	NP	23.1	17.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 102.2 pcf Optimum moisture = 10.9 %	GRAVELY SAND

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

Source of Sample: TP16-05 BK-02 **Sample Number:** TP16-05 BK-02

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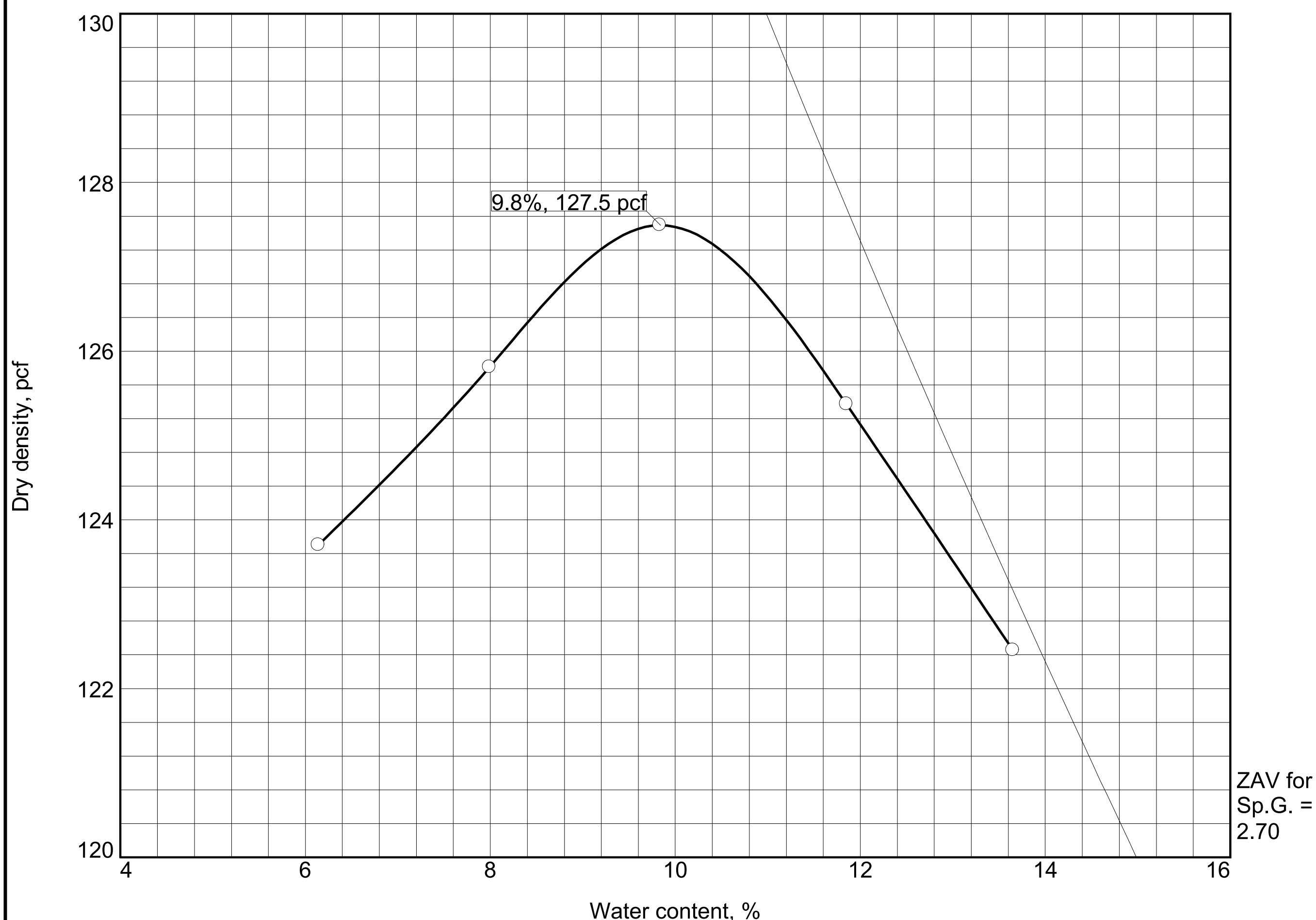
Remarks:

Figure

Tested By: TM

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
1.5-5.0			1.3	2.70			47.4	7.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 127.5 pcf Optimum moisture = 9.8 %	GRAVEL (GW)

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○**Source of Sample:** TP16-10 BK-02 **Sample Number:** TP16-10 BK-02

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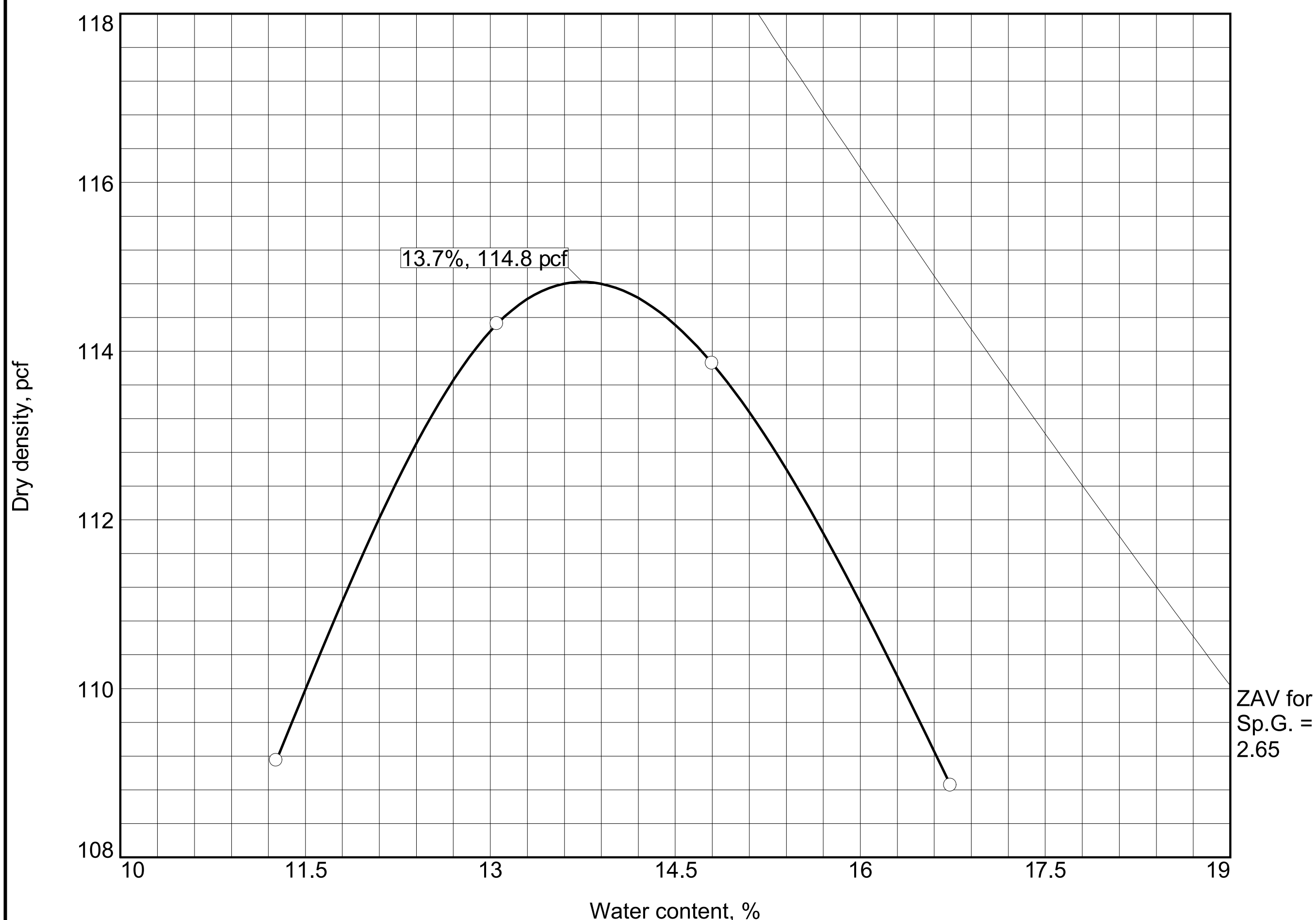
Remarks:

Figure

Tested By: TM

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
2.0-5.0			2.8	2.65			14.2	38.5

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 114.8 pcf Optimum moisture = 13.7 %	SILTY GRAVEL (GM)

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

Source of Sample: TP16-11 BK-02 **Sample Number:** TP16-11 BK-02

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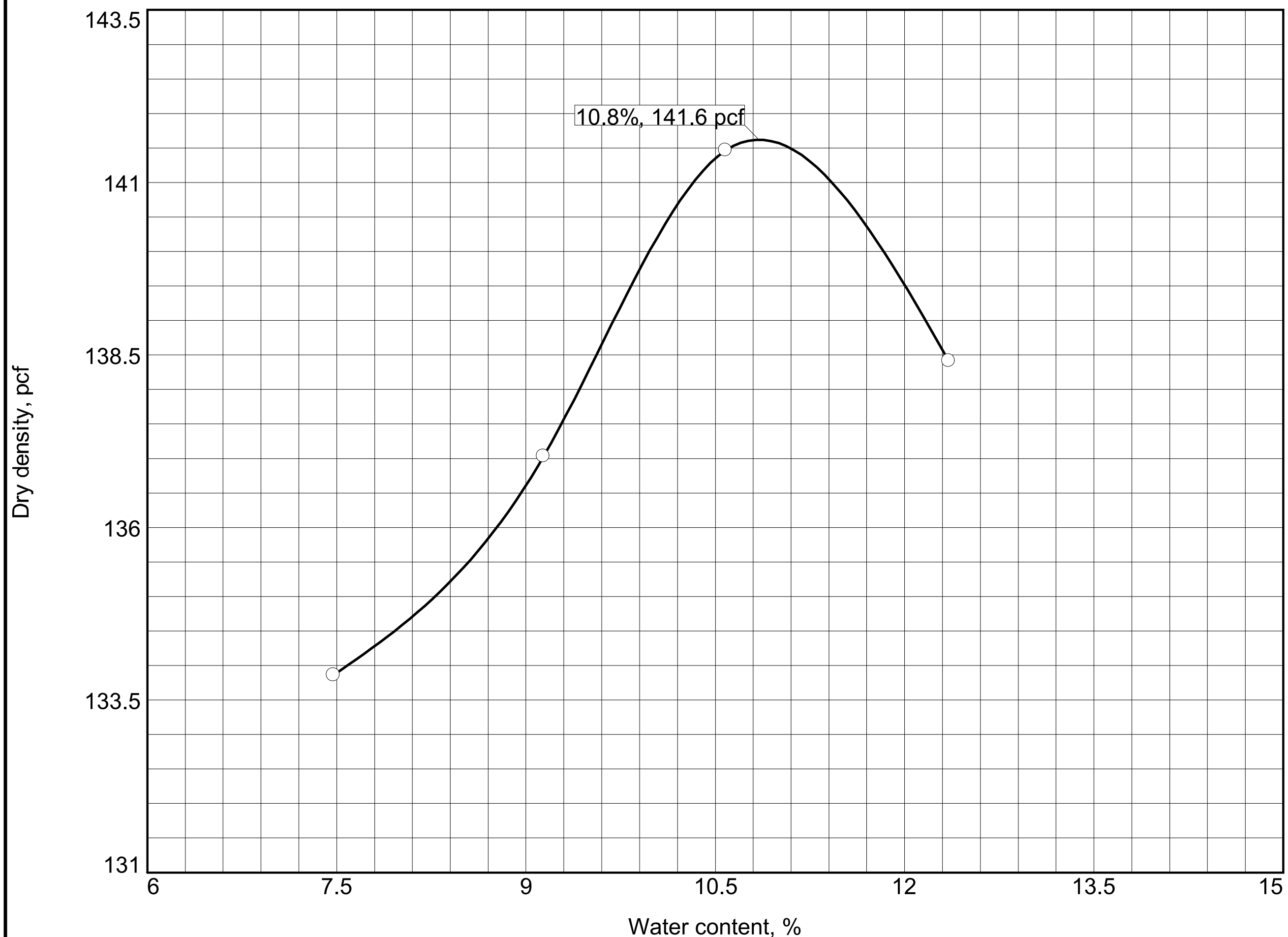
Remarks:

Figure

Tested By: TM

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
8'	GM	A-1-a	2.2		NV	NP	44.3	12.7

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 141.6 pcf Optimum moisture = 10.8 %	GP-GM

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○**Source of Sample:** TP 16-19 **Sample Number:** TP16-19 #4

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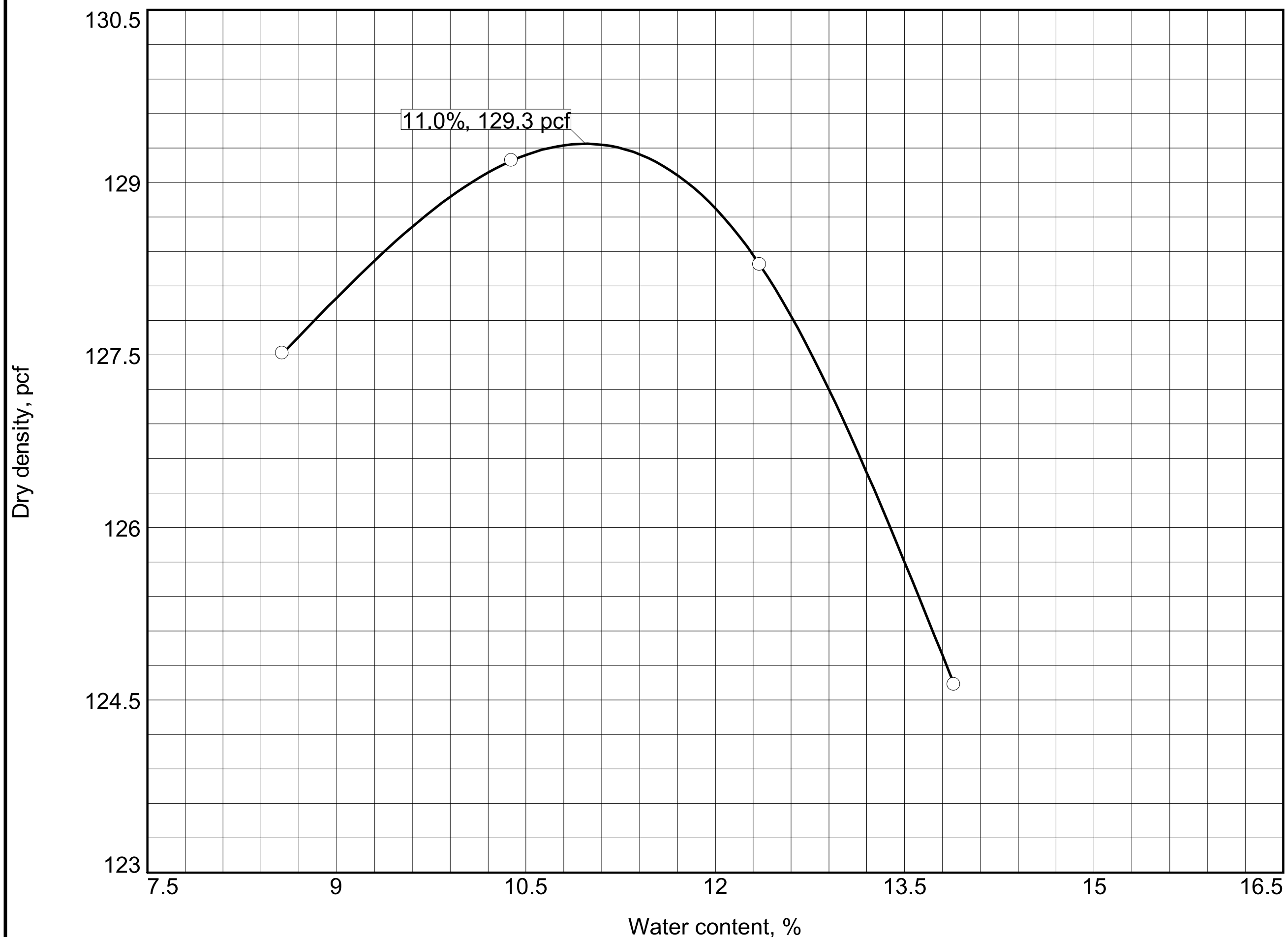
Remarks:

Figure

Tested By: HS

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
4'	SM	A-1-b	1.1		NV	NP	33.1	25.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 129.3 pcf Optimum moisture = 11.0 %	GM

Project No. 506 **Client:** Resolution Copper Mining
Project: Resolution Near West Site Investigation

○**Source of Sample:** TP16-23 **Sample Number:** TP16-23 #2

ATL - CMT
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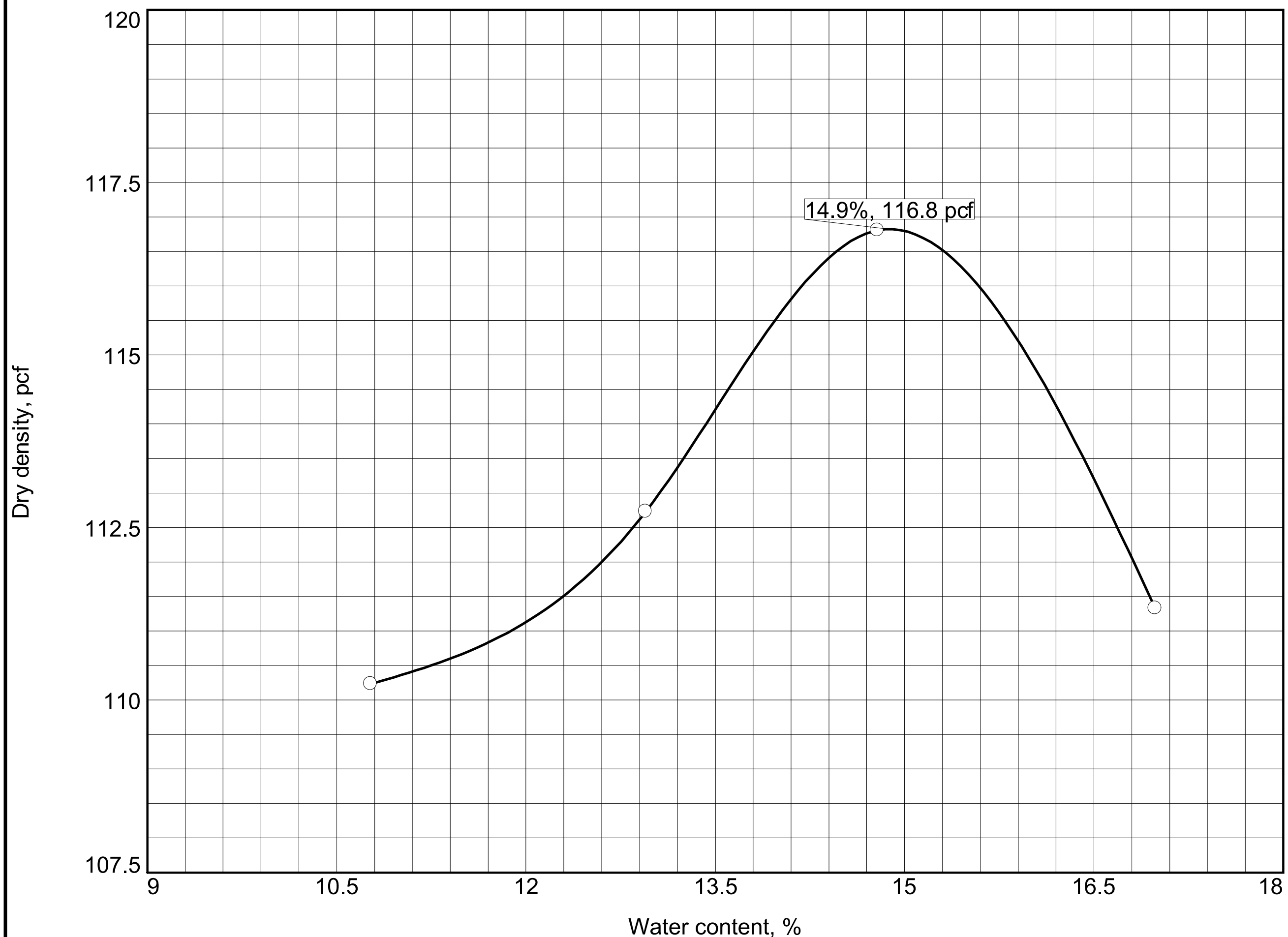
Remarks:

Figure

Tested By: HS / MC

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
7'	GP-GM	A-1-a	3.5		NV	NP	50.1	10.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 116.8 pcf Optimum moisture = 14.9 %	GP-GM

Project No. 506 **Client:** Resolution Copper Mining

Project: Resolution Near West Site Investigation

○**Source of Sample:** TP16-25 **Sample Number:** TP16-25 #3

ATL - CMT

Geotechnical • Environmental • Civil • Inspections

Remarks:

Figure

Tested By: HS / MC

Specific Gravity

ATL-CMT

Geotechnical • Environmental • Civil • Inspections • Construction Materials Testing

Client:	Resolution Copper Mining	Lab#:	10638
Project:	Resolution Near West Site Inv.	Job#:	506
Source:	Various	Material:	Various

SPECIFIC GRAVITY OF SOIL SOLIDS BY WATER PYCNOMETER
ASTM D854

Sample Number	Depth	Specific gravity
TP16-02 BK-02	2.0-4.0	2.620
TP16-03 BK-03	4.0-6.0	2.613
TP16-04 BK-02	2.0-4.0	2.577
TP16-05 BK-02	1.0-4.0	2.615
TP16-10 BK-02	1.5-5.0	2.783
TP16-11 BK-02	2.5-5.0	2.769

Tested By:	MC	Date:	1/17/2017
Reviewed By:	Matt Crawford	Title:	1/17/2017

Total Soluble Salt Content

IAS Laboratories

2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248

Soil Analysis Report

Grower 506
Submitted By Matt Crawford
Send To ATL-CMT
Report Number 6654886
Date Received 01/04/2017

Sample ID	Depth	Lab #	1 Sulfate ppm	2 Chloride ppm	3 Soluble Salts ppm	pH	Other
DH-16-06/S10		285			230		
DH-16-06/S11		286			160		
DH16-06/S12		287			211		
DH16-06/S13		288			224		
DH16-06/S14		289			192		
DH16-07/S9		290			230		
DH16-07/S10		291			160		
DH17-07/S11		292			211		
DH16-07/S12		293			160		
DH16-07/S13		294			134		
DH16-08/S13		295			454		
DH16-08/S16		296			192		
DH16-08/S18		297			141		
DH16-08/S19		298			166		
DH16-08/S20		299			160		
DH16-12/S8		300			173		
DH16-12/S9		301			198		
DH16-12/S10		302			218		
DH16-12/S14		303			160		
DH16-12/S15		304			243		
DH16-12/S16		305			230		
DH16-12/S17		306			186		

Reference:

1 ADOT Method ARIZ 733

2 ADOT Method ARIZ 736

3 ADOT Method ARIZ 237b

IAS Laboratories

2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248

Soil Analysis Report

Grower 506
Submitted By Matt Crawford
Send To ATL-CMT
Report Number 6654886
Date Received 01/04/2017

DH16-13/S12		307			237		
DH16-13/S13		308			122		
DH16-13/S14		309			122		
DH16-13/S15		310			192		
DH16-13/S16		311			230		
DH16-13/S17		312			147		
TP16-01/BK-02		313			512		
TP16-01/BK-03		314			1274		
TP16-01/BK-04		315			992		
TP16-02/BK-02		316			153		
TP16-02/BK-03		317			154		
TP16-03/BK-02		318			192		
TP16-03/BK-03		319			307		
TP16-04/BK-02		320			250		
TP16-05/BK-01		321			218		
TP16-05/BK-02		322			614		
TP16-05/BK-03		323			243		
TP16-06/BK-02		324			128		
TP16-06/BK-03		325			627		
TP16-07/BK-02		326			173		
TP16-07/BK-03		327			371		
TP16-08/BK-01		328			134		
TP16-08/BK-03		329			160		
TP16-09/BK-01		330			218		
TP16-09/BK-02		331			141		

Reference:

[1] ADOT Method ARIZ 733

[2] ADOT Method ARIZ 736

[3] ADOT Method ARIZ 237b

IAS Laboratories

2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248

Soil Analysis Report

Grower 506
Submitted By Matt Crawford
Send To ATL-CMT
Report Number 6654886
Date Received 01/04/2017

TP16-09/BK-03		332			198		
TP16-10/BK-02		333			154		
TP16-10/BK-03		334			134		
TP16-11/BK-02		335			154		
TP16-11/BK-03		336			166		
TP16-12/BK-02		337			154		
TP16-12/BK-03		338			83		
TP16-13/BK-02		339			256		
TP16-14/BK-02		340			218		
TP16-14/BK-03		341			154		
TP16-14/BK-04		342			141		

Comments:

Reference:

1 ADOT Method ARIZ 733

2 ADOT Method ARIZ 736

3 ADOT Method ARIZ 237b

IAS Laboratories

2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248
Fax (602) 275-3836

Date: March 10, 2017
Submitted by: ATL-CMT
Report To: Matt Crawford
Report #: 6655290
Date Received: March 01 2017

Moisture Analysis

Sender ID	Lab ID	* Moisture %	** Soluble Salts ppm
DH16-15/S6/16.0-16.3'	999	2.93	1216
DH16-15/S7/27.7-27.9'	1	3.12	1088
DH16-15/S8/51.5-51.8'	2	3.84	742
DH16-15/S9/69.5-69.8'	3	2.93	870
DH16-15/S10/89.5-89.8'	4	2.59	1075
DH17-26/S9/14.3-14.6'	5	5.78	1178
DH17-26/S10/41.5-41.8'	6	4.06	429
DH17-26/S13/60.0-60.2'	7	4.28	262
DH17-26/S14/79.9-80.2'	8	9.89	1011
DH17-28/S10/17.7-18.0'	9	5.29	723
DH17-28/S11/39.3-39.6'	10	5.29	518
DH17-28/S12/60.7-61.0'	11	8.99	237
DH17-28/S13/80.4-80.7'	12	4.81	883
DH17-30/S10/18.1-18.3'	13	7.61	1050
DH17-30/S11/41.1-41.7'	14	7.91	806
DH17-30/S12/59.6-59.8'	15	4.91	480
DH17-30/S13/88.3-88.5'	16	6.61	1146

*ASTM D2216-09
**Methods of Soil Analysis ASA No. 9, Part 2, 10-3.3

IAS Laboratories

2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248
Fax (602) 275-3836

Date: March 17, 2017
Submitted by: ATL-CMT
Report To: Matt Crawford
Report #: 6655408
Date Received: March 13 2017

Moisture Analysis

Sender ID	Lab ID	* Moisture %	** Soluble Salts ppm
DH17-33 / S1 / 10	235	6.38	435
DH17-33 / S2 / 20	236	5.74	282
DH17-33 / S3 / 35	237	6.23	275
DH17-33 / S4 / 55	238	5.62	122
DH17-33 / S5 / 70	239	3.75	250
DH17-34 / S1 / 10	240	2.60	211
DH17-34 / S2 / 20	241	2.14	243
DH17-34 / S3 / 35	242	2.66	307
DH17-34 / S4 / 65	243	1.84	192
DH17-34 / S5 / 80	244	1.99	130
DH17-37 / S1 / 10	245	2.28	742
DH17-37 / S2 / 20	246	2.52	262
DH17-37 / S3 / 35	247	4.30	218
DH17-37 / S4 / 65	248	3.06	211

*ASTM D2216-09
**Methods of Soil Analysis ASA No. 9, Part 2, 10-3.3

Unconfined Compressive Strength

ATL-CMT

Date: December 7, 2016

COMPRESSIVE STRENGTH OF ROCK CORES

ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X Remarks: compressive strength only: no moduli measurements / Method C

Wet:

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Identification
1	16-01-S11	2.37	5.19	4.41	2.19	0.96	4,756	1123	
2	16-02-S3	2.40	4.79	4.52	2.00	1.00	2,630	581	
3	16-02-S4	2.40	4.41	4.52	1.84	1.00	7,554	1670	
4	16-03-S12	2.40	4.97	4.52	2.07	0.92	5,376	1292	
5	16-04-S7	2.40	4.19	4.52	1.75	0.95	18,254	4247	
6	16-04-S8	2.39	2.93	4.49	1.23	1.00	22,046	4914	
7	16-05-S2	2.40	4.70	4.52	1.96	1.00	35,210	7783	
8	16-05-S3	2.39	3.37	4.49	1.41	1.00	6,520	1453	
9									
10									
Averages									

IAS Laboratories

2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248

Soil Analysis Report

Grower DH16-01 DH 16-03
Submitted By Randy
Send To ATL-CMT
Report Number 6654603
Date Received 11/14/2016

Sample ID	Depth	Lab #	[1] Sulfate ppm	[2] Chloride ppm	[3] Soluble Salts ppm	pH	Other
DH16-01 / S4		858			500		
DH16-01 / S5		859			672		
DH16-01 / S6		860			426		
DH16-01 / S7		861			205		
DH16-01 / S8		862			243		
DH16-01 / S9		863			184		
DH16-03 / S16		864			177		
DH16-03 / S17		865			363		
DH16-03 / S18		866			180		
DH16-03 / S19		867			179		
DH16-03 / S20		868			178		

Comments:

Reference:

[1] ADOT Method ARIZ 733

[2] ADOT Method ARIZ 736

[3] ADOT Method ARIZ 237b

ATL-CMT

Date: January 5, 2017

COMPRESSIVE STRENGTH OF ROCK CORES
ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X
Wet:

Remarks: compressive strength only: no moduli measurements / Method C

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Identification
1	16-05 S5	2.40	5.00	4.52	2.08	0.96	75,800	17454	
2	16-06 S15	2.40	5.83	4.52	2.43	1.00	8,430	1863	
3	16-06 S16	2.40	4.97	4.52	2.07	1.00	13,070	2889	
4	16-07 S14	2.40	4.00	4.52	1.67	0.92	13,820	3321	
5	16-07 S15	2.40	5.40	4.52	2.25	0.95	16,260	3783	
6	16-07 S17	2.40	5.15	4.52	2.15	1.00	12,270	2712	
7	16-08 S14	2.40	5.34	4.52	2.23	1.00	7,860	1737	
8	16-08 S17	2.40	5.00	4.52	2.08	1.00	16,280	3599	
9	16-09 S1	2.40	4.97	4.52	2.07	1.00	21,450	4741	
10	16-09 S2	2.40	4.89	4.52	2.04	1.00	90,720	20053	
11	16-10 S1	2.40	5.00	4.52	2.08	0.96	3,620	834	
12	16-10 S3	2.40	4.70	4.52	1.96	1.00	56,040	12388	
13	16-10 S4	2.40	5.22	4.52	2.18	1.00	26,010	5749	
14	16-11 S2	2.40	4.84	4.52	2.02	0.92	4,790	1151	
15	16-11 S3	2.40	5.40	4.52	2.25	0.95	8,180	1903	
16	16-12 S11	2.40	4.89	4.52	2.04	1.00	5,450	1205	
17	16-12 S13	2.40	5.13	4.52	2.14	1.00	5,190	1147	
18	16-13 S9	2.40	4.89	4.52	2.04	1.00	2,910	643	
19	16-13 S18	2.40	5.30	4.52	2.21	1.00	9,120	2016	

ATL - CMT

Date: March 7, 2017

COMPRESSIVE STRENGTH OF ROCK CORES

ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation Lab # 11462

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X Wet:

Remarks: compressive strength only: no moduli measurements / Method C

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Identification
1	DH16-07 S19	2.41	4.40	4.56	1.83	0.96	10,370	2368	
2	DH16-07 S20	2.40	5.15	4.52	2.15	1.00	10,990	2429	
3	DH16-07 S21	2.43	4.54	4.64	1.87	1.00	19,230	4146	
4	DH16-07 S22	2.41	5.96	4.56	2.47	0.92	21,810	5197	
5	DH16-08 S21	2.38	3.99	4.45	1.68	0.95	13,020	3081	
6	DH16-08 S22	2.38	5.16	4.45	2.17	1.00	14,440	3246	
7	DH16-08 S23(17-08)	2.39	6.23	4.49	2.61	1.00	10,330	2303	
8	DH16-08 S24	2.39	6.22	4.49	2.60	1.00	1,500	334	
9	DH16-08 S25	2.39	5.10	4.49	2.13	1.00	7,560	1685	
10	DH16-14 S3	2.39	3.86	4.49	1.62	#N/A	12,910	#N/A	
Averages									

ATL - CMT

Date: March 7, 2017

COMPRESSIVE STRENGTH OF ROCK CORES

ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation Lab # 11462

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X Wet:

Remarks: compressive strength only: no moduli measurements / Method C

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Notes
1	DH16-14 S4	2.40	4.16	4.52	1.73	0.96	35,460	8165	
2	DH16-15 S11	2.38	6.32	4.45	2.66	1.00	6,910	1553	
3	DH16-16 S3	2.40	6.37	4.52	2.65	1.00	50,320	11123	
4	DH16-17 S2					1.00		#VALUE!	Shattered while cutting
5	DH16-17 S3	2.40	3.32	4.52	1.38	1.00	35,950	7947	
6	DH16-18 S2	2.45	3.44	4.71	1.40	0.92	11,400	2628	
7	DH16-18 S3					0.95		#VALUE!	Broke while capping
8	DH16-18 S4	2.40	5.02	4.52	2.09	1.00	6,450	1426	
9	DH16-19 S1	2.40	6.19	4.52	2.58	1.00	19,610	4335	
10	DH16-19 S2	2.40	5.61	4.52	2.34	1.00	14,250	3150	
Averages									

ATL - CMT

Date: March 7, 2017

COMPRESSIVE STRENGTH OF ROCK CORES
ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation Lab # 11462

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X Remarks: compressive strength only: no moduli measurements / Method C
Wet:

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Identification
1	DH16-20 S2	2.41	5.62	4.56	2.33	1.00	20,410	4474	
2	DH16-20 S3							#VALUE!	Was unable to cut core/ see photo
3	DH16-21 S3	2.38	2.62	4.45	1.10	0.96	1,137	266	
4	DH16-21 S4	2.40	5.92	4.52	2.47	1.00	2,840	628	
5	DH16-22 S2	2.39	7.02	4.49	2.94	1.00	6,080	1355	
6	DH17-23 S1	2.39	5.90	4.49	2.47	0.92	27,670	6704	
7	DH17-24 S1 (17-25)					1.00		#VALUE!	shattered while cutting
8	DH17-24 S2(17-25)	2.39	3.20	4.49	1.34	0.95	23,820	5589	
9	DH17-24 S3(17-25)	2.41	3.72	4.56	1.54	1.00	5,060	1109	
10	DH17-26 S7	2.40	6.86	4.52	2.86	1.00	8,800	1945	
Averages									

ATL-CMT

Date: March 7, 2017

COMPRESSIVE STRENGTH OF ROCK CORES
ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation Lab # 11462

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X Wet:

Remarks: compressive strength only: no moduli measurements / Method C

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Identification
1	DH17-27 S1	2.38	4.97	4.45	2.09	1.00	45,690	10270	
2	DH17-27 S2	2.40	5.96	4.52	2.48	1.00	15,160	3351	
3	DH17-28 S2	2.41	6.43	4.56	2.67	1.00	8,980	1969	
4	DH17-28 S3	2.39	6.23	4.49	2.61	0.96	10,160	2359	
5	DH17-30 S2	2.40	6.08	4.52	2.53	1.00	17,420	3851	
Averages									

ATL-CMT

Date: March 7, 2017

COMPRESSIVE STRENGTH OF ROCK CORES

ASTM D7012

Client: Resolution Copper Mining

Project No: 506 Project Name: Resolution Near West Site Investigation Lab # 12134

Description: Various Coring Holes Specified PSI:

Curing Type: Dry: X Wet: Remarks: compressive strength only: no moduli measurements / Method C

Core #	Lab #	Diameter Inches	Height inches	Area Inches^2	Length / Diameter Ratio	Correction Factor	Load in Pounds	Corrected Psi	Identification
1	DH17-31/S1/28-28.8	2.40	5.86	4.52	2.44	0.96	27,570	6348	
2	DH17-31/S2/182.5-183.5	2.39	6.06	4.49	2.54	1.00	35,790	7978	
3	DH17-31/S3/232.5-233.5	2.41	6.19	4.56	2.57	1.00	14,760	3236	
4	DH17-32/S5/41.4-42	2.40	3.08	4.52	1.28	0.92	18,240	4383	
5	DH17-33/S11/20-21	2.39	4.83	4.49	2.02	0.95	6,800	1596	
6	DH17-33/S12/22-23	2.39	5.87	4.49	2.46	1.00	4,950	1103	
7	17-34/S10/23-23.8	2.40	4.05	4.52	1.69	1.00	15,590	3446	
8	DH17-34/S11/22.2-23	2.40	4.04	4.52	1.68	1.00	8,260	1826	
9	DH17-35/S1/48-49	2.40	4.48	4.52	1.87	1.00	4,970	1099	
10	DH17-35/S4/219-220	2.40	5.16	4.52	2.15	1.00	21,130	4671	
11	DH17-37/S8/37								received broken
12	DH17-37/S9/40-41	2.40	3.08	4.52	1.28	0.92	8,220	1977	
13	DH17-38/S2/11.3-12	2.40	4.68	4.52	1.95	1.00	5,880	1300	
14	DH17-38/S3/12.1-13.1	2.40	6.10	4.52	2.54	1.00	6,240	1379	
Averages									

LA Abrasion Tests

ATL, INC.
Excellence In Quality

RESOLUTION COPPER MINING
Resolution Near West Site Investigation
ATL JOB NO. 0506

L.A. ABRASION (C535)

GRADATION	SOURCE	L.A. ABRASION (loss after 100 rev) (%)	L.A. ABRASION (loss after 500 rev) (%)
B	TP16-04 BK-02 2.0-4.0 ft.	13	33

GRADATION	SOURCE	L.A. ABRASION (loss after 100 rev) (%)	L.A. ABRASION (loss after 500 rev) (%)
C	TP16-05 BK-02 1.0-4.0 ft.	33	61

Appendix III-B

KCB Laboratory Results

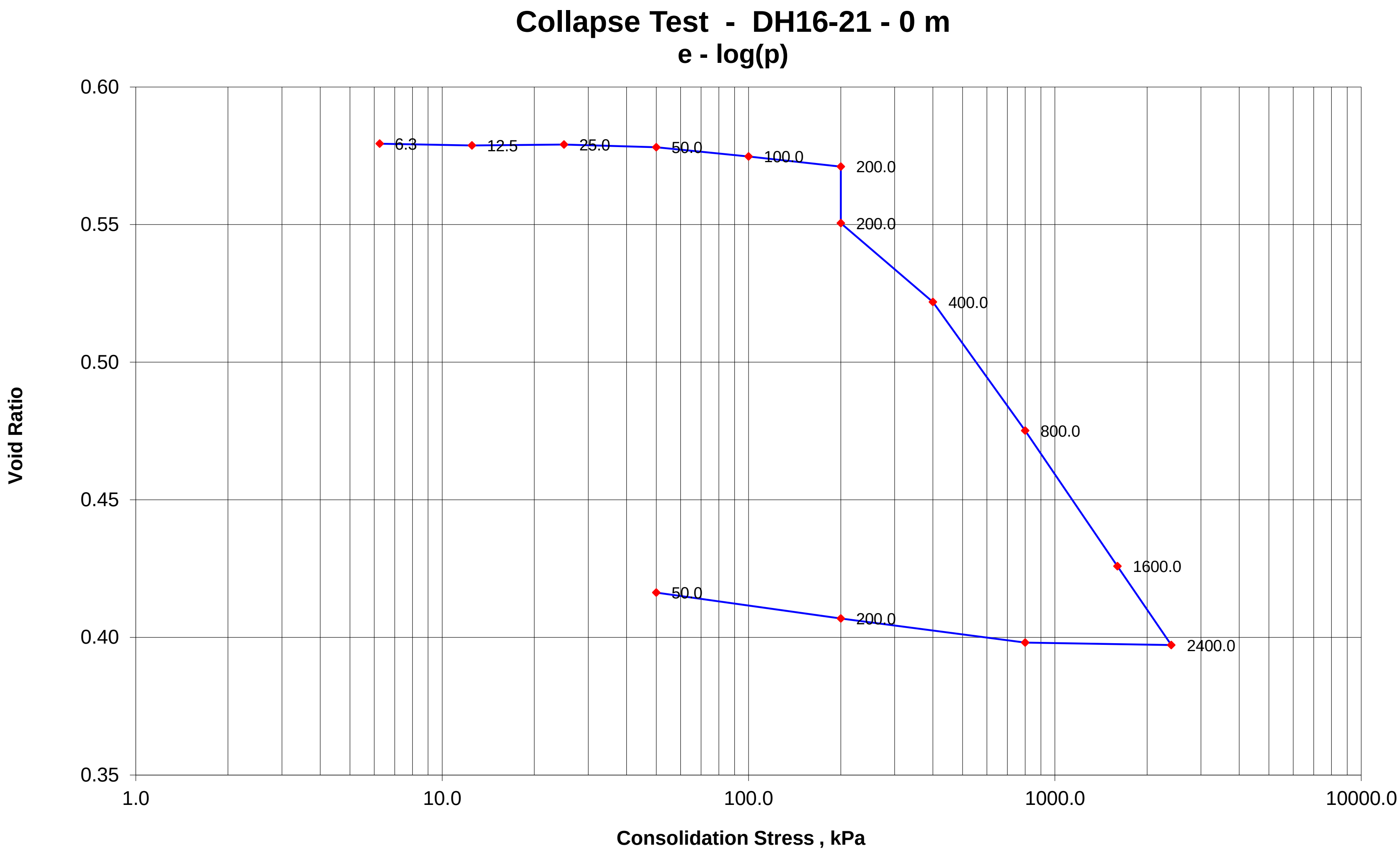
(ongoing)

WATER CONTENT OF SOIL
(ASTM D2216)

Hole Number	Sample Number	Depth (m)	Wet Weight + Tare (g)	Dry Weight + Tare (g)	Tare (g)	Water Weight (g)	Total Dry Weight (g)	Water Content (%)	Notes
TP17-33	Below 3/4"	0.8	1269.55	1159.56	190.35	109.99	969.21	**11.3**	
TP17-33	Above 3/4"	0.8	178.21	172.82	117.20	5.39	55.62	**9.7**	
TP17-33	Total	0.8						**10.8**	Based on 65.7% passing 3/4" from PSA
TP17-35	Below 3/4"	0.9	1206.24	1067.32	155.40	138.92	911.92	**15.2**	
TP17-35	Above 3/4"	0.9	163.45	159.45	117.20	4.00	42.25	**9.5**	
TP17-35	Total	0.9						**13.9**	Based on 76.5% passing 3/4" from PSA
TP17-37	Below 3/4"	0.9	1489.33	1407.02	174.45	82.31	1232.57	**6.7**	
TP17-37	Above 3/4"	0.9	177.06	171.94	75.11	5.12	96.83	**5.3**	
TP17-37	Total	0.9						**6.2**	Based on 66.7% passing 3/4" from PSA

Klohn Crippen Berger

PROJECT No.:	M0944aA18
PROJECT NAME:	Near West TSF Pre-Feasibility Study
LOCATION:	Arizona
DATE:	2017-05-03
TESTED BY:	CM CHECKED BY: JG



Klohn Crippen Berger	PROJECT NO.:	M09441A18		
	PROJECT:	Resolution Near West TSF PFS		
	LOCATION:	Arizona	DATE TESTED:	2017-08-18
	SAMPLE NO.:	DH16-21 - 0 m	DETAILS	Trimmed from Rock Core
	TESTED BY:	CM	CHECKED BY:	JG

CONSOLIDATION

PROJECT NO.:	M09441A18
PROJECT:	Resolution Near West TSF PFS
SAMPLE NO.:	DH16-21 - 0 m
DETAILS	Trimmed from Rock Core
TEST NO.:	CONS02
LOADING MACHINE NO.:	OED3 / ID82

Test Specimen Information:

Initial water content:	3.81	% (based on trimmings)
Final water content:	15.70	% (based on final dry weight)
Dry mass:	128.33	g
Diameter	61.37	mm
Area	29.580	cm^2
Specific Gravity	2.66	

Initial Specimen Height (mm):	25.77
Height of Solid (mm):	16.310
Initial void ratio:	0.580
Void Ratio Factor	0.0613

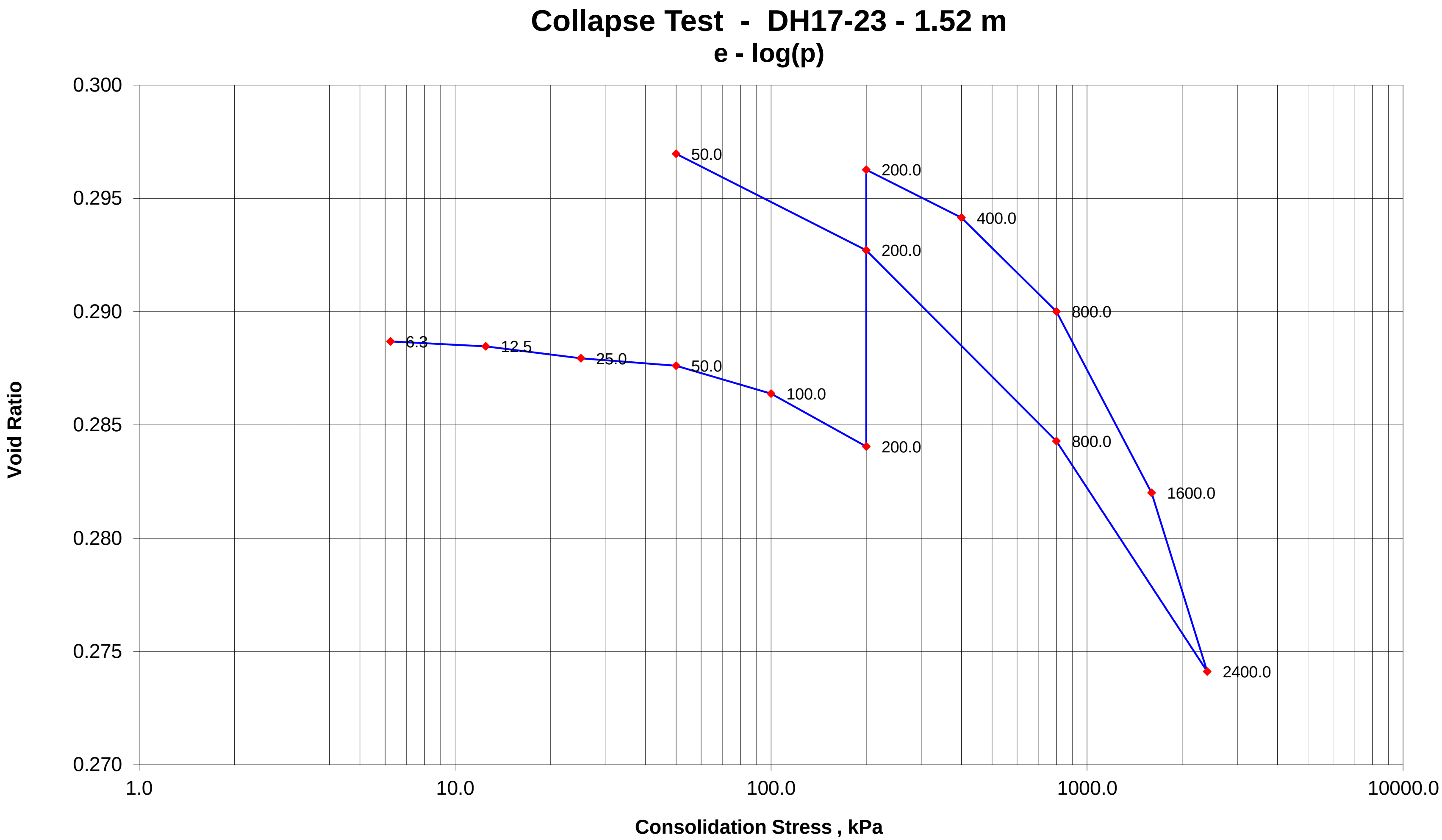
Collapse Strain	98.7	%
Change in Height after Wetting:	0.4818	mm
Collapse Potential Ic:	**0.019**	
Degree of Collapse	**Slight**	

** Estimated t_{50}

Pressure (kPa)		*Change in Height	Final	Change in	Change in	Void	t_{50**}	Cv	Mv	k	Cc
From	To	Corrected (mm)	Height (mm)	Void Ratio	Void Ratio Acc	Ratio	(min)	(cm^2/sec)	(cm^2/N)	(cm/sec)	
0.0	**6.3**	0.011	25.759	0.001	0.001	**0.58**					
6.3	**12.5**	0.010	25.749	0.001	0.001	**0.58**					
12.5	**25.0**	-0.005	25.754	0.000	0.001	**0.58**					
25.0	**50.0**	0.015	25.739	0.001	0.002	**0.58**					
50.0	**100.0**	0.055	25.684	0.003	0.005	**0.57**					
100.0	**200.0**	0.060	25.624	0.004	0.009	**0.57**					
200.0	**200.0**	0.336	25.288	0.021	0.030	**0.55**	0.60	8.9E-03	1.3E-03	1.1E-07	**0.068**
200.0	**400.0**	0.468	24.821	0.029	0.058	**0.52**	0.03	1.7E-01	9.2E-04	1.6E-06	**0.095**
400.0	**800.0**	0.761	24.059	0.047	0.105	**0.48**	0.06	8.2E-02	7.7E-04	6.1E-07	**0.155**
800.0	**1600.0**	0.804	23.255	0.049	0.154	**0.43**	0.04	1.1E-01	4.2E-04	4.7E-07	**0.164**
1600.0	**2400.0**	0.467	22.788	0.029	0.183	**0.40**	0.02	2.2E-01	2.5E-04	5.4E-07	**0.163**
2400.0	**800.0**	-0.014	22.802	-0.001	0.182	**0.40**					
800.0	**200.0**	-0.144	22.946	-0.009	0.173	**0.41**					
200.0	**50.0**	-0.153	23.099	-0.009	0.164	**0.42**					

Klohn Crippen Berger

PROJECT NO.:	M09441A18		
PROJECT:	Resolution Near West TSF PFS		
LOCATION:	Arizona	DATE TESTED:	2017-08-18
SAMPLE NO.:	DH16-21 - 0 m	DETAILS	Trimmed from Rock Core
TESTED BY:	CM	CHECKED BY:	JG



Klohn Crippen Berger	PROJECT NO.:	M09441A18		
	PROJECT:	Resolution Near West TSF PFS		
	LOCATION:	Arizona	DATE TESTED:	2017-08-18
	SAMPLE NO.:	DH17-23 - 1.52 m	DETAILS	Trimmed from Rock Core
	TESTED BY:	CM	CHECKED BY:	JG

CONSOLIDATION

PROJECT NO.: M09441A18
PROJECT: Resolution Near West TSF PFS
SAMPLE NO.: DH17-23 - 1.52 m
DETAILS Trimmed from Rock Core

TEST NO.: CONS02
LOADING MACHINE NO.: OED3 / ID82

Test Specimen Information:

Initial water content:	3.87	% (based on trimmings)
Final water content:	11.62	% (based on final dry weight)
Dry mass:	147.58	g
Diameter	60.49	mm
Area	28.738	cm^2
Specific Gravity	2.59	

Initial Specimen Height (mm):	25.58
Height of Solid (mm):	19.828
Initial void ratio:	0.290
Void Ratio Factor	0.0504

Swell Strain	101.0	%
Change in Height after Wetting:	-0.122	mm
Collapse Potential Ic:	**-0.005**	
Degree of Swell	**Slight**	

** Estimated t_{50}

Pressure (kPa)		*Change in Height	Final	Change in	Change in	Void	t_{50**}	Cv	Mv	k	Cc
From	To	Corrected (mm)	Height (mm)	Void Ratio	Void Ratio Acc	Ratio	(min)	(cm^2/sec)	(cm^2/N)	(cm/sec)	
0.0	**6.3**	0.028	25.552	0.001	0.001	**0.29**					
6.3	**12.5**	0.004	25.547	0.000	0.002	**0.29**					
12.5	**25.0**	0.011	25.537	0.001	0.002	**0.29**					
25.0	**50.0**	0.006	25.530	0.000	0.003	**0.29**					
50.0	**100.0**	0.025	25.506	0.001	0.004	**0.29**					
100.0	**200.0**	0.046	25.460	0.002	0.006	**0.28**					
200.0	**200.0**	-0.242	25.702	-0.012	-0.006	**0.30**					
200.0	**400.0**	0.042	25.660	0.002	-0.004	**0.29**	0.02	3.6E-01	8.2E-05	2.9E-07	**0.007**
400.0	**800.0**	0.082	25.578	0.004	0.000	**0.29**	0.02	3.0E-01	8.0E-05	2.3E-07	**0.014**
800.0	**1600.0**	0.159	25.419	0.008	0.008	**0.28**	0.02	2.7E-01	7.8E-05	2.0E-07	**0.027**
1600.0	**2400.0**	0.156	25.263	0.008	0.016	**0.27**	0.02	3.5E-01	7.7E-05	2.6E-07	**0.045**
2400.0	**800.0**	-0.202	25.464	-0.010	0.006	**0.28**					
800.0	**200.0**	-0.167	25.631	-0.008	-0.003	**0.29**					
200.0	**50.0**	-0.084	25.716	-0.004	-0.007	**0.30**					

Klohn Crippen Berger

PROJECT NO.:	M09441A18		
PROJECT:	Resolution Near West TSF PFS		
LOCATION:	Arizona	DATE TESTED:	2017-08-18
SAMPLE NO.:	DH17-23 - 1.52 m	DETAILS	Trimmed from Rock Core
TESTED BY:	CM	CHECKED BY:	JG

Direct Shear Test (ASTM D3080)

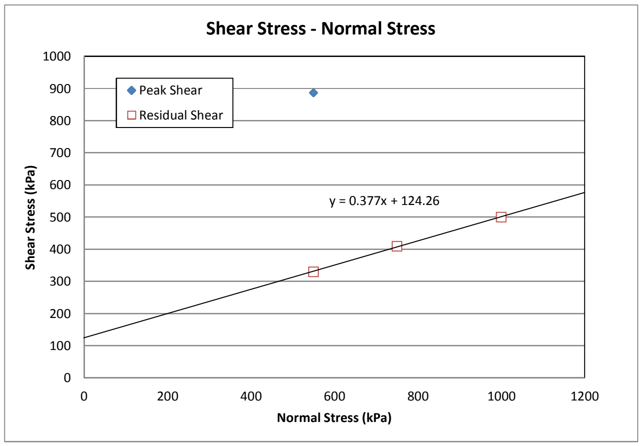
DH16-08 / #1, Peak and Multi-Stage Residual

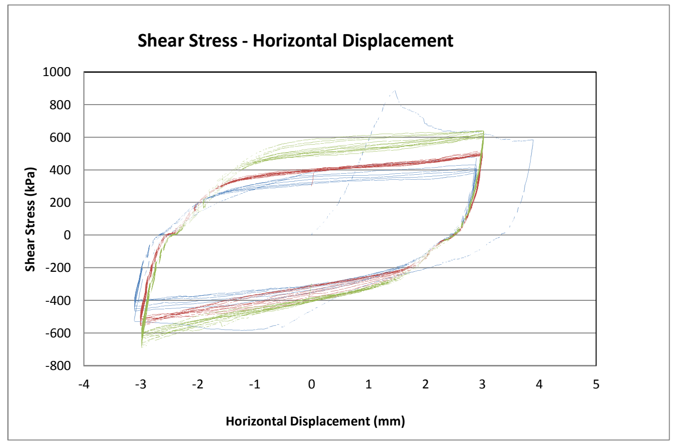
Project Number: M09941A18
Project Name: Near West TSF Pre-Feasibility Study
Location: AZ, USA

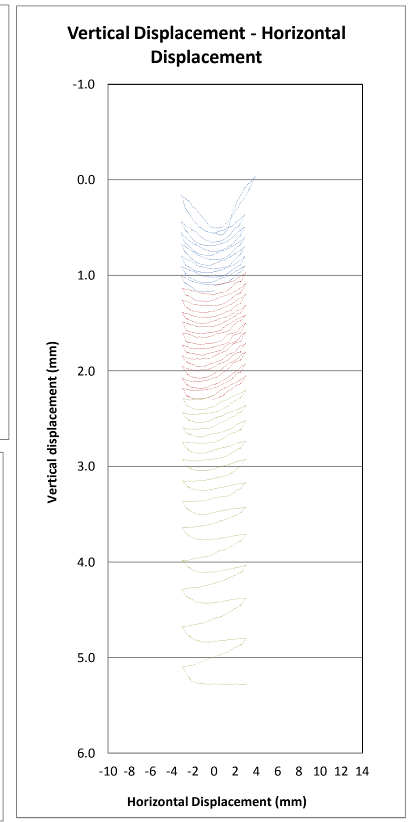
Date of Testing: 2016-05-26
Tested by: BY
Checked by: JG

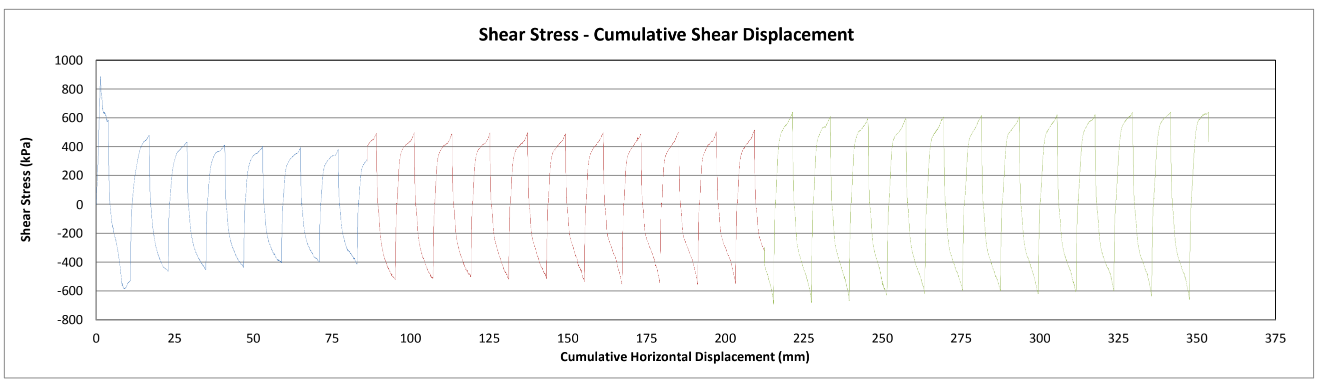
Hole No./ Sample No.	Depth (m)	Specimen Dimension (mm)	Initial Height (mm)	Area (mm2)	Volume (cm3)	Initial WC (%)	Initial Wet weight (g)	Initial Dry Weight (g)	Initial Bulk Density (g/cm3)	Initial Dry Density (g/cm3)	Normal Stress (kPa)	Height at shearing (mm)	Volume at shearing (cm3)	Dry Density at shearing (kg/m3)	Final WC (%)	Peak Shear Stress (kPa)	Φ (°)	c (kPa)	Residual Shear Stress (kPa)	Residual Φ (°)	Residual c (kPa)
DH16-08 / #1		61.18	28.17	2939.74	82.81	5.66	192.55	182.24	2.18	2.06	**550.0**	29.51	86.74	2.10	-	**887.0**	58.2	0*	**330.0**	20.7	124.3
		61.18	28.90	2939.74	84.95	-	-	-	-	-	**750.0**	28.95	85.09	2.10	-	-			**410.0**		
		61.18	27.75	2939.74	81.58	-	-	-	-	-	**1000.0**	27.79	81.70	2.10	13.24	-			**500.0**		

* Assuming c=0









Klohn Crippen Berger

Direct Shear Test (ASTM D3080)

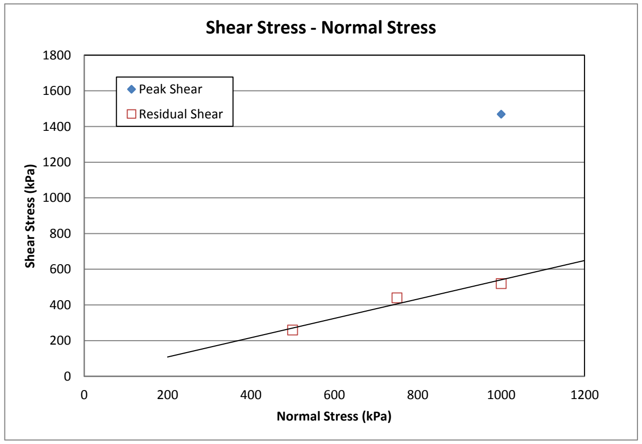
DH17-23 / 1.5 m, Peak and Multi-Stage Residual

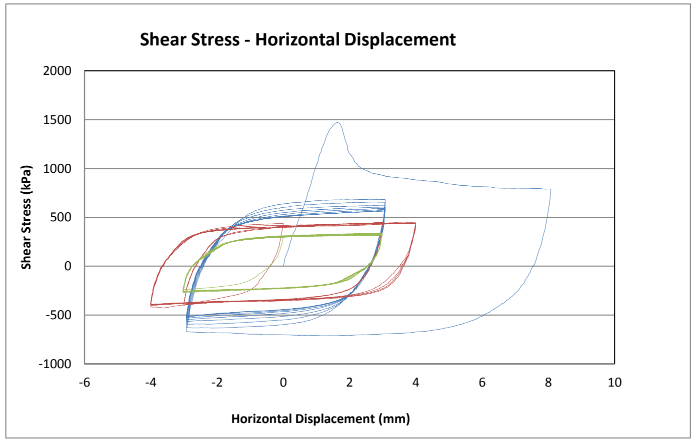
Project Number: M09441A18
Project Name: Resolution Near West TSF PFS
Location: Arizona

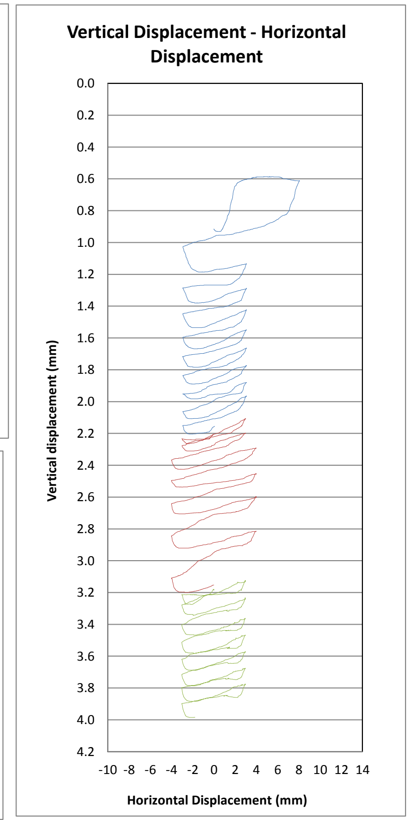
Date of Testing: 2017-08-06
Tested by: CM
Checked by: JG

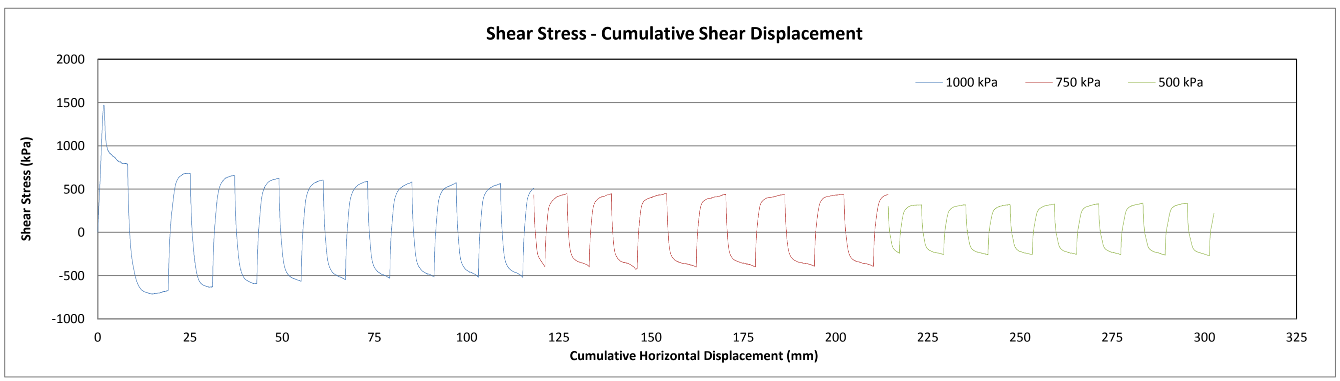
Hole No./ Sample No.	Depth (m)	Specimen Diameter (mm)	Initial Height (mm)	Area (mm2)	Volume (cm3)	Initial WC (%)	Initial Wet weight (g)	Initial Dry Weight (g)	Initial Bulk Density (g/cm3)	Initial Dry Density (g/cm3)	Normal Stress (kPa)	Height at shearing (mm)	Volume at shearing (cm3)	Dry Density at shearing (kg/m3)	Final WC (%)	Peak Shear Stress (kPa)	Φ (°)	c (kPa)	Residual Shear Stress (kPa)	Residual Φ (°)	Residual c (kPa)
		60.35	31.20	2860.52	89.25	3.87	187.06	180.09	2.10	2.02	**1000.0**	30.39	86.94	2.07	-	**1469**			**520.0**		
DH17-23	1.52	60.35	28.55	2860.52	81.67	-	-	-	-	-	**750.0**	29.06	83.14	2.07	-	-	55.8	0*	**440.0**	28.4	0.0
		60.35	26.09	2860.52	74.63	-	-	-	-	-	**500.0**	28.09	80.35	2.08	11.92	-			**260.0**		

* Assuming c=0









Direct Shear Test (ASTM D3080)

DH17-29 / C6, Peak and Multi-Stage Residual

22 ft

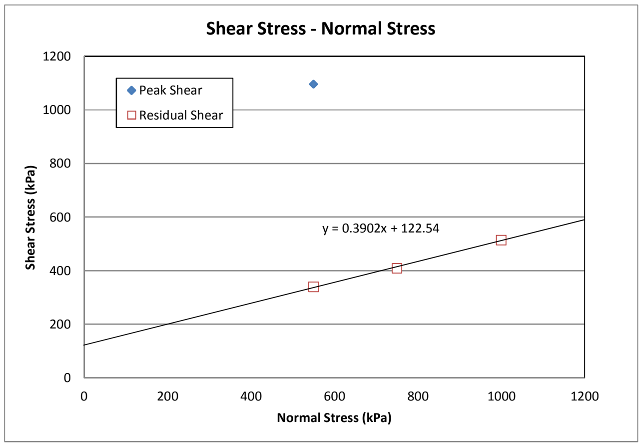
Project Number: M09941A18
Project Name: Near West TSF Pre-Feasibility Study
Location: AZ, USA

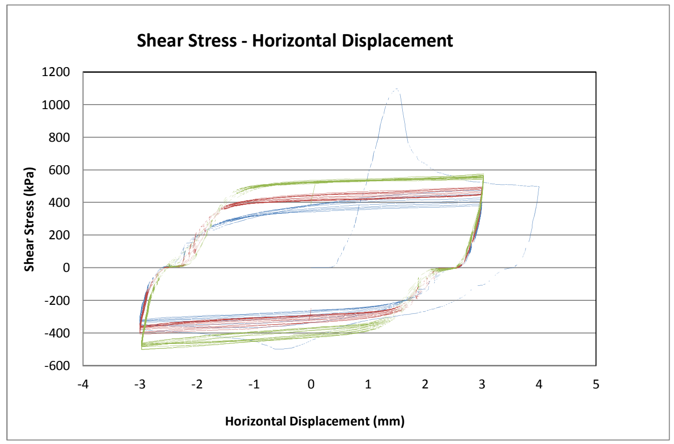
Date of Testing: 2016-05-26
Tested by: BY
Checked by: JG

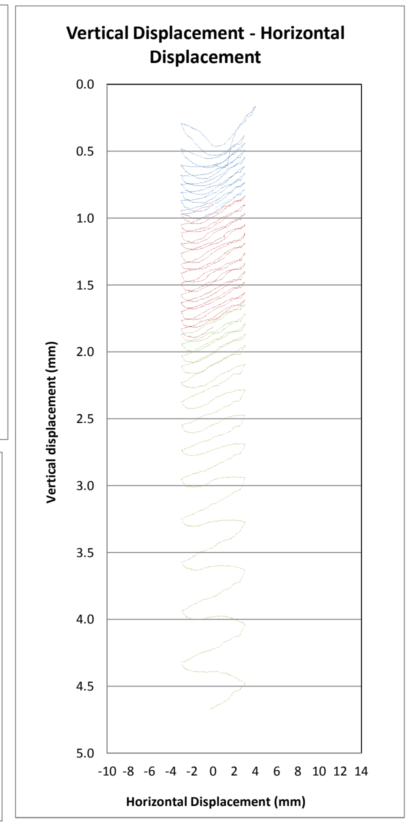
Soaked in process water for 1 week

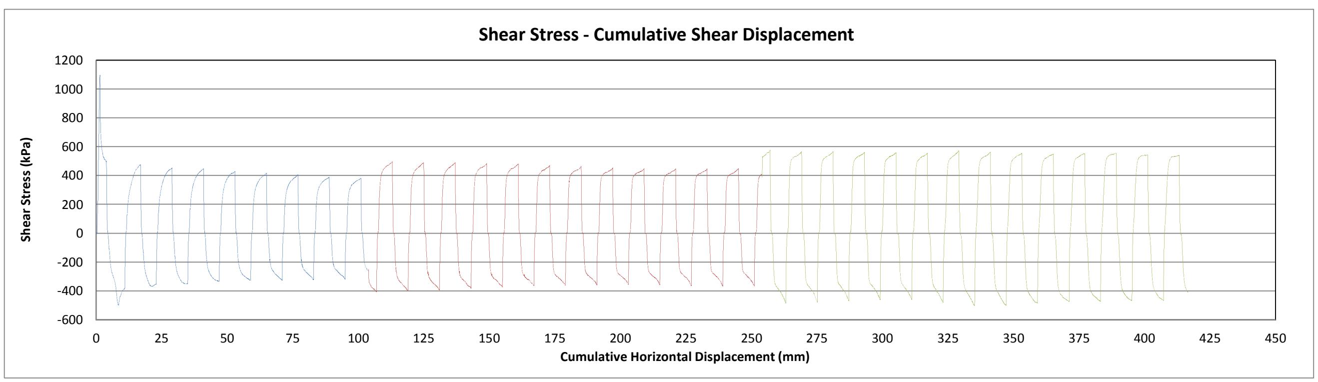
Hole No./ Sample No.	Depth (m)	Specimen Dimension (mm)	Initial Height (mm)	Area (mm2)	Volume (cm3)	Initial WC (%)	Initial Wet weight (g)	Initial Dry Weight (g)	Initial Bulk Density (g/cm3)	Initial Dry Density (g/cm3)	Normal Stress (kPa)	Height at shearing (mm)	Volume at shearing (cm3)	Dry Density at shearing (kg/m3)	Final WC (%)	Peak Shear Stress (kPa)	Φ (°)	c (kPa)	Residual Shear Stress (kPa)	Residual Φ (°)	Residual c (kPa)
DH17-29 / C6		61.44	28.17	2964.78	83.52	9.59	183.98	167.88	2.20	2.01	**550.0**	27.57	81.75	2.05	-	**1096.3**	63.4	0*	**340.0**	21.3	122.5
		61.44	27.24	2964.78	80.75	-	-	-	-	-	**750.0**	27.27	80.85	2.05	-	-			**410.0**		
		61.44	26.35	2964.78	78.13	-	-	-	-	-	**1000.0**	26.39	78.23	2.05	12.69	-			**515.0**		

* Assuming c=0









Direct Shear Test (ASTM D3080)

DH17-33 / 103 ft , Peak and Multi-Stage Residual

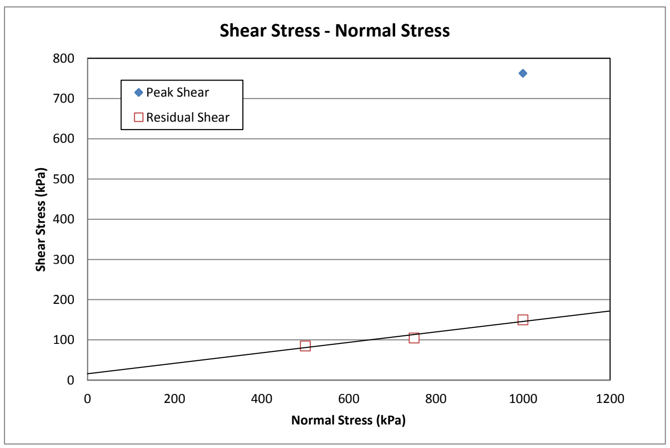
Klohn Crippen Berger

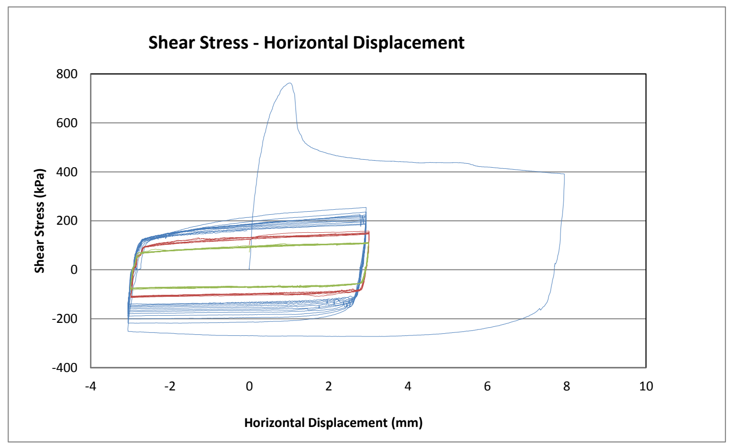
Project Number: M09441A18
Project Name: Resolution Near West TSF PFS
Location: Arizona

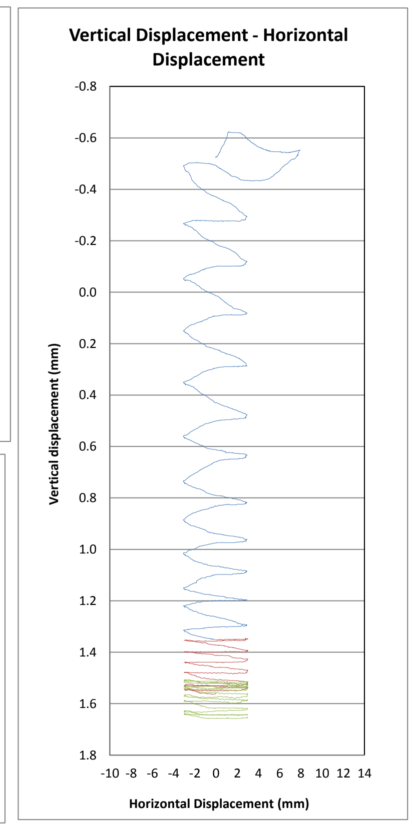
Date of Testing: 2017-08-06
Tested by: CM
Checked by: JG

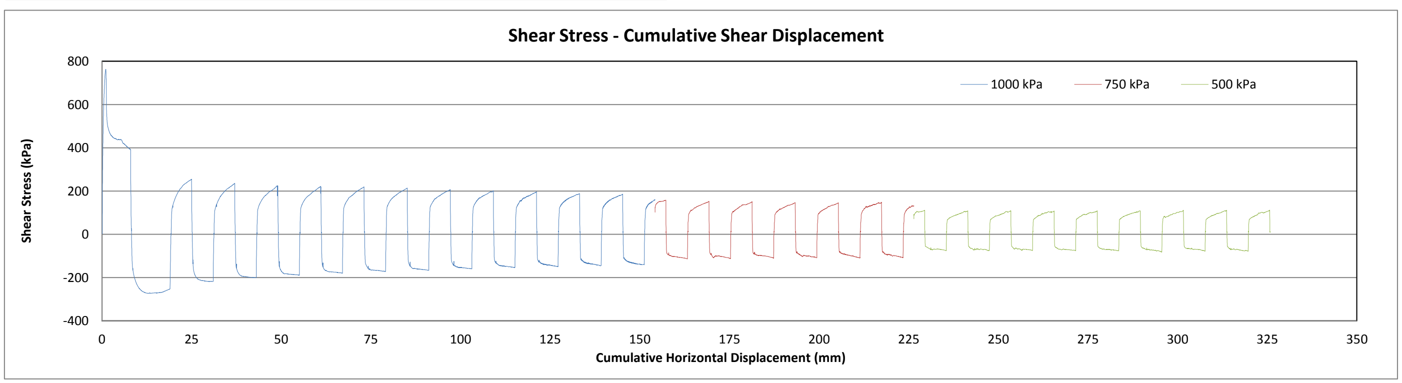
Hole No./ Sample No.	Depth (m)	Specimen Diameter (mm)	Initial Height (mm)	Area (mm2)	Volume (cm3)	Initial WC (%)	Initial Wet weight (g)	Initial Dry Weight (g)	Initial Bulk Density (g/cm3)	Initial Dry Density (g/cm3)	Normal Stress (kPa)	Height at shearing (mm)	Volume at shearing (cm3)	Dry Density at shearing (kg/m3)	Final WC (%)	Peak Shear Stress (kPa)	Φ (°)	c (kPa)	Residual Shear Stress (kPa)	Residual Φ (°)	Residual c (kPa)
		57.58	26.60	2603.95	69.27	17.80	129.83	110.21	1.87	1.59	**1000.0**	28.54	74.32	1.48	-	**762.8**			**150.0**		
DH17-33	31.40	57.58	26.67	2603.95	69.44	-	-	-	-	-	**750.0**	26.67	69.44	1.48	-	-	37.3	0*	**105.0**	7.4	15.8
		57.58	26.46	2603.95	68.89	-	-	-	-	-	**500.0**	26.48	68.95	1.48	37.20	-			**85.0**		

* Assuming c=0

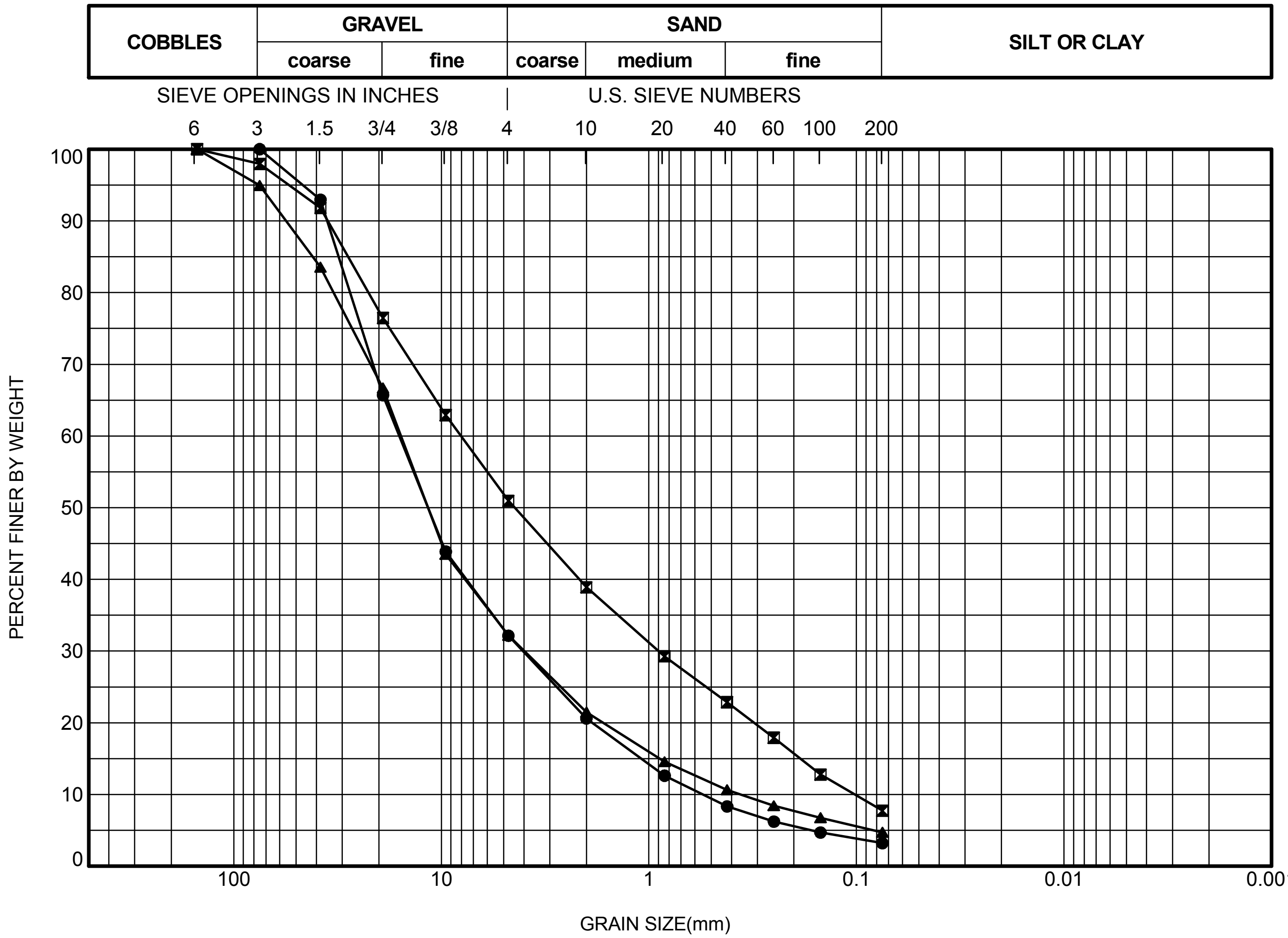








GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D30	D10	CC	CU	%GRAVEL	%SAND	%FINES
●	TP17-33	1.0	31.205	15.926	4.047	0.55	1.87	28.94	67.9	28.9	3.2
⧖	TP17-35	1.0	28.088	8.037	0.897	0.102	0.98	78.68	47.0	43.2	7.7
▲	TP17-37	1.0	41.615	15.623	3.982	0.361	2.81	43.24	62.8	27.5	4.7

	HOLE	SAMPLE	DEPTH (m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP17-33	S3-S6	1.0					Crushed Bedrock
⧖	TP17-35	S1-S4	1.0					Crushed Bedrock
▲	TP17-37	S1-S4	1.0					Crushed Bedrock

CU = COEFFICIENT OF UNIFORMITY = D60/D10 **PARTICLE SIZES, e.g. D85, in mm** **Tested by Wet Sieving Method (ASTM D6913 & ISO/TS 17892-4)**

Klohn Crippen Berger

PROJECT NO.: M09441A18

PROJECT: Near West TSF Pre-Feasibility Study

LOCATION: Arizona

FIGURE:

DRAWN BY: CM **CHECKED BY:** JG

KCB_GRAIN_SIZE-SI M09441A18 RESOLUTION - T1717.GPJ SIEVE.GDT 17-5-4

POINT LOAD TEST
(ASTM D5731)

Hole Number	Depth (m)	Specimen Number	Test Type	Soaking Time	Soaking Fluid	D (mm)	W (mm)	Load (P) (KN)	De^2 (mm^2)	I_s (MPa)	F	$I_{s\ (50)}$ (MPa)	NOTE
DH16-07		C3-1	a	-	Dry	24.0	61.13	1.850	1868.0	0.99	0.94	0.93	
DH16-07		C3-2	a	1 hr	Process Water	27.4	61.13	1.754	2132.6	0.82	0.96	0.79	
DH16-07		C3-3	a	1 hr	Distilled Water	25.6	61.00	1.164	1988.3	0.59	0.95	0.56	
DH16-07		C4-1	a	-	Dry	25.4	61.16	3.416	1977.9	1.73	0.95	1.64	
DH16-07		C4-2	a	2 hr	Process Water	26.4	61.17	3.896	2056.1	1.89	0.96	1.81	
DH16-07		C4-3	a	2 hr	Distilled Water	26.7	61.13	4.072	2078.1	1.96	0.96	1.88	
DH16-07		C6-1	a	-	Dry	23.4	61.13	N/A	1821.3	N/A	0.93	N/A	Failed
DH16-07		C6-2	a	5 hr	Process Water	23.2	61.16	0.648	1806.6	0.36	0.93	0.33	
DH16-07		C6-3	a	5 hr	Distilled Water	24.8	61.07	1.006	1928.4	0.52	0.94	0.49	
DH16-07		C8-1	a	-	Dry	26.2	61.17	4.096	2040.6	2.01	0.96	1.92	
DH16-07		C8-3	a	24 hr	Process Water	26.4	61.17	1.072	2056.1	0.52	0.96	0.50	
DH16-07		C8-4	a	24 hr	Distilled Water	28.4	61.14	1.280	2210.8	0.58	0.97	0.56	
DH16-07		C10-1	a	-	Dry	24.9	61.18	4.846	1939.6	2.50	0.94	2.36	
DH16-07		C10-2	a	48 hr	Process Water	26.4	61.17	1.732	2056.1	0.84	0.96	0.81	
DH16-07		C10-3	a	48 hr	Distilled Water	26.9	61.21	2.002	2096.5	0.95	0.96	0.92	
DH16-07		C11-1	a	-	Dry	26.2	61.14	4.702	2039.6	2.31	0.96	2.20	
DH16-07		C11-2	a	1 week	Process Water	27.4	61.15	1.440	2133.3	0.68	0.96	0.65	
DH16-07		C11-3	a	1 week	Distilled Water	27.9	61.17	1.418	2173.0	0.65	0.97	0.63	
DH16-07		C12-1	a	-	Dry	25.7	61.16	2.730	2001.3	1.36	0.95	1.30	
DH16-07		C12-2	a	2 weeks+	Process Water	24.9	61.17	1.160	1939.3	0.60	0.94	0.56	
DH16-07		C12-3	a	2 weeks+	Distilled Water	26.4	61.21	2.204	2057.5	1.07	0.96	1.03	

Test Equipment:
Load Gauge No.:

* a: axial

* d : diametral |: perpendicular to plane of weakness
1 : irregular lump

Klohn Crippen Berger		
	PROJECT NO.:	M09441A18
	PROJECT:	Near West TSF PFS
	LOCATION:	Arizona
	DATE:	2017-05-08
	TESTED BY:	BY CHECKED BY: JG

POINT LOAD TEST
(ASTM D5731)

Hole Number	Depth (m)	Specimen Number	Test Type	Soaking Time	Soaking Fluid	D (mm)	W (mm)	Load (P) (KN)	De^2 (mm^2)	I_s (MPa)	F	$I_{s(50)}$ (MPa)	NOTE
DH16-08		C1-1	a	-	Dry	20.4	60.75	2.662	1577.9	1.69	0.90	1.52	
DH16-08		C1-2	a	1 hr	Process Water	23.6	60.65	2.236	1822.4	1.23	0.93	1.14	
DH16-08		C1-3	a	1 hr	Distilled Water	23.8	60.62	1.920	1837.0	1.05	0.93	0.98	
DH16-08		C2a-1	a	-	Dry	24.7	60.57	3.644	1904.9	1.91	0.94	1.80	
DH16-08		C2a-2	a	2 hr	Process Water	21.4	60.52	0.918	1649.0	0.56	0.91	0.51	
DH16-08		C2a-3	a	2 hr	Distilled Water	24.0	60.53	0.886	1849.7	0.48	0.93	0.45	
DH16-08		C2b-1	a	-	Dry	24.9	60.54	1.890	1919.3	0.98	0.94	0.93	
DH16-08		C2b-2	a	5 hr	Process Water	24.6	60.51	0.264	1895.3	0.14	0.94	0.13	
DH16-08		C2b-3	a	5 hr	Distilled Water	27.9	60.50	0.190	2149.2	0.09	0.97	0.09	
DH16-08		C3-1	a	-	Dry	19.4	60.68	1.074	1498.8	0.72	0.89	0.64	
DH16-08		C3-2	a	24 hr	Process Water	26.4	60.68	0.102	2039.7	0.05	0.96	0.05	
DH16-08		C3-3	a	24 hr	Distilled Water	24.4	60.71	0.042	1886.1	0.02	0.94	0.02	
DH16-08		C4a-1	a	-	Dry	28.4	60.53	1.546	2188.8	0.71	0.97	0.69	
DH16-08		C4a-2	a	48 hr	Process Water	25.6	60.53	0.302	1973.0	0.15	0.95	0.15	
DH16-08		C4a-3	a	48 hr	Distilled Water	26.4	60.56	0.102	2035.6	0.05	0.95	0.05	
DH16-08		C4b-1	a	-	Dry	23.9	60.60	1.778	1844.1	0.96	0.93	0.90	
DH16-08		C4b-2	a	1 week	Process Water	22.4	60.50	0.210	1725.5	0.12	0.92	0.11	
DH16-08		C4b-3	a	1 week	Distilled Water	24.1	60.51	0.320	1856.8	0.17	0.94	0.16	
DH16-08		C5-1	a	-	Dry	22.9	60.47	3.724	1763.1	2.11	0.92	1.95	
DH16-08		C5-2	a	2 weeks+	Process Water	25.4	60.52	1.458	1957.2	0.74	0.95	0.71	
DH16-08		C5-3	a	2 weeks+	Distilled Water	25.4	60.50	1.612	1956.6	0.82	0.95	0.78	

Test Equipment: * a: axial * d : diametral ⊥ : perpendicular to plane of weakness

Load Gauge No.: 1 : irregular lump

Klohn Crippen Berger

PROJECT NO.:	M09441A18
PROJECT:	Near West TSF PFS
LOCATION:	Arizona
DATE:	2017-05-08
TESTED BY:	BY CHECKED BY: JG

POINT LOAD TEST
(ASTM D5731)

Hole Number	Depth (m)	Specimen Number	Test Type	Soaking Time	Soaking Fluid	D (mm)	W (mm)	Load (P) (KN)	De^2 (mm^2)	I_s (MPa)	F	$I_{s(50)}$ (MPa)	NOTE
DH17-29		C1-1	a	-	Dry	25.3	61.14	2.568	1969.5	1.30	0.95	1.24	
DH17-29		C1-2	a	1 hr	Process Water	24.8	61.16	1.878	1931.2	0.97	0.94	0.92	
DH17-29		C1-3	a	1 hr	Distilled Water	25.8	61.13	2.944	2008.1	1.47	0.95	1.40	
DH17-29		C2a-1	a	-	Dry	24.2	61.13	3.038	1883.6	1.61	0.94	1.51	
DH17-29		C2a-2	a	2 hr	Process Water	23.7	61.14	1.568	1844.9	0.85	0.93	0.79	
DH17-29		C2a-3	a	2 hr	Distilled Water	24.1	61.12	1.512	1875.5	0.81	0.94	0.76	
DH17-29		C2b-1	a	-	Dry	23.6	61.12	3.968	1836.6	2.16	0.93	2.02	
DH17-29		C2b-2	a	5 hr	Process Water	24.4	61.10	1.262	1898.2	0.66	0.94	0.62	
DH17-29		C2b-3	a	5 hr	Distilled Water	26.0	61.09	1.816	2022.3	0.90	0.95	0.86	
DH17-29		C3a-1	a	-	Dry	23.1	61.13	3.422	1797.9	1.90	0.93	1.77	
DH17-29		C3a-2	a	24 hr	Process Water	24.7	61.13	0.764	1922.5	0.40	0.94	0.37	
DH17-29		C3a-3	a	24 hr	Distilled Water	26.4	61.07	1.024	2052.8	0.50	0.96	0.48	
DH17-29		C3b-1	a	-	Dry	24.8	61.08	2.916	1928.7	1.51	0.94	1.43	
DH17-29		C3b-2	a	48 hr	Process Water	23.4	61.08	0.904	1819.8	0.50	0.93	0.46	
DH17-29		C3b-3	a	48 hr	Distilled Water	23.9	61.08	0.598	1858.7	0.32	0.94	0.30	
DH17-29		C3c-1	a	-	Dry	24.1	61.03	2.816	1872.7	1.50	0.94	1.41	
DH17-29		C3c-2	a	1 week	Process Water	26.4	61.10	0.334	2053.8	0.16	0.96	0.16	
DH17-29		C3c-3	a	1 week	Distilled Water	25.8	61.06	0.390	2005.8	0.19	0.95	0.19	
DH17-29		C8-1	a	-	Dry	26.4	61.09	4.870	2053.5	2.37	0.96	2.27	
DH17-29		C8-2	a	2 weeks+	Process Water	26.4	61.11	1.886	2054.1	0.92	0.96	0.88	
DH17-29		C8-3	a	2 weeks+	Distilled Water	27.1	61.15	1.400	2110.0	0.66	0.96	0.64	

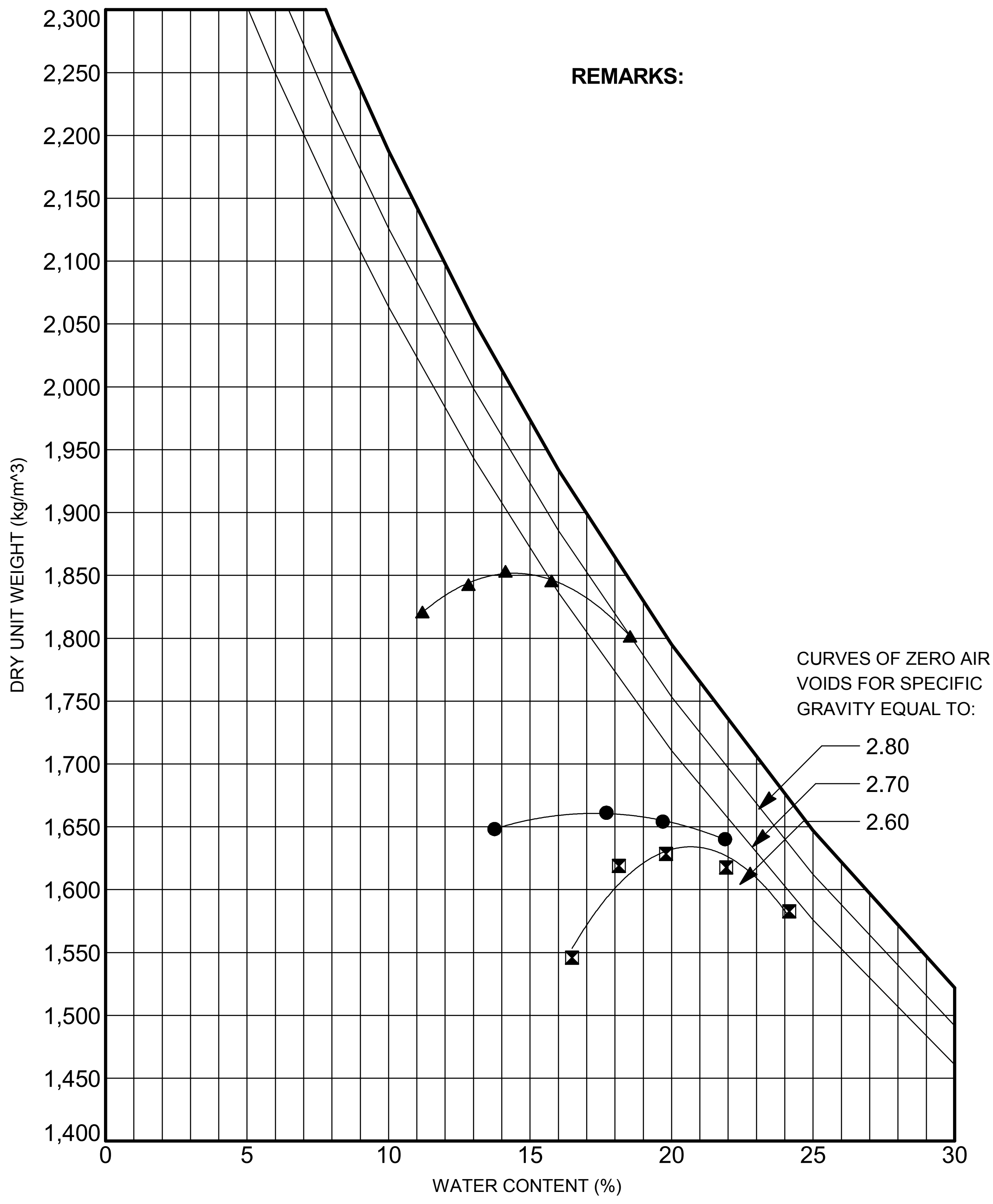
Test Equipment:
Load Gauge No.:

* a: axial
* d : diametral I : perpendicular to plane of weakness
1 : irregular lump

Klohn Crippen Berger

PROJECT NO.:	M09441A18
PROJECT:	Near West TSF PFS
LOCATION:	Arizona
DATE:	2017-05-08
TESTED BY:	BY CHECKED BY: JG

MOISTURE - DENSITY RELATIONSHIP



	TEST	DEPTH(m)	METHOD	OWC	MDW	MATERIAL DESCRIPTION
●	TP17-33	1.0	698C	17.5	1665.0	
⊠	TP17-35	1.0	698C	20.0	1630.0	
▲	TP17-37	1.0	698C	14.0	1855.0	

OWC = Optimum Water Content (%) MDW = Maximum dry Unit Weight (kg/m^3)

Klohn Crippen Berger

PROJECT NO.: M09441A18

PROJECT: Near West TSF Pre-Feasibility Study

LOCATION: Arizona

FIGURE:

DRAWN BY: CM **CHECKED BY:** JG

KCB_COMPACTION_TEST-SI M09441A18 RESOLUTION - T1719.GPJ 17-5-5

SLAKE DURABILITY
(ASTM D4644)

Hole No.	TP17-33	TP17-33	TP17-35	TP17-35	TP17-37	TP17-37
Sample No.	Various	Various	Various	Various	Various	Various
Depth (m)	1.00	1.00	1.00	1.00	1.00	1.00
Description	Pieces from test pit, distilled water	Pieces from test pit, process water	Pieces from test pit, distilled water	Pieces from test pit, process water	Pieces from test pit, distilled water	Pieces from test pit, process water
NATURAL MOISTURE CONTENT OF SAMPLE						
Drum No.	Left	Right	Left	Right	Left	Right
Drum wt. (g)	1778.26	1775.75	1778.26	1775.75	1778.26	1775.75
Wet wt. + Drum (g)	2333.79	2329.28	2277.27	2252.90	2245.29	2308.80
Dry wt. + Drum (g)	2278.65	2276.35	2227.46	2197.88	2216.69	2274.31
Moisture content (%)	**11.02**	**10.57**	**11.09**	**13.03**	**6.52**	**6.92**
CYCLE #1						
Beginning water temp. (°C)	22.9	21.9	21.9	22.1	22.6	22.7
Ending water temp. (°C)	22.9	22.0	22.7	22.6	22.5	22.6
Average water temp. (°C)	22.9	22.0	22.3	22.4	22.6	22.7
Dry wt. + drum (g)	2256.73	2251.99	2201.45	2153.64	2183.63	2234.1
CYCLE #2						
Beginning water temp. (°C)	22.2	22.4	21.4	21.8	21.5	21.6
Ending water temp. (°C)	23.0	23.1	21.6	22	21.4	21.6
Average water temp. (°C)	22.6	22.8	21.5	21.9	21.5	21.6
Dry wt. + drum (g)	2242.77	2235.46	2177.26	2119.74	2156.82	2195.60
SLAKE DURABILITY INDEX (second cycle)	**92.83%**	**91.83%**	**88.82%**	**81.49%**	**86.34%**	**84.21%**
Standard Verbal	**Type II**	**Type II**	**Type II**	**Type II**	**Type II**	**Type II**
Comments						
Description	**Type I:** Retained specimens remain virtually unchanged **Type II:** Retained specimens consist of large and small fragments **Type III:** Retained specimens are exclusively small fragments					

Klohn Crippen Berger

PROJECT No.:	M09441A18		Page 1 of 2
PROJECT NAME:	Near West TSF Pre-feasibility Study		
LOCATION:	Arizona, USA		
DATE:	2017-05-05		
TESTED BY:	BY	**CHECKED BY:**	JG

SLAKE DURABILITY
(ASTM D4644)

Sample ID	Before Test	After Test
TP17-33 Distilled Water		
TP17-33 Process Water		
TP17-35 Distilled Water		
TP17-35 Process Water		
TP17-37 Distilled Water		
TP17-37 Process Water		

Klohn Crippen Berger

JOB NO.:	M09441A18		Page 2 of 2
PROJECT:	Near West TSF Pre-feasibility Study		
LOCATION:	Arizona, USA		
DATE:	2017-05-05		
TESTED BY:	BY	CHECKED BY:	JG

Direct Shear Test (ASTM D3080)

DH17-36 / S3 / 6.80 m, 400 kPa Normal Stress, Peak and Residual

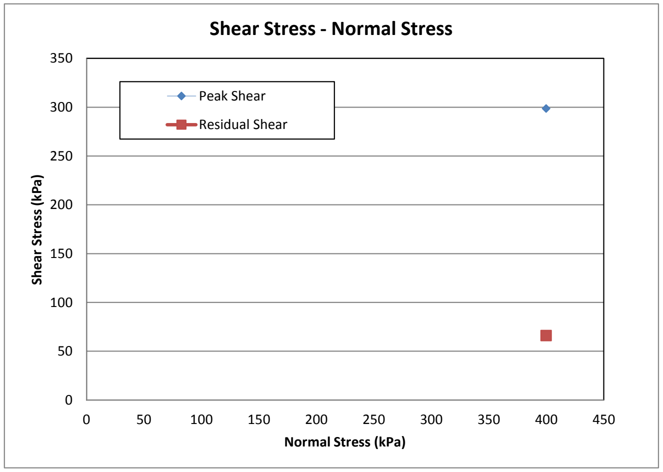
Klohn Crippen Berger

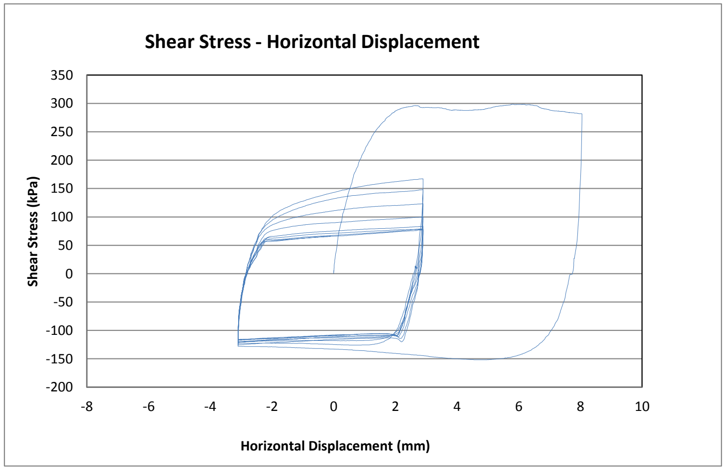
Project Number: M09941A18
Project Name: Resolution Near West TSF PFS
Location: AZ, USA

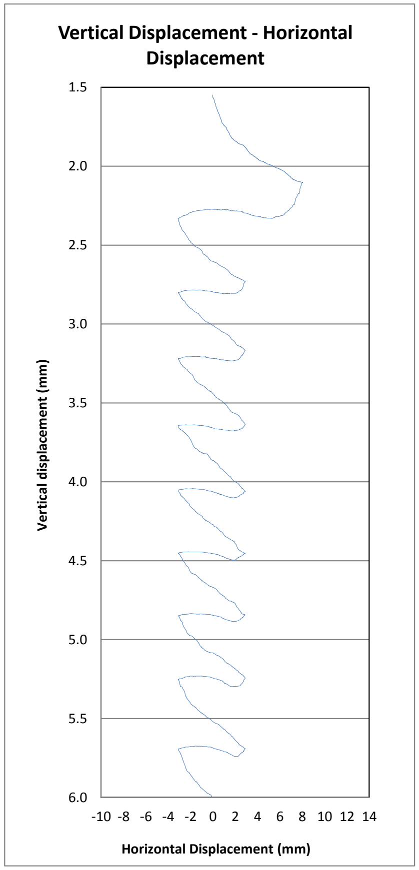
Date of Testing: 2017-04-10
Tested by: BY
Checked by: JG

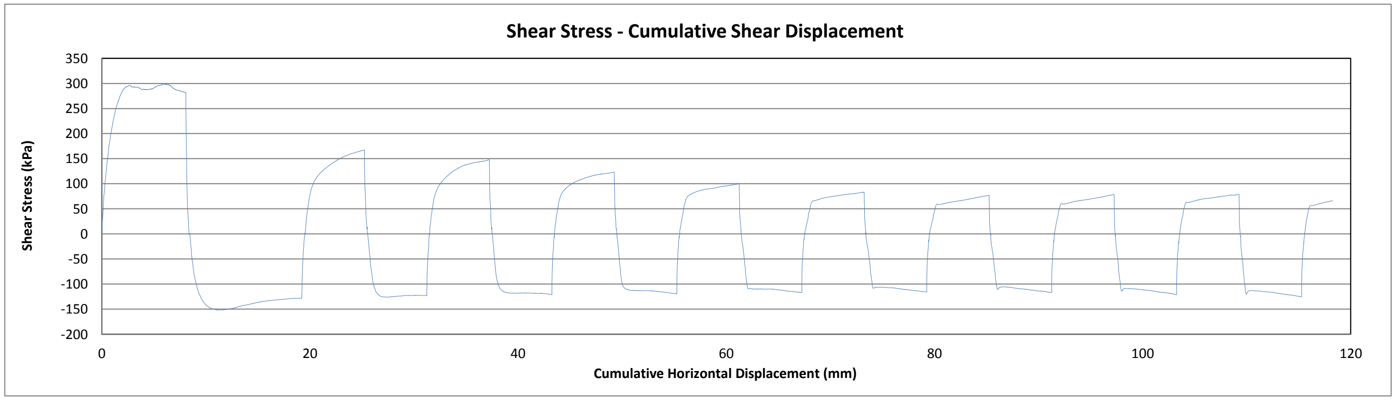
Hole No./ Sample No.	Depth (m)	Specimen Diameter (mm)	Initial Height (mm)	Area (mm2)	Volume (cm3)	Initial WC (%)	Initial Wet weight (g)	Initial Dry Weight (g)	Initial Bulk Density (g/cm3)	Initial Dry Density (g/cm3)	Normal Stress (kPa)	Height at shearing (mm)	Volume at shearing (cm3)	Dry Density at shearing (kg/m3)	Final WC (%)	Peak Shear Stress (kPa)	Φ (°)	c (kPa)	Residual Shear Stress (kPa)	Residual Φ (°)	Residual c (kPa)
DH17-36 / S3	6.80	61.44	32.61	2964.79	96.68	13.71	192.19	169.02	1.99	1.75	**399.9**	31.06	92.09	1.84	18.03	**298.6**	36.7	0*	**66.0**	9.4	0*

* Assuming c=0

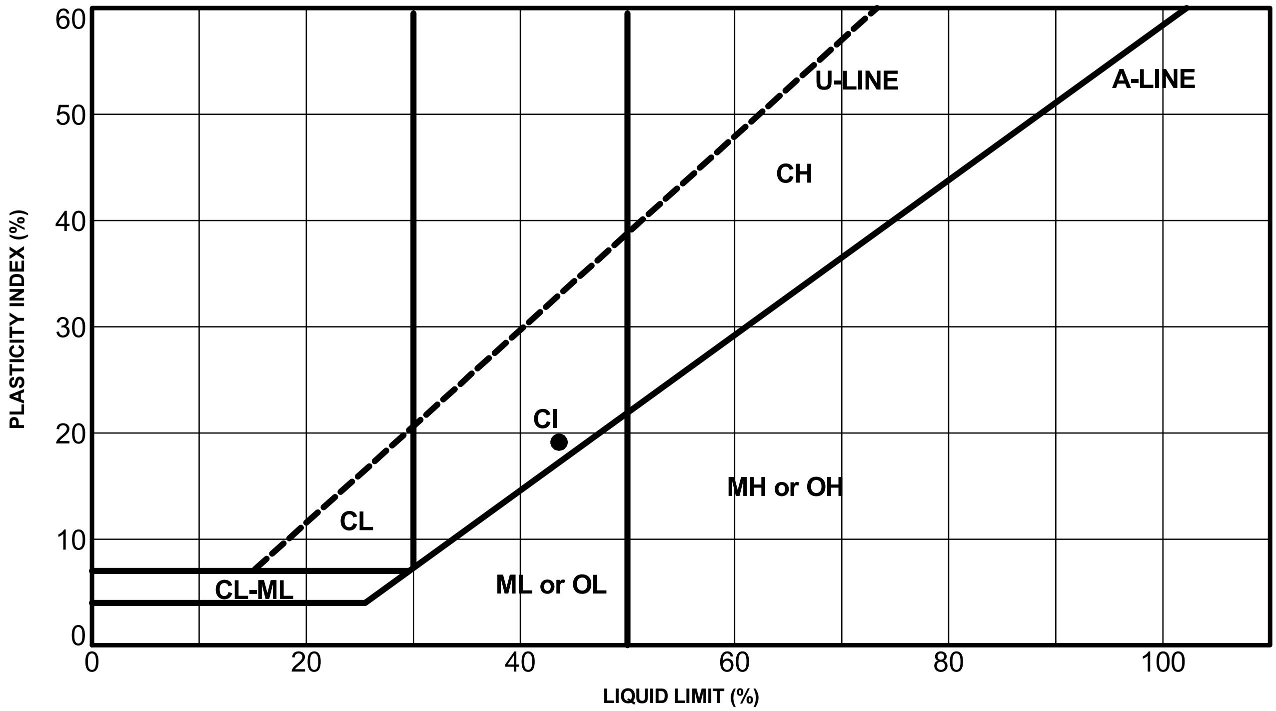








PLASTICITY CHART



	HOLE	SAMPLE	DEPTH (m)	W_L	W_P	PI	% FINES	REMARKS/SAMPLE DESCRIPTION
●	DH17-36	S3	6.8	44	24	19		Direct Shear Sample

Klohn Crippen Berger

PROJECT NO.: M09441A18

PROJECT: Near West TSF Pre-Feasibility Study

LOCATION: Arizona

FIGURE:

DRAWN BY: CM **CHECKED BY:** JG

SLAKE DURABILITY
(ASTM D4644)

Hole No.	DH17-24	DH17-24				
Sample No.	Various	Various				
Depth (m)	1.00	1.00				
Description	Pieces from test pit, distilled water	Pieces from test pit, process water				
NATURAL MOISTURE CONTENT OF SAMPLE						
Drum No.	Left	Right				
Drum wt. (g)	1778.26	1775.75				
Wet wt. + Drum (g)	2208.37	2202.01				
Dry wt. + Drum (g)	2206.73	2200.28				
Moisture content (%)	**0.38**	**0.41**				
CYCLE #1						
Beginning water temp. (°C)	22.7	21.6				
Ending water temp. (°C)	22.4	21.5				
Average water temp. (°C)	2201.1	21.6				
Dry wt. + drum (g)	2256.73	2194.35				
CYCLE #2						
Beginning water temp. (°C)	22.6	22.6				
Ending water temp. (°C)	22.4	22.4				
Average water temp. (°C)	22.5	22.5				
Dry wt. + drum (g)	2197.36	2189.03				
SLAKE DURABILITY INDEX (second cycle)	**97.81%**	**97.35%**				
Standard Verbal	**Type II**	**Type II**				
Comments						

Description

Type I: Retained specimens remain virtually unchanged
Type II: Retained specimens consist of large and small fragments
Type III: Retained specimens are exclusively small fragments

Klohn Crippen Berger

PROJECT No.:	M09441A18		Page 1 of 2
PROJECT NAME:	Near West TSF Pre-feasibility Study		
LOCATION:	Arizona, USA		
DATE:	2017-05-10		
TESTED BY:	BY	CHECKED BY:	JG

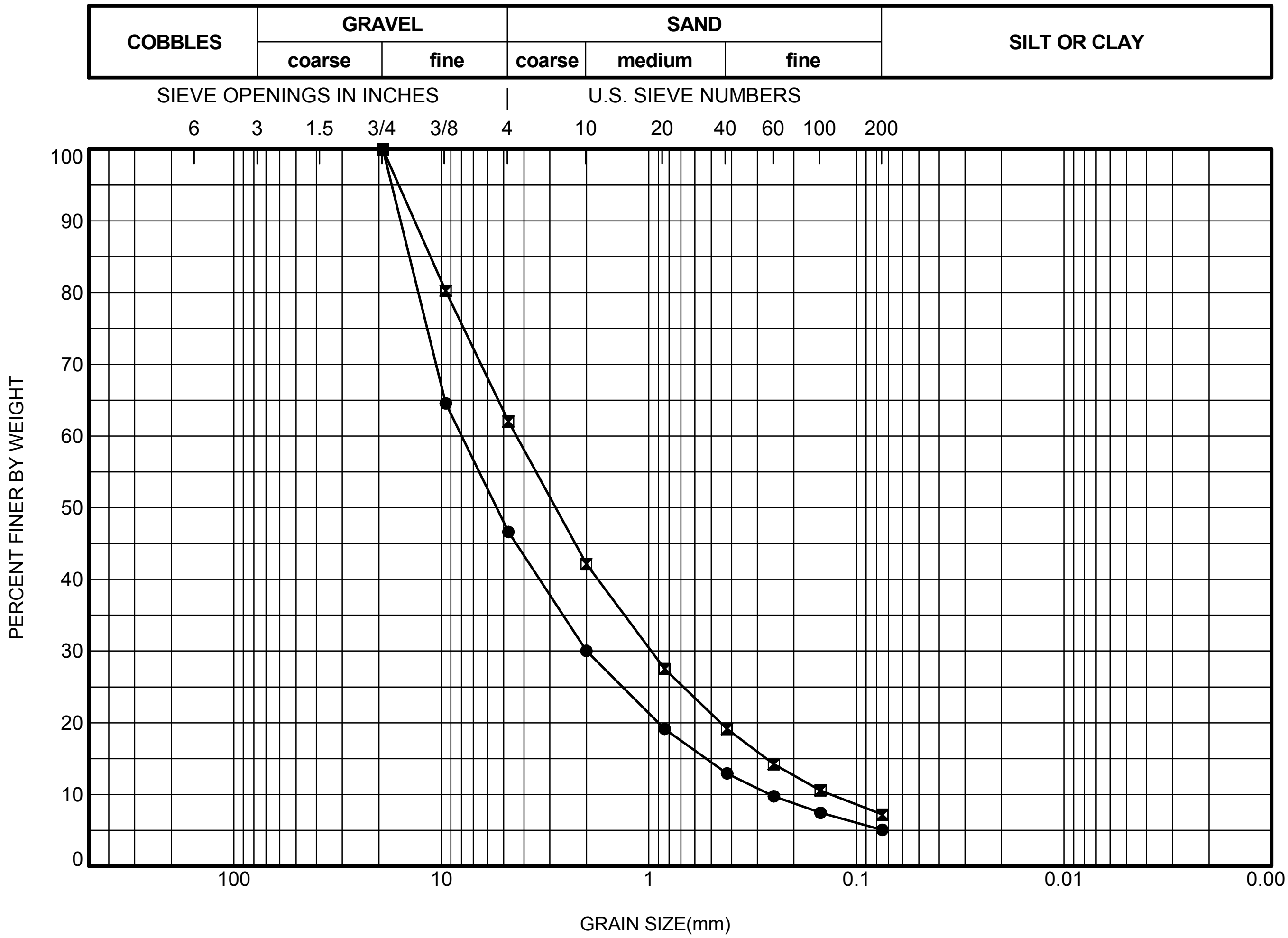
SLAKE DURABILITY
(ASTM D4644)

Sample ID	Before Test	After Test
DH17-24 Distilled Water		
DH17-24 Process Water		

Klohn Crippen Berger

JOB NO.:	M09441A18	Page 2 of 2	
PROJECT:	Near West TSF Pre-feasibility Study		
LOCATION:	Arizona, USA		
DATE:	2017-05-10		
TESTED BY:	BY	CHECKED BY:	JG

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D30	D10	CC	CU	%GRAVEL	%SAND	%FINES
●	TP17-33	1.0	14.225	7.979	1.996	0.261	1.92	30.62	53.4	41.6	5.1
⊠	TP17-33	1.0	11.257	4.351	0.974	0.133	1.64	32.77	38.0	54.8	7.2

	HOLE	SAMPLE	DEPTH (m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP17-33		1.0					Before Proctor & Cementation
⊠	TP17-33		1.0					After Proctor & Cementation

CU = COEFFICIENT OF UNIFORMITY = D60/D10 **PARTICLE SIZES, e.g. D85, in mm** **Tested by Wet Sieving Method (ASTM D6913 & ISO/TS 17892-4)**

Klohn Crippen Berger

PROJECT NO.: M09441A18

PROJECT: Near West TSF Pre-Feasibility Study

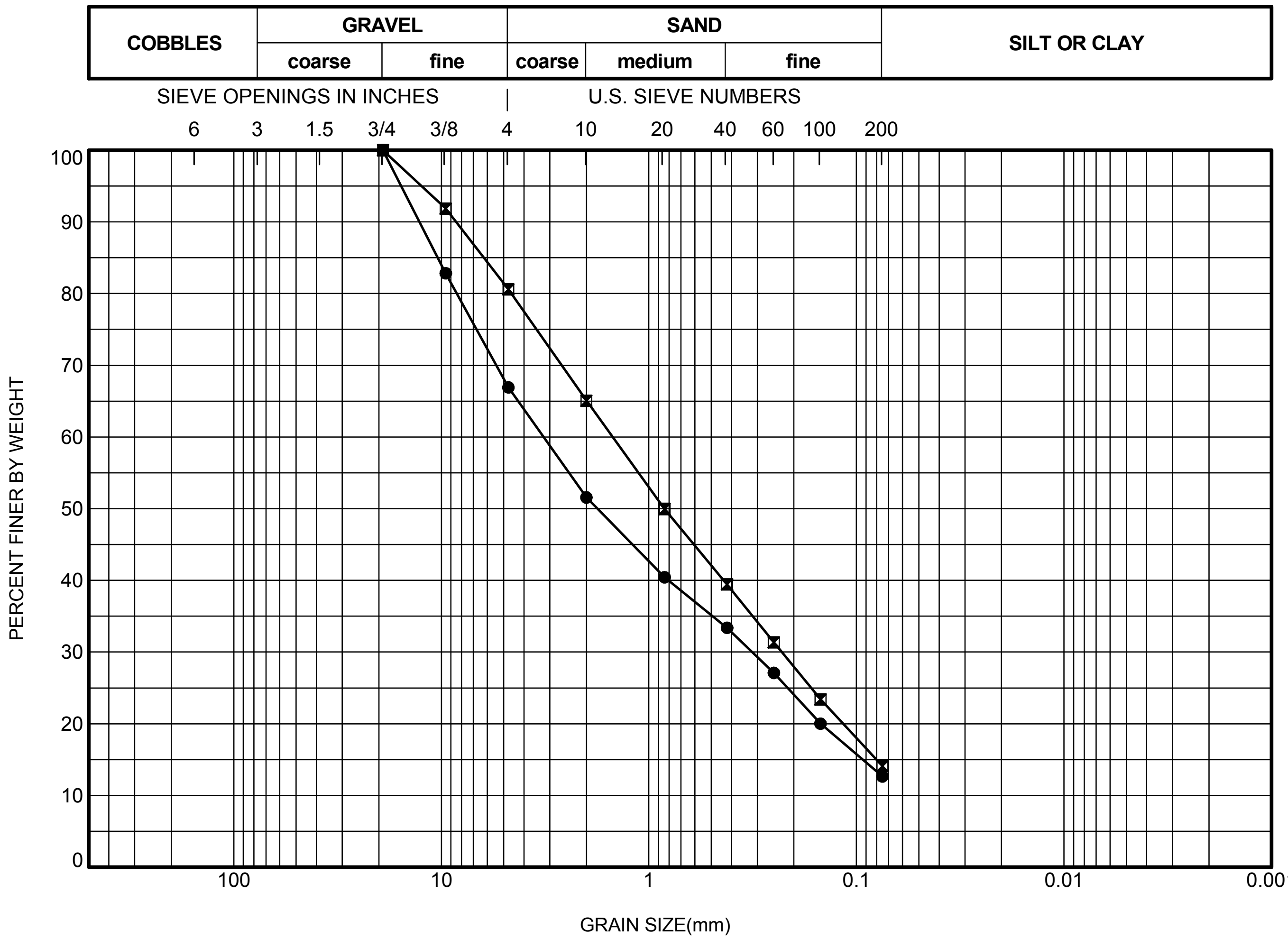
LOCATION: Arizona

FIGURE:

DRAWN BY: CM **CHECKED BY:** JG

KCB_GRAIN_SIZE-SI M09441A18 RESOLUTION - T1721.GPJ SIEVE.GDT 17-6-2

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D30	D10	CC	CU	%GRAVEL	%SAND	%FINES
●	TP17-35	1.0	10.396	3.218	0.318				33.1	54.2	12.7
⧗	TP17-35	1.0	6.24	1.496	0.229				19.4	66.5	14.1

	HOLE	SAMPLE	DEPTH (m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP17-35		1.0					Before Proctor & Cementation
⧗	TP17-35		1.0					After Proctor & Cementation

CU = COEFFICIENT OF UNIFORMITY = D60/D10 PARTICLE SIZES, e.g. D85, in mm Tested by Wet Sieving Method (ASTM D6913 & ISO/TS 17892-4)

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Near West TSF Pre-Feasibility Study
LOCATION: Arizona
FIGURE:
DRAWN BY: CM **CHECKED BY:** JG

Constant Head Permeability Test

(ASTM D2434)

PROJECT NO. :	M0944A1A18	**PROJECT :**	Resolution - Near West TSF Pre-Feasibility Study
LOCATION:	AZ, USA	**DATE :**	2017-06-28
TEST BY:	BY	**CHECKED BY:**	JG

Sample No.: TP17-37 (after cementation)
Description: Gravelly Sand
Method of Preparation: Compacted at 14.04 % moisture content in four layers to the maximum dry density of standard proctor test, soaked sample in process water for 7 days, then air-dried the sample in 14 days before permeability test

Sample Dimensions:

Diameter (D):	15.44 cm	Area (A):	187.19 cm^2
Length (L):	15.49 cm	Volume (V):	2898.947 cm^3

Mass of sample:

Mould + sample:	6180.81 g	Sample:	6180.81 g
Mould:	0 g		

Sample initial water content and density:

Bulk density:	2.132 g/cm^3	Water content:	14.04 %
Dry density:	1.870 g/cm^3		

Coef. of Permeability at 20 °C (k20): 1.54E-05 cm/sec

Constant Head Test 1				
	Water head	H	cm	20.4
	Hydraulic gradient	i	-	1.32

Measurement No.	-	-	1	2	3	4	5
Elapsed Time	-	min	24	36	48	65	80
Test duration	t	sec	1440	720	720	900	900
Quantity of Discharge	Q	cm^3	5.75	2.84	2.89	3.6	3.52
Discharge Rate	Q/t	cm^3/sec	3.99E-03	3.94E-03	4.01E-03	4.00E-03	3.91E-03
Test temperature	T	°C	21.6	21.9	21.8	21.8	21.6
Visc. (Test °C)/Visc. (20 °C)	R_T	-	0.96	0.96	0.96	0.96	0.96
Turbidity	-	-	Clear	Clear	Clear	Clear	Clear
Coef. of Perm. at 20 °C	k_{20}	cm/sec	1.56E-05	1.53E-05	1.56E-05	1.55E-05	1.53E-05

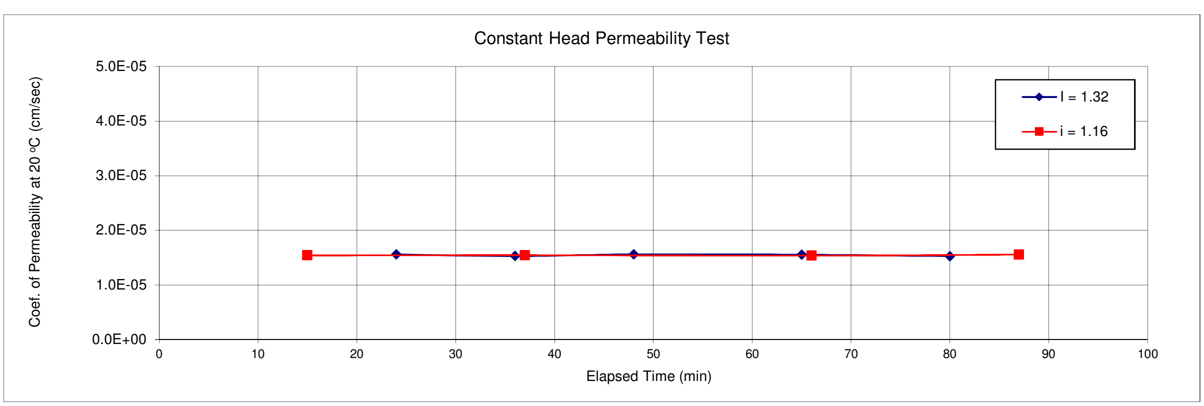
Constant Head Test 2				
	Water head	H	cm	18.0
	Hydraulic gradient	i	-	1.16

Measurement No.	-	-	1	2	3	4	
Elapsed Time	-	min	15	37	66	87	
Test duration	t	sec	900	1260	1680	1140	
Quantity of Discharge	Q	cm^3	3.12	4.38	5.81	3.98	
Discharge Rate	Q/t	cm^3/sec	3.47E-03	3.48E-03	3.46E-03	3.49E-03	
Test temperature	T	°C	21.4	21.4	21.4	21.3	
Visc. (Test °C)/Visc. (20 °C)	R_T	-	0.97	0.97	0.97	0.97	
Turbidity	-	-	Clear	Clear	Clear	Clear	
Coef. of Perm. at 20 °C	k_{20}	cm/sec	1.54E-05	1.55E-05	1.54E-05	1.56E-05	

Constant Head Test 3				
	Water head	H	cm	
	Hydraulic gradient	i	-	

Measurement No.	-	-	1	2	3	4	5
Elapsed time	-	min					
Time of discharge	t	sec					
Quantity of Discharge	Q	cm^3					
Discharge Rate	Q/t	cm^3/sec					
Test temperature	T	°C					
Visc. (Test °C)/Visc. (20 °C)	R_T	-					
Turbidity	-	-					
Coef. of Perm. at 20 °C	k_{20}	cm/sec					

Turbidity Scale: Dark, Moderately Dark, Slightly Dark, Barely Visible, Clear, Completely Clear



Constant Head Permeability Test

(ASTM D2434)

Klohn Crippen Berger

PROJECT NO. :	M0944A1A18	**PROJECT :**	Resolution - Near West TSF Pre-Feasibility Study
LOCATION:	AZ, USA	**DATE :**	2017-06-02
TEST BY:	BY	**CHECKED BY:**	JG

Sample No.: TP17-37
Description: Gravelly Sand
Method of Preparation: Compacted at 14.04 % moisture content in four layers to the maximum dry density of standard proctor test

Sample Dimensions:

Diameter (D):	15.44 cm	Area (A):	187.19 cm^2
Length (L):	15.49 cm	Volume (V):	2898.947 cm^3

Mass of sample:

Mould + sample:	6180.81 g	Sample:	6180.81 g
Mould:	0 g		

Sample initial water content and density:

Bulk density:	2.132 g/cm^3	Water content:	14.04 %
Dry density:	1.870 g/cm^3		

Coef. of Permeability at 20 °C (k20): **3.02E-06 cm/sec**

Constant Head Test 1	Water head	H	cm	20.0
	Hydraulic gradient	i	-	1.29

Measurement No.	-	-	1	2	3	4	5
Elapsed Time	-	min	15	30	45	60	75
Test duration	t	sec	900	900	900	900	900
Quantity of Discharge	Q	cm^3	0.56	0.72	0.69	0.68	0.68
Discharge Rate	Q/t	cm^3/sec	6.22E-04	8.00E-04	7.67E-04	7.56E-04	7.56E-04
Test temperature	T	°C	22.5	22.5	22.3	22.1	22.2
Visc. (Test °C)/Visc. (20 °C)	R_T	-	0.94	0.94	0.95	0.95	0.95
Turbidity	-	-	Clear	Clear	Clear	Clear	Clear
Coef. of Perm. at 20 °C	k_{20}	cm/sec	2.43E-06	3.12E-06	3.00E-06	2.97E-06	2.97E-06

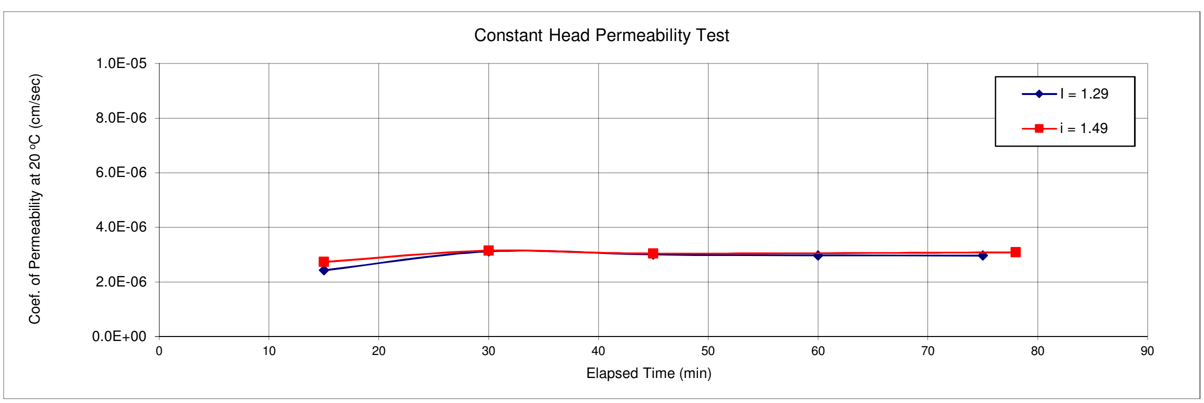
Constant Head Test 2	Water head	H	cm	23.1
	Hydraulic gradient	i	-	1.49

Measurement No.	-	-	1	2	3	4	
Elapsed Time	-	min	15	30	45	78	
Test duration	t	sec	900	900	900	1980	
Quantity of Discharge	Q	cm^3	0.72	0.83	0.8	1.78	
Discharge Rate	Q/t	cm^3/sec	8.00E-04	9.22E-04	8.89E-04	8.99E-04	
Test temperature	T	°C	22.0	22.0	21.9	21.8	
Visc. (Test °C)/Visc. (20 °C)	R_T	-	0.95	0.95	0.96	0.96	
Turbidity	-	-	Clear	Clear	Clear	Clear	
Coef. of Perm. at 20 °C	k_{20}	cm/sec	2.73E-06	3.15E-06	3.04E-06	3.08E-06	

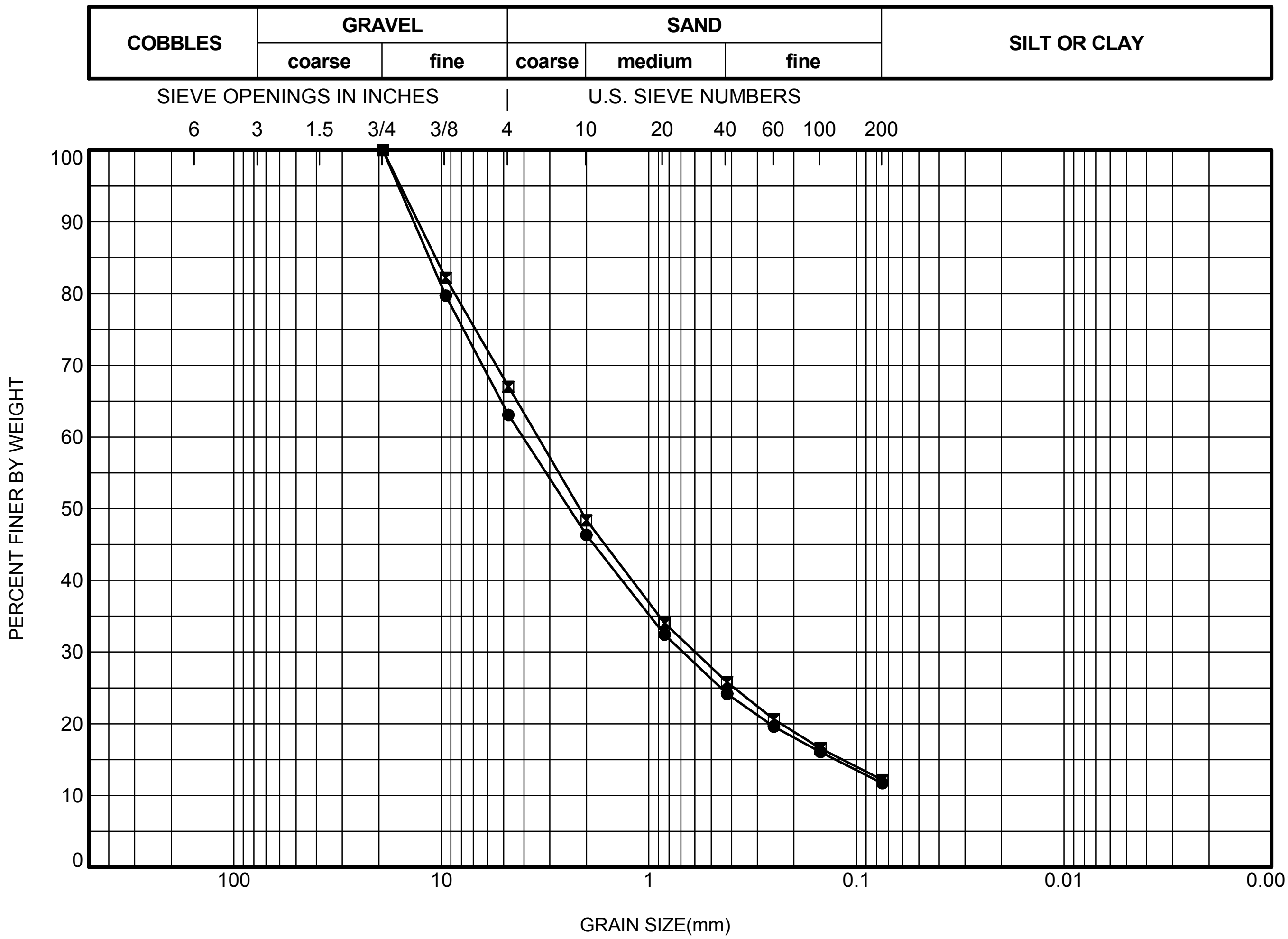
Constant Head Test 3	Water head	H	cm	
	Hydraulic gradient	i	-	

Measurement No.	-	-	1	2	3	4	5
Elapsed time	-	min					
Time of discharge	t	sec					
Quantity of Discharge	Q	cm^3					
Discharge Rate	Q/t	cm^3/sec					
Test temperature	T	°C					
Visc. (Test °C)/Visc. (20 °C)	R_T	-					
Turbidity	-	-					
Coef. of Perm. at 20 °C	k_{20}	cm/sec					

Turbidity Scale: Dark, Moderately Dark, Slightly Dark, Barely Visible, Clear, Completely Clear



GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D30	D10	CC	CU	%GRAVEL	%SAND	%FINES
●	TP17-37	1.0	11.414	4.052	0.685		2.02	70.69	36.9	51.4	11.7
⧗	TP17-37	1.0	10.625	3.431	0.598		1.94	63.84	33.0	54.9	12.1

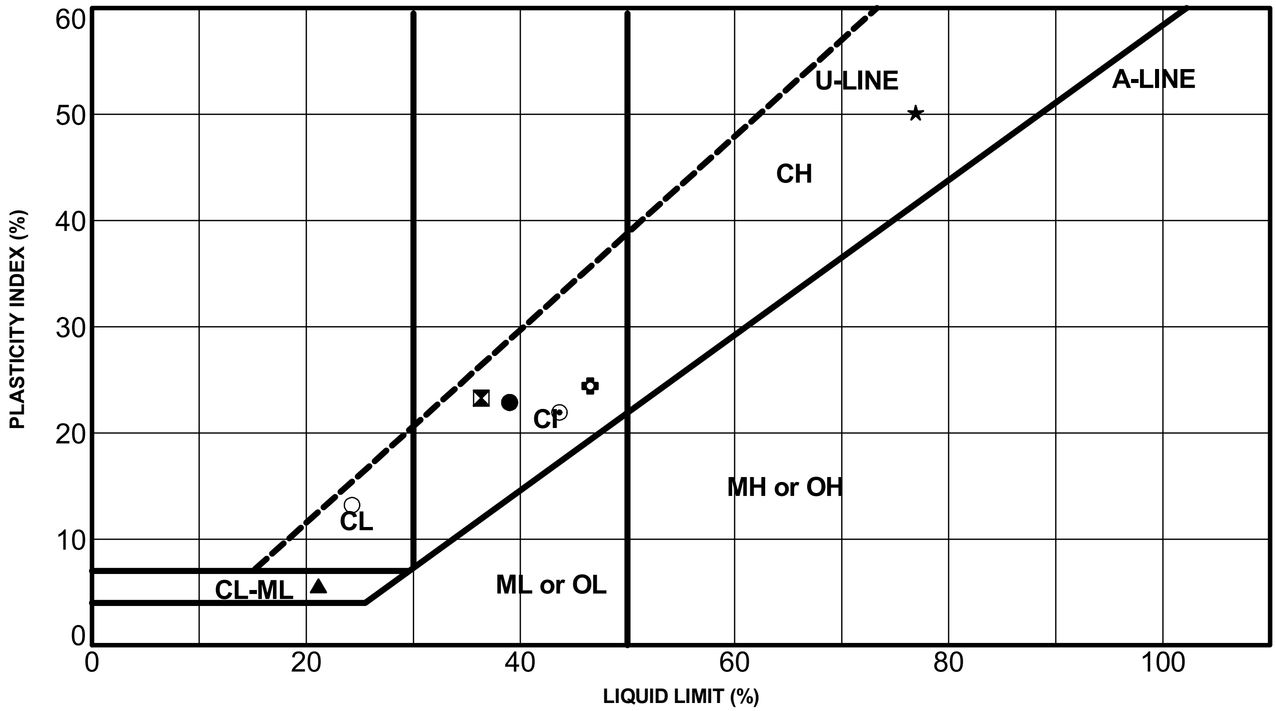
	HOLE	SAMPLE	DEPTH (m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP17-37		1.0					Before Proctor & Cementation
⧗	TP17-37		1.0					After Proctor & Cementation

CU = COEFFICIENT OF UNIFORMITY = D60/D10   PARTICLE SIZES, e.g. D85, in mm   Tested by Wet Sieving Method (ASTM D6913 & ISO/TS 17892-4)

Klohn Crippen Berger

PROJECT NO.: M09441A18	
PROJECT: Near West TSF Pre-Feasibility Study	
LOCATION: Arizona	
FIGURE:	
DRAWN BY: CM	**CHECKED BY:** JG

PLASTICITY CHART



	HOLE	SAMPLE	DEPTH (m)	W_L	W_P	PI	% FINES	REMARKS/SAMPLE DESCRIPTION
●	DH17-21		0.0	39	16	23		
⧗	DH17-23		1.5	36	13	23		
▲	DH17-32		13.6	21	16	6		
★	DH17-33		31.4	77	27	50		
⊙	DH17-35	2	34.3	44	22	22		
✿	DH17-35	3	40.4	47	22	24		
○	DH17-42		11.7	24	11	13		

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Resolution Near West TSF PFS
LOCATION: Arizona
FIGURE:
DRAWN BY: CM **CHECKED BY:** JG

KCB_ATTERBERG-SI M09441A18 RESOLUTION - T1733.GPJ SIEVE.GDT 17-10-6

SPECIFIC GRAVITY OF SOIL SOLIDS (ASTM-D854)

Hole Number	TP17-33			TP17-35		
Sample Number						
Depth (m)	1.00			1.00		
Sample Description	< 2 mm			< 2 mm		
Flask No.	SG4	SG5	8	10	3	SG12
Volume of Flask @ 20° C ml	500	500	500	500	500	500
Method of Air removal	Boiling	Boiling	Boiling	Boiling	Boiling	Boiling
De-airing Period hr	2	2	2	2	2	2
Test temperature °C	21.1	21.1	21.1	21.1	21.1	21.1
Mass of Flask+Water (M_a) g	670.83	672.26	678.82	679.84	671.59	670.77
Mass of Flask+Water+Soil (M_b) g	741.04	743.73	748.69	748.66	735.64	737.38
Mass of Dish/Flask+Soil	285.45	288.78	293.36	291.50	275.14	279.14
Mass of Dish/Flask	172.60	173.94	180.51	181.57	172.71	172.57
Mass of Dry Soil (M_o) g	112.85	114.84	112.85	109.93	102.43	106.57
Correction factor (K) @ Test Temperature	0.99977	0.99977	0.99977	0.99977	0.99977	0.99977
Specific Gravity of Solids @ 20° C	**2.65**	**2.65**	**2.63**	**2.67**	**2.67**	**2.67**
Average Specific Gravity of Solids @ 20° C	**2.64**			**2.67**		

Hole Number	TP17-37					
Sample Number						
Depth (m)	1.00					
Sample Description	< 2 mm					
Flask No.	KL3	11	KL2			
Volume of Flask @ 20° C ml	500	500	500			
Method of Air removal	Boiling	Boiling	Boiling			
De-airing Period hr	2	2	2			
Test temperature °C	21.1	21.1	21.1			
Mass of Flask+Water (M_a) g	675.95	678.72	675.63			
Mass of Flask+Water+Soil (M_b) g	750.30	754.10	751.13			
Mass of Dish/Flask+Soil	293.82	298.52	295.75			
Mass of Dish/Flask	177.38	180.41	177.10			
Mass of Dry Soil (M_o) g	116.44	118.11	118.65			
Correction factor (K) @ Test Temperature	0.99977	0.99977	0.99977			
Specific Gravity of Solids @ 20° C	**2.77**	**2.76**	**2.75**			
Average Specific Gravity of Solids @ 20° C	**2.76**					

Specific Gravity of Solids @ 20° C = $(K \times M_o)/(M_o + M_a - M_b)$

Klohn Crippen Berger

PROJECT#:	M09441A18		
PROJECT:	Resolution - Near West TSF Pre-Feasibility Study		
LOCATION:	Arizona		
DATE:	2017-08-04		
TESTED BY:	CM	CHECKED BY:	JG

Klohn Crippen Berger

Direct Shear Test (ASTM D3080)

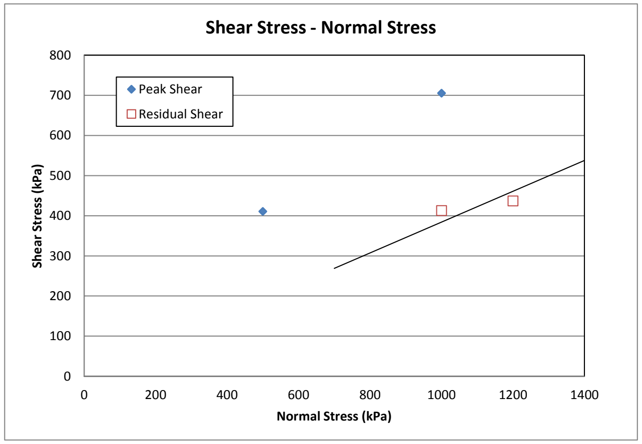
TP17-35 / 1.0 m, Peak and Multi-Stage Residual

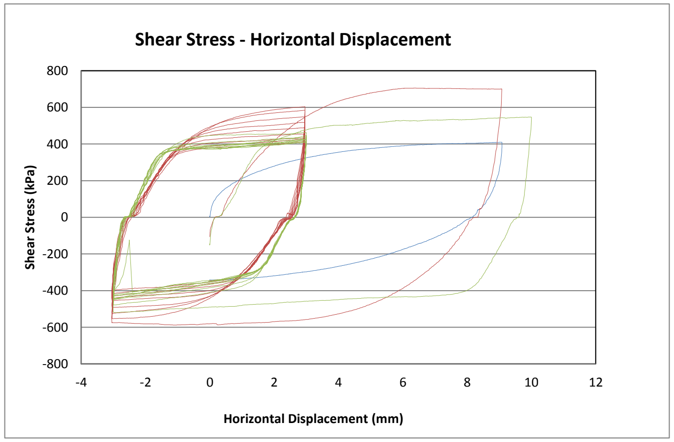
Project Number: M09441A18
Project Name: Resolution Near West TSF PFS
Location: Arizona

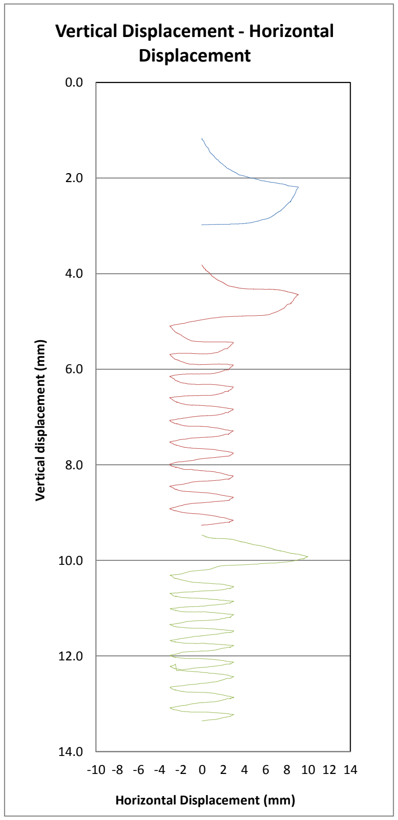
Date of Testing: 2017-07-14
Tested by: CM
Checked by: JG

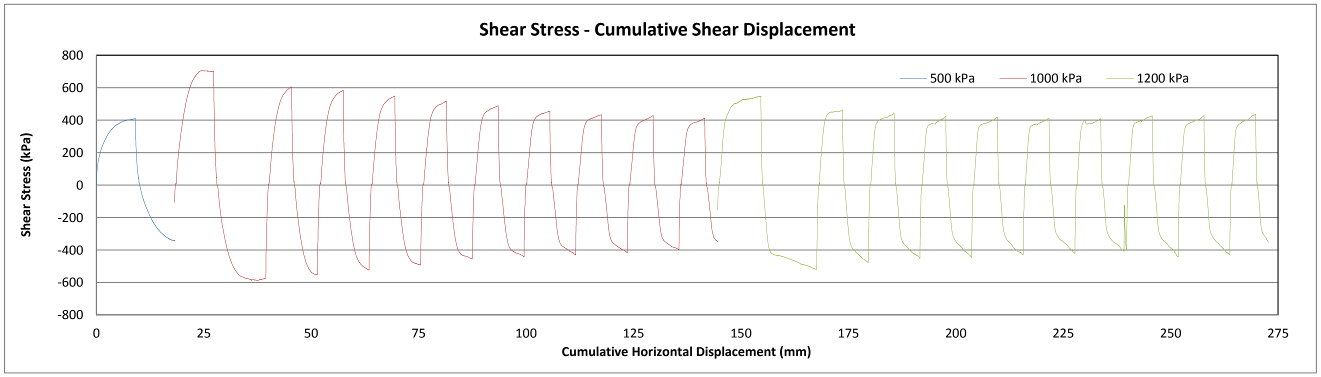
Hole No./ Sample No.	Depth (m)	Specimen Diameter (mm)	Initial Height (mm)	Area (mm2)	Volume (cm3)	Initial WC (%)	Initial Wet weight (g)	Initial Dry Weight (g)	Initial Bulk Density (g/cm3)	Initial Dry Density (g/cm3)	Normal Stress (kPa)	Height at shearing (mm)	Volume at shearing (cm3)	Dry Density at shearing (kg/m3)	Final WC (%)	Peak Shear Stress (kPa)	Φ (°)	c (kPa)	Residual Shear Stress (kPa)	Residual Φ (°)	Residual c (kPa)
		63.49	31.93	3165.92	101.09	22.40	183.37	149.81	1.81	1.48	**500**	30.79	97.49	1.54	-	**411**	39.4		-	-	
TP17-35	1.00	63.49	31.93	3165.92	101.09	-	-	-	-	-	**1000**	28.18	89.21	1.58	-	**705**	35.2	0*	**413**	22.4	0.0
		63.49	31.93	3165.92	101.09	-	-	-	-	-	**1200**	22.46	71.10	1.59	25.40	-	-		**437**	20.0	

* Assuming c=0









Appendix III-C

Colorado School of Mines Laboratory Results

Prepared For:
Klohn Crippen Berger

Project Name:
RNW-PFS

Client Contact:
ckowalchuk@klohn.com

Prepared by:

Excavation Engineering and Earth Mechanics Institute (EMI)
Colorado School of Mines
1312 Maple Street
Golden, Colorado 80401
+1 (303) 273-3123

May 08 2017

EMI Project # 276

Earth Mechanics Institute

Client: Klohn Crippen Berger

Project: RNW-PFS

Date: 5/8/2017

Colorado School of Mines

Mining Engineering Department

ASTM D5607

Sample ID	Rock Type	Joint Roughness Coefficient	Normal Stress	Shear Stress	Normal Stress	Shear Stress	Shear Strength Parameters	
							Cohesion	Friction Angle
		(JRC)	(psi)	(psi)	(MPa)	(Mpa)	(psi)	(degrees)
DH 17-29_S2-18.2	Gila Sandstone	6-8	64	174	0.443	1.198	129	32
			125	199	0.863	1.371		
			229	274	1.576	1.888		
DH-17-29-S3-29.6	Gila Sandstone	6-8	64	173	0.444	1.191	137	29
			106	197	0.731	1.360		
			230	266	1.582	1.835		
DH-17-32-S2-42.5	Pinal Schist	6-8	63	145	0.435	1.001	105	32
			164	205	1.130	1.413		
			259	267	1.788	1.841		
DH-17-32-S4-48.2	Pinal Schist	4-6	78	138	0.541	0.951	98	33
			144	207	0.995	1.428		
			293	283	2.022	1.954		
DH-17-36-S2-16	Gila Sandstone	2-4	55	147	0.377	1.012	114	31
			120	185	0.826	1.277		
			229	251	1.576	1.728		

Earth Mechanics Institute, CSM
Mining Engineering Department
Direct Shear Strengh Test (D5607)

Client: Klohn Crippen Berger
Project: RNW-PFS
Location: N/A
Rock Type: Sedimentary

Test Performed by: OF & WH
Date Tested: 5/8/2017
Data Reduced by: OF
Date Reduced: 5/8/2017

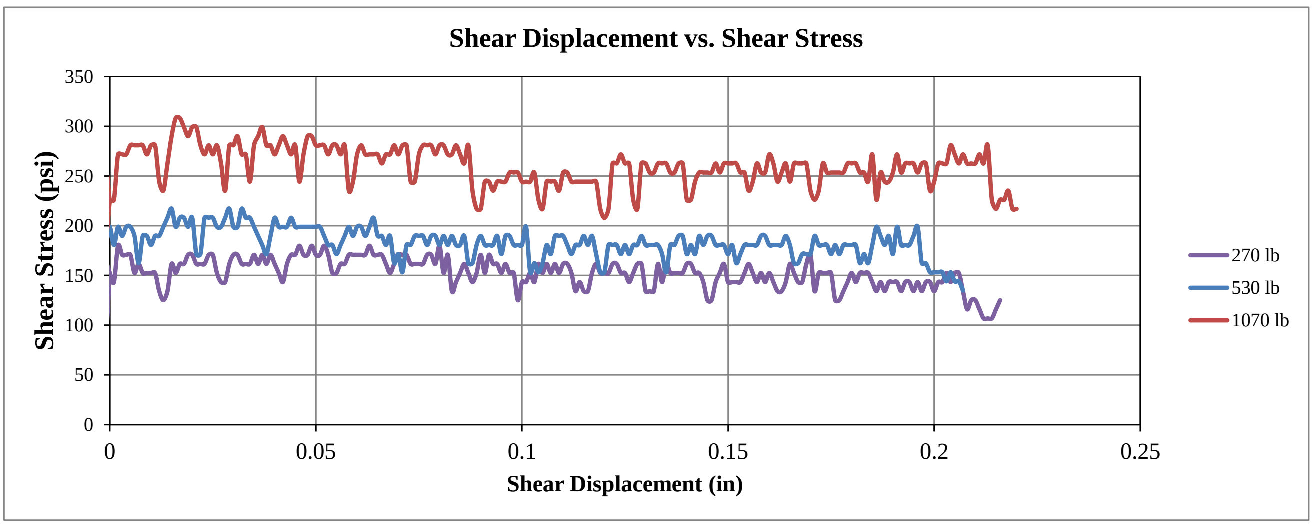
Sample ID: DH 17-29_S2-18.2
Diameter: 2.404 **in**
Diameter: 2.411 **in**
Area: 4.55 **in^2**

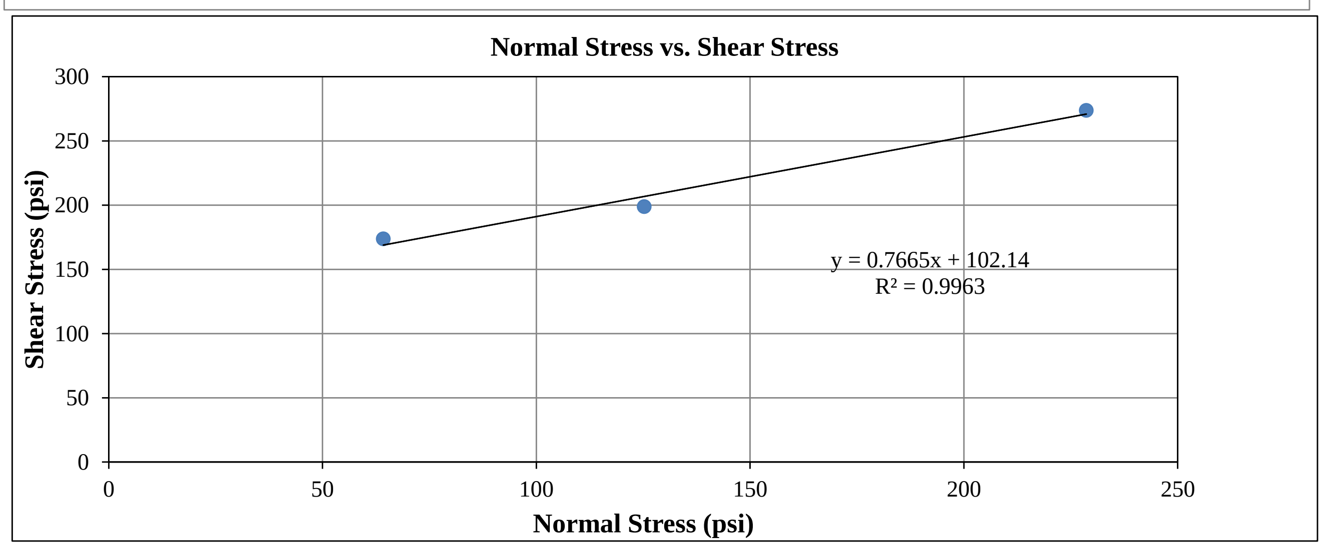
JRC: 6-8
Characteristics: The moisture content of joint filling materials are unknown.

ID	Avg. Normal Stress *(psi)*	Peak Shear Stress *(psi)*
270	64	174
530	125	199
1070	229	274

Cohesion: 129 **psi**
Friction Angle: 32 **deg**

Correlation Coefficient (R^2): 0.98





Earth Mechanics Institute, CSM
Mining Engineering Department
Direct Shear Strengh Test (D5607)

Client: Klohn Crippen Berger
Project: RNW-PFS
Location: N/A
Rock Type: Sedimentary

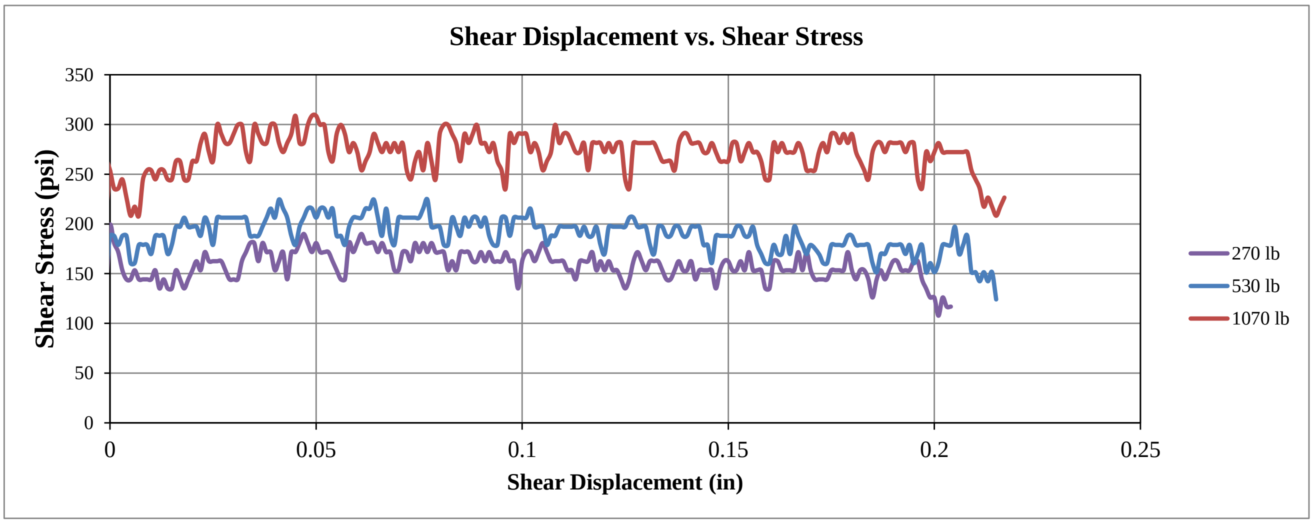
Test Performed by: OF & WH
Date Tested: 5/8/2017
Data Reduced by: OF
Date Reduced: 5/8/2017

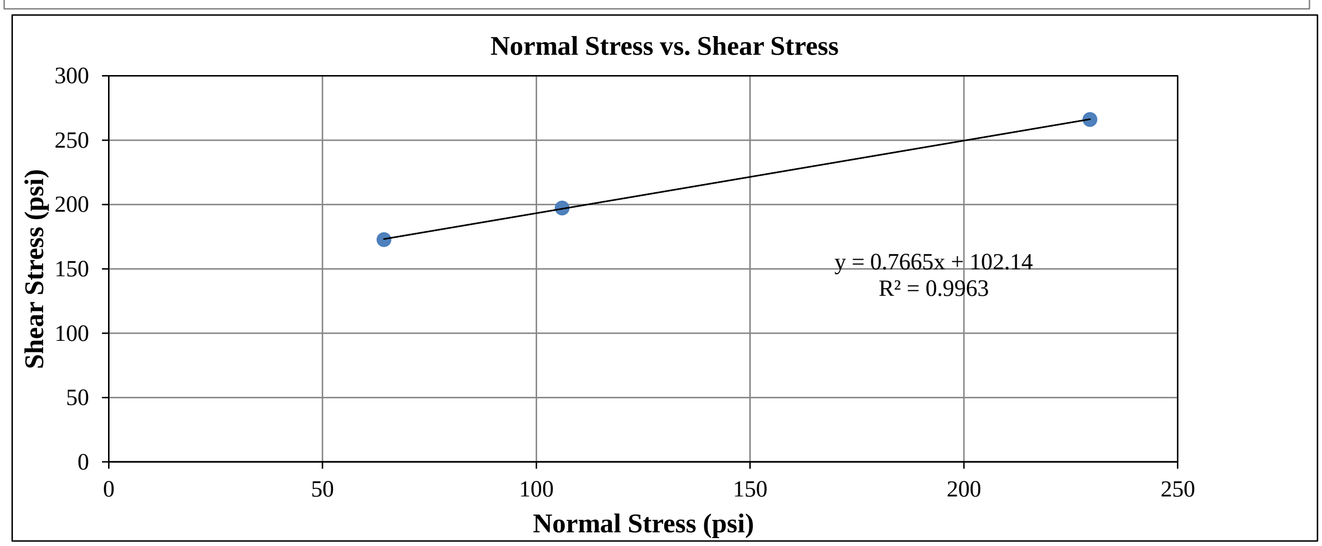
Sample ID: DH-17-29-S3-29.6
Diameter: 2.407 **in**
Diameter: 2.407 **in**
Area: 4.55 **in^2**

JRC: 6-8
Characteristics: The moisture content of joint filling materials are unknown.

ID	Avg. Normal Stress *(psi)*	Peak Shear Stress *(psi)*
270	64	173
530	106	197
1070	230	266

Cohesion: 137 **psi**
Friction Angle: 29 **deg**
Correlation Coefficient (R^2): 0.9999





Earth Mechanics Institute, CSM
Mining Engineering Department
Direct Shear Strengh Test (D5607)

Client: Klohn Crippen Berger
Project: RNW-PFS
Location: N/A
Rock Type: Sedimentary

Test Performed by: OF & WH
Date Tested: 5/8/2017
Data Reduced by: OF
Date Reduced: 5/8/2017

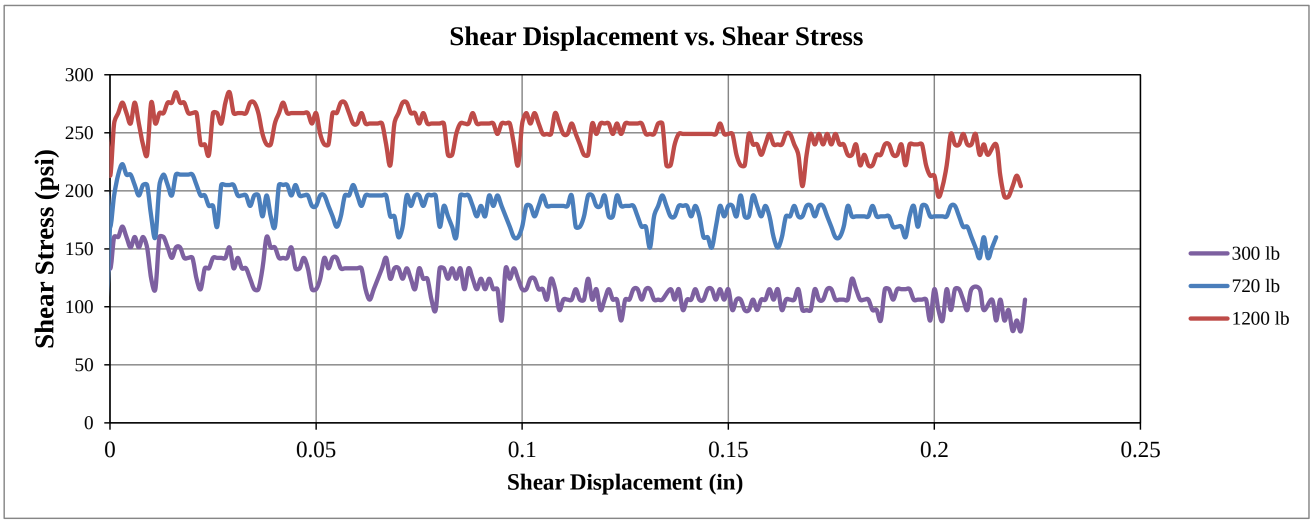
Sample ID: DH-17-32-S2-42.5
Diameter: 2.545 **in**
Diameter: 2.313 **in**
Area: 4.62 **in^2**

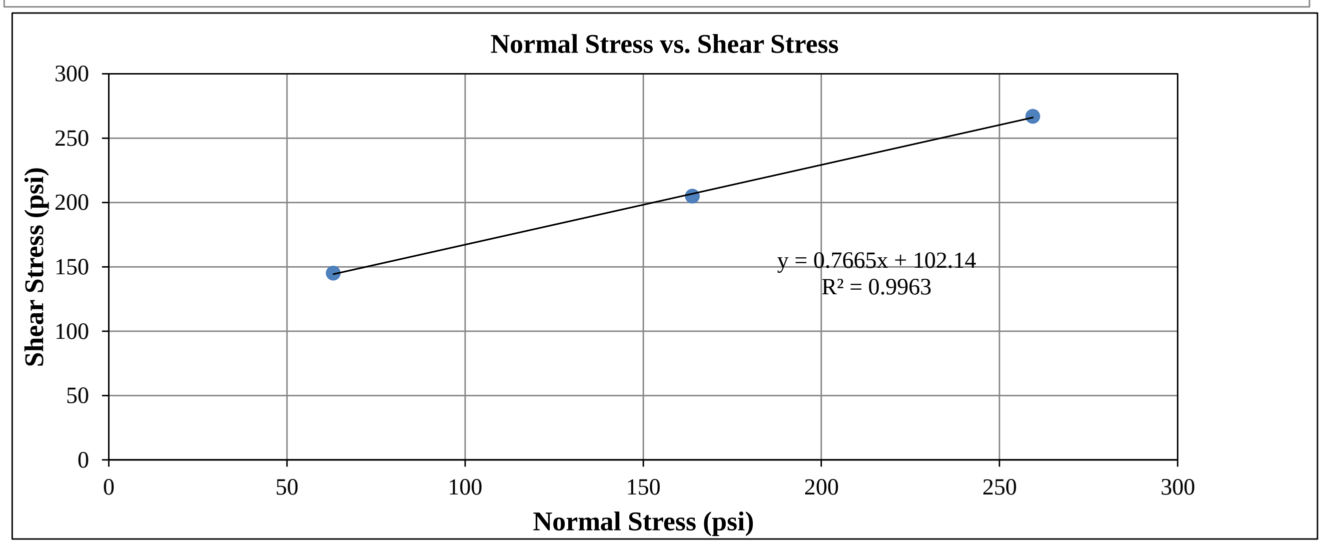
JRC: 6-8
Characteristics: The moisture content of joint filling materials are unknown.

ID	Avg. Normal Stress *(psi)*	Peak Shear Stress *(psi)*
300	63	145
720	164	205
1200	259	267

Cohesion: 105 **psi**
Friction Angle: 32 **deg**

Correlation Coefficient (R^2): 0.9993





Earth Mechanics Institute, CSM
Mining Engineering Department
Direct Shear Strengh Test (D5607)

Client: Klohn Crippen Berger
Project: RNW-PFS
Location: N/A
Rock Type: Sedimentary

Test Performed by: OF & WH
Date Tested: 5/8/2017
Data Reduced by: OF
Date Reduced: 5/8/2017

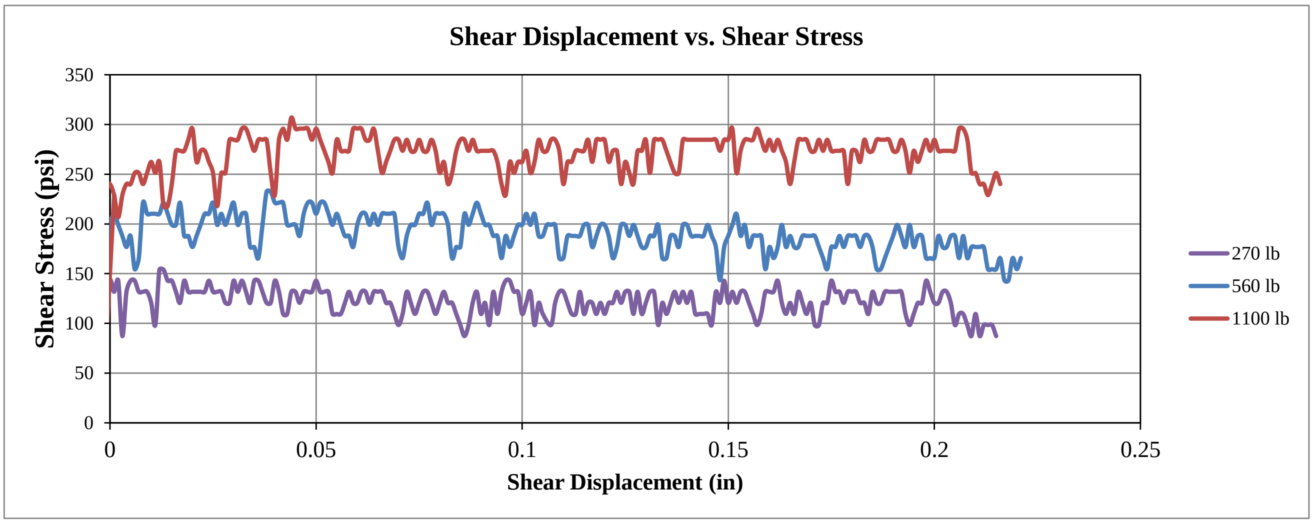
Sample ID: DH-17-32-S4-48.2
Diameter: 2.155 **in**
Diameter: 2.205 **in**
Area: 3.73 **in^2**

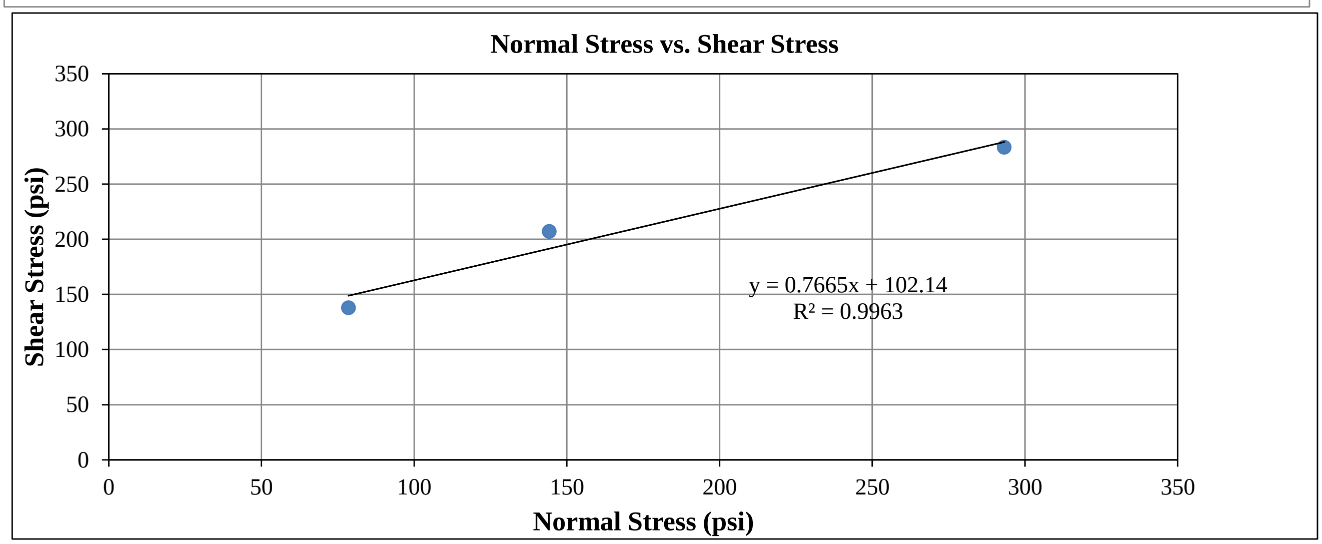
JRC: 4-6
Characteristics: The moisture content of joint filling materials are unknown.

ID	Avg. Normal Stress *(psi)*	Peak Shear Stress *(psi)*
270	78	138
560	144	207
1100	293	283

Cohesion: 98 **psi**
Friction Angle: 33 **deg**

Correlation Coefficient (R^2): 0.96





Earth Mechanics Institute, CSM
Mining Engineering Department
Direct Shear Strengh Test (D5607)

Client: Klohn Crippen Berger
Project: RNW-PFS
Location: N/A
Rock Type: Sedimentary

Test Performed by: OF & WH
Date Tested: 5/8/2017
Data Reduced by: OF
Date Reduced: 5/8/2017

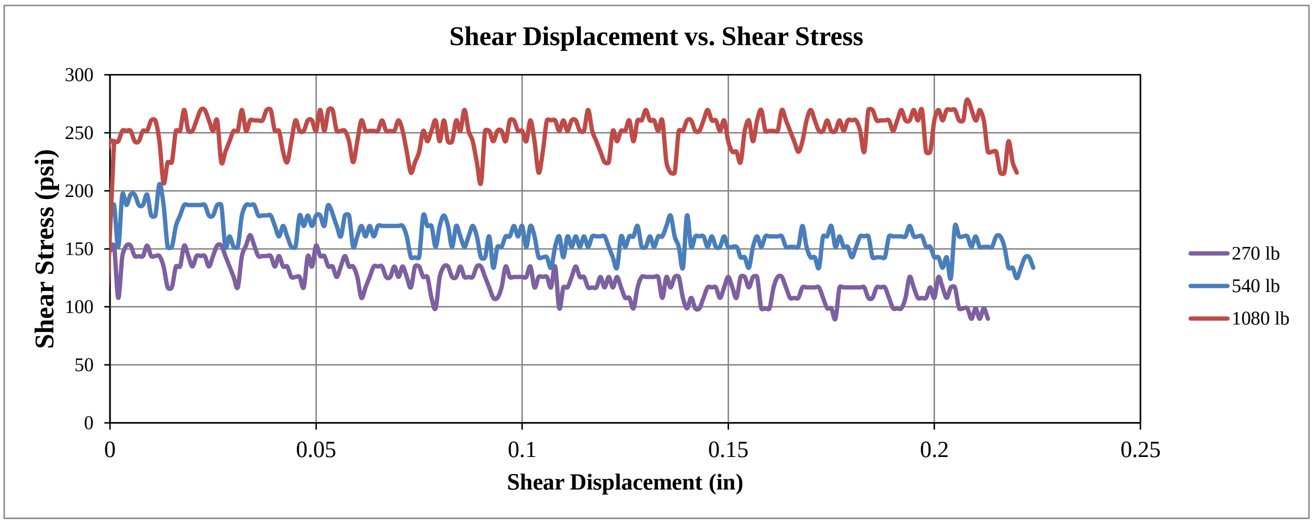
Sample ID: DH-17-36-S2-16
Diameter: 2.44 **in**
Diameter: 2.408 **in**
Area: 4.61 **in^2**

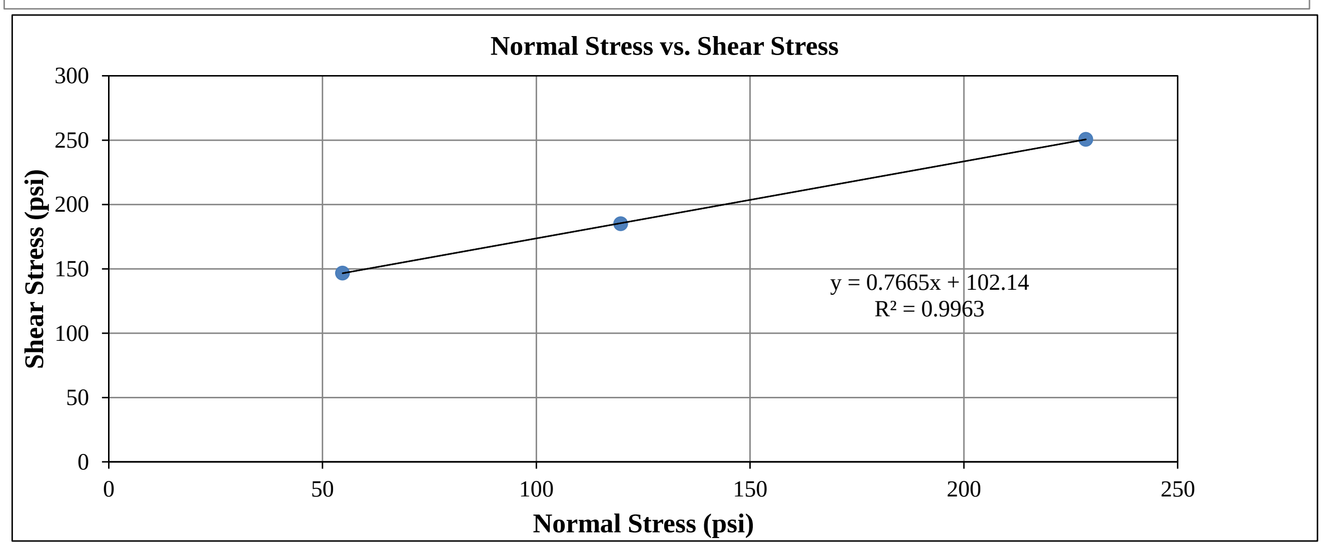
JRC: 2-4
Characteristics: The moisture content of joint filling materials are unknown.

ID	Avg. Normal Stress *(psi)*	Peak Shear Stress *(psi)*
270	55	147
540	120	185
1080	229	251

Cohesion: 114 **psi**
Friction Angle: 31 **deg**

Correlation Coefficient (R^2): 0.99997

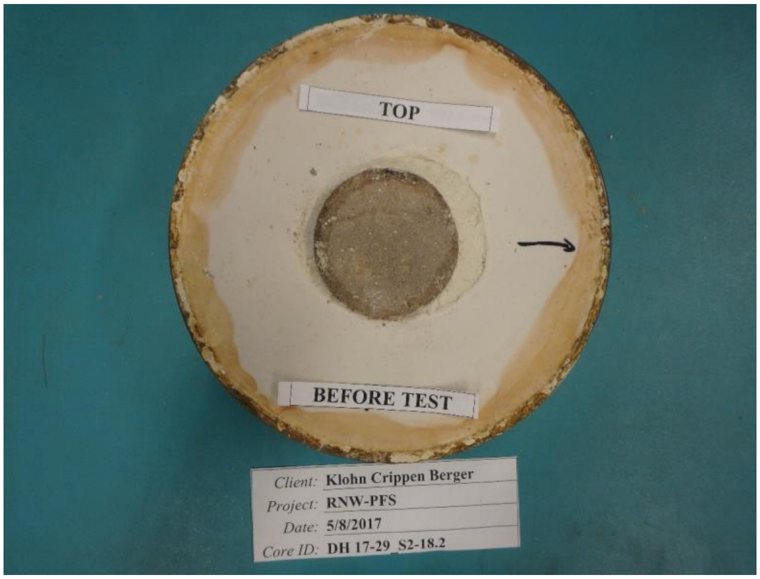




Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-29_S2-18.2



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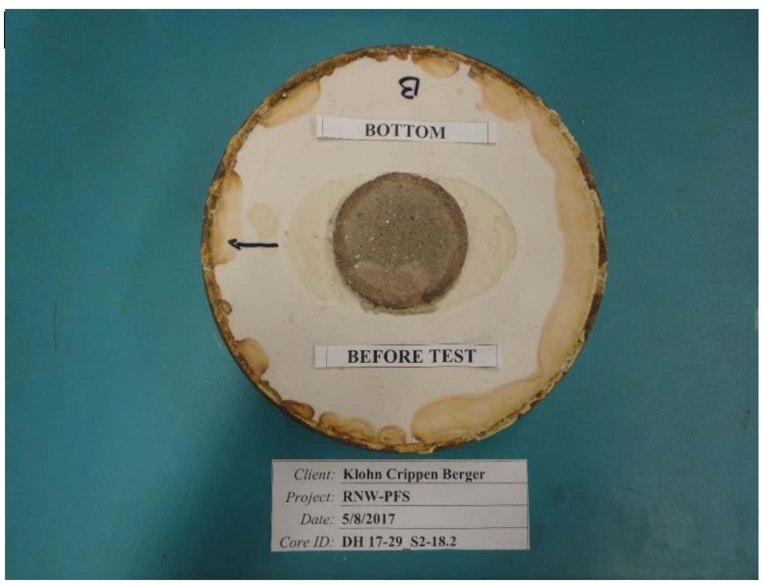

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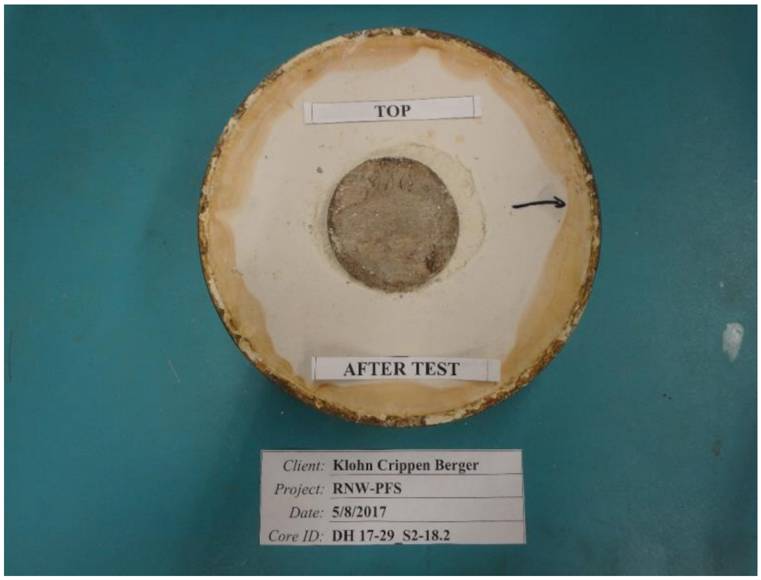
Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-29_S2-18.2



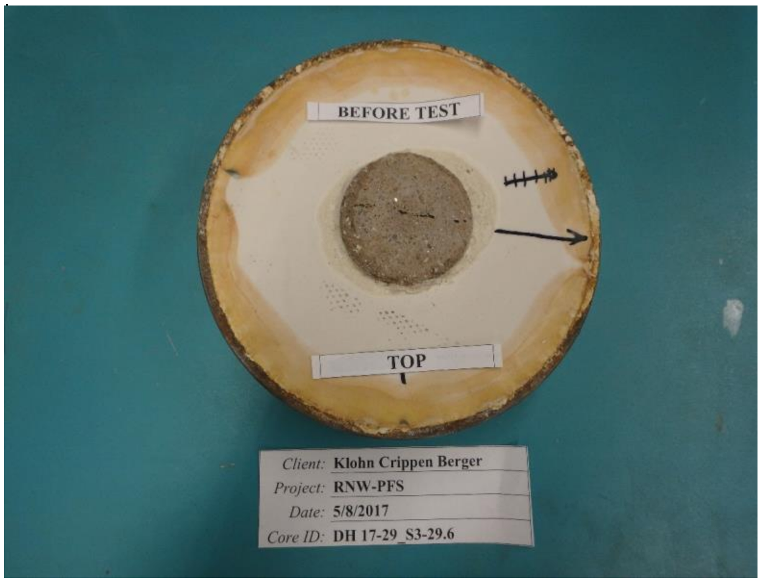
TOP

BOTTOM

Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-29_S3-29.6



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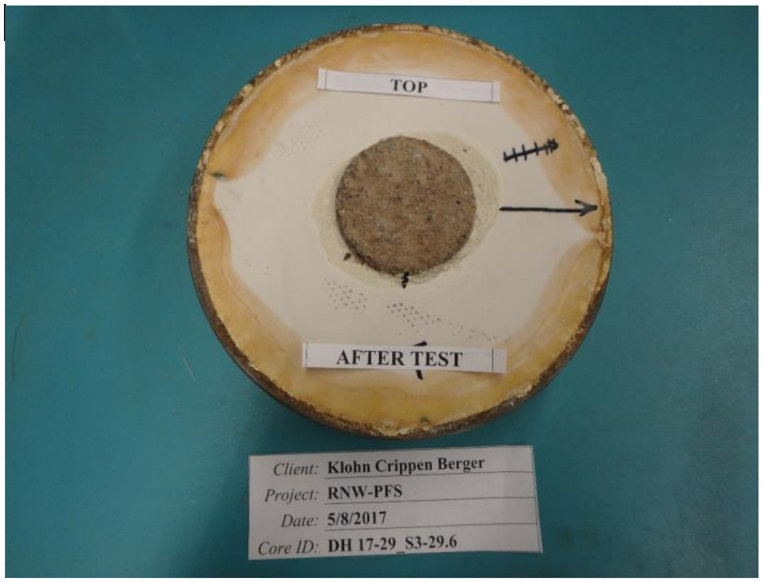
Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-29_S3-29.6



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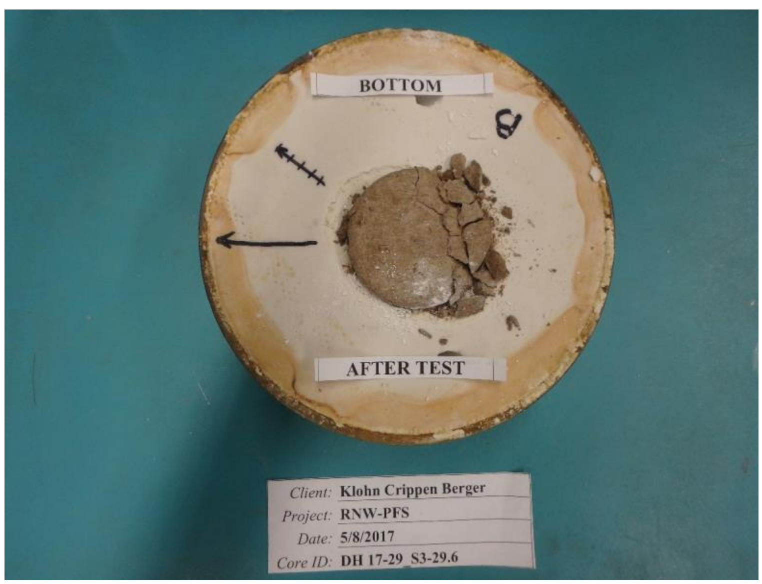

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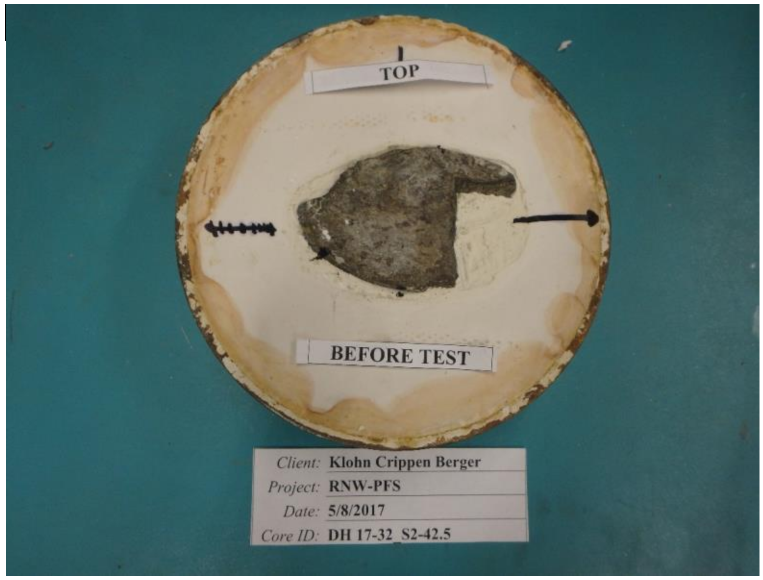
Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-32_S2-42.5



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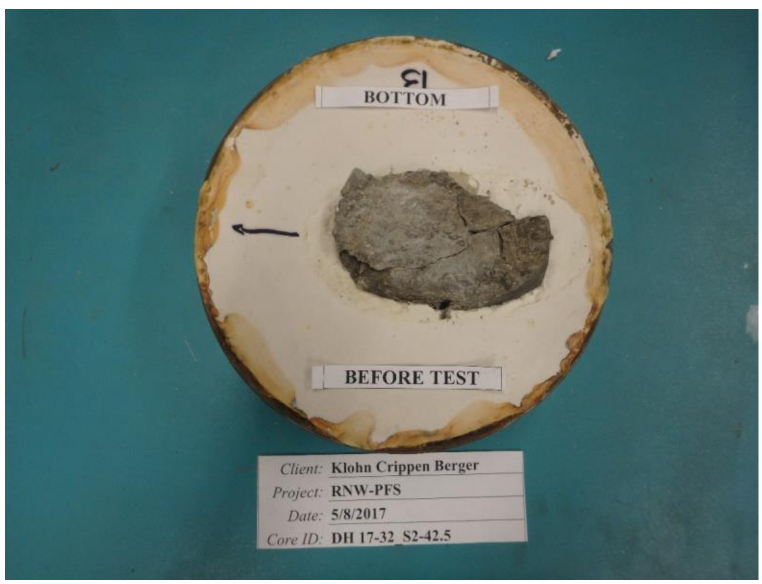


BOTTOM

Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-32_S2-42.5

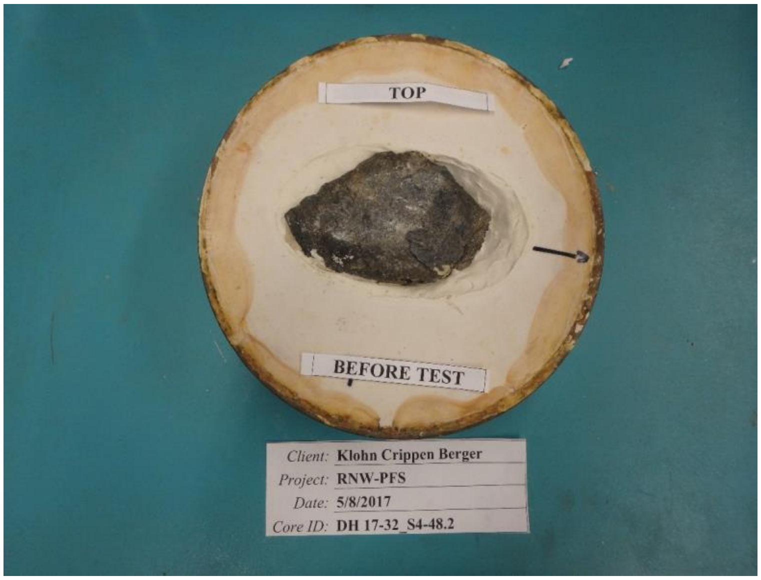
TOP

BOTTOM

Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-32_S4-48.2



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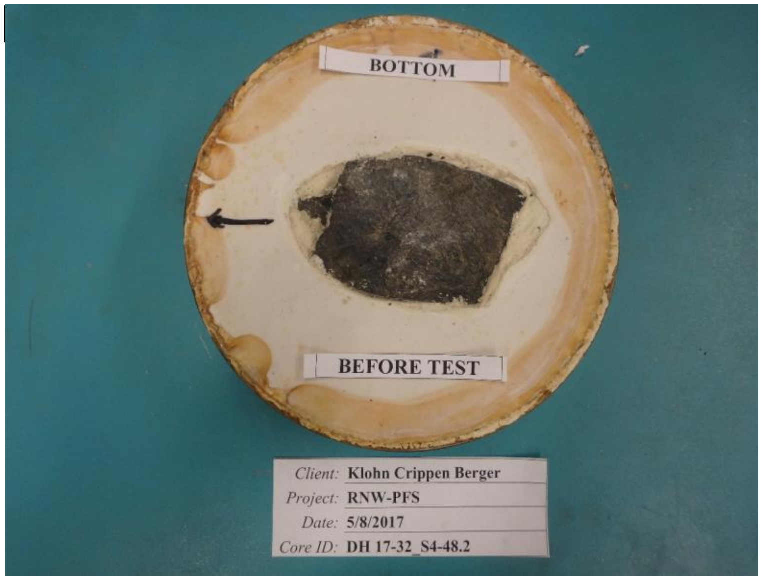


BOTTOM

Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-32_S4-48.2

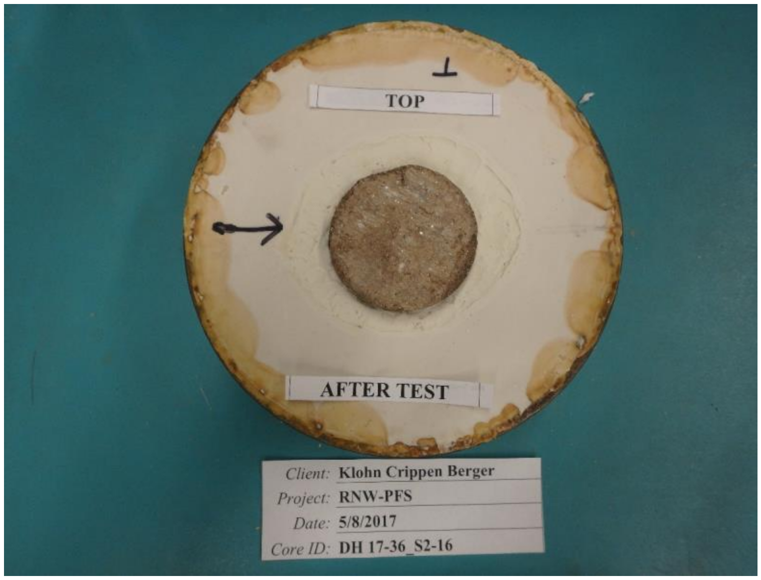
TOP

BOTTOM

Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-36_S2-16



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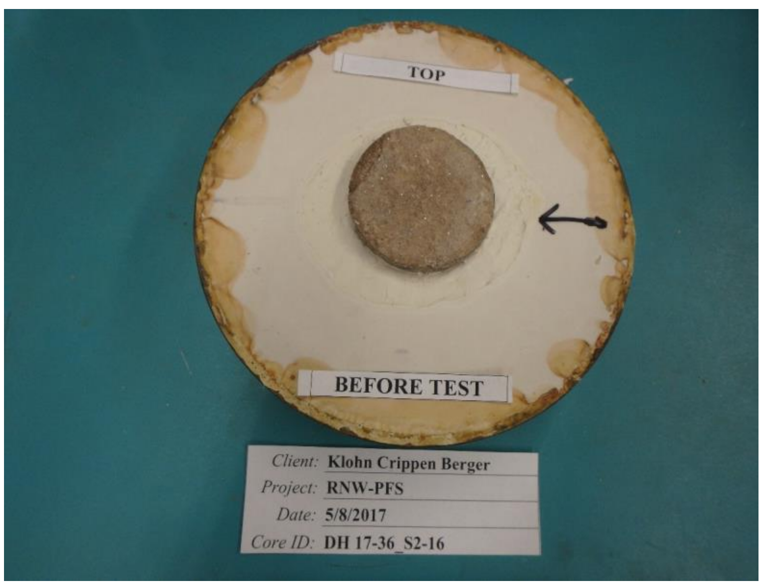

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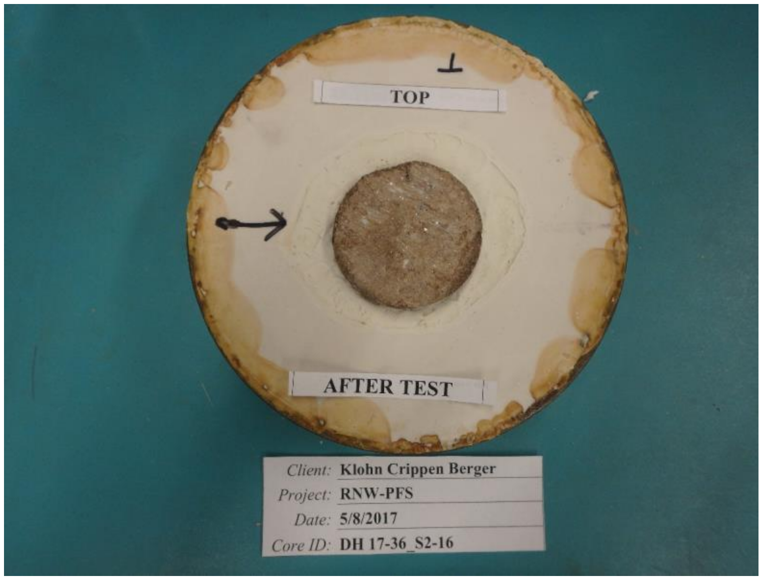
Pictures of Sample Before and After
Direct Shear Test

Client Name: Klohn Crippen Berger
Project Name: RNW-PFS
Date: 5/8/2017

Sample ID: DH 17-36_S2-16



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Appendix III-D

Argile Analytica Laboratory Results

Petrographic Report

On the

Near West Tailings Storage Facility

For

Klohn Crippen Berger

By

Amir Iqbal (P.Geo)

Argile Analytica Inc.

Bay#7, 2280 – 39th Ave, Calgary, Alberta T2E 6P7

Phone: (403) 264-7625 Email: info@argileanalytica.com

Table of Contents

A Petrographic Study of the Gila Conglomerates

Near West Tailings Storage Facility

Introduction:

The main purpose of this study is to evaluate and characterize the mineralogy and geologic characteristics of the Near West Tailings Storage Facility (Pinal County Arizona, 6 miles west of the town of Superior) by petrographic analyses from Thin Section slides for 6 samples collected from three core: DH16-07, DH16-08 and DH17-29. The samples originated from the Pleistocene alluvial deposits, namely Gila Conglomerates. The Gila Conglomerates are composed of poorly sorted, subrounded to subangular sand, silt and gravel size grains commonly consolidated and cemented, matrix poor or matrix rich conglomerates in the studied samples. The conglomeratic fraction is mainly composed of volcanic lithoclasts composed of cryptocrystalline volcanic tuff, lithoclasts with coarse crystals of feldspars, micas, polycrystalline quartz and monocrystalline quartz (likely sourced from the Precambrian granites) and metamorphic lithoclasts that are mainly schists with quartz and mica observed as stretched minerals. Sedimentary lithoclasts were observed at one location only and are composed of quartz, with minor feldspars (DH16-07).

Sample Summary:

For this study, a total of six samples from three wells were collected, prepared and analyzed petrographically. The samples are summarized in the following table, and are arranged in order by borehole and depth.

Sample ID	Well location	Depth (ft)	Thin Section
C07	DH16-07	*24.5*	TS 01
C12	DH16-07	*43.5*	TS 02
C02b	DH16-08	*58.5*	TS 03
C03 – C04	DH16-08	62.0	TS 04
C03a	DH17-29	*9.5*	TS 05
C08	DH17-29	38.6	TS 06

This study was commissioned by Chris Kowalchuk at Klohn Crippen Berger, and conducted at Argile Analytica Inc., Calgary, Alberta.

Methodology:

Thin Sections (TSs 01-06)

Core samples were provided by the client for the creation of thin section slides for petrographic analysis. Samples were impregnated with blue epoxy to show effective visible porosity and provide structural support to micro-structures within the sample. All six Thin sections (TS) were stained for carbonates. The TSs were cut to an industry standard thickness of 30 μm and mounted on frosted glass slides with glass covers.

Cross-polarized light (XPL) and plane-polarized light (PPL) were used in combination for mineral observations and identification. Petrographic imaging was conducted using a Nikon E400 Polarizing transmitted light microscope combined with a Nikon Digital Camera (DL-05).

Petrographic observations including framework mineralogy, cements/matrix, fabric-selective and non-fabric-selective porosity types are summarized in Tables 1 (Appendix). The rock types are determined according to the Folk Classification (Folk, 1968)[1]. The thin section mineralogy is plotted on a QFL (ternary) diagram in Figure 1 (Appendix). High-quality TS microphotograph PPL images are also included in the Appendix; each sample for TSs 01-06 has plate descriptions on a Photo Plate with illustrative photographic images at 40x and 100x magnification as annotated following each.

[1] Folk, R. L., 1968, Petrology of Sedimentary Rocks: Austin, University of Texas Publication, 170 p.

Observations and Analyses from Thin Sections:

Well location: DH16-07

Sample ID: C07 (24. ft)

This zone is composed of matrix rich, well compacted, poorly cemented conglomerate of the Gila Conglomerate complex. Framework grains in general order of abundance include volcanic and metamorphic lithoclasts, plagioclase feldspar, monocrystalline quartz, K-feldspar, micas and polycrystalline quartz. Volcanic lithoclasts include Rhyolitic tuff identified as grains composed of cryptocrystalline quartz, with minor feldspar laths that are locally preserved or dissolved. Other volcanic lithoclasts include feldspars, micas, polycrystalline quartz and pyroxene were also observed. Metamorphosed lithoclasts are present in the thin section were identified due to elongated fine crystals of mica, polycrystalline quartz and chloritized biotite. Locally chloritized biotite (7%) and sericitized K-feldspars are present in abundance. Most of the observed porosity is formed by dissolution of K-feldspar grains due to meteoric water flushing (Plate 01). Comparing to K-spar grains, plagioclase feldspars grains are less altered and/or disintegrated. Sample is poorly cemented with patchy distribution of sparry calcite cement. Minor amounts of pyrite (up to 5%) rhombs are locally present. Matrix clays are generally observed within fine grained matrix (between framework grains) and could not be identified petrographically due to its inherent size. Clays within the dissolved framework grains are termed as pseudo matrix clays.

Sample ID: C12 (43.5 ft)

This section represents matrix poor conglomerates. Framework grains consist of sedimentary, volcanic and metamorphic lithoclasts, with poor matrix of diversified grains of similar composition as of lithoclasts with varying degree of alterations. 65% of TS is composed of sedimentary lithoclasts, made up of monocrystalline quartz and altered/sericitized feldspars. Rest of the TS is composed of volcanic and metamorphic lithoclasts. Overall, this sample is matrix poor, however trace amount of unidentified iron rich clays are present within lithoclasts. Numerous iron oxide alterations were observed in sedimentary lithoclasts. The other alterations are within feldspar grains, dominated by sericitization. In generals feldspar grains are less altered however, locally dissolved to form secondary porosity. Dissolution porosity is associated with sedimentary and volcanic lithoclasts. Dissolution porosity is identified as over sized pores formed after unstable minerals such as feldspars and chert are dissolved due to meteoric water flushing.

Well location: DH16-08

Sample ID: C02b (58.5 ft) and C03-C04 (62.0 ft)

Thin sections (TS03 and TS04) are composed of poorly sorted, matrix poor conglomerates. Framework grains in general order of abundance include volcanic lithoclasts, metamorphic lithoclasts, mica and feldspars. The volcanic rock fragments consists of crystals of pyroxene, quartz, alkali feldspars and plagioclase feldspars, all enclosed in fine grained glassy matrix (rhyolite). Various sizes and shapes of rhyolite fragments, cryptocrystalline tuff and granites are abundant (Plate 04 B&C). Approximately, 20% of both TSs consist of metamorphic lithoclasts (Plate 03C & Plate 04A), which are dominantly made of polycrystalline quartz and stretched muscovite mica sheets. The mica flakes show a preferential alignment suggesting schistose texture. Porosity has been estimated between 5% to 7%. Main type of porosity for this section is solution enhanced dissolution porosity, which is commonly associated with feldspar grains. Small amount of matrix has been observed made entirely of cryptocrystalline material which cannot be resolved at this magnification. In both samples (TS03 and TS04), calcite cement is present patchily either within grains or within matrix and is poorly cemented. Minor amount (up to 2%) of zeolites crystals (probably authigenic) have been observed. Minor microporosity is associated with matrix clays distributed between lithoclasts.

Well location: DH17-29

Sample ID: C03a (9.5 ft) and C08 (38.6 ft)

This zone (TS05 and TS06) is composed of matrix rich, poorly sorted conglomerates. Overall lithology consists of volcanic and metamorphic lithoclasts, monocrystalline and polycrystalline quartz, plagioclase feldspar and micas. Volcanic rock fragments are mainly basalts and rhyolites, where feldspar phenocrysts are partially and/or completely dissolved. Volcanic rock fragments are rich in pyroxene crystals. Second dominant lithology in this section is metamorphic fragments (10% to 14%). Metamorphic lithoclasts are mainly composed of polycrystalline quartz and muscovite which gives typical muscovite-schist texture with bright interference colours under crossed polarized light. Generally, this section of Gila Conglomerate is poorly cemented. In both samples, calcite cement is present as minor authigenic component (up to 4%). Small amount (2-5%) of elongated, euhedral authigneic zeolite crystals have been observed within the secondary pores. Their authigenic nature is suggested from the shape of the crystals and growth patterns within the available pore spaces. Large feldspar/volcanic lithoclast grains were observed partially or completely dissolved creating secondary pores and pseudomatrix clays. Porosity is estimated between 15% to 20% in this section. Dissolution porosity is the main type of porosity observed in this section mainly associated with unstable grains such as feldspars and/or volcanic lithoclasts.

Conclusions:

The sediments of the Gila Conglomerate complex are composed of matrix supported conglomerates. These conglomerates are mainly composed of volcanic, metamorphic and sedimentary lithoclasts with varying amounts of matrix. The matrix is largely composed of similar minerals as observed within clasts with variable amounts of cryptocrystalline materials (likely siliceous) and matrix clays of lesser importance.

Unstable grains such as feldspars and volcanic lithoclast (mainly rhyolitic tuffs) have undergone dissolution at low temperature by meteoric water flushing creating secondary dissolution porosity and pseudomatrix clays within these zones. Such grains can contribute to weaknesses in its strength along with clays within the matrix.

APPENDIX

Klohn Crippen Berger
Near West Tailings
Storage Facility

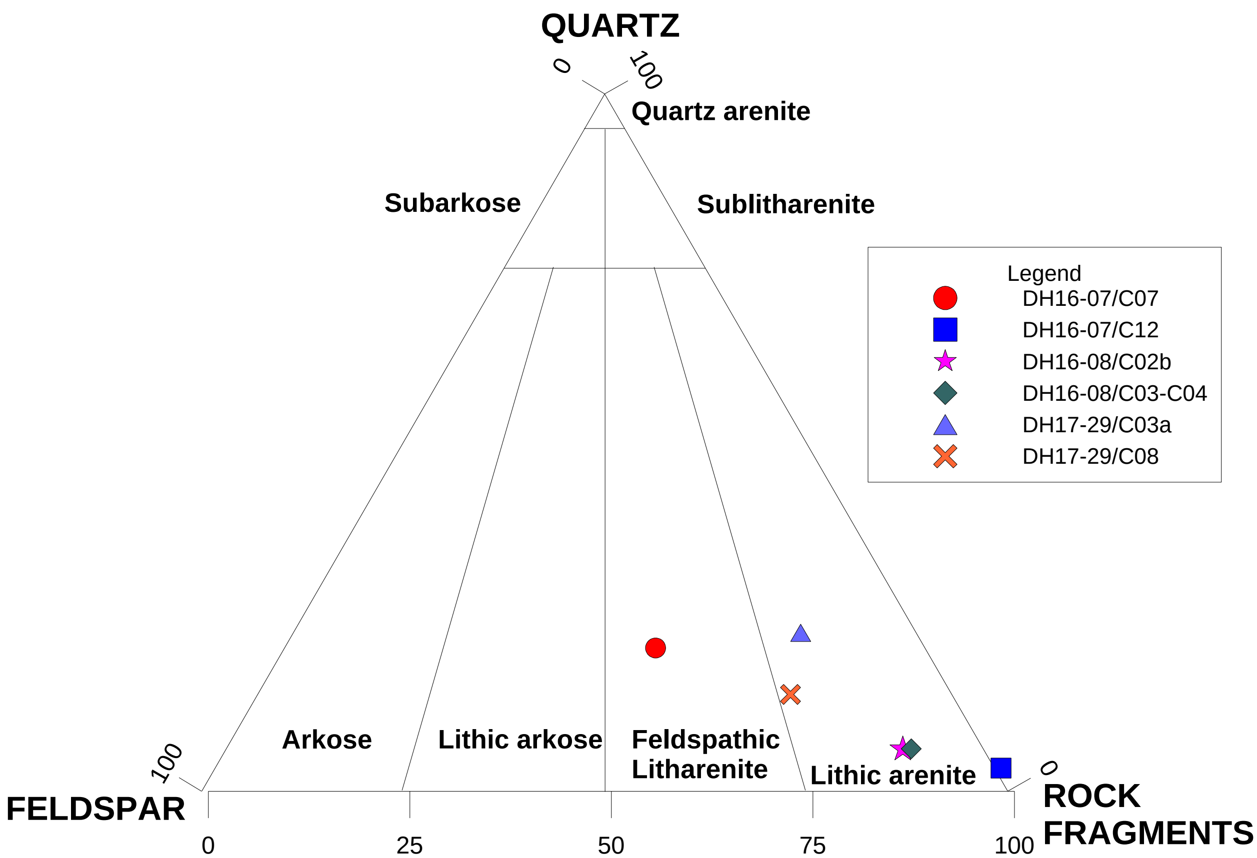


Figure 1: Ternary Diagram

Near West Tailings Storage Facility

Table 1: Petrography Summary TS 01-06

Well Location	DH16-07	DH16-07	D16-08	DH16-08	DH17-29	DH17-29
Sample ID	C07	C12	C02b	C03-C04	C03a	C08
Depth (ft):	24.50	43.50	58.50	62.00	9.50	38.60
Thin Section ID	TS01	TS02	TS03	TS04	TS05	TS06
Rock type:	Mtx Rich Cgl	Mtx Poor Cgl	Mtx Poor Cgl	Mtx Poor Cgl	Mtx Rich Cgl	Mtx Rich Cgl
Rock Clan (Folk, 1968):	Feld.Lith Arenite	Lithic Arenite	Lithic Arenite	Lithic Arenite	Lithic Arenite	Lithic Arenite

Framework Grains

Monocrystalline Quartz	10	2	3	3	10	8
Polycrystalline Quartz	5	1	2	2	5	2
Chert						2
Alkali Feldspar	10		2	2	2	3
Plagioclase Feldspar	15		7	6	8	12
Sedimentary Lithoclasts	2	65				
Volcanic Lithoclasts	12	15	32	33	25	31
Metamorphic Lithoclasts	5	5	20	19	10	14
Mica - Muscovite	4		15	14	4	
Mica - Biotite	7	2	2	3	2	
Mica - Chloritic	3					

Cements

Quartz	Trace					
Calcite	6	3	1	2	4	4
Iron Oxide	2					
Zeolites			2	1	5	2
Pyrite	5		1	1		2

Matrix

Clays	4	2	8	7	5	5

Texture

Sorting	poor	poor	poor	poor	poor	poor
Roundness	subang - sbrdd	subang - sbrdd	subang - sbrdd	subang - sbrdd	subang - sbrdd	subang - sbrdd
Maturity						
Degree of Bioturbation						
Degree of Compaction						

Pore Types

Intergranular						
Secondary Dissolution	8	5	3	5	19	14
Microporosity	2	Trace	2	2	1	1

PLATE 01

a) 40X magnification in PPL. The zone is characterized as matrix rich conglomerate of the Gila Conglomerate composed mainly of mafic and felsic minerals within the matrix grains as well as matrix sand size fraction. Note the dissolution of feldspar grains (mainly potassium feldspars) leaching at shallow depths due to meteoric water flushing (remnants of the grains can be seen as well as clay rich matrix formed as a result). Oversize pores in the image are formed after leaching of grains such as feldspars (E4, B7) and rhyolitic tuff (M10). Note the patchy distribution of Calcite cement (stained red).

b) 100X magnification in PPL. The image is showing clasts composed of feldspars, rhyolitic tuff (light brown), calcite cement (red stained). The leached feldspar grain showing extensive leaching, formation of clays within it and authigenic minerals such as calcite and unidentified zeolite minerals. The matrix grains may have also undergone minor alterations at low temperature water flooding in the zone and have formed matrix clays (identified as smectite by XRD in a separate report).

c) 40X magnification in PPL. Low magnification view showing similar observations such as leaching of framework grains, patchy calcite cement, pyroxene (greenish brown) and pyrite (black). Pyrite is generally rhombic and replacing the framework grains. The sediments (both clasts and matrix) are mainly composed of volcanic and metamorphic origin. The main minerals are monocrystalline quartz, polycrystalline quartz, feldspars (both plagioclase and potassium feldspars), micas and locally sedimentary lithoclasts. Authigenic minerals are not very common but dominated by calcite, iron oxides, zeolites and pyrite.

d) 100X magnification in PPL. High magnification view showing secondary pores after framework grains (mainly feldspars and volcanic grains), pyroxene (M5), biotite (light brown flaky grains; K8, H6 e.g.) and scattered monocrystalline quartz (white).

Plate 01 **DH16-07/C07 (24.5 ft)**

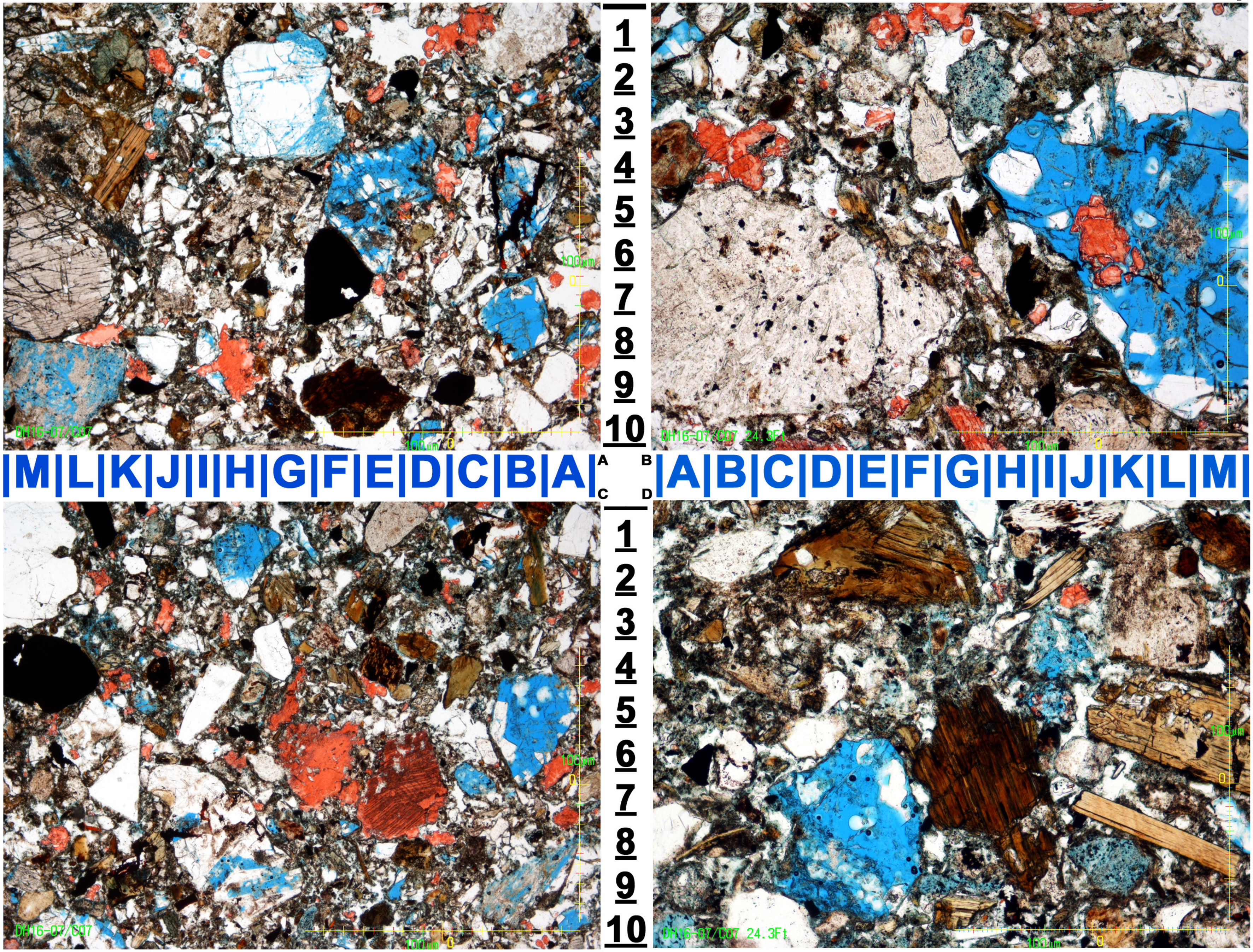


PLATE 02

a) 40X magnification in PPL. The low magnification view showing leached feldspar grain creating secondary pores and also forming pseudo matrix clays (clays within clasts), also shown is a large clast composed of cryptocrystalline quartz and mica predominantly (see image beside under crossed polarized light) showing alteration minerals such as mica and pyrite. It is evident that sericitization (alteration of mica within grains) prevented such grains to undergo dissolution. Such grains are considered rhyolitic tuff grains. The zone is composed of very large lithoclast of sedimentary origin discussed in image d.

b) 40X magnification under Crossed Polarized Light. The cross polarized image showing sericitized volcanic rhyolitic tuff, scattered calcite cement (red stained in Image a) and remnant fraction of feldspar after extensive leaching.

c) 40X magnification in PPL. Low magnification view showing large framework grains being leached, note feldspar grain (J6) is leached extensively whereas volcanic lithoclasts composed of feldspars and pyroxene leaving pyroxene (B6). The calcite cement is patchy (red stained) and is not an important cement in this zone. Note also few grains being replaced by pyrite at bottom (black).

d) 40X magnification in PPL. Large sandstone lithoclasts showing abundant secondary dissolution porosity likely formed after leaching of softer grains such as feldspars, note chert grains (light brown grains) being selectively altered by pyrite.

Plate 02

DH16-07/C12 (43.5 ft)

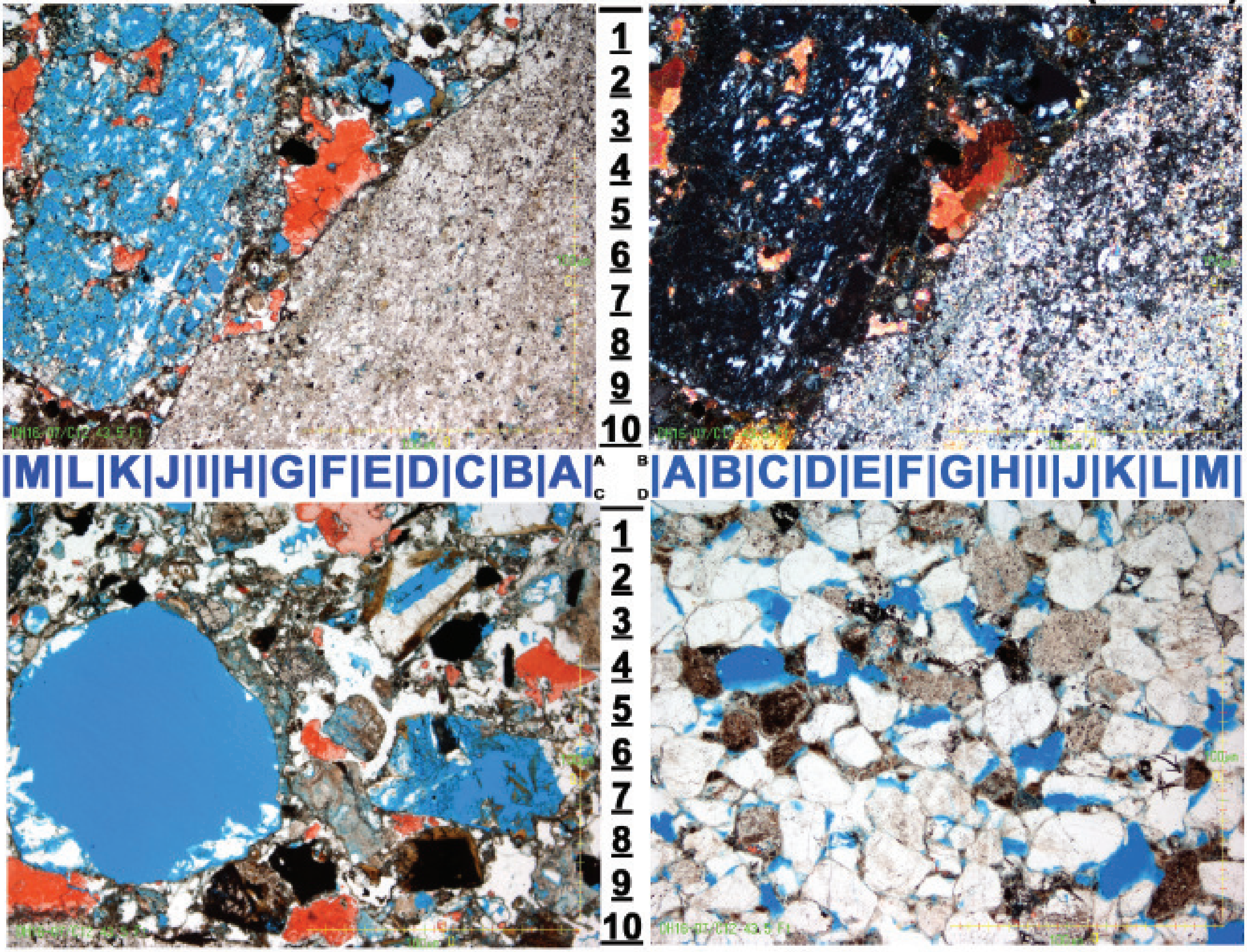


PLATE 03

a) 40X magnification in PPL. Low magnification view showing a large volcanic lithoclast that has been altered (leached), remnants of feldspars laths or their ghosts were observed with cryptocrystalline quartz (relatively large brown areas) matrix. The matrix around the leached grains is dominated by mica, biotite, cryptocrystalline quartz and very fine grained quartz and feldspar grains. The zone is dominated by matrix poor conglomerate. The conglomerates are mainly composed of volcanic and metamorphic origin.

b) 40X magnification in PPL. Low magnification view illustrating a volcanic lithoclast mainly composed of feldspars, polycrystalline quartz and mica (granite). Note the common alteration and/or sericitization on feldspar grains. Feldspar grains within clasts show little or no dissolution.

c) 40X magnification Crossed Polarized Light. Low magnification view showing numerous tiny mica crystals being formed within the cryptocrystalline matrix (mainly silica). Such alterations are common with certain volcanic lithoclasts and termed as sericitization. Higher birefringence of mice helps identifying such grains.

d) 40X magnification in PPL. Low magnification view showing laths of feldspar, mica and biotite within a volcanic lithoclast. Note Calcite cement within dissolved framework grains, the distribution of calcite is patchy and is considered minor authigenic component. The fine grained matrix is composed of cryptocrystalline quartz, mica, biotite and minor mafic minerals such as pyroxene. It is possible that such matrix would alter and form clays locally, but difficult to evaluate petrographically due to fine size.

Plate 03 **DH16-08/C02b (58.5 ft)**

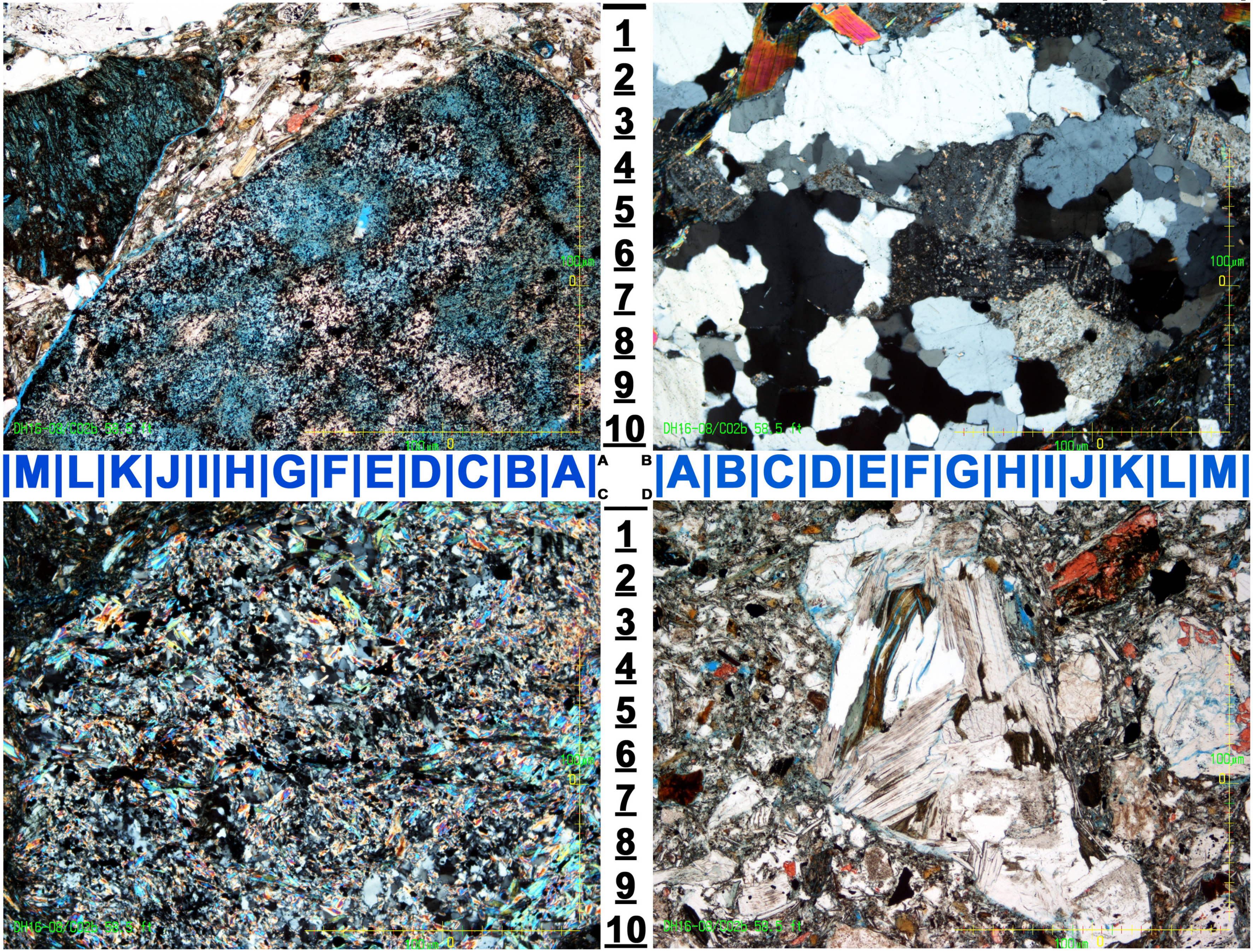


PLATE 04

a) 40X magnification under Crossed Polarized Light. Low magnification view showing a large metamorphic lithoclast predominantly composed of stretched quartz and mica (mica schist). The zone is characterized by very large lithoclasts of Volcanic and metamorphic origin with common matrix composed of feldspars, mica, biotite, pyroxene, monocrystalline quartz and cryptocrystalline materials that may have undergone transformation to matrix clays. Secondary dissolution porosity is less common within this zone.

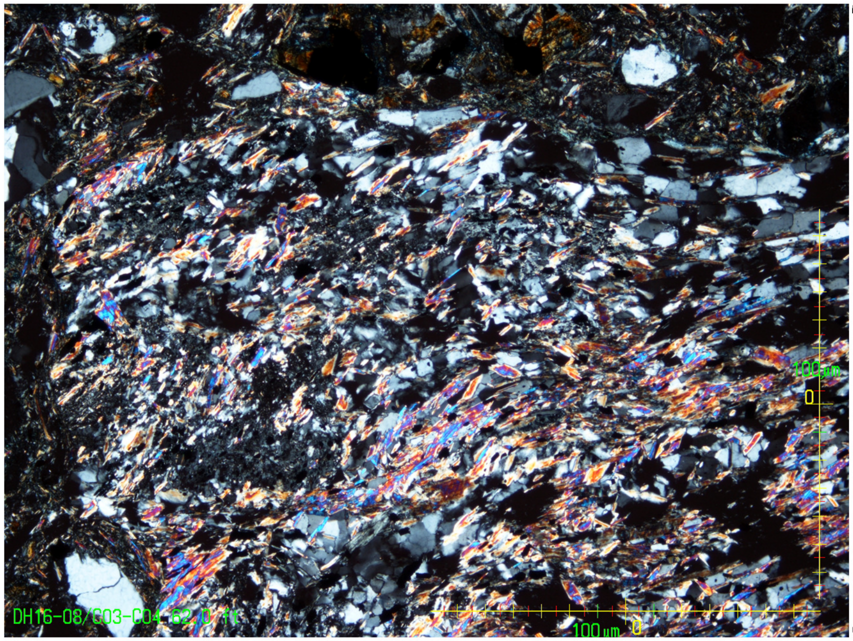
b) 40X magnification in PPL. Low magnification view illustrating two large volcanic litho clasts embedded within the matrix as describe above. Note that the laths of feldspars (elongated) have been leached to create secondary pores and the cryptocrystalline matrix is also altered to pseudo matrix clays in the lower left grain. The upper grain shows variable dissolution due to varying composition (such as microcrystalline quartz and feldspars) within the grain.

c) 40X magnification under Crossed Polarized Light. Low magnification view showing a large volcanic lithoclast mainly composed of feldspars, micas (both muscovite and biotite) and monocrystalline quartz (granite). Alterations (such as sericitization) are common on feldspar grains only. Note that such clasts do not show significant dissolution within them.

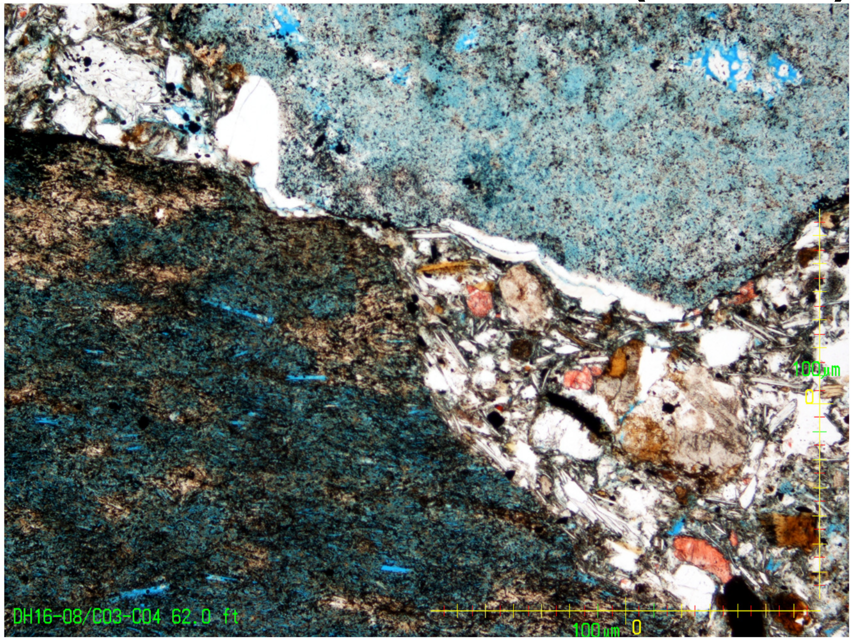
d) 40X magnification in PPL. Low magnification view showing lithoclasts mainly composed of polycrystalline quartz, metamorphic and volcanic origin embedded within matrix composed of feldspars, mica, biotite, pyroxene, monocrystalline quartz and cryptocrystalline materials that may have undergone transformation to matrix clays. Variable but insignificant dissolution observed within matrix. Note minor patchy calcite cement in the view (red stained).

Plate 04

DH16-08/C03-04 (62.0 ft)

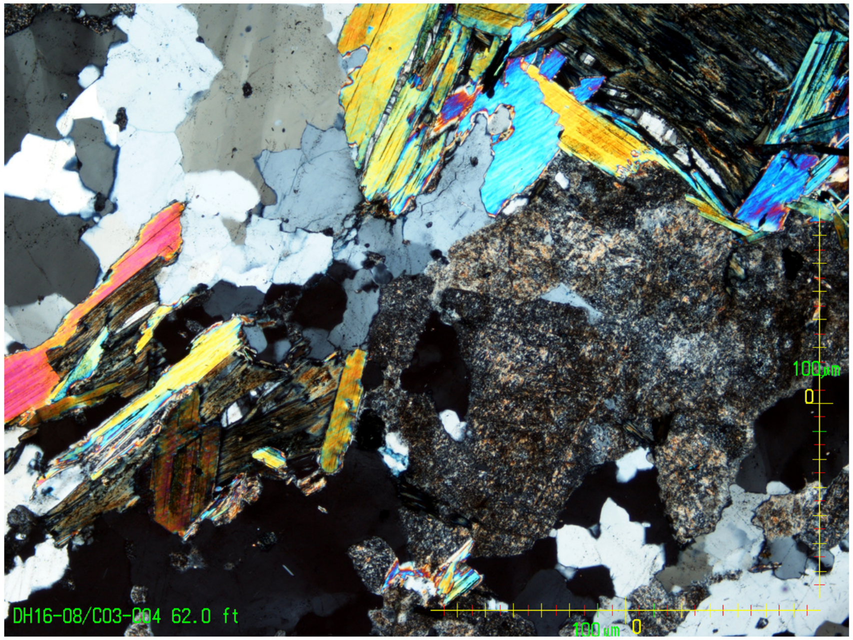


1 2 3 4 5 6 7 8 9 10



|M|L|K|J|I|H|G|F|E|D|C|B|A| A B |A|B|C|D|E|F|G|H|I|J|K|L|M|

C D



1 2 3 4 5 6 7 8 9 10

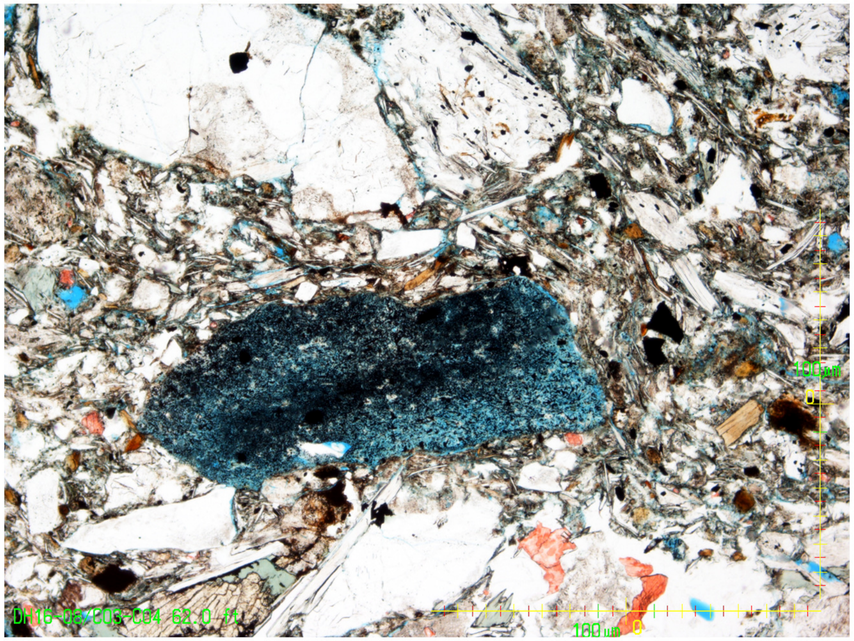


PLATE 05

a) 40X magnification in PPL. The zone is characterized as matrix rich conglomerate of the Gila Conglomerate composed mainly of mafic and felsic minerals within the matrix grains as well as within matrix sand size fraction. Two large lithoclasts are volcanic grains composed of cryptocrystalline quartz and laths of feldspars (leached in the lower grain). Note secondary dissolution porosity within the matrix grains (likely after dissolution of feldspars) and authigenic zeolite crystals within them (lath shaped, euhedral tiny crystals within pores). Secondary dissolution porosity is abundant in this zone.

b) 40X magnification in PPL. Low magnification view showing extensive dissolution of matrix gains. The dissolution of unstable grains such as feldspars and some lithoclasts undergone dissolution creating secondary porosity, pseudomatrix clays and accommodation for authigenic minerals (e.g., zeolites and calcite) to grow within them. This particular zone has undergone extensive leaching and alterations (such as chloritization of biotites; e.g., H10).

c) 40X magnification in PPL. Low magnification view showing framework grains dominated by volcanic lithoclasts, feldspars (generally leached), muscovite and biotite and secondary pores with authigenic minerals.

d) 40X magnification under Crossed Polarized Light. Same image as above (c) under crossed polarized light showing albitic twinning within a feldspar grain. Note calcite is a minor component.

Plate 05

DH17-29/C03a (9.5 ft)

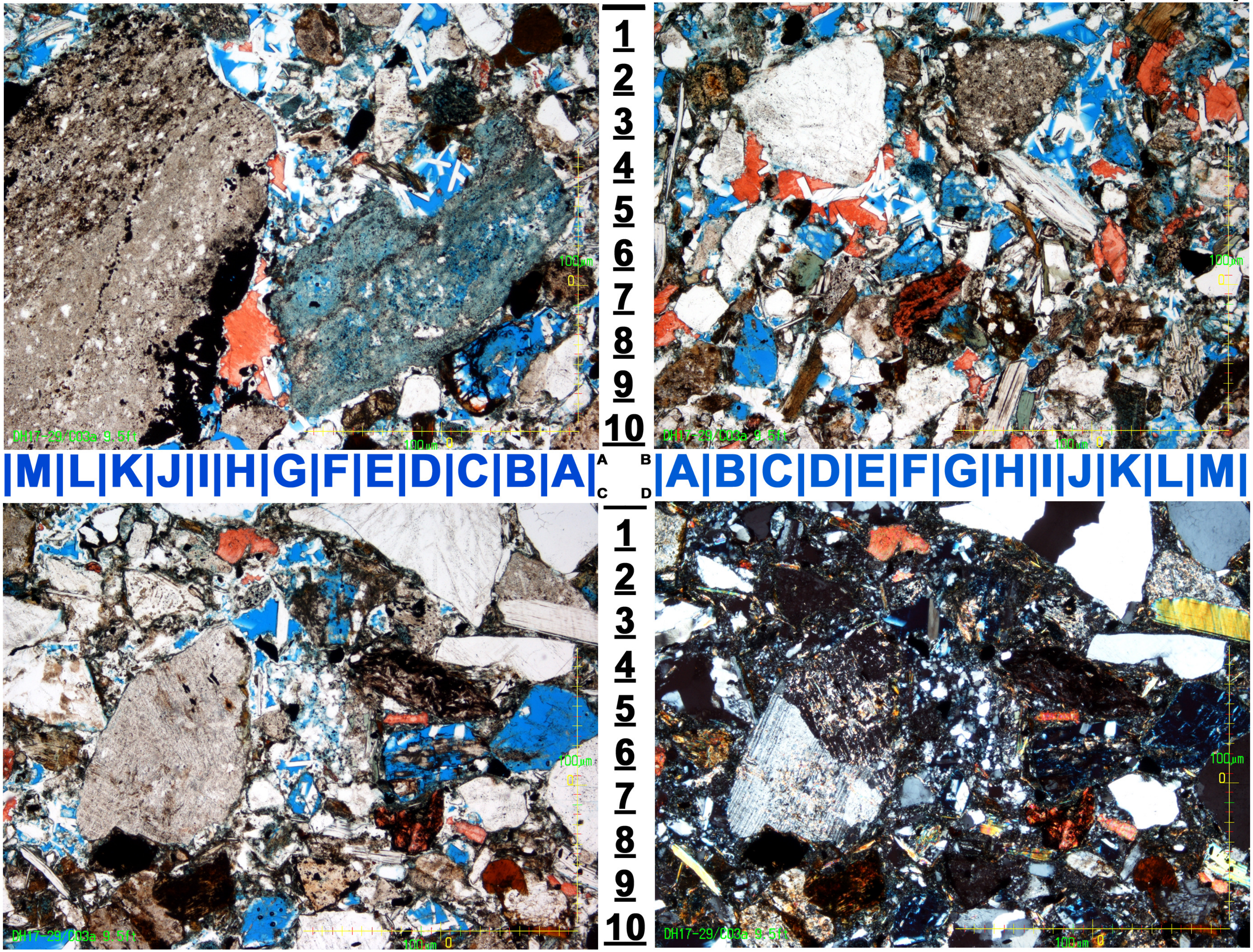


PLATE 06

a) 40X magnification in PPL. Low magnification view showing large feldspar grains and volcanic lithoclasts heavily leached during meteoric water flushing. Minerals such as pyroxene, quartz, polycrystalline quartz do not show much alterations or dissolution being stable crystals. Leached grains show pseudomatrix clays within the dissolved grains. The zone is characterized by common to abundant secondary pores and dissolution of matrix grains is also common.

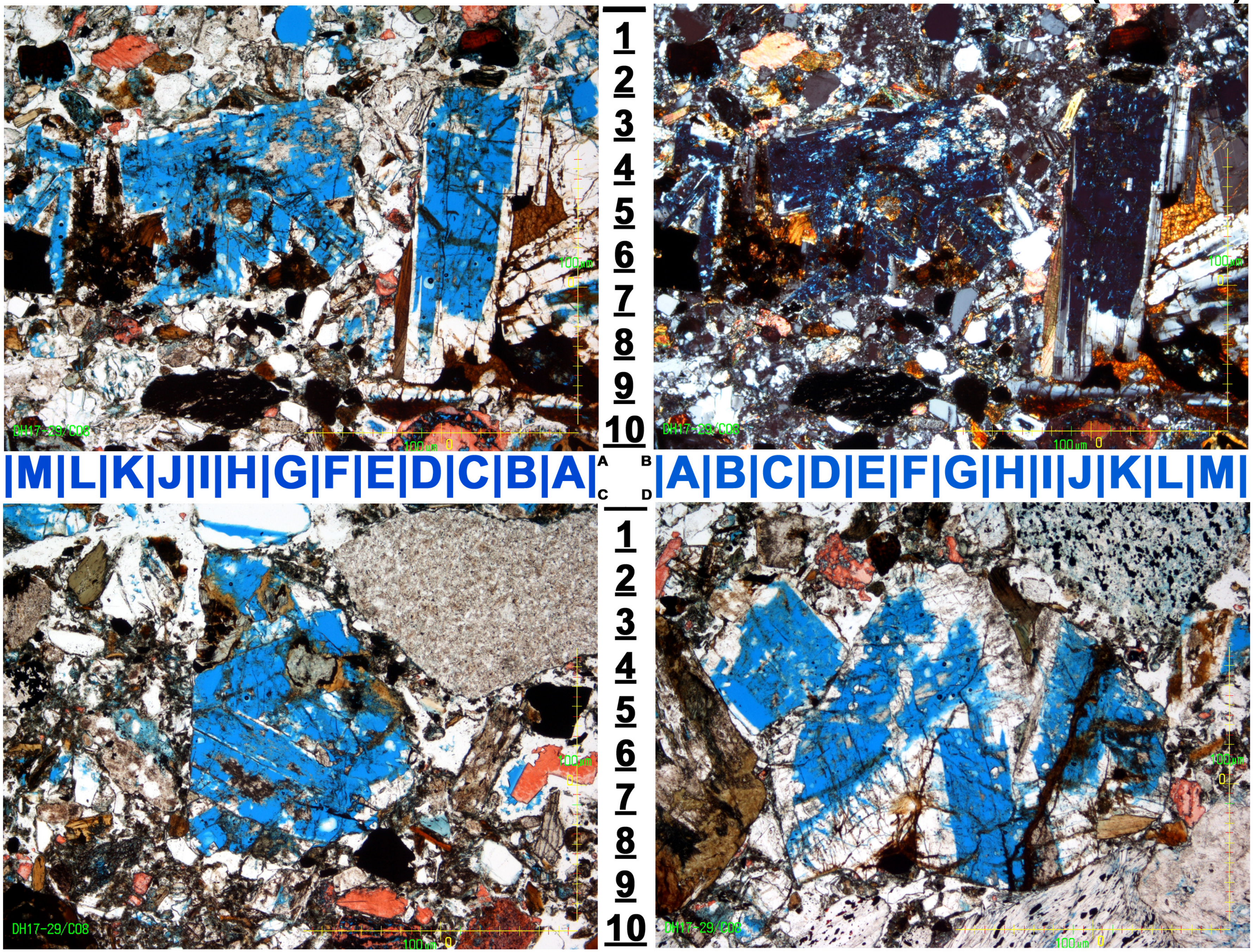
b) 40X magnification Under Crossed Polarized light. Same view as above (a) showing birefringence of framework grains. The matrix is similar in composition as the clasts within this zone. Feldspars are dominated by plagioclase feldspars with albitic twinning. Authigenic minerals are less common that include pyrite, calcite and minor zeolite crystals.

c) 40X magnification in PPL. Low magnification view illustrating large volcanic lithoclast partially dissolved leaving stable mineral fraction within the grains. The cements include patchy calcite (red stained), pyrite (black) and minor growing euhedral zeolite crystals.

d) 40X magnification in PPL. Low magnification view showing feldspars and volcanic lithoclasts being leached creating pseudomatrix clays and secondary porosity.

Plate 06

DH17-29/C08 (38.6 ft)



Appendix III-E

UBC Laboratory Results

QUANTITATIVE PHASE ANALYSIS OF 6 POWDER SAMPLES USING THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.

Project: M09441A18 11 01 Resolution Near West PFS– PO#M02017-PO031

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May 23, 2017

EXPERIMENTAL METHOD

The six samples of **Project M09441A18 11 01 Resolution Near West PFS** 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 (separate file, ***Klohn Crippen Berger Results May 23 2017 - Project M09441A18 11 01 Resolution Near West PFS – 6 samples.xlsx***). These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots are shown in Figures 1 – 6.

All the X-ray patterns show a broad peak at about 7º2θ that likely corresponds to a smectite group mineral or mixed chlorite-smectite. Fitting was possible using an empirical montmorillonite structure. All the results should be considered approximate.

Table 2.

Mineral	**Ideal Formula**
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Anatase	TiO_2
Biotite	$K(Mg,Fe^{2+})_3AlSi_3O_{10}(OH)_2$
Calcite	$CaCO_3$
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$
Clinoptilolite-Ca	$(Ca_{0.5},Na,K)_6[Al_6Si_{30}O_{72}]\cdot{\sim}20H_2O$
Diopside	$CaMgSi_2O_6$
Hematite	α-Fe_2O_3
Illite/Muscovite 2M1	$\sim K_{0.65}Al_{2.0}Al_{0.65}Si_{3.35}O_{10}(OH)_2$
Ilmenite	$Fe^{2+}TiO_3$
K-feldspar	$KAlSi_3O_8$
Montmorillonite, model	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot nH_2O$
Plagioclase	$NaAlSi_3O_8$ – $CaAlSi_2O_8$
Quartz	SiO_2
Stilbite	$(Ca_{0.5},Na,K)_9[Al_9Si_{27}O_{72}]$ $28H_2O$
Talc	$Mg_3Si_4O_{10}(OH)_2$

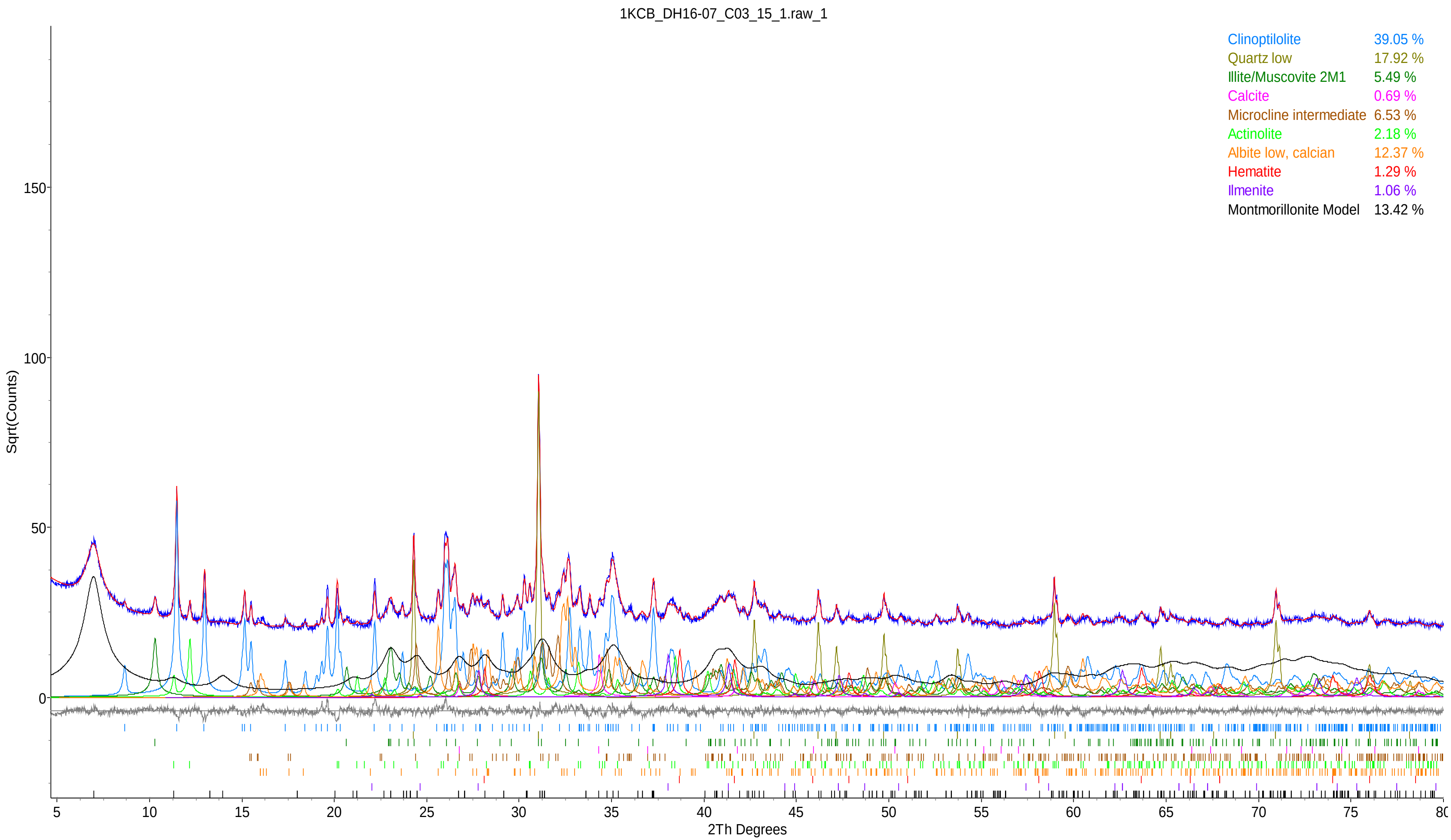


Figure 1. Rietveld refinement plot of sample **Klohn Crippen Berger – DH16-07/C03, 15.1'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

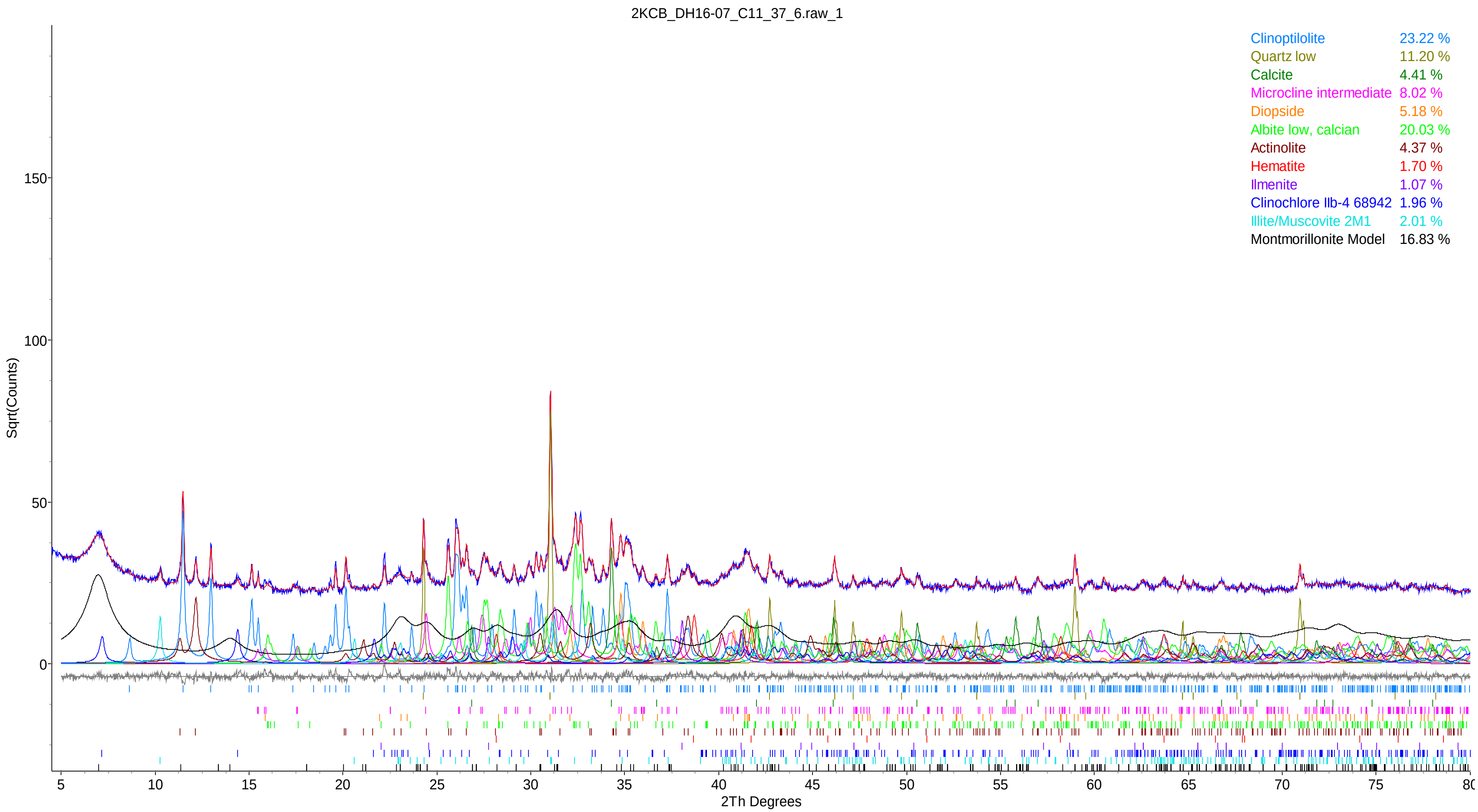


Figure 2. Rietveld refinement plot of sample **Klohn Crippen Berger – DH16-07/C11, 37.6'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

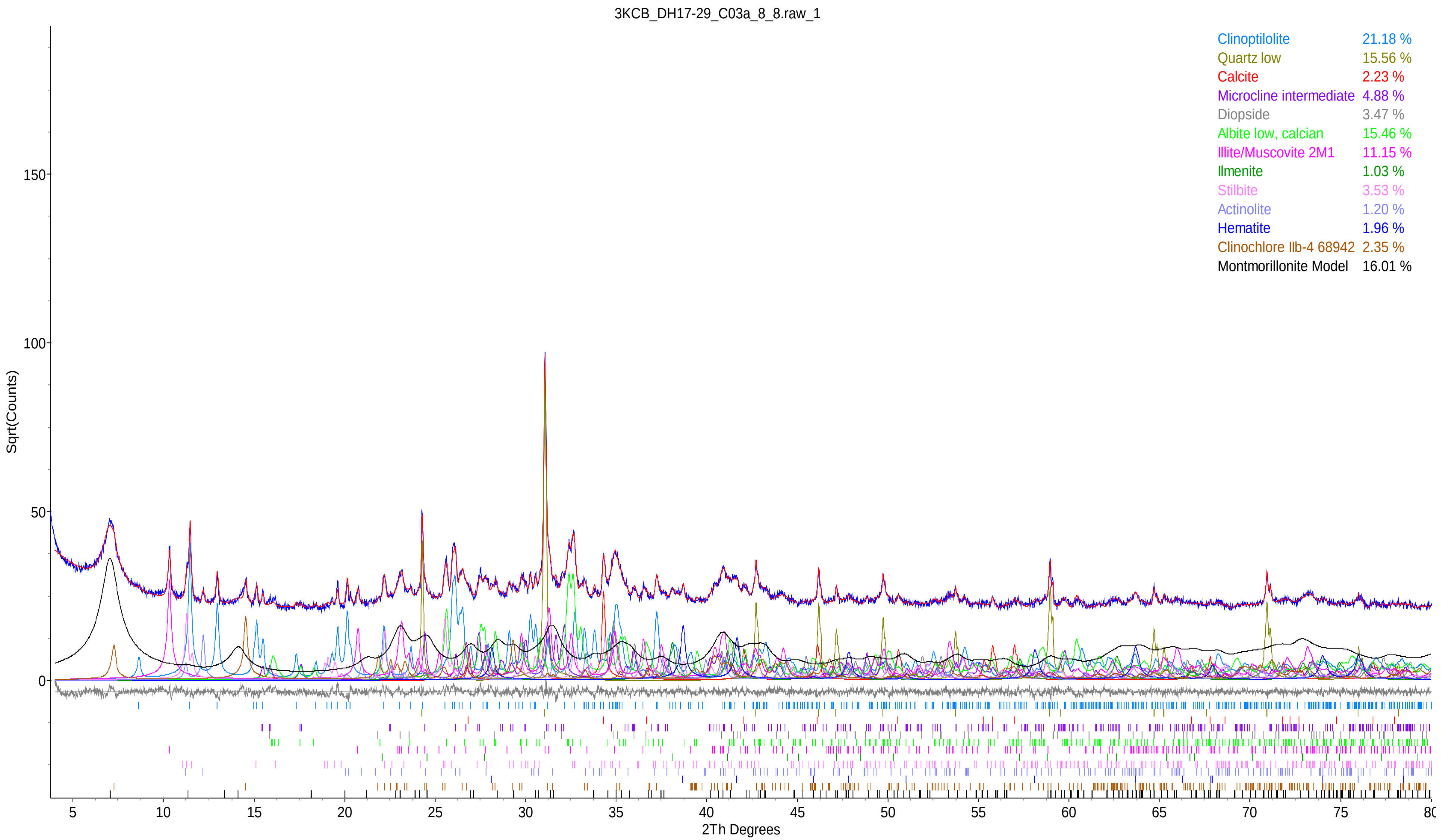


Figure 3. Rietveld refinement plot of sample **Klohn Crippen Berger – DH17-29/C03a, 8.8'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

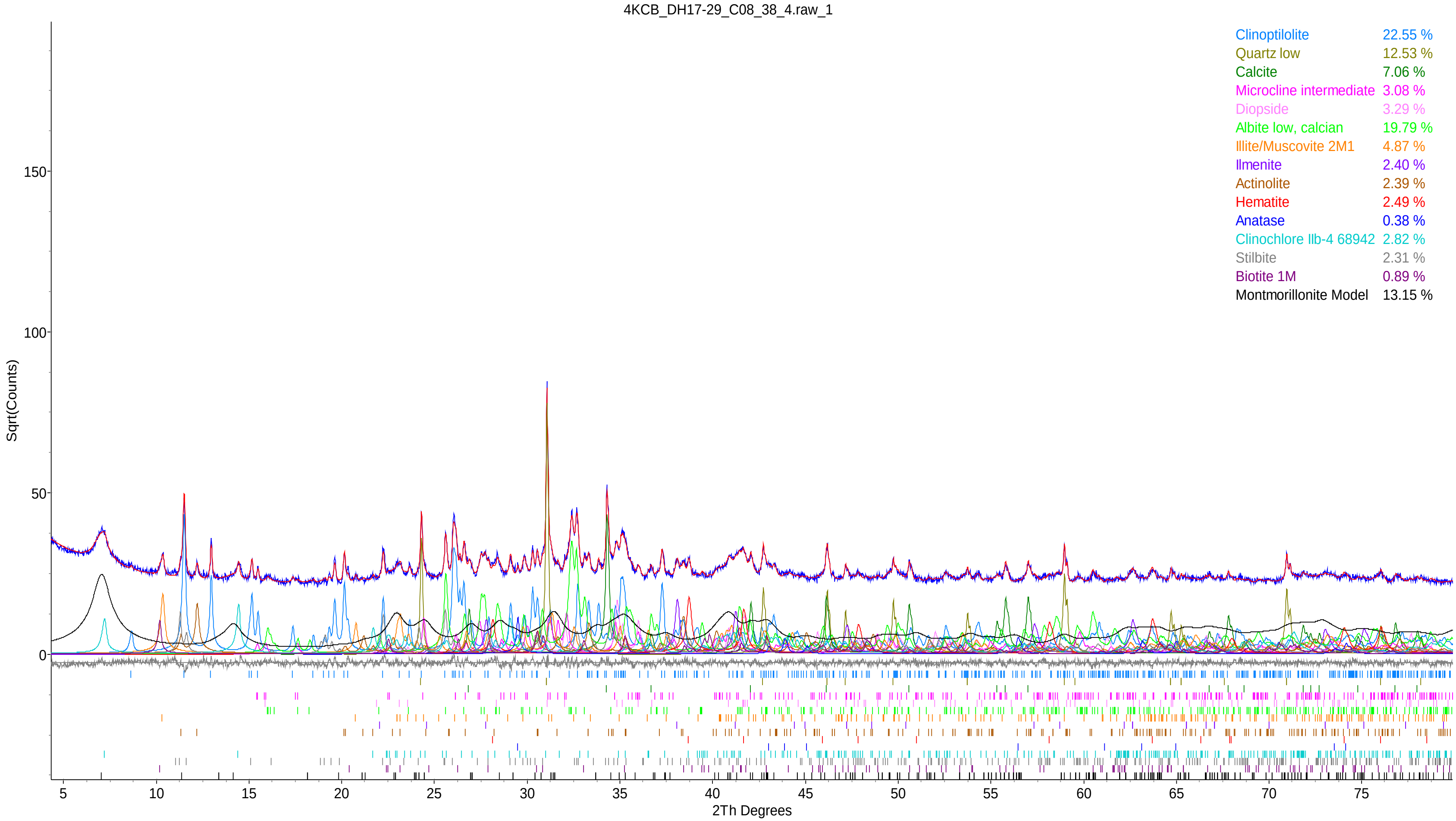


Figure 4. Rietveld refinement plot of sample **Klohn Crippen Berger – DH17-29/C08, 38.4'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

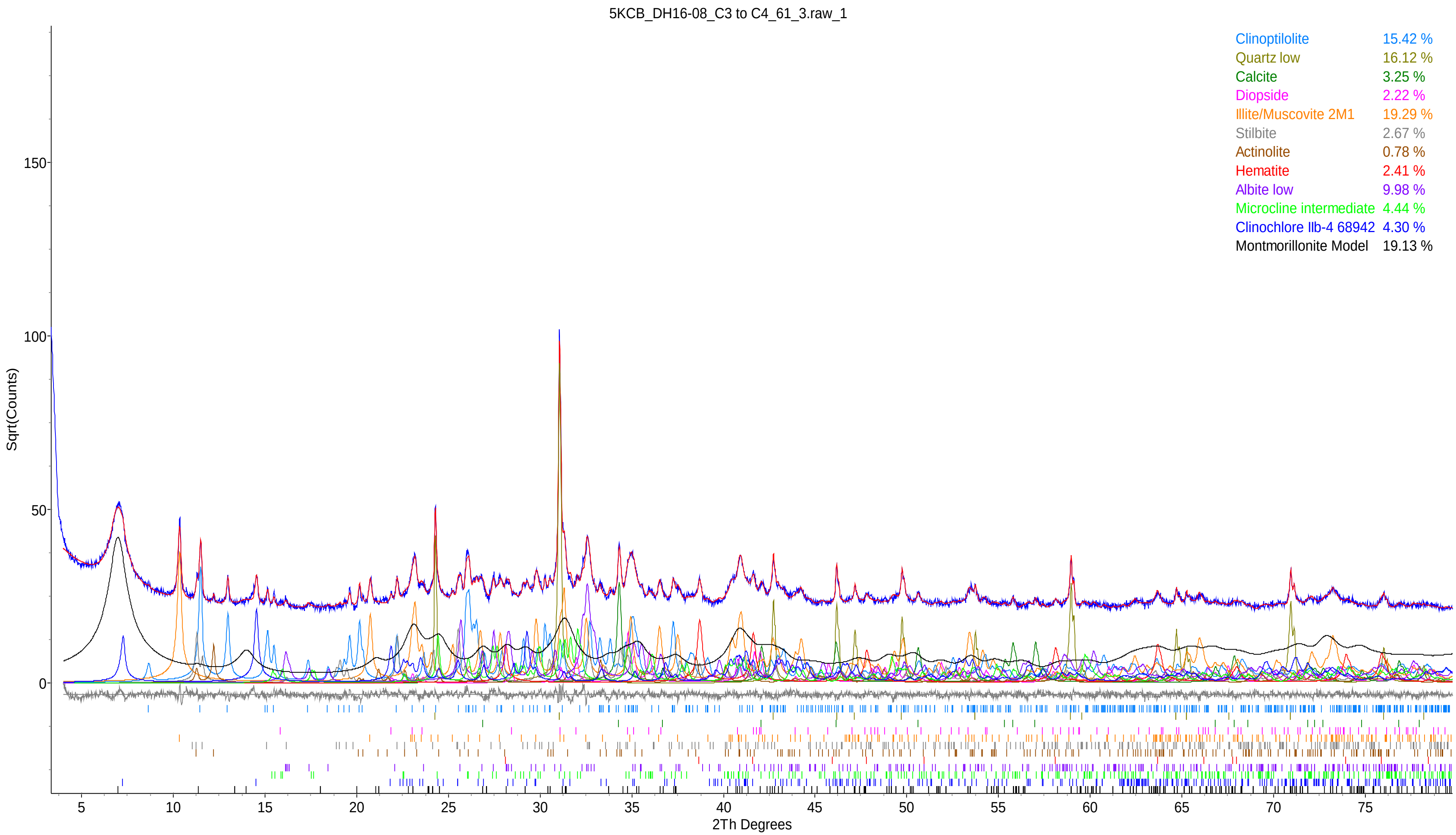


Figure 5. Rietveld refinement plot of sample **Klohn Crippen Berger – DH16-08/C3 to C4, 61.3'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

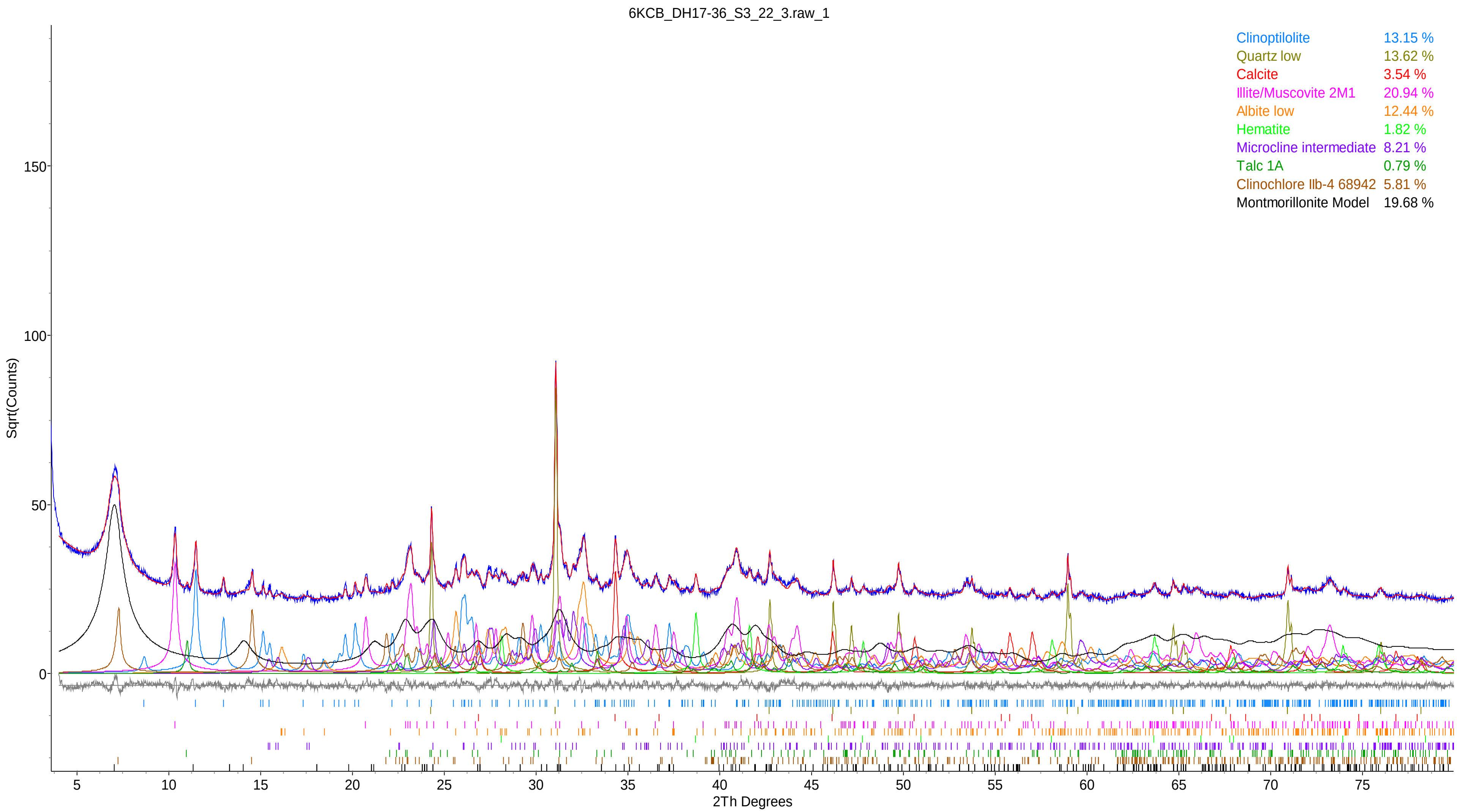


Figure 6. Rietveld refinement plot of sample **Klohn Crippen Berger – DH17-36/S3, 22.3'** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

Table 1. Results of quantitative phase analysis (wt.%) XRD-Rietveld - Klohn Crippen Berger Project M09441A18 11 01 Resolution Near West PFS - PO M02017-PO031

	#1		#2		#3		#4		#5		#6
	DH16-07/C03, 15.1'		DH16-07/C11, 37.6'		DH17-29/C03a, 8.8'		DH17-29/C08, 38.4'		DH16-08/C3 to C4, 61.3'		DH17-36/S3, 22.3'
	Tcg		Tcg		Tss		Tss		Tcg		Tss
Clinoptilolite	39.1	Clinoptilolite	23.2	Clinoptilolite	21.2	Clinoptilolite	22.5	Clinoptilolite	15.4	Clinoptilolite	13.1
Quartz	17.9	Quartz	11.2	Quartz	15.6	Quartz	12.5	Quartz	16.1	Quartz	13.6
Illite/Muscovite 2M1	5.5	Calcite	4.4	Calcite	2.2	Calcite	7.1	Calcite	3.3	Calcite	3.5
Calcite	0.7	K-feldspar	8.0	K-feldspar	4.9	K-feldspar	3.1	Diopside	2.2	Illite/Muscovite 2M1	20.9
K-feldspar	6.5	Diopside	5.2	Diopside	3.5	Diopside	3.3	Illite/Muscovite 2M1	19.3	Plagioclase	12.4
Actinolite	2.2	Plagioclase	20.0	Plagioclase	15.5	Plagioclase	19.8	Stilbite	2.7	Hematite	1.8
Plagioclase	12.4	Actinolite	4.4	Illite/Muscovite 2M1	11.2	Illite/Muscovite 2M1	4.9	Actinolite	0.8	K-feldspar	8.2
Hematite	1.3	Hematite	1.7	Ilmenite	1.0	Ilmenite	2.4	Hematite	2.4	Talc 1A	0.8
Ilmenite	1.1	Ilmenite	1.1	Stilbite	3.5	Actinolite	2.4	Plagioclase	10.0	Clinochlore	5.8
Montmorillonite Model	13.4	Clinochlore	2.0	Actinolite	1.2	Hematite	2.5	K-feldspar	4.4	Montmorillonite Model	19.7
		Illite/Muscovite 2M1	2.0	Hematite	2.0	Anatase	0.4	Clinochlore	4.3		
		Montmorillonite Model	16.8	Clinochlore	2.4	Clinochlore	2.8	Montmorillonite Model	19.1		
				Montmorillonite Model	16.0	Stilbite	2.3				
						Biotite 1M	0.9				
						Montmorillonite Model	13.2				
Total	100.0		100.0		100.0		100.0		100.0		100.0

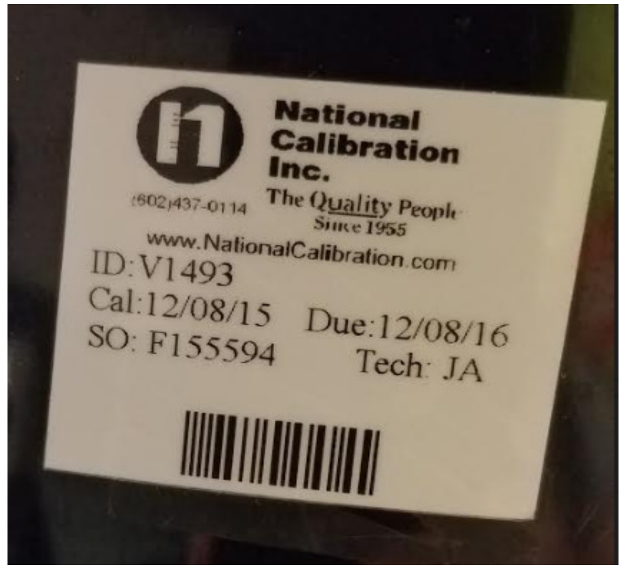
Appendix III-F

RCM Point Load Results

(ongoing)

Operator	Date	HoleID	Geologist	Rock Type	Moisture	Depth (ft)	Axial/Diametral	Width (cm)	Length (cm)	Pressure (kN)	Failure Type
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	24.48	D	6.07	7.99	3.83	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	32.53	D	6.09	7.99	1.16	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	45.13	D	6.07	7.71	2.49	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	54.28	D	6.05	8.06	2.81	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	65.96	D	6.05	8.06	3.67	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	74.21	D	6.06	7.98	2.79	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	84.57	D	6.02	8.2	2.36	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	95.38	D	6.03	7.6	2.64	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	103.81	D	6.03	7.93	3.69	1st break - small clast fell out - moved breaking point - 2nd break - intact rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	113.87	D	6.05	8.16	2.92	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	124.16	D	6.06	8.2	1.36	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	133.43	D	6.05	7.78	5.62	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	144.38	D	6.06	8.25	3.11	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	154.25	D	6.04	7.46	4.89	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	163.84	D	6.05	7.77	4.55	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	174.23	D	6.04	8.04	4.77	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	183.28	D	6.05	7.82	3.8	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	193.44	D	6.04	8.23	4.4	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	204.21	D	6.04	7.96	6.01	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	214.16	D	6.05	7.94	2.25	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	225.15	D	6.04	8.41	1.6	Broke around clast
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	233.45	D	6.06	9.04	2.7	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-08	William Garner	Tertiary Gila Conglomerate (Tg)	Dry	246.7	D	6.05	8.25	2.65	Intact Rock

Operator	Date	HoleID	Geologist	Rock Type	Moisture	Depth (ft)	Axial/Diametral	Width (cm)	Length (cm)	Pressure (kN)	Failure Type
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	31.67	A	6.1	4.27	1.92	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	33.74	A	6.09	3.67	0.83	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	86	A	6.11	3.73	5.09	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	96.32	D	6.08	8.3	11.65	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	112.2	D	6.06	7.8	20.48	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	112.4	A	6.07	4.2	15.05	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	123.23	D	6.06	8.13	3.39	Invalid
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	134.51	D	6.08	8.09	4.81	Invalid / Microdefect (hard to tell)
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	135.36	A	6.07	3.57	3.77	Invalid
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	146.96	D	6.06	7.24	2.51	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	147.15	A	6.06	4.07	2.09	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	156	D	6.07	7.94	13.39	Invalid
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	156.21	A	6.07	3.7	5.67	Intact Rock
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	189.12	D	6.09	7.19	0.88	Completely Shattered
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	198.7	D	6.09	7.9	2.5	Invalid / Microdefect (hard to tell)
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	198.9	A	6.08	4.04	0.31	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	208.45	D	6.1	8.01	7.96	MicroDefect
Rueben Rodriguez	2017-05-09	DH16-22	William Garner	Precambrian Pinal Schist (Pcpi)	Dry	236.33	D	6.09	8.26	2.09	Invalid


National
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ID:V1493
Cal:12/08/15
Due:12/08/16
SO: F155594
Tech: JA


Model #: PG-10000-99.71-KN-G-L2-E1-W2-M1-MOD0042
Part #: 548010-8099
Serial #: V1493
Output: 0 - 2 vdc
Range: 0 - 99.71 kN
Wiring:
Pin A: N/C
Pin B: + Out
Pin C: - Out
Pin D: N/C
Pin E: N/C
Pin F: N/C
Made in USA
Mfg.: 09 - 2005


GCTS
0562
ENERPAC

APPENDIX IV

Field Mapping

Klohn Crippen Berger

Resolution Copper Mining LLC

Resolution Copper Project

Near West Tailings Storage Facility

2016/2017 Field Mapping, Rev. 1

CANADA'S BEST MANAGED COMPANIES Platinum member

ISO 9001
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M09441A18.730

October 2017

October 20, 2017

Resolution Copper Mining LLC
P.O. Box 1944
Superior, Arizona
85273

Ms. Kim Huether
General Manager - Studies

Dear Ms. Huether:

Resolution Copper Project
Near West Tailings Storage Facility
2016/2017 Field Mapping, Rev. 1

We are pleased to provide a summary of the 2016/2017 field mapping program at the Near West and Happy Camp sites.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Kate Patterson, P.E., M.Eng.
Project Manager

KP:dl

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Resolution Copper Mining LLC

Resolution Copper Project

Near West Tailings Storage Facility

2016/2017 Field Mapping, Rev. 1

TABLE OF CONTENTS

List of Figures

List of Appendices

1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) conducted field reconnaissance and surface mapping of the proposed Near West Tailings Storage Facility (TSF) and Happy Camp TSF sites on December 1, 2016 and between January 18, 2017 and January 25, 2017. Mapping was conducted by Mr. Jim Casey, P.Eng., with support from Resolution Copper Mining (RCM) personnel. The primary objectives of the mapping program for the Near West and Happy Camp sites are summarized below:

Near West Site

- Identify, if possible, structural features within the Pinal Schist and characterize their potential to transmit seepage, from the TSF and seepage collection dams.
- Further characterize the Gila Conglomerate throughout the TSF footprint.
- Characterize surface features of the Gila Conglomerate (e.g., weathering, gradation, cementation, strength) and assess variability:
  - prioritize small, steep gullies perpendicular to major drainages to look for exposure through a significant thickness of Gila Conglomerate. Also, visit strongly-linear northeast-southwest oriented drainages to look for sub-vertical faults or joints that these drainages could be tracing; and
  - Identify, if possible, faults, joints or bedding planes that could be conduits for fluid flow.
- Identify, if possible, any joints or discontinuities surrounding drill holes GT-7, GT-14 and GT-19, where fluid circulation was lost during drilling.
- Identify any significant differences in the Perlitic Aphyric Rhyolite exposed around drill holes GT-31 and GT-32. Packer testing results have shown that the rhyolite in GT-32 is much more permeable than in GT-31.
- Describe surficial rock units within the northern cleaner tailings cell, including differences between the various facies of Pinal Schist.
- Confirm surface bedrock units near GT-41 where Pinal Schist was encountered in an area shown as Pioneer Shale on the site geology map used for the Mine Plan of Operations study (MPO) (KCB 2014). The source geology report upon which the MPO geology map is based had also identified the rock type in the area as Pinal Schist (Spencer and Richard 1995).
- Collect samples for laboratory testing, if appropriate.

Happy Camp Site

- Characterize surface features of the Gila Conglomerate properties (e.g., weathering, gradation, cementation, strength) and identify, if possible, faults, joints or bedding planes that could be conduits for fluid flow at the north end of the site.
- Characterize the contact between the Gila Conglomerate and the Apache Group rock units, if visible, at the northern end of the site.

- Identify, if possible, describe and photograph Apache Group rock units at the north end of the site.
- Collect samples for laboratory testing, if appropriate.

This program builds on the information collected during the 2013 field mapping program. Details of the 2013 program are provided in the MPO, Appendix I (KCB 2014).

2 MAPPING METHODOLOGY AND OBSERVATIONS

At the beginning of each day, a mapping route was planned and discussed with RCM to confirm mapping priorities and the location of personnel in case of emergency. An RCM vehicle was used to drive to the starting location and traverses were performed on foot. Mapping was conducted in pairs at all times for safety, and a GPS SPOT device was used to send regular check-in updates to the RCM office. Mr. Casey was either accompanied by RCM employees Mr. Will Garner or Mr. Mike Arriola during mapping.

The locations of mapping traverses and waypoints are shown on Figures 2.1 through 2.10, organized by the day on which the traverse was conducted. Waypoints were marked with a handheld GPS and photographs were taken at points of interest along each traverse. Waypoint descriptions and photographs are provided in Appendix I and Appendix II, respectively. Most traverses were performed in active drainage channels where rock exposures are typically best.

Structural measurements (i.e., bedding, foliations, folds, etc.) were taken at select locations with a pocket transit compass. Compass readings were corrected from magnetic to true north by setting the declination on the compass to 10^{o} east. Measurements are shown on plan on Figure 2.11 and 2.12, and on polar stereonets on Figures 2.13 through 2.16.

The site geology map prepared for the MPO and based on a mapping report by Spencer and Richard (1995) was used to plan traverses and served as reference during the site investigation. The locations of the geologic contacts and faults shown on figures throughout this report were derived from this map.

3 OBSERVATIONS

3.1 General

Key observations form the mapping program are discussed in the following sections.

3.2 Gila Conglomerate

Gila Conglomerate (Tcg) observations were generally consistent with those made during the 2013 mapping program. These observations included:

- Tcg becomes more broadly graded with thicker beds and larger clasts from the south end of the site to the north end. Sandy and silty beds, typically less than 1 ft thick, are prevalent in Tcg outcrops roughly immediately south of the cleaner tailings starter dam location (refer to Figure 2.1 for cleaner starter dam location).
- The gradation of Tcg appears to be correlated with its positon north-south, and does not appear variable in elevation at a given location (i.e. through the thickness of the rock unit). This was evident in the traverses conducted in steep, narrow drainage channels perpendicular to the Potts Canyon ridge. Along these traverses, the gradation of the Tcg did not visibly vary from the top of the ridge to the bottom. However, along the southernmost traverse (WP130 to WP135) there were more instances of thinner, finer bedding than the northernmost traverses.
- Preferential weathering of certain beds within Tcg outcrops is commonly observed. Typically, well graded sand beds with variable gravel content are most weathering resistant. No correlation between bed weathering susceptibility and hydrochloric acid reaction (as a qualitative estimate of calcium carbonate cement content) has been made from tests performed. The weathering of susceptible beds commonly results in sub-horizontal voids, overhangs and ledges in Tcg outcrops. Voids are typically shallow in outcrop, however one was observed to extend at least 16 inches into the rock (WP36).
- In drainage channels incising Tcg, rock outcrops are commonly observed in the channel banks and extending across the channel bottoms. Shallow water ponding on Tcg surfaces is also common. In more active drainages, the drainage invert is obscured by young alluvium (Qal/Qs).

Updates to the understanding of the Tcg in the Near West and Happy Camp areas based on 2016/2017 mapping observations include:

- Several sub-vertical joints were observed in Tcg outcrops, primarily clustered in Bear Tank Canyon upstream of the cleaner tailings starter dam (WP28, WP29, WP30 on). One normal fault with inferred displacement of approximately 6 ft was also identified in this area (WP25) and is in relatively close proximity (approximately 700 ft) to Bear Tank Canyon Spring. These features, indicative of post-depositional deformation in the Tcg as they cut across multiple beds, are not commonly observed.

- The gradation of Tcg exposed in Happy Camp along the mapped traverse in the northern end of Rice Water Canyon is typical of Tcg exposed at the northern side of Near West.
- The dip angle of Tcg bedding is typically less than 10° in the Near West area, whereas some beds in Happy Camp area have dip angles as high as 25° (WP139). The orientation of Tcg bedding is relatively consistent in both Near West and Happy Camp, striking north-south.

3.3 Pinal Schist

- The Pelitic (Xps) and Calc-silicate (Xpc) facies of Pinal Schist are the main units exposed in the north cleaner cell area:
  - Several good exposures of Xps in the drainage channel running through the center of the cleaner cell indicate that the rock mass is strongly foliated, heavily fractured/disturbed, and medium-strong (WP74, WP77). Folds and crenulations are common in the Xps however there does appear to be some regional consistency in the strike of the foliations (approximately east-northeast) with local variability (refer to Figure 2.12).
  - Significant outcrops of Xpc were not observed within the cleaner tailings cell. The transition between the Xps and Xpc facies is abrupt without any noticeable structural surface expression. The contact is identified by a change in the color (from light grey (Xps) to dark grey (Xpc)) and by the properties of the cobbles exposed on surface (WP82); small outcrops of Xpc indicate that the rock is harder (strong rock) and less friable than the Xps (WP81).
- Few large outcrops of Psammite facies Pinal Schist (Xpm) were observed on high ground along the southern edge of the Near West area between the seepage collection dams (refer to Figure 2.7). Small outcrops, often protruding less than 1 ft above the ground surface, typically displayed tightly spaced foliation cleavage and small scale folding and crenulations. There appears to be a regional northeastern trend in the orientation of the foliations observed in these outcrops on high ground (refer to Figure 2.11). The orientation of foliations mapped in larger outcrops exposed in drainage channels shows more variability which may indicate the presence of multiple foliations within the rock unit and/or the influence of folding.
- Two folds were mapped in Xpm, both trending to the east with shallow plunge (15° to 25°) (WP121, WP129).
- Parallel cleavage surfaces were often observed in larger Xpm outcrops, cutting across the dominant foliations (WP112).

3.4 Drill Holes with Lost Circulation

GT-7

Circulation was lost during drilling in Tcg at 55 ft below ground surface (El. 2,435 ft). A contact with Apache Leap Tuff (Tal) was identified approximately 200 ft from the borehole location. The contact runs up the ridge on which GT-7 was drilled, across the elevation where circulation was lost. A surface exposure of disintegrated Tal was noted at the base of the ridge near the Tal/Tcg contact where it crosses a drainage channel, suggesting that the contact could be a preferential pathway for seepage (WP3-2016). There were no indications of drill fluid daylighting from the slopes adjacent to the drill hole. Drilling was completed on October 6, 2016 and the area was not mapped until December 1, 2016.

GT-14

Circulation was lost in Tcg at 26 ft below ground surface (El. 2,380 ft). GT-14 is on relatively flat terrain at the south end of the Near West site and the elevation of circulation loss was slightly below the elevation of an adjacent drainage channel. Sub-horizontally bedded sandstone (Tss) is exposed in the drainage channel and was observed to extend across the bottom of the channel (WP4-2016). No signs of disturbance or drill fluid daylighting from the banks of the drainage were observed. Drilling was completed on September 27, 2016 and the area was not mapped until December 1, 2016.

GT-19

Circulation was lost in Tcg at 124 ft below ground surface (El. 2,536 ft). GT-19 is on a ridge between two drainage channels. Some sub-horizontal voids were observed below competent sandy beds in a Tcg outcrop at the bottom of the western drainage channel that penetrated at least 16 inches into the outcrop (WP36). Some sub-horizontal sandy beds were observed at the downstream end of the erosion gully where it met the main drainage east of GT-19, similar to what was seen at WP36 (WP37). The sub-horizontal sandy beds and voids were noted at approximately El. 2,585 ft (western drainage) and El. 2,526 ft (eastern drainage). A similar feature may have provided a high conductivity conduit for fluid flow.

No signs of disturbance or drill fluid daylighting from the ridge adjacent to GT-19 near the elevation of circulation loss were observed. Drilling was completed on November 20, 2016 and the area was not mapped until January 17, 2017.

3.5 Mixed Geology Area Surrounding Drill Hole GT-41

The surficial geology at GT-41 is shown as Pioneer Shale (Yp) on the MPO geological map, with a number of rock units of different age and origin exposed in the nearby area. Traverses in this area were aimed at confirming the presence and contacts of the rock units, and the nature of the mapped faults.

Based on rock exposures, much of the Yp shown on the MPO geology map is actually Pinal Schist (Xp); this appears to be confirmed by the source mapping report (Spencer and Richard 1995). The inferred contact between Yp and Xp is shown on Figure 2.10. With this exception, the rock units and contacts verified in our field work agrees with the geology map.

The east-west oriented fault mapped to the east of GT-41 (refer to Figure 2.10) appears to have experienced deformation following deposition of the Tal and Tcg based on the following evidence:

- the abrupt contact between the Tertiary rocks and Apache Group units;
- sub-vertical parallel joints observed in a Tcg outcrop 100 ft from the fault (WP155); and
- heavily disturbed Tal along the contact (WP156).

Several shear or fault zones were observed in the Dripping Springs Quartzite (Yds) and Yp units in this area (WP158, WP161) which may be associated with the faulting in the Tcg/Tal. Diabase (Yd) was commonly observed intruding the Apache Group sedimentary units.

3.6 Northern Happy Camp

Topography at the contact between the Tcg and the Apache Group units at the north end of Rice Water Canyon is relatively flat, and the exact location and nature of the contact is obscured by alluvium. Yd rock mass was heavily fractured/disturbed often with surface weathering and oxidation. In numerous locations, completely weathered Yd outcrops were observed, where the rock mass had broken down to sand sized particles. In these outcrops some relict structure was commonly seen with intact calcite veins.

3.7 Perlite Exposure near Drill Holes GT-31 and GT-32

Exposures of Peritic Aphyric Rhyolite (Tp) near drill holes GT-31 and GT-32 were limited and no definitive visual differences were observed between small outcrops in this area. Unrelated to the Tp, two fractures were noted in a small outcrop of Tcg deposited overtop of the Tp (WP5-2016).

4 CONCLUSIONS

The primary findings of the 2016/2017 field mapping program relevant to the design and construction of the Near West TSF are as follows:

- Generally, the observations made during the 2016/2017 program support the conclusions and rock unit descriptions summarized in the MPO. A notable exception was identification at several locations of sub-vertical fracturing, jointing and faulting in the Gila Conglomerate, primarily concentrated in Bear Tank Canyon. Montgomery and Associates (M&A), who also conducted a field mapping program in 2013, identified some sparse fractures and joints in the Gila Conglomerate, which support these 2016/2017 observations (M&A 2013). While apparently localized, the presence of these features should be considered in design as potential pathways for seepage.
- The locations of contacts between the various units provided on the MPO geology map are relatively consistent with our mapping observations. An exception being the extent of the Yp mapped in the vicinity of GT-41. The majority of the Yp mapped in that area is Pinal Schist which is consistent with the drilling results from GT-41 and the source mapping report (Spencer and Richard 1995). These observations will be incorporated during geological site characterization.
- No direct evidence of pathways that could have provided a conduit for drilling circulation loss in drill holes GT-7, GT-14 and GT-19 was identified. However, indirect evidence of higher permeability zones that could help explain the loss of circulation include: the proximity of GT-7 to a contact between Tcg and Tal and presence of sub-horizontal voids observed in Tcg outcrops surrounding GT-19.
- The Pinal Schist (Xps facies) exposed over most of the northern cleaner tailings cell is strongly foliated, folded and appears heavily fractured/disturbed. Rock mass properties (i.e., strength, structure, and weathering) of the Xps unit appear similar to the more thoroughly investigated Xpm unit at the south end of the Near West site.
- Further investigation into the nature of the Apache Group rock units and Tcg is warranted at the north end of the Happy Camp site, if that site is to be considered as an option for tailings storage. Observations of the diabase unit which is dominant in the area indicate that the rock is heavily disturbed at surface.

5 CLOSING

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KLOHN CRIPPEN BERGER LTD.

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Project Engineer

Kate Patterson, P.E., M.Eng.
Project Manager

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Klohn Crippen Berger Ltd. (KCB). 2014. Near West Tailings Management Mine Plan of Operations Study. September.

Montgomery and Associates (M&A). 2013. Phase I Hydrogeologic Field Investigations, Near West Tailings Site, Pinal County, Arizona. April.

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FIGURES

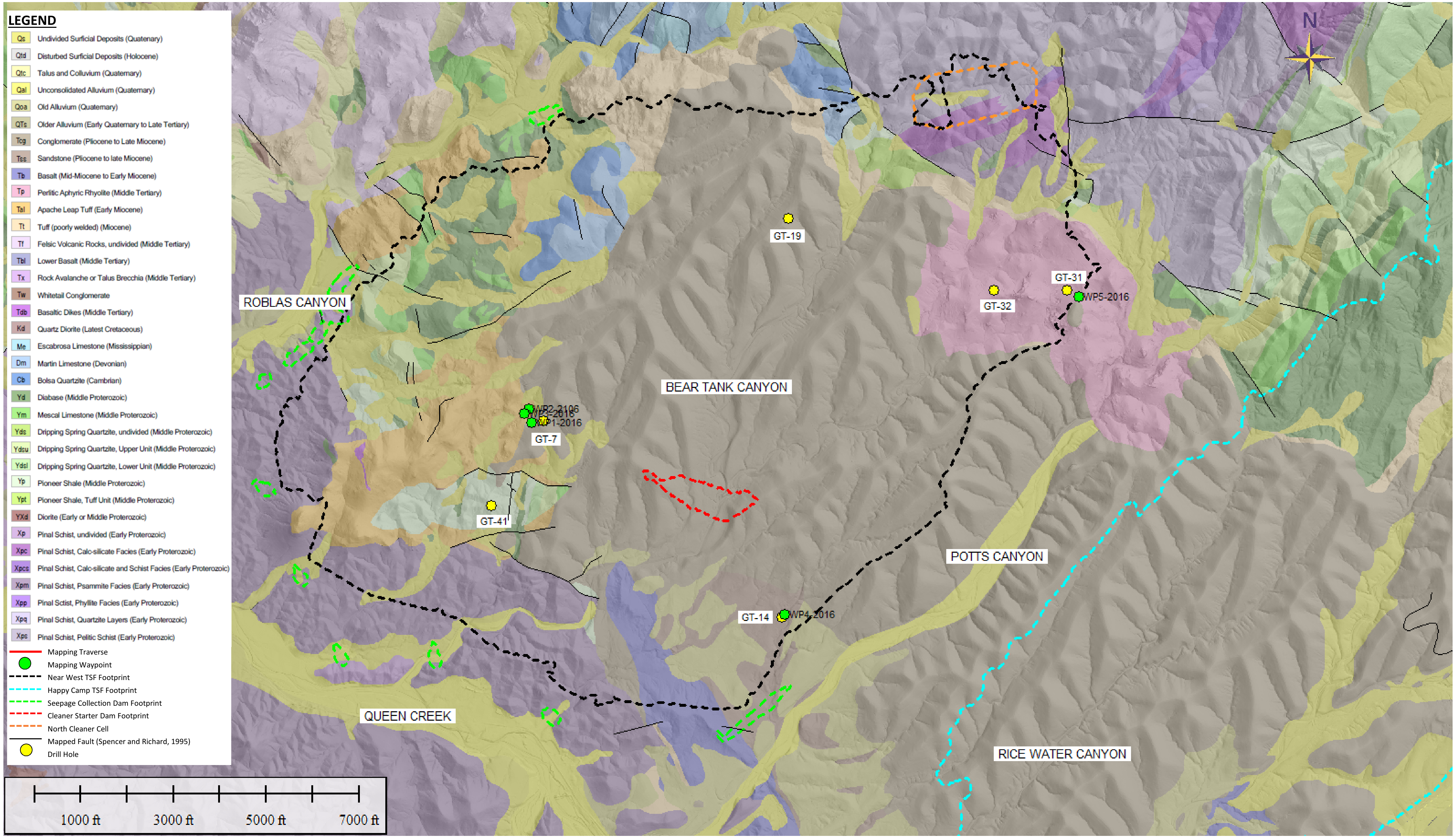

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FIG No. 2.1

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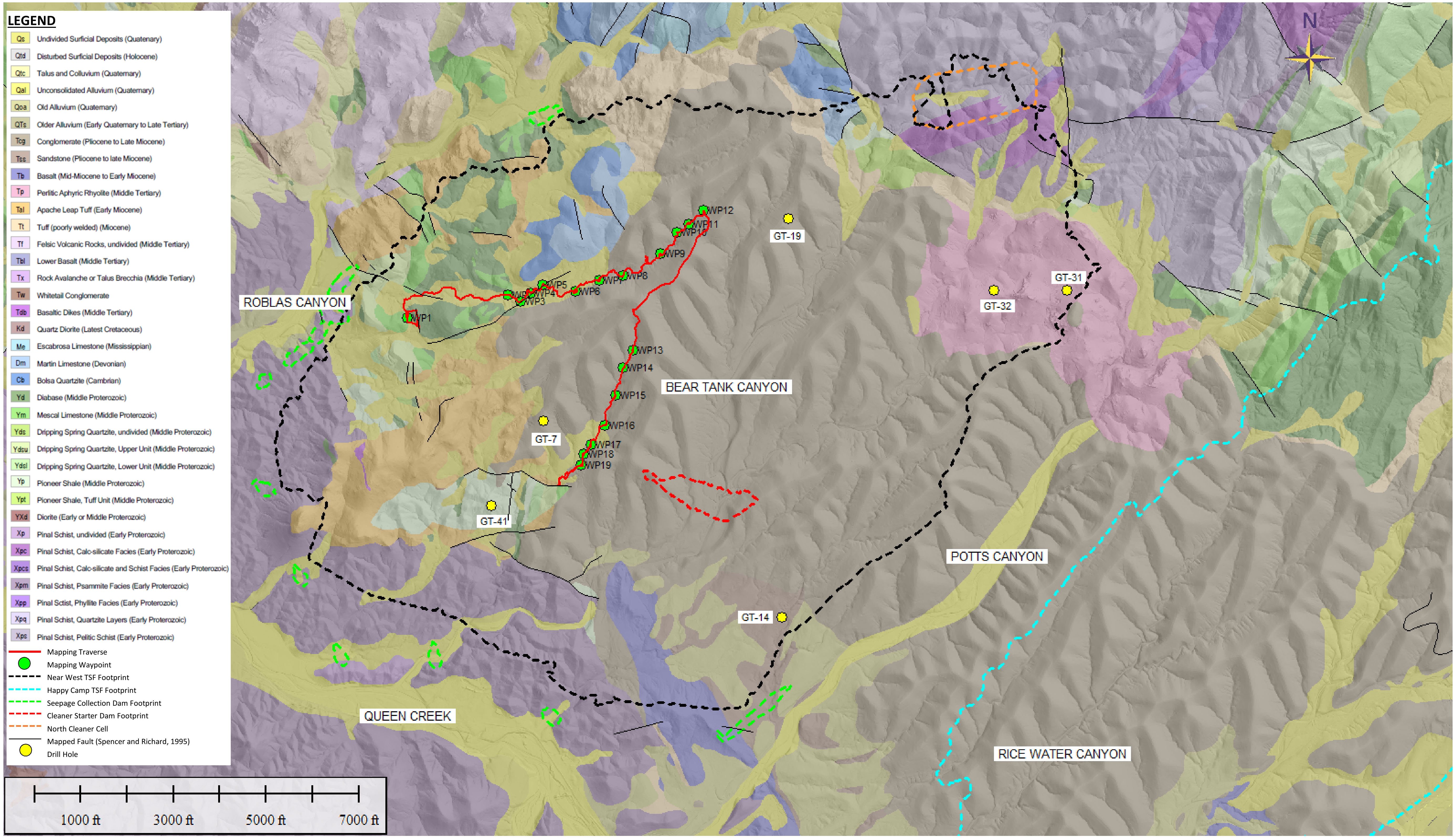

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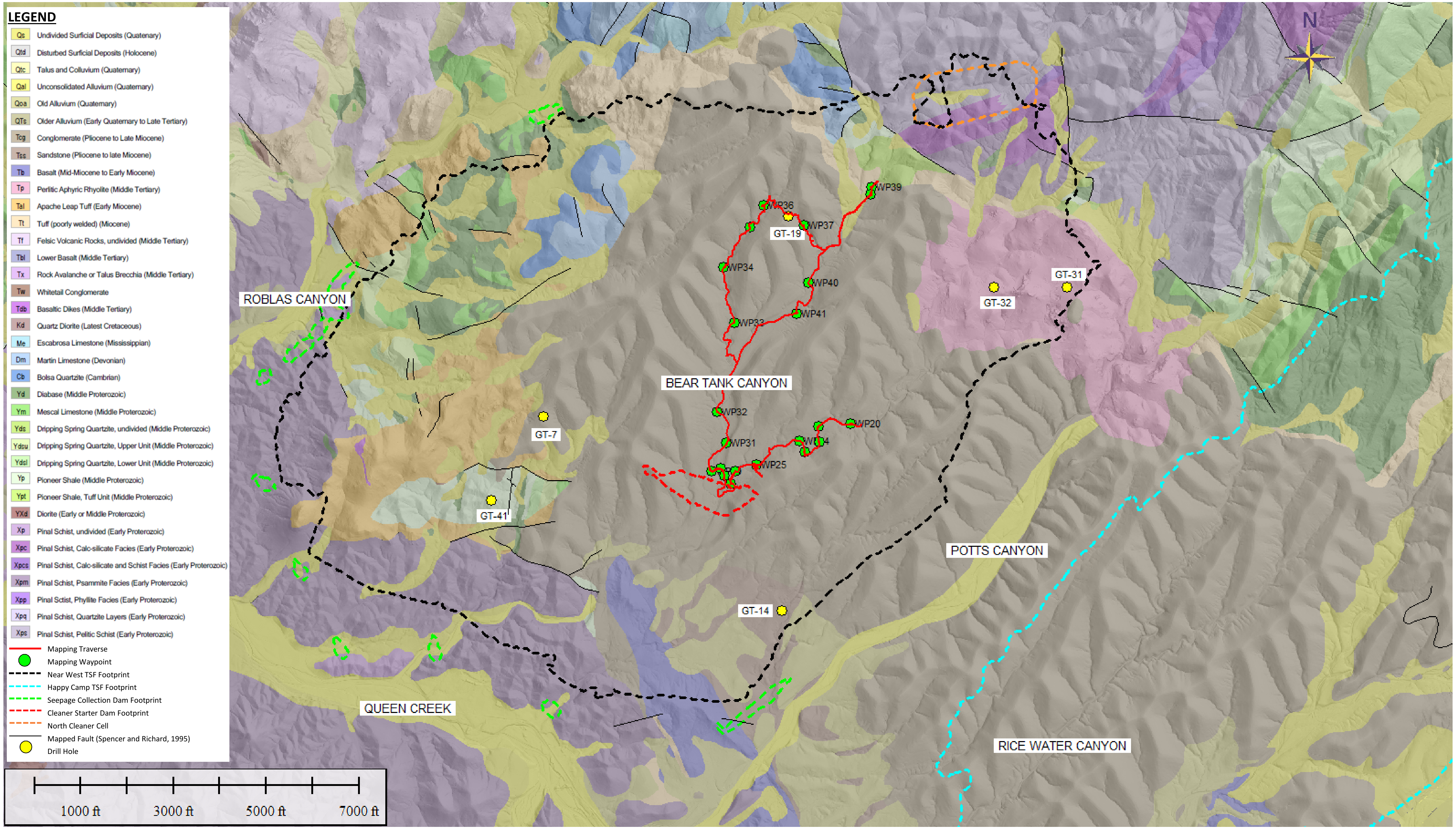

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FIG No. 2.3

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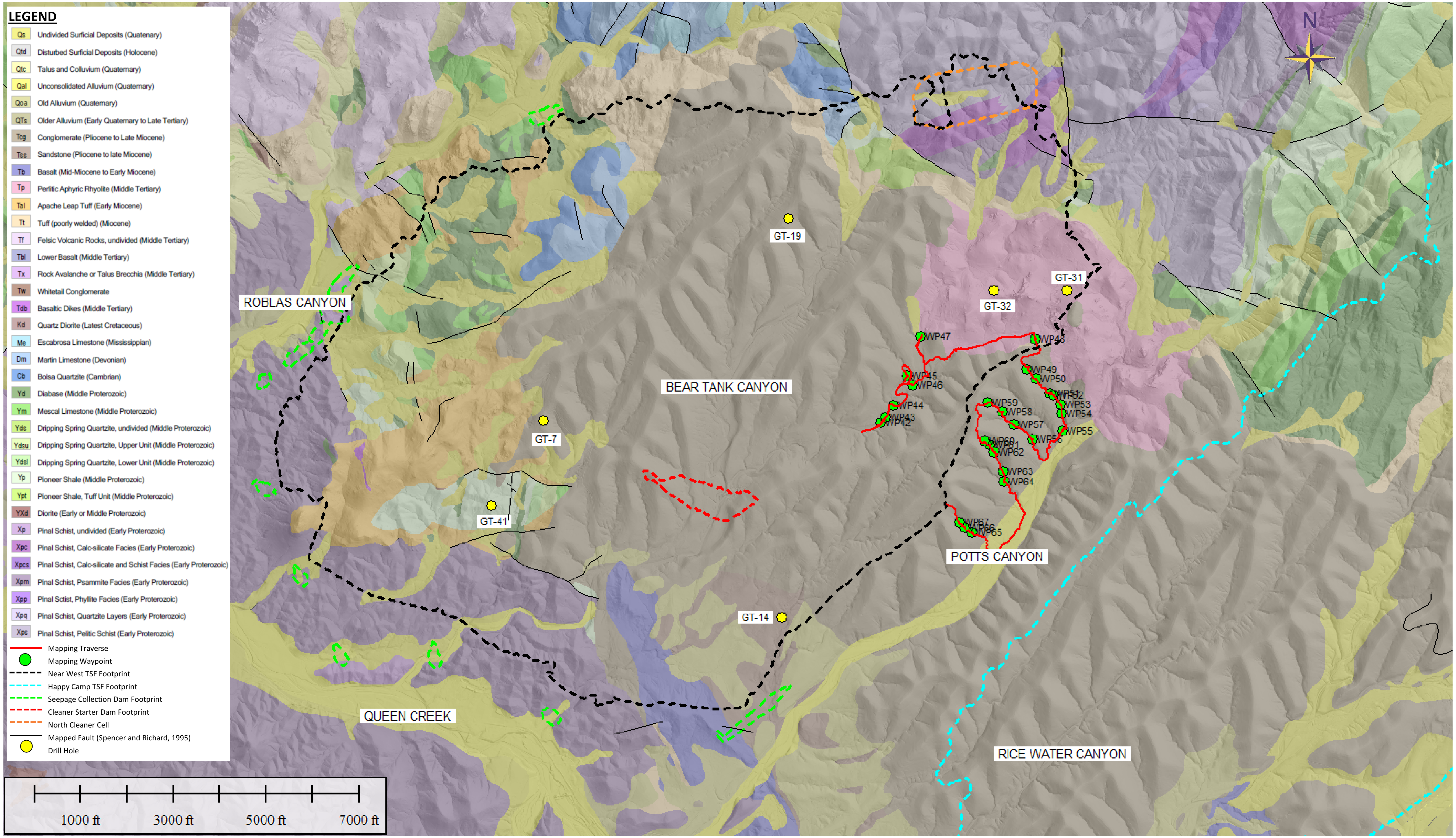

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FIG No. 2.4

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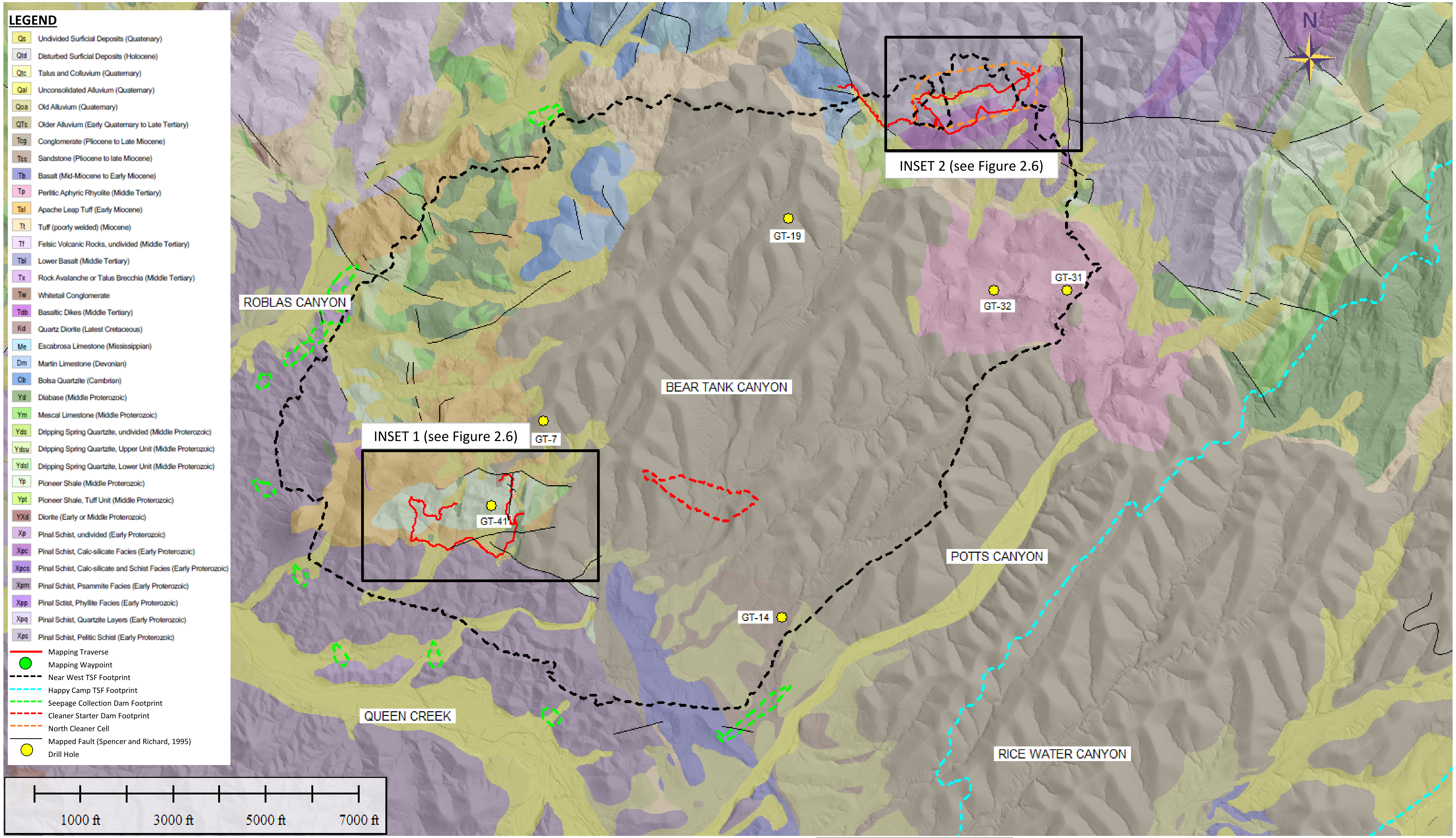

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FIG No. 2.5

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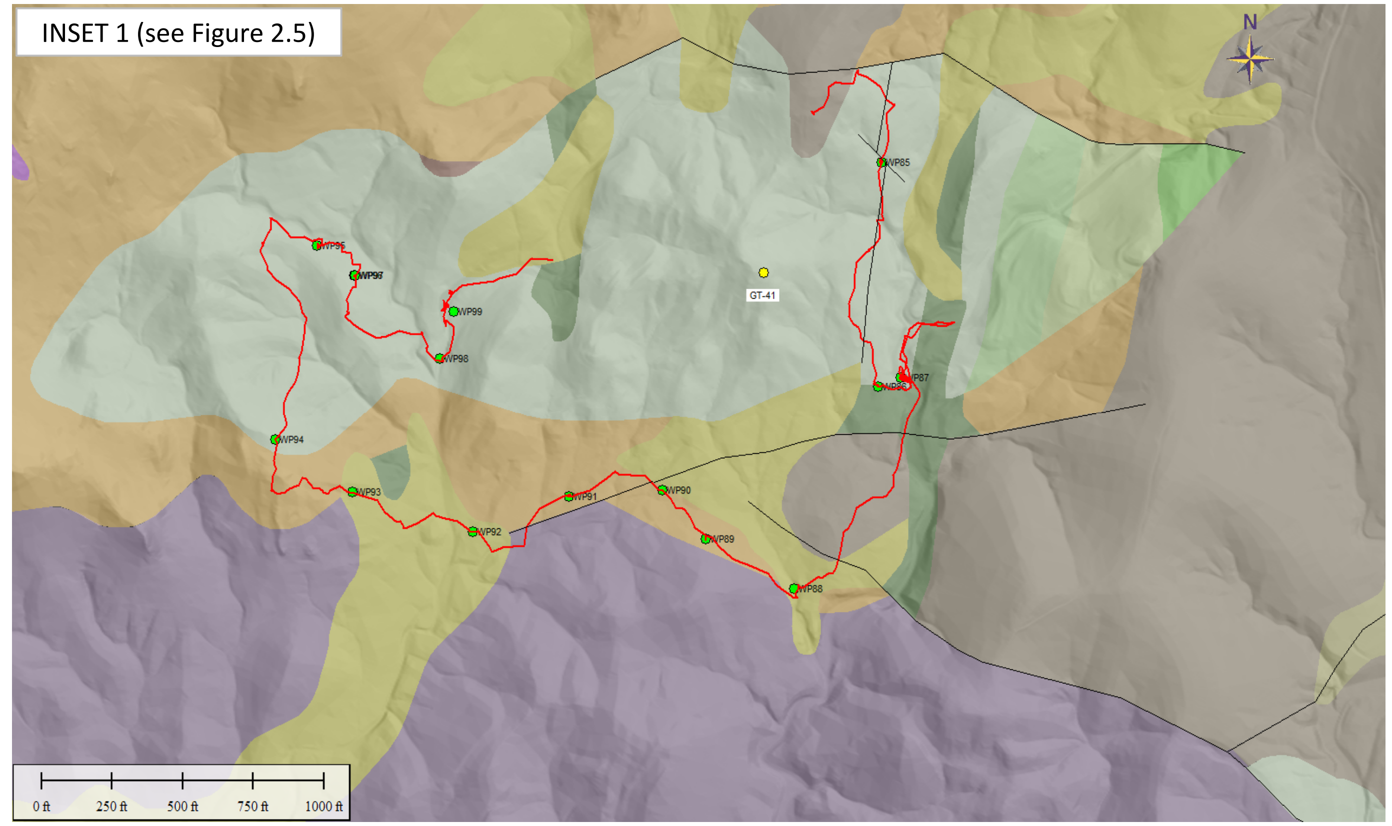
LEGEND

- Qs — Undivided Surficial Deposits (Quaternary)
- Qtd — Disturbed Surficial Deposits (Holocene)
- Qtc — Talus and Colluvium (Quaternary)
- Qal — Unconsolidated Alluvium (Quaternary)
- Qoa — Old Alluvium (Quaternary)
- QTs — Older Alluvium (Early Quaternary to Late Tertiary)
- Tcg — Conglomerate (Pliocene to Late Miocene)
- Tss — Sandstone (Pliocene to late Miocene)
- Tb — Basalt (Mid-Miocene to Early Miocene)
- Tp — Perlitic Aphyric Rhyolite (Middle Tertiary)
- Tal — Apache Leap Tuff (Early Miocene)
- Tt — Tuff (poorly welded) (Miocene)
- Tf — Felsic Volcanic Rocks, undivided (Middle Tertiary)
- Tbl — Lower Basalt (Middle Tertiary)
- Tx — Rock Avalanche or Talus Breccia (Middle Tertiary)
- Tw — Whitetail Conglomerate
- Tdb — Basaltic Dikes (Middle Tertiary)
- Kd — Quartz Diorite (Latest Cretaceous)
- Me — Escabrosa Limestone (Mississippian)
- Dm — Martin Limestone (Devonian)
- Cb — Bolsa Quartzite (Cambrian)
- Yd — Diabase (Middle Proterozoic)
- Ym — Mescal Limestone (Middle Proterozoic)
- Yds — Dripping Spring Quartzite, undivided (Middle Proterozoic)
- Ydsu — Dripping Spring Quartzite, Upper Unit (Middle Proterozoic)
- Ydsl — Dripping Spring Quartzite, Lower Unit (Middle Proterozoic)
- Yp — Pioneer Shale (Middle Proterozoic)
- Ypt — Pioneer Shale, Tuff Unit (Middle Proterozoic)
- YXd — Diorite (Early or Middle Proterozoic)
- Xp — Pinal Schist, undivided (Early Proterozoic)
- Xpc — Pinal Schist, Calc-silicate Facies (Early Proterozoic)
- Xpcs — Pinal Schist, Calc-silicate and Schist Facies (Early Proterozoic)
- Xpm — Pinal Schist, Psammite Facies (Early Proterozoic)
- Xpp — Pinal Sctist, Phyllite Facies (Early Proterozoic)
- Xpq — Pinal Schist, Quartzite Layers (Early Proterozoic)
- Xps — Pinal Schist, Pelitic Schist (Early Proterozoic)
- Mapping Traverse
- Mapping Waypoint
- Near West TSF Footprint
- Happy Camp TSF Footprint
- Seepage Collection Dam Footprint
- Cleaner Starter Dam Footprint
- North Cleaner Cell
- Mapped Fault (Spencer and Richard, 1995)
- Drill Hole



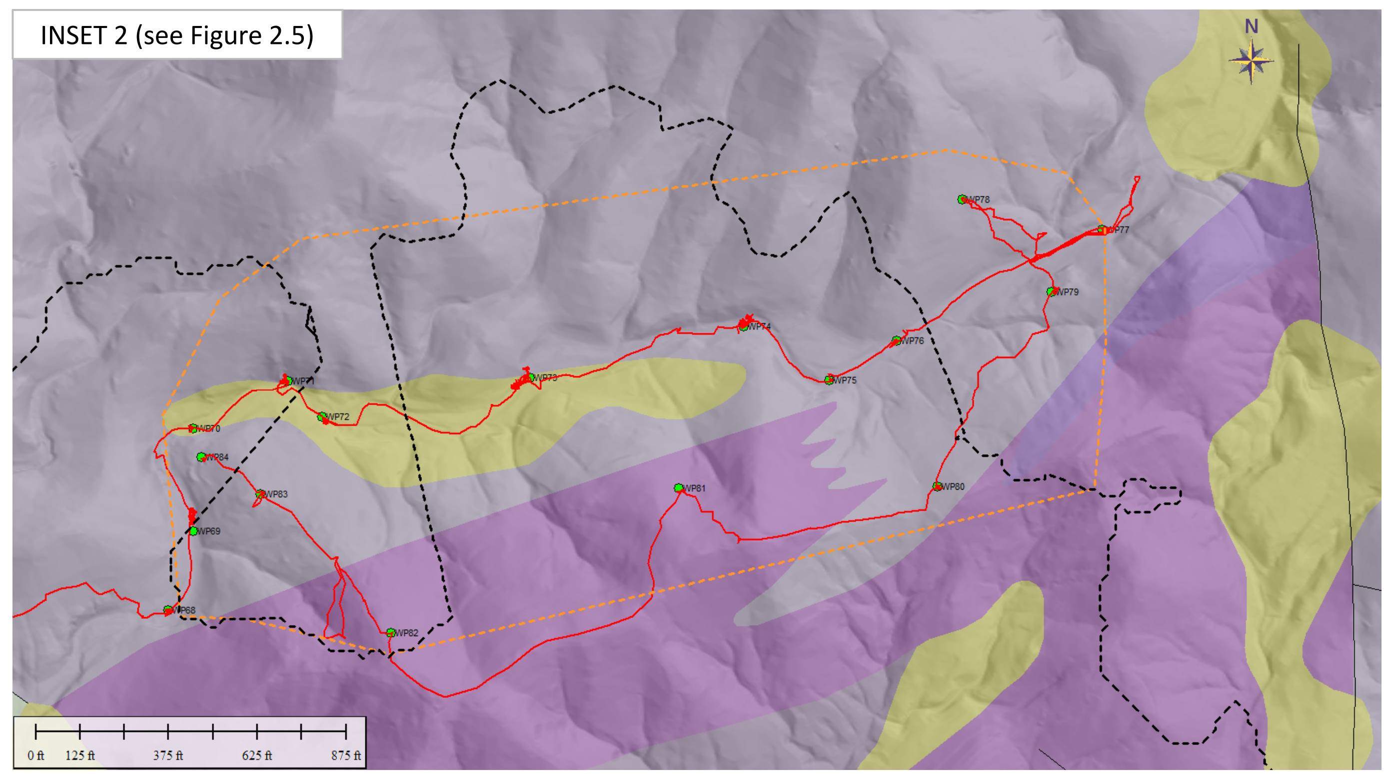


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FIG No. 2.6

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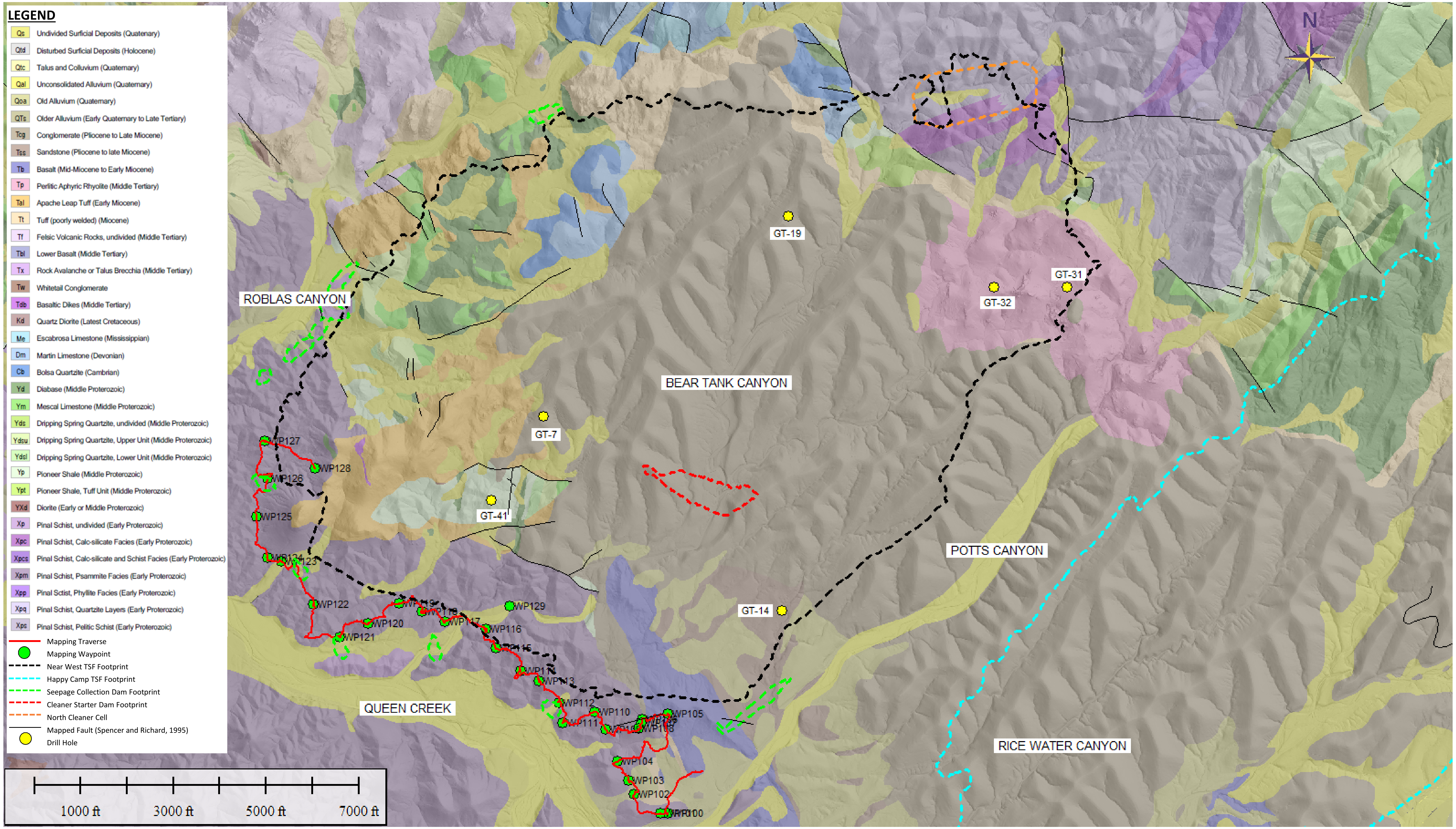

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FIG No. 2.7

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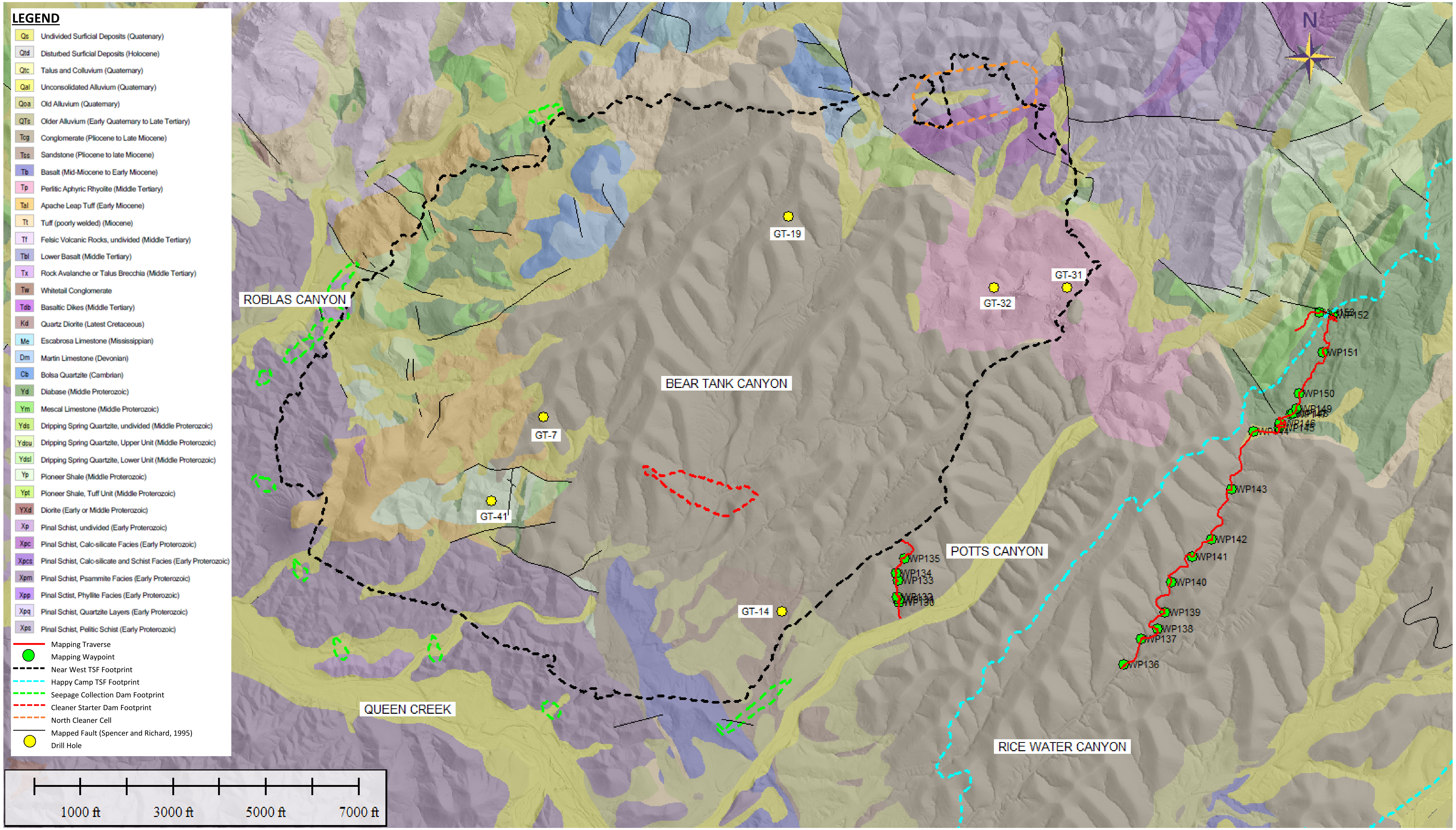

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FIG No. 2.8

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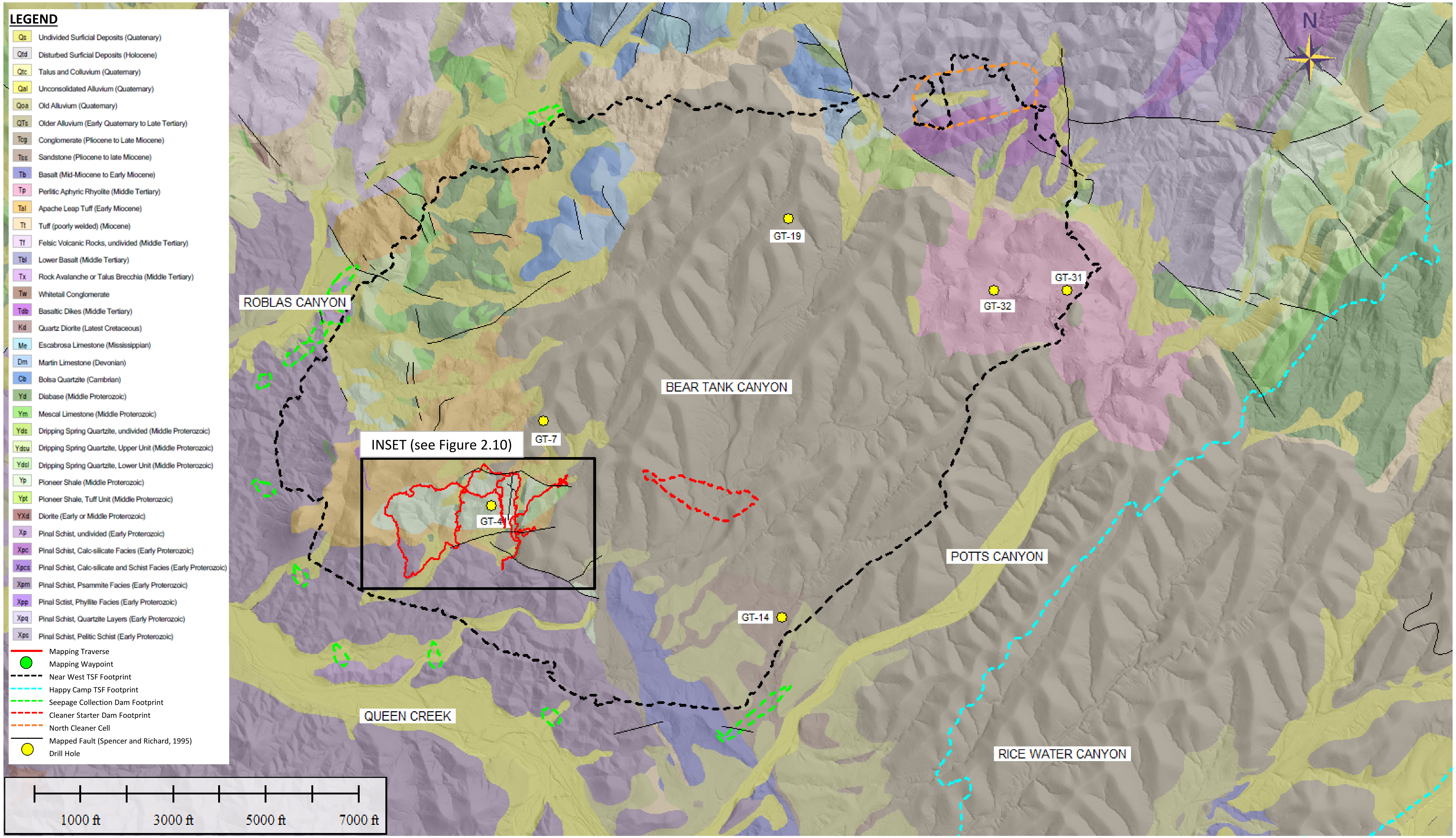

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FIG No. 2.9

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LEGEND

- Qs — Undivided Surficial Deposits (Quaternary)
- Qtd — Disturbed Surficial Deposits (Holocene)
- Qtc — Talus and Colluvium (Quaternary)
- Qal — Unconsolidated Alluvium (Quaternary)
- Qoa — Old Alluvium (Quaternary)
- QTs — Older Alluvium (Early Quaternary to Late Tertiary)
- Tcg — Conglomerate (Pliocene to Late Miocene)
- Tss — Sandstone (Pliocene to late Miocene)
- Tb — Basalt (Mid-Miocene to Early Miocene)
- Tp — Perlitic Aphyric Rhyolite (Middle Tertiary)
- Tal — Apache Leap Tuff (Early Miocene)
- Tt — Tuff (poorly welded) (Miocene)
- Tf — Felsic Volcanic Rocks, undivided (Middle Tertiary)
- Tbl — Lower Basalt (Middle Tertiary)
- Tx — Rock Avalanche or Talus Breccia (Middle Tertiary)
- Tw — Whitetail Conglomerate
- Tdb — Basaltic Dikes (Middle Tertiary)
- Kd — Quartz Diorite (Latest Cretaceous)
- Me — Escabrosa Limestone (Mississippian)
- Dm — Martin Limestone (Devonian)
- Cb — Bolsa Quartzite (Cambrian)
- Yd — Diabase (Middle Proterozoic)
- Ym — Mescal Limestone (Middle Proterozoic)
- Yds — Dripping Spring Quartzite, undivided (Middle Proterozoic)
- Ydsu — Dripping Spring Quartzite, Upper Unit (Middle Proterozoic)
- Ydsl — Dripping Spring Quartzite, Lower Unit (Middle Proterozoic)
- Yp — Pioneer Shale (Middle Proterozoic)
- Ypt — Pioneer Shale, Tuff Unit (Middle Proterozoic)
- YXd — Diorite (Early or Middle Proterozoic)
- Xp — Pinal Schist, undivided (Early Proterozoic)
- Xpc — Pinal Schist, Calc-silicate Facies (Early Proterozoic)
- Xpcs — Pinal Schist, Calc-silicate and Schist Facies (Early Proterozoic)
- Xpm — Pinal Schist, Psammite Facies (Early Proterozoic)
- Xpp — Pinal Sctist, Phyllite Facies (Early Proterozoic)
- Xpq — Pinal Schist, Quartzite Layers (Early Proterozoic)
- Xps — Pinal Schist, Pelitic Schist (Early Proterozoic)
- Mapping Traverse
- Mapping Waypoint
- Near West TSF Footprint
- Happy Camp TSF Footprint
- Seepage Collection Dam Footprint
- Cleaner Starter Dam Footprint
- North Cleaner Cell
- Mapped Fault (Spencer and Richard, 1995)
- Drill Hole

INSET (see Figure 2.9)

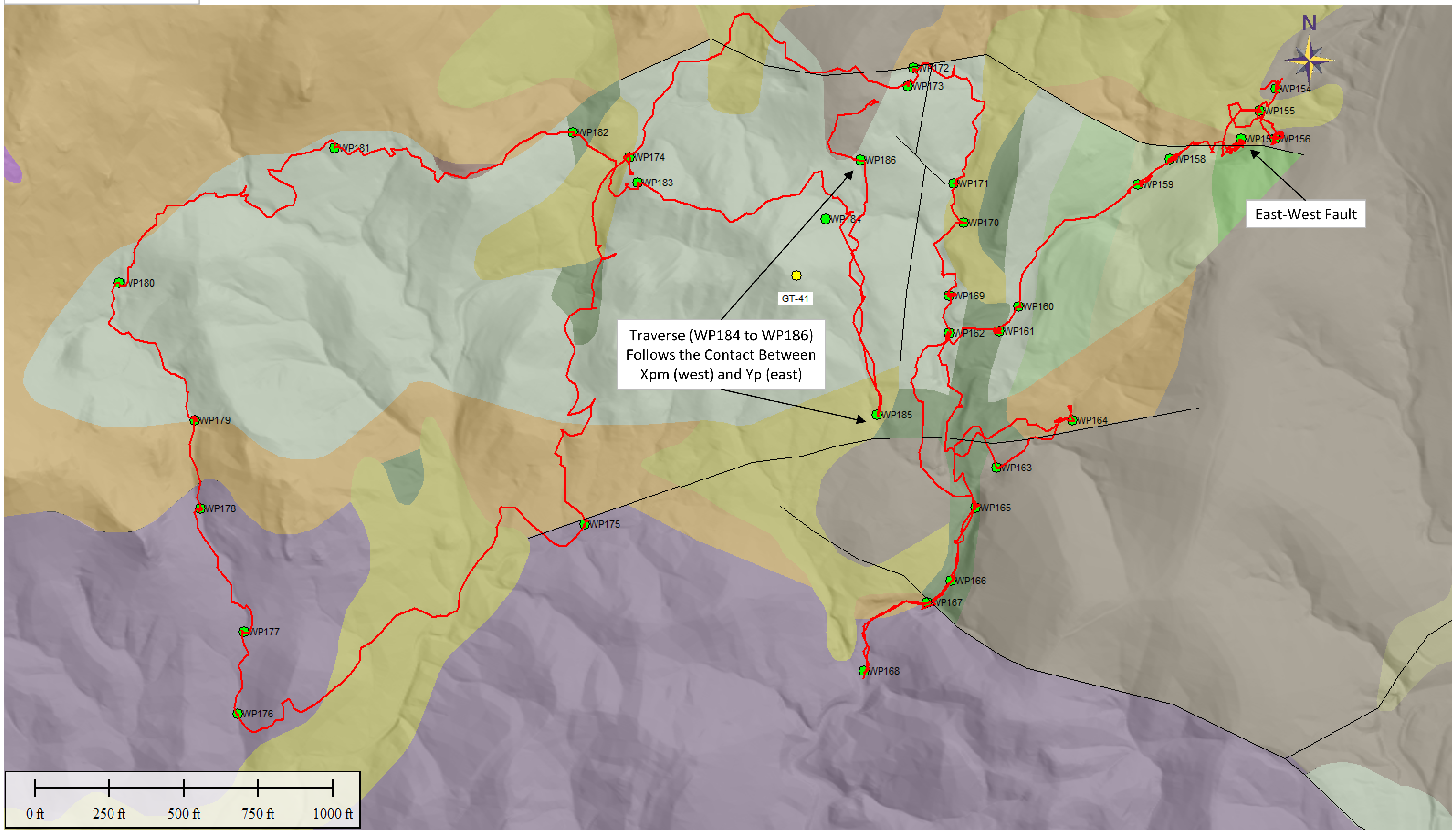

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FIG No. 2.10

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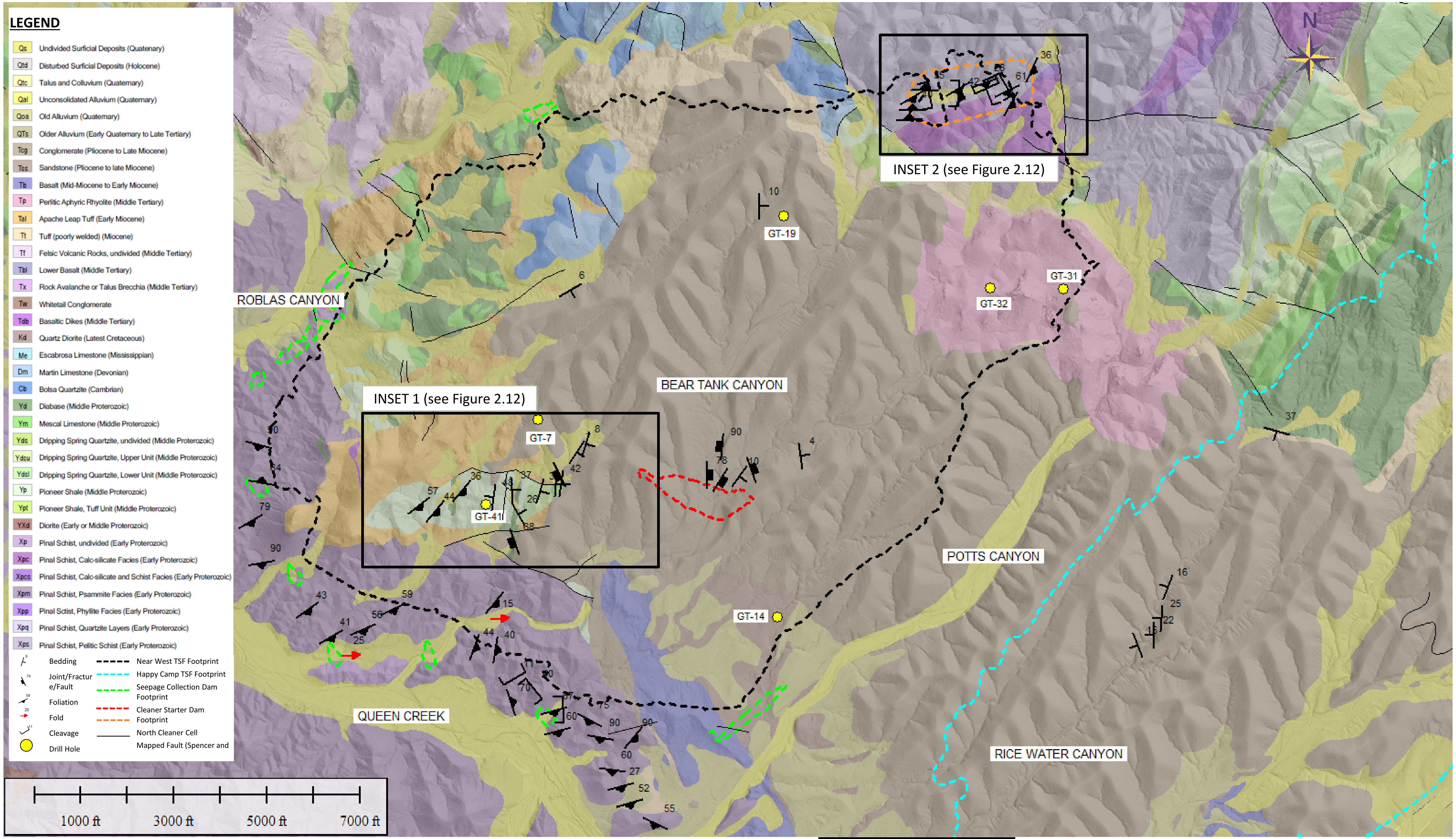

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FIELD MAPPING STRUCTURAL MEASUREMENTS

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FIG No. 2.11

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LEGEND

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- Ypt — Pioneer Shale, Tuff Unit (Middle Proterozoic)
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- Xpcs — Pinal Schist, Calc-silicate and Schist Facies (Early Proterozoic)
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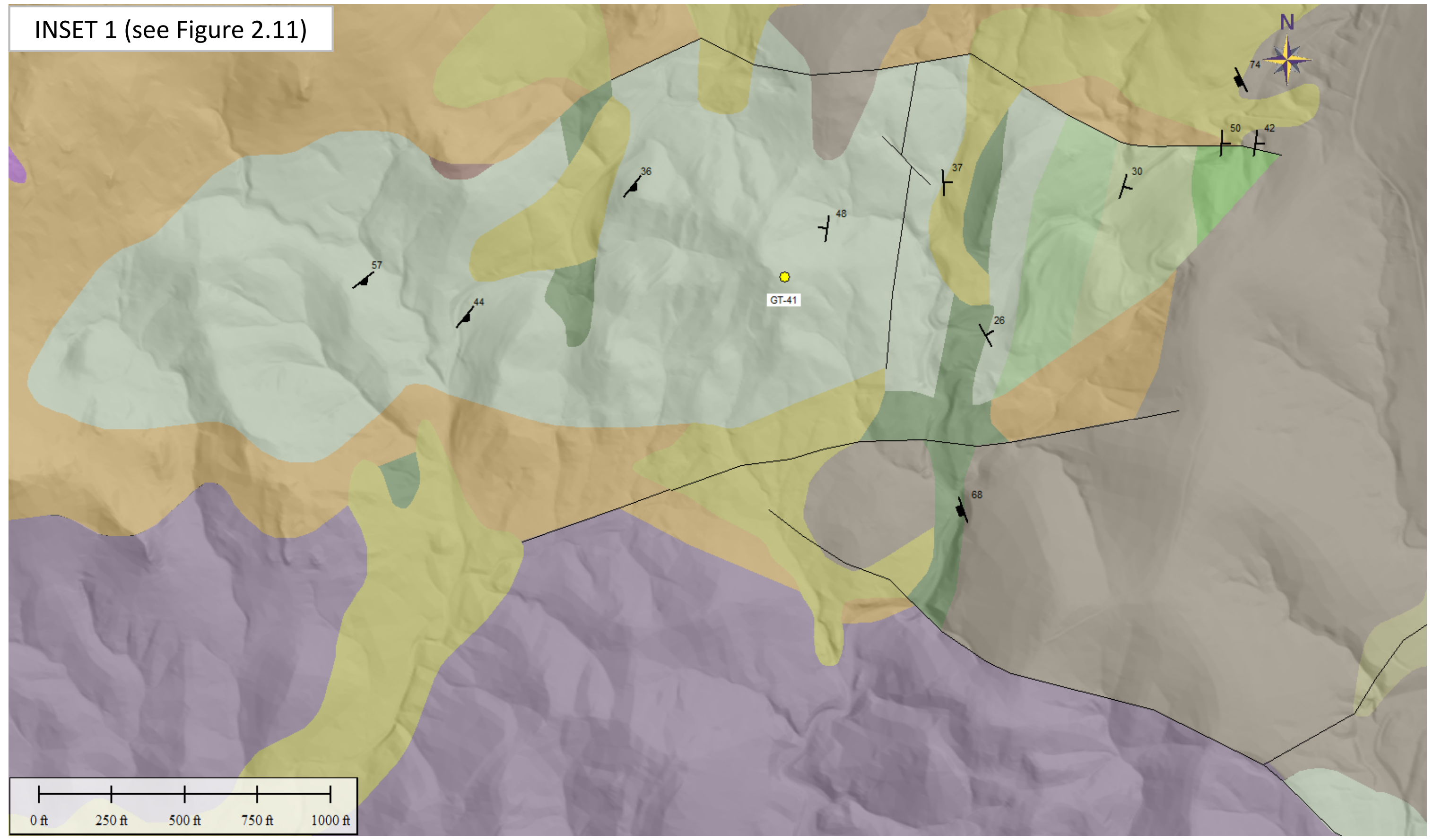
- Xpq — Pinal Schist, Quartzite Layers (Early Proterozoic)
- Xps — Pinal Schist, Pelitic Schist (Early Proterozoic)

- Bedding
- Joint/Fracture/Fault
- Foliation
- Fold
- Cleavage
- Drill Hole

- Near West TSF Footprint
- Happy Camp TSF Footprint
- Seepage Collection Dam Footprint
- Cleaner Starter Dam Footprint
- North Cleaner Cell
- Mapped Fault (Spencer and

INSET 1 (see Figure 2.11)



INSET 2 (see Figure 2.11)

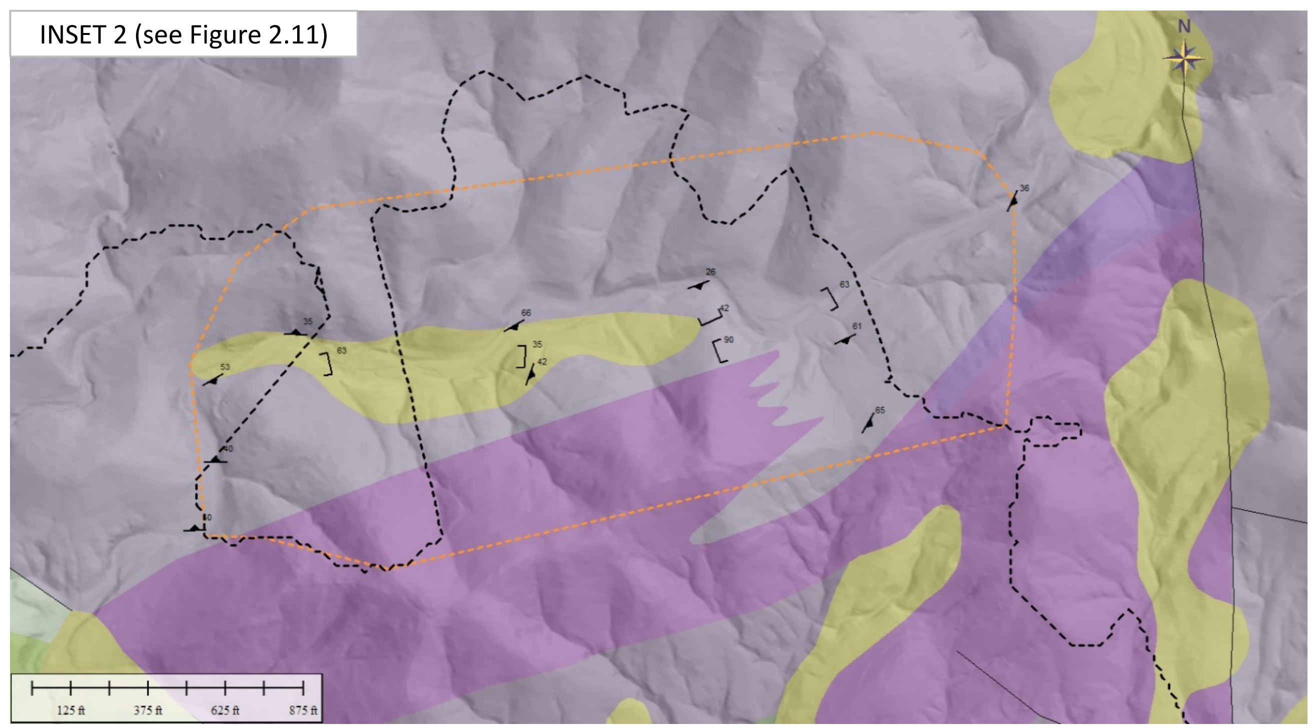


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FIG No. 2.12

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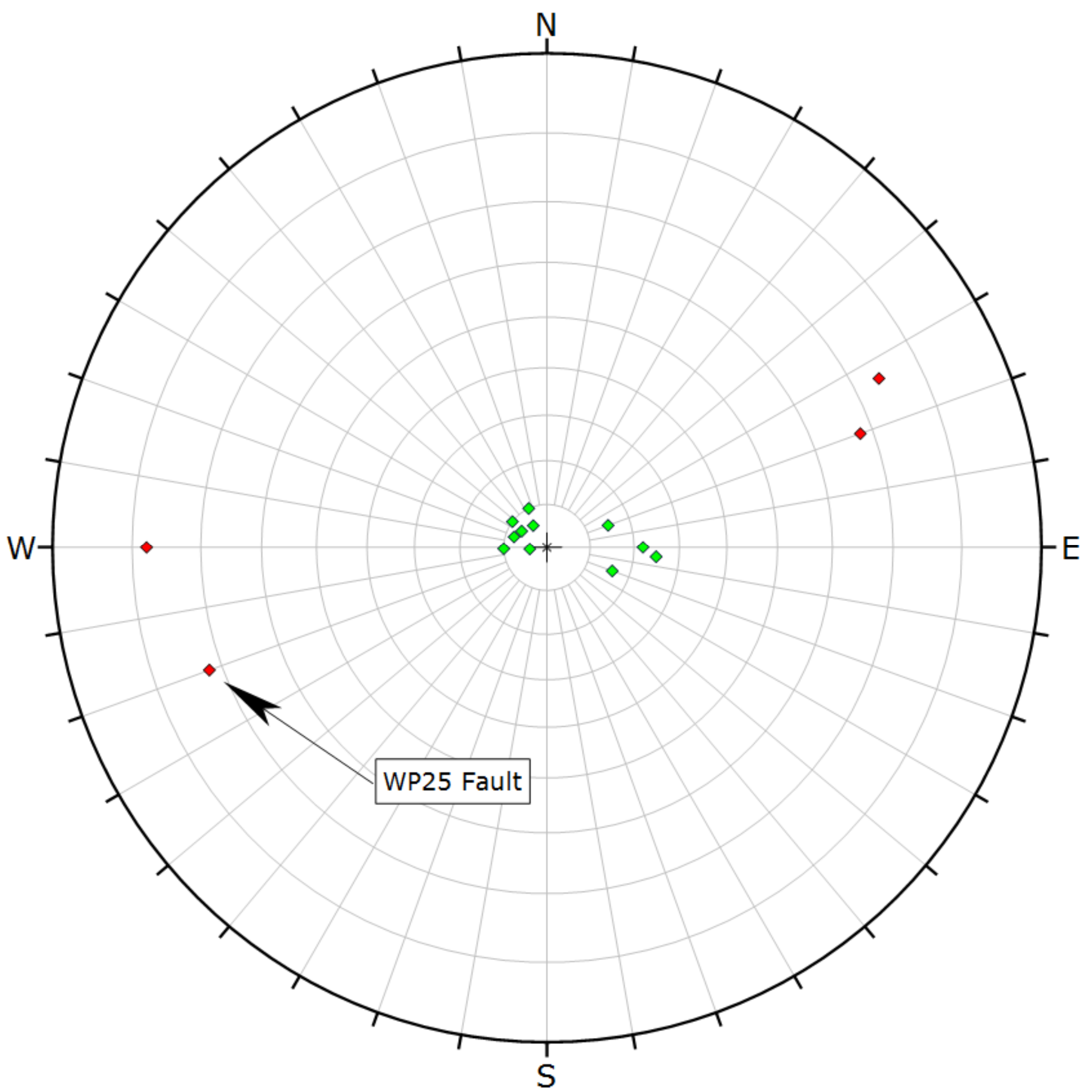

Symbol	FEATURE	Quantity
◆	Bedding	11
◆	Joint/Fault	4

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FIG No. 2.13

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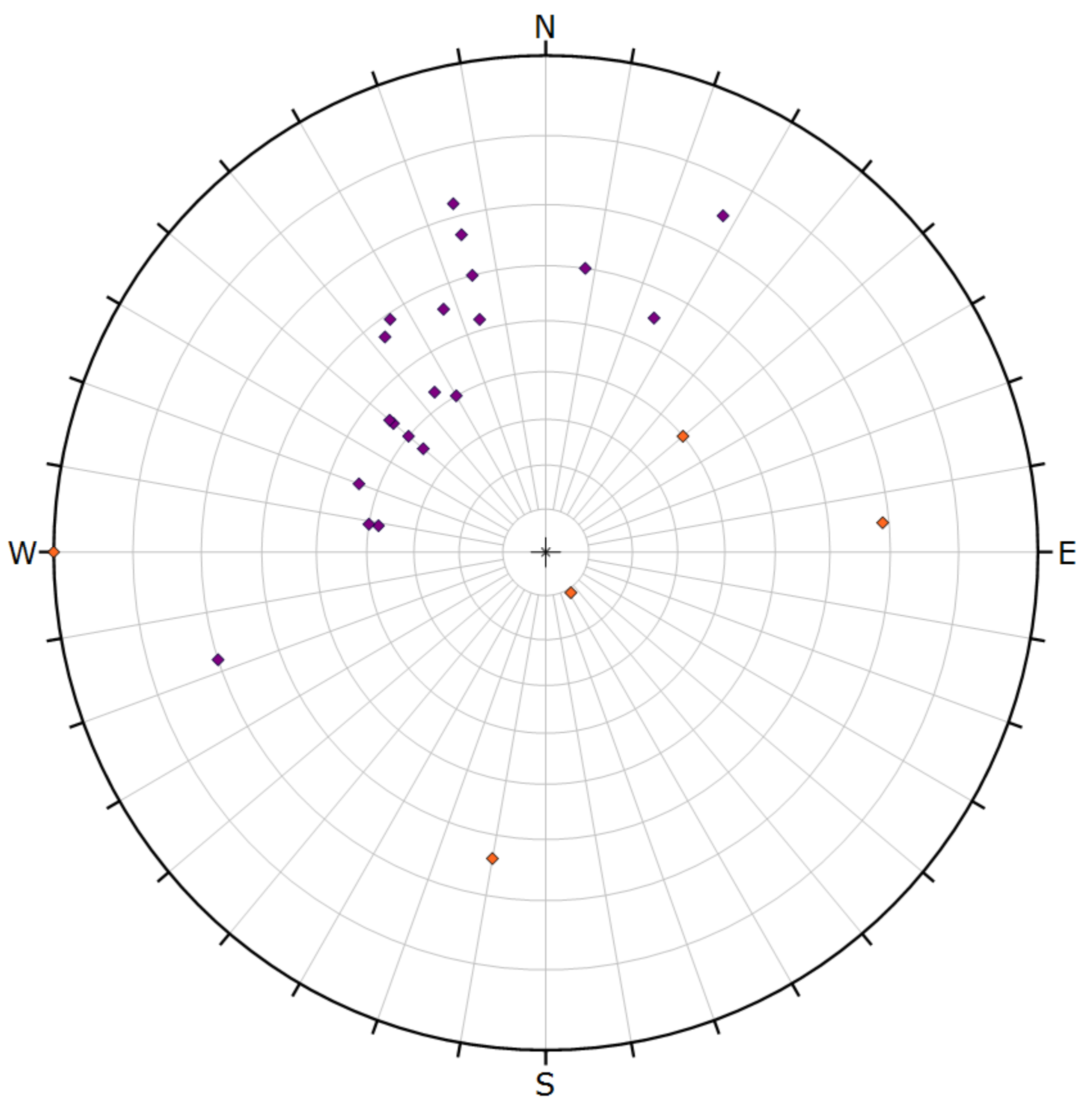

Symbol	FEATURE	Quantity
◆	Foliation	20
◆	Joint/Cleavage Surface	5

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POLES TO FOLIATIONS AND STRUCTURAL FEATURES IN Xpm

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FIG No. 2.14

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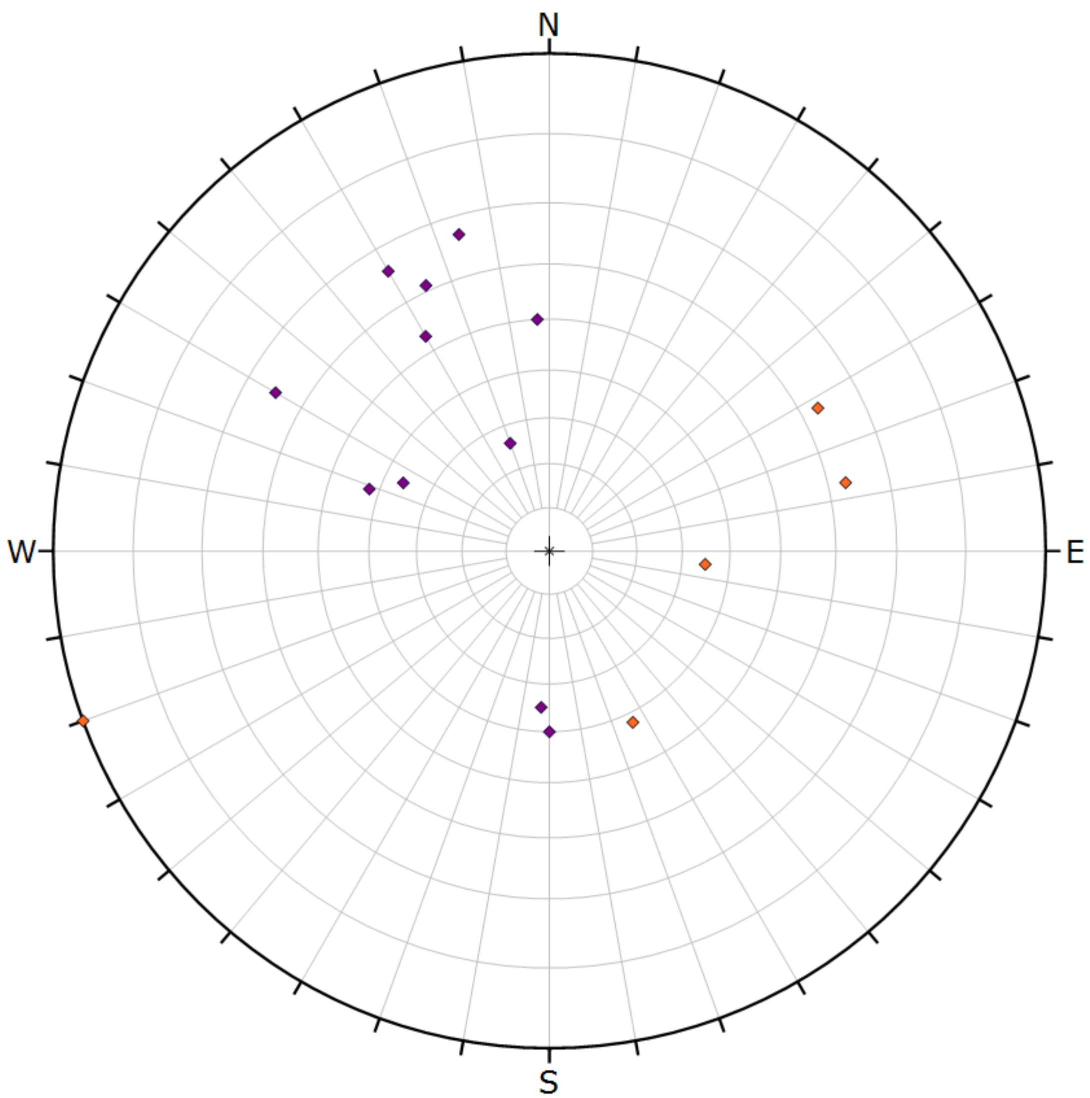

Symbol	FEATURE	Quantity
◆	Foliation	11
◆	Joint/Cleavage Surface	5

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TITLE
POLES TO FOLIATIONS AND STRUCTURAL FEATURES IN Xps

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FIG No. 2.15

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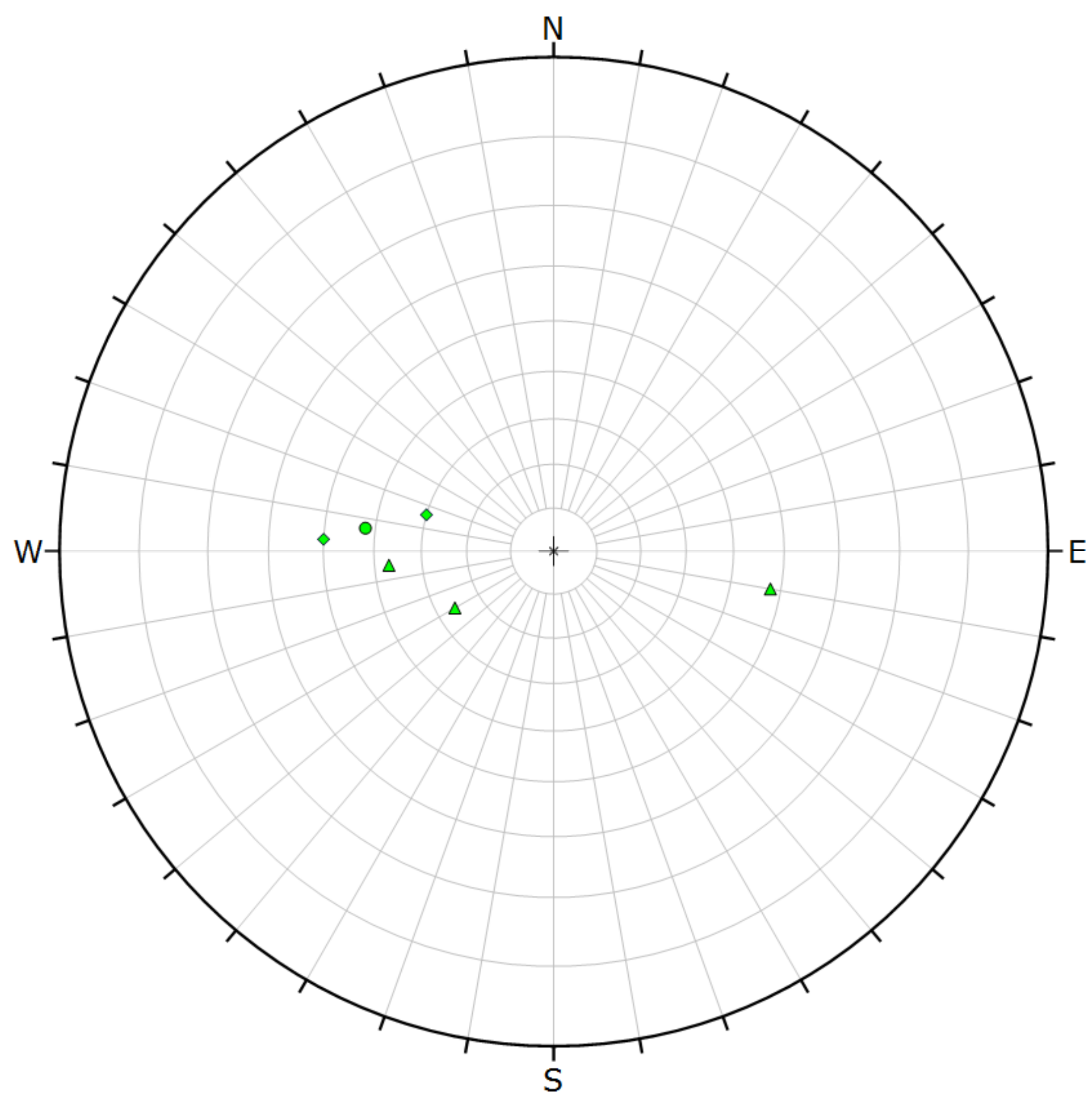

Symbol	FEATURE	Quantity
◆	Ydsu - Bedding	2
●	Ym - Bedding	1
▼	Yp - Bedding	3

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TITLE: POLES TO BEDDING IN APACHE GROUP

PROJECT No. M09441A18

FIG No. 2.16

Date & Time: 2017-03-10 13:57
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APPENDIX I

Waypoint Descriptions

Appendix I
Waypoint Descriptions

Table I-1 2016 Waypoint Descriptions

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
December 1, 2016	WP1-2016	917871	842577	Tal	n/a	Tal outcrop in small drainage adjacent to (approximately 100 ft from) drill hole GT-7. Elevation of outcrop approximately the same elevation as circulation loss.
	WP2-2016	917806	842882	Tal	n/a	Tal outcrop near the base of drainage.
	WP3-2016	917708	842773	Tal	Photo II-1 and Photo II-2	Flat area with completely disintegrated Tal exposed at surface. Tal broken down into sand sized particles.
	WP4-2016	923322	838490	Tss	n/a	Small drainage adjacent to drill hole GT-14. Horizontally bedded Tss exposed in drainage banks and bottom. Water ponding on Tss surfaces.
	WP5-2016	929653	845284	Tp/Tcg	Photo II-3 and Photo II-4	Tp/Tcg contact. 2 parallel, closed joints visible in the Tcg, terminating the at the contact with the Tp.

Notes: 1. Coordinates measured with a handheld GPS and given in Arizona State Plane Central; NAD83 Datum.

Table I-2 2017 Waypoint Descriptions

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
January 16, 2017	WP1	915191	844820	Ym/Yd	Photo II-5	Contact between Ym and Yd. A narrow, shallow depression is evident along the contact with Yd and Yd gravel and cobbles visible at surface on either side of the contact.
	WP2	917349	845320	Yd/Ym	Photo II-6	Yd exposed below a large outcrop of Ym outcropping in the west bank of a drainage near a mapped fault.
	WP3	917631	845185	Yd/Ym/Cb	Photo II-7	Intersection of mapping traverse with mapped fault separating Yd/Ym on the east side of the drainage with Cb on the other. Small depression along the trace of the mapped fault infilled with weathered Tcg. ***Strike of depression: 335***
	WP4	917834	845364	Cb/Tcg	Photo II-8	Intersect of mapped fault with drainage. At this location the drainage hits the Cb forcing a channel meander. Tcg exposed in the channel bank: SAND, GRAVEL and COBBLES, fine to coarse, well graded, max. particle size = 8”, sub-rounded to sub-angular clasts, pinkish beige, various lithology dominated by schist, clast supported, strong acid reaction, massive, R1.
	WP5	918101	845538	Cb/Tcg	Photo II-9	Exposure (12 ft high) of completely weathered Cb along the trace of mapped fault. Rock has completely disintegrated into well graded, angular sand sized particles.
	WP6	918807	845389	Tcg	Photo II-10	Vertical Tcg exposure on hillslope adjacent to drainage. Minor vertical joints terminate at bed interfaces. Three clearly defined beds: Top Bed (2 ft thick): SAND (SW), trace gravel, well graded, sub-angular to angular clasts, pinkish beige, various clast lithology, matrix (sand) supported, no to moderate acid reaction, massive, R2/R1. Most weathering resistant. Middle Bed (3 ft thick): SAND, GRAVEL and COBBLES (SW-GW), some silt, well graded, max. particle size = 10”, sub-angular to angular clasts, beige, various clast lithology but quartz and schist dominates, variably clast or matrix supported, strong acid reaction, massive, R1. Least weathering resistant. Lower Bed (3 ft thick): Gradation as Middle Bed, dominantly matrix supported, moderate to strong acid reaction, R2/R1. Average weathering resistance. ***Orientation of Top Bed: 058/06.***
	WP7	919316	845622	Tcg	Photo II-11	Thick (8 ft) deposit of Qoa or completely weathered Tcg (soil-like). Gravelly SAND (SW), some cobbles/boulders, trace silt, well graded, max. particle size = 10”, sub-angular to sub-rounded clasts, beige, moderate to strong acid reaction, massive with some sub-horizontal “wispy” laminae of calcareous silt.
	WP8	919829	845723	Tcg/Qoa	Photo II-12	Exposure of completely weathered Tcg or Qoa. SAND and GRAVEL (SW), some cobbles/boulders, trace silt, well graded, max. particle size = 12”, sub-rounded to angular clasts, brown, various clast lithology, no to weak acid reaction.

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
						"Ledge" of more competent Tcg at base of the weathered unit described above (R1). Same gradation.
	WP9	920637	846193	Tcg	Photo II-13	Tcg outcrop on the west side of drainage. SAND, GRAVEL and COBBLES (SW), some silt, well graded, maximum particle size = 10", sub-angular to angular clasts, beige, various clast lithology but dominated by schist, strong acid reaction, root penetration, R0.
	WP10	921002	846657	Tcg	Photo II-14	Tcg exposure on west channel bank. Sandy GRAVEL (GW), some silt, some cobbles, well graded, sub-rounded to angular, beige, various clast lithology but dominated by schist, dominantly matrix supported, strong acid reaction, R0.
	WP11	921240	846838	Tcg	n/a	Small sub-horizontal Tcg bed exposed in bottom of drainage. ***Orientation of bed: 065/10***
	WP12	921567	847116	Tcg	Photo II-15	Tcg exposure in west channel bank and in channel bottom. SAND and GRAVEL (SW), some silt, some cobbles, well graded, max. particle size = 6", sub-angular to angular, beige, various clast lithology dominated by schist and tuff, weak acid reaction. R2/R1.
	WP13	920045	844141	Tcg	Photo II-16	Small outcrop of Tcg at upstream end of drainage. Silty, Gravelly SAND (SW), some silt, some cobbles, well graded, max. particle size = 12", sun-angular to angular, brown, various lithology dominated by schist and tuff, strong acid reaction, R0.
	WP14	919841	843759	Tcg	Photo II-17	Tcg characteristics as described at WP13, R1/R0 exposed in drainage bottom.
	WP15	919670	843166	Tcg	Photo II-18	Small Tcg overhang outcrop exposed in the east bank. SAND (SW), some silt, some gravel, well graded, max. particle size = 1", sub-rounded to angular, beige, strong acid reaction, sub-horizontally bedded, one sub-vertical joints terminating at bed interface with penetrating roots.
	WP16	919431	842517	Tcg	Photo II-19	Small Tcg outcrop near base of drainage exposed along outside of channel meander. Gravelly SAND (SW), trace silt, some cobbles (outcrop higher in banks is "cobbly"), well graded, max. particle size extremely variable on scale of outcrop up to boulders, sub-rounded to angular, brown, various clast lithology, variably matrix to clast supported, moderate to strong acid reaction, R0. Tcg exposed at the bottom on the channel: R1.
	WP17	919136	842098	Tcg	Photo II-20	3 ft high Tcg outcrop: Top Bed (1.5 ft thick): SAND (SW), trace silt, trace gravel, well graded, angular to sub-angular, pinkish beige, various clast lithology, weak acid reaction, bedded, open cracks parallel to more competent beds appear to close off close to the surface of the outcrop, R2. Bottom Bed (1.5 ft thick): SAND and GRAVEL (SW), trace silt, some cobbles, well graded, max. particle size = 4", sub-angular to angular, brown, various clast lithology, strong acid reaction, R0/R1. ***Orientation of bedding in Top Bed: 018/08***
	WP18	918979	841905	Tcg	Photo II-21	Sub-horizontally bedded sandy Tcg in channel banks and bottom. ***Orientation of beds: 033/07***
	WP19	918928	841676	Tcg	Photo II-22 and Photo II-23	Large Tcg outcrop exposed high up on drainage bank. Outcrop-scale general description: Gravelly SAND (SW), some cobbles, trace silt, trace boulders, well graded, max. particle size = 11", sub-rounded to angular clasts, brown, various clast lithology, dominantly matrix (sand) supported, no to weak acid reaction, persistent sub-horizontal openings between parallel beds appear to close off a shallow depth below outcrop surfaces, sub-vertical joints terminate at bedding interfaces, R2 (typical). Outcrops in channel bottom and typical of other channel bottom exposures upstream: SAND and GRAVEL (SW), some cobbles, well graded, max. particle size = 10", sub-rounded to angular, beige to brown, various clast lithology, no to weak acid reaction, R2 (top of exposure/dry) to R1/R0 (bottom of exposure/wet).
January 17, 2017	WP20	924735	842453	Tcg	Photo II-24	6 ft high exposure of Qoa or completely weathered Tcg. SAND and GRAVEL (SW), some cobbles, traces silt, well graded, max. particle size = 12", sub-angular to angular, brown, various clast lithology dominated by tuff and schist, weak acid reaction, R0 (soil-like).
	WP21	924043	842408	Tcg	Photo II-25	Tcg exposed in the west bank. Inch to foot-scale bedding. Sandy beds: SAND (SW), some gravel, trace fines, well graded. Coarse beds: SAND and GRAVEL (SW), some cobbles, trace fines, well graded, max. particle size = 8", sub-rounded to angular clasts. All beds: various clast lithology dominated by granodiorite, schist and tuff, variably clast or matric supported, moderate to strong acid reaction, voids and burrows in the surface of the outcrop don't appear to penetrate deep, R0/R1.
	WP22	924054	842068	Tcg	Photo II-26	Tcg outcrop covering full width of drainage floor. Massive, strong acid reaction, R2. Water ponding on the Tcg surfaces downstream and upstream of this location.

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP23	923742	841853	Tcg	Photo II-27	Large Tcg outcrop forcing 90º change in drainage direction. Sub-horizontal beds on inch to foot-scale, variably clast or matrix supported, various clast lithology, acid reaction highly variable (strong to weak), some variability in bed weathering not linked to gradation with the exception of one eroded sandy bed, no vertical joints persisting across bedding interfaces. ***Orientation of beds: 345/04***
	WP24	923640	842089	Tcg	Photo II-28	12 ft high Tcg outcrop at bend in drainage. Characteristics similar to WP23.
	WP25	922697	841565	Tcg	Photo II-29	~30 ft high Tcg exposure in drainage bank. Sub-horizontally bedded with beds on inch to foot-scale, variably clast to matric supported, various lithology, weak to moderate acid reaction, R0/R1. Sub-vertical persistent normal fault cutting through outcrop. Inferred displacement of headwall approximately 6 ft based on relative location of a similar bed on either side of the fault, well infilled with silty sand. ***Orientation of fault: 340/72***
	WP26	922260	841438	Tcg	n/a	***Orientation of Tcg bed in small outcrop on bank of drainage: 037/10***
	WP27	922150	841162	Tcg	Photo II-30	Exposure of Tcg on outside of channel meander. Thick “bed” of more erosive sand and silt with trace gravel at top of exposure, strong to moderate acid reaction, some wispy calcareous silt laminations throughout, soft (R0).
	WP28	922024	841332	Tcg	Photo II-31	Sub-vertical joints persisting across multiple beds in Tcg outcrop and into the drainage floor, silty sand infill, ½” aperture. ***Strike of joint: 032***
	WP29	921943	841502	Tcg	Photo II-32	Sub-vertical joint persisting across multiple beds in Tcg outcrop. Similarly, thick and graded beds observed to continue over the joint (possible indication of limited displacement).
	WP30	921747	841434	Tcg	Photo II-33	Sub-vertical joint (fault?) in large Tcg outcrop. Some beds appear to terminate at the feature, infilled with well graded sand, some silt, strong acid reaction. Roots penetrating the feature. ***Orientation of joint/fault: 000/78***
	WP31	922064	842051	Tcg	Photo II-34	Sub-vertical joint in large Tcg outcrop. Sub-parallel to the face of the outcrop (flexure/toppling?). Good continuity of beds on either side of joint.
	WP32	921861	842725	Tcg	Photo II-35	Sub-vertical Tcg outcrop. Generally massive although with some sub-horizontal beds visible at top of outcrop at inch-scale. Majority of material exposed: SAND and GRAVEL/COBBLES (SW), trace silt, trace boulders, well graded, max. particle size = 12”, sub-rounded to angular, various lithology (schist, granodiorite and tuff dominate), variably clast to matrix supported, R1.
	WP33	922230	844654	Tcg	Photo II-36	8 ft high Tcg outcrop on outside of channel meander. SAND and GRAVEL (SW), some silt, some cobbles, well graded, max. particle size = 6”, sub-rounded to angular, variably clast to matric supported, various lithology (dominantly schist), moderate acid reaction, R1/R0.
	WP34	922003	845841	Tcg	Photo II-37	6 ft high Tcg outcrop in bank of drainage. SAND and GRAVEL/COBBLES (SW), trace silt, well graded, max. particle size = 10”, sub-rounded to angular, brown, various lithology (schist, tuff and granodiorite dominate), strong acid reaction, R0 (pulls apart with hammer, soil-like).
	WP35	922569	846712	Tcg	Photo II-38	6 ft high exposure of Tcg in bank of drainage. Similar characteristics to WP34.
	WP36	922871	847175	Tcg	Photo II-39	Tcg exposure in west bank of drainage. SAND and GRAVEL (SW), some cobbles, trace silt, well graded, max. particle size = 8”, sub-rounded to angular, various lithology (no dominant rock type), class supported, strong acid reaction, R0 (soil-like). One sub-horizontal void observed between two sandy beds, 2” opening extends at least 16” into outcrop. ***Orientation of beds/void: 358/10. Approximate elevation (GPS) = 2,585 ft.***
	WP37	923729	846744	Tcg	Photo II-40	Tcg exposed in shallow drainage downslope of drill hole GT-19. Same general characteristics as described at WP36 although voids not observed. Tcg exposed in portions of wash bottom at this location. General notes on traverse downslope east of GT-19: generally massive Tcg exposed in narrow drainage sides, with gradation as described at WP36. Some sub-horizontal beds start appearing at the downstream end of the wash with some voids visible between beds (approximate El. when sub-horizontal beds start appearing – 2,525 ft.
	WP38	925164	847415	Tcg	Photo II-41 and Photo II-42	Poorly welded tuff (Tt) in channel bank Rock appears to be a mixture of mineral grains and clasts, beige to reddish brown, no acid reaction. Adjacent to Rebel Tank windmill.
	WP39	925181	847587	Tcg	Photo II-43	Tt near contact with Tcg.

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP40	923829	845511	Qoa	Photo II-44	8 ft outcrop of Qoa in bank of drainage. SAND and GRAVEL/COBBLES (SW), trace silt, some boulders, well graded, max. particle size = 18”, angular to sub-rounded, light brown, various lithology dominated by schist, no to weak acid reaction.
	WP41	923565	844851	Tcg	Photo II-45	15 ft high Tcg outcrop at channel meander. General description: SAND and GRAVEL/COBBLES (SW), trace silt, some boulders, well graded, angular to sub-rounded, beige, various lithology (dominated by schist), variably clast to matrix supported (dominantly clast), no to moderate acid reaction, massive. Sub-vertical (~60°) joint cutting through outcrop: 1.5” aperture, well infilled with calcareous sandy silt.
January 18, 2017	WP42	925386	842569	Tcg	Photo II-46	Tcg outcrop on the east back of the drainage. GRAVEL and SAND (GW), some cobbles, well graded, max. particle size = 10”, sub-angular to angular, reddish brown, clast supported, various lithology (Yds dominant), weak to strong acid reaction, sub-horizontal bedding structure apparent in outcrop with shallow voids present along bedding interfaces, R1.
	WP43	925477	842696	Tcg	Photo II-47	Tcg outcrops span entire drainage with rock exposed in the channel bottom, water ponding on Tcg surfaces.
	WP44	925648	842960	Tcg	Photo II-48	Intersection of main drainage with inferred (by KCB) lineament. Tcg exposed in drainage bottom forming sub-horizontal ledges, water ponding on Tcg surfaces.
	WP45	925953	843584	Tcg	Photo II-49	Traversing along same drainage path along trend of inferred (KCB) lineament. Narrow valley with Tcg outcrops occasionally on both channel banks. Tcg description: Gravelly SAND (SW), some cobbles, trace silt, well graded, max. particle size = 10”, sub-angular to angular, brown, dominantly clast supported, various lithology (schist, tuff and sandstone dominate), no acid reaction, R1.
	WP46	926063	843391	Tcg	Photo II-50	12 ft Tcg exposure on east channel bank. Gravelly SAND (SW), some cobbles, some silt, well graded, max. particle size = 12”, sub-rounded to angular, variably matrix to clast supported, various lithology, no acid reaction, R0/R1.
	WP47	926258	844438	Tcg	Photo II-51	Tcg exposure in drainage bank and bottom, along inferred lineament (KCB) adjacent to Tp contact. Tcg surface gradually dipping towards the west with Qal/Qoa exposed in west drainage bank. Description of Tcg in drainage bottom: Sandy GRAVEL and COBBLES (GW), well graded, max. particle size = 8”, angular to sub-angular, clast supported, various lithology (sandstone, schist, granodiorite), moderate to strong acid reaction.
	WP48	928714	844372	Tp	Photo II-52	4 ft exposure of Tp in road cut on west side of Potts Canyon ridge. Flow banded at cm-scale, bands have variable orientation, grey, glassy texture, R1.
	WP49	928534	843724	Tcg	Photo II-53	Scoured exposure of Tcg at the base of drainage. SAND and GRAVEL (SW), well graded, max. particle size = 9”, angular to sub-angular, clast supported, various lithology, (dominantly Yds, diabase), moderate acid reaction, R1.
	WP50	928724	843519	Tcg	Photo II-54	4 ft exposure of Tcg in north bank of drainage. SAND, GRAVEL and COBBLES (GW), well graded, sub-angular to angular, max. particle size = 8”, generally clast supported, various lithology (diabase and Yds dominate), moderate acid reaction. Observed to extend into channel bottom.
	WP51	929020	843208	Tcg	Photo II-55	Completely weathered Tcg or alluvium. SAND and GRAVEL (SW), trace silt, well graded, reddish brown, max. particle size = 6”, sub-angular to angular, various lithology (diabase and Yds dominate), no acid reaction, some faint cm-scale “layering” visible based on orientation of small joints and subtle changes in gradation, R0 (soil-like).
	WP52	929110	843172	Tcg	Photo II-56	Tcg observed in base of drainage. Rock characteristics as WP51.
	WP53	929262	842967	Tcg	Photo II-57	Deeply incised Tcg in area of concentrated water flow. Sandy (to “some” sand) GRAVEL and COBBLES, well graded, max. particle size = 8”, sub-angular to angular, brown, clast supported, various lithology (diabase, tuff, quartzite dominate), moderate to strong acid reaction, R1/R2. Water ponding on Tcg surfaces. Rock extends to bottom and across drainage.
	WP54	929286	842770	Tcg	Photo II-58	Foot-scale sub-horizontal beds overtop of massive Tcg (as WP53).
	WP55	929307	842409	Tcg	Photo II-59	30 ft high Tcg exposure on the west bank of Potts Canyon. Gradation of rock exposed generally consistent with what was observed traversing the northernmost Potts Canyon ridge small drainage (WP49 to WP54). Indication of sub-horizontal bedding.
	WP56	928649	842227	Tcg	Photo II-60	Exposure of Tcg in north bank of small drainage. SAND and GRAVEL (SW), some cobbles, trace silt, well graded, max. particle size = 10”, sub-angular to angular, brown, various lithology (diabase, tuff and quartzite dominate), moderate acid reaction, faint evidence of sub-horizontal bedding, R0. Same material exposed in the drainage bottom.
	WP57	928255	842532	Tcg	Photo II-61	10 ft Tcg outcrop in north drainage bank. SAND and GRAVEL (SW), some cobbles, well graded, max. particle size = 5”, angular to sub-angular, brown, clast supported, clast supported, various lithology (tuff, quartzite, diabase dominate), strong acid reaction, massive but with some indications of sub-horizontal bedding (i.e. parallel sub-horizontal hairline fractures), R1.
	WP58	928003	842809	Tcg	Photo II-62	20 ft Tcg exposure in north bank of drainage. Sandy GRAVEL and COBBLES (GW), well graded, max. particle size = 10”, sub-angular to angular, brown, clast supported, various lithology (tuff, quartzite, diabase), strong acid reaction, R1.
	WP59	927692	843012	Tcg	Photo II-63	Tcg outcrop. SAND and GRAVEL (SW), some cobbles, trace silt, well graded, max. particle size = 4”, sub-angular to angular, beige, variably clast or matrix (sand) supported, various lithology (tuff, diabase, quartzite), moderate acid reaction, R1/R2.

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP60	927635	842194	Tcg	Photo II-64	3 ft Tcg exposure at upstream end of small drainage emptying into Potts Canyon. SAND and GRAVEL (SW), some cobbles, well graded, max. particle size = 6”, sub-rounded to angular, brown, matrix supported, various lithology (schist, tuff, Yds, diabase), no acid reaction, R0 (soil-like).
	WP61	927733	842111	Tcg	Photo II-65	Sub-horizontal beds in Tcg outcrop on north drainage bank. Tcg characteristics general as WP60. Some shallow sub-horizontal voids parallel to bedding.
	WP62	927828	841942	Tcg	Photo II-66	Noted gradation change in Tcg outcropping in bottom of drainage. Sandy GRAVEL and COBBLES (GW), well graded, max. particle size = 8”, sub-angular to angular, brown, various lithology (tuff, Yds and schist dominate), clast supported, moderate to strong acid reaction, R1/R2.
	WP63	928013	841543	Tcg	Photo II-67	Tcg exposure in bottom of drainage. Tcg characteristics same as WP62 except higher sand content (SAND and GRAVEL). Extends across channel bottom with water pooling on exposed surfaces.
	WP64	928033	841319	Tcg	Photo II-68	Broad outcropping of Tcg in bottom of drainage. “Sandy” Tcg bed noted as most erosion resistant.
	WP65	927344	840226	Tcg	Photo II-69	Tcg outcrop in north bank of drainage. Top 3 ft of exposure: Gravelly SAND (SW), trace silt, well graded, max. particle size = 2”, sub-angular to angular, brown, matrix supported, various lithology, strong acid reaction, sub-horizontal inch-scale beds with parallel fractures along bedding interfaces, R1. Bottom 4 ft: As above except: GRAVEL and SAND (GW), some cobles, max. particle size = 4”, massive.
	WP66	927200	840328	Tcg	Photo II-70 and Photo II-71	Tcg starts being exposed throughout bottom of drainage and extends into both banks. Gradation of outcrops as WP65 bottom 4 ft.
	WP67	927075	840455	Tcg	n/a	Tcg no longer observed outcropping from the drainage bottom.
January 19, 2017	WP68	926088	849007	Xps	Photo II-72	Outcrop in drainage bottom near the Xps/Xpc contact. Schist, light grey, fresh, R5, some quartz veins, some sub-vertical joints variably spaced.
	WP69	926159	849228	Xps	Photo II-73 and Photo II-74	Xps outcrop in bank of drainage. Schist, greenish grey, fresh, R3, disturbed rock mass, strongly foliated, foliation orientation highly variable with folding of foliations observed throughout outcrop, abundant quartz veins typically running with foliations, some other quartz inclusions observed do not follow foliations, rock breaks preferentially along foliations. ***Dominant foliation orientations: 270/40; 074/67; 087/50.***
	WP70	926159	849512	Xps	Photo II-75	***Dominant foliation orientation in schist outcrop: 060/53***
	WP71	926427	849646	Xps	Photo II-76 and Photo II-77	Schist, light grey (orange-grey along narrow wash cutting through the outcrop), fresh to slightly weathered, R3/R4, disturbed rock mass, foliated, breaks preferentially along foliations, evidence of intense folding, quartz veins common following foliations. ***Orientation of dominant foliation: 273/35.***
	WP72	926523	849545	Xps	Photo II-78	Schist outcrop displaying distinct joint set cutting across dominant foliation orientation. Very closely to closely jointed, closed to open, smooth, planar, calcareous silt and sand infill, fresh, R3. ***Joint set orientation: 167/63***
	WP73	927108	849655	Xps	Photo II-79 and Photo II-80	Schist, light grey, fresh, R3, very blocky to disturbed, foliated with folding throughout, some joints parallel to foliations (typically closed, some open, fresh, smooth undulating to planar surfaces, extremely variable spacing, several joint sets), quartz common along foliations. ***Orientation of one dominant foliation: 060/66*** ***Orientation of one dominant foliation: 019/42*** ***Orientation of one joint set: 185/35***
	WP74	927709	849800	Xps	Photo II-81 to Photo II-84	Schist exposures in bottom of drainage. Appear to have a general consistency in foliation orientation with small scale variations such as pronounced folding and crenulations. 2 ft wide intrusion of purplish grey fine grained mafic rock (R4/R5) through schist near bottom of drainage. General rock mass description: Schist, blueish grey, fresh, R3/R4, foliated, very blocky. Several joint sets identified but two perpendicular sets (sub-vertical and sub-horizontal) most pervasive: moderate to close joint spacing, aperture closed to partly open (one identified with ½” aperture was infilled with quartz), fresh, smooth, undulating surfaces. ***Orientation of dominant foliation: 070/26*** ***Strike of joint set (sub-vertical): 340*** ***Orientation of joint set (sub-horizontal): 244/42***

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
						Strike of mafic intrusive: 237
	WP75	927952	849649	Xps	Photo II-85	Brownish grey fine grained mafic rock (disturbed and heavily fractured) exposed in bottom of drainage.
	WP76	928141	849759	Xps	Photo II-86	Schist exposed in drainage. ***Dominant foliation orientation: 065/61*** ***Dominant joint set: 152/63***
	WP77	928720	850068	Xps	Photo II-87	Schist exposed in drainage bank. Blueish grey, fresh, R3, disturbed, foliated, quartz veins and inclusions of varying thickness aligned with foliations, clear trend in foliation orientation across outcrop. ***Orientation of dominant foliation: 025/36***
	WP78	928326	850153	Xps	Photo II-88	Quartz cobbles exposed at surface of proposed dam abutment. Indicative of schist. No outcrops.
	WP79	928578	849896	Xps	Photo II-89	Schist outcrop on proposed dam abutment. Orange/brown surface discoloration, grey below, slightly weathered to fresh, R3, foliated with variable orientation, folding of foliations throughout.
	WP80	928255	849352	Xps	n/a	Small outcrops of schist (Xps facies) exposed on slope. Slightly weathered as WP79, R3, consistent foliation orientation. ***Orientation of dominant foliation: 030/65***
	WP81	927527	849346	Xpc	Photo II-90	Small outcrops of schist (Xpc) exposed at surface. Slightly weathered, dark grey to oxidized brown, R4, foliated.
	WP82	926717	848943	Xps/Xpc	Photo II-91	Contact between Xps and Xpc schist facies. Surface exposures at the contact abruptly change from dark grey schist cobbles (Xpc) upslope to mainly quartz cobbles (Xps) downslope.
	WP83	926349	849329	?	Photo II-92	Surface exposures (cobbles) of dark grey, green, orange, hard (R4/R5) schist downslope of the Xps/Xpc contact. Parallel banding of quartz with orange oxidized layers, appears more weathering resistant than surrounding Xps.
	WP84	926183	849434	?	Photo II-93 and Photo II-94	Abandoned test pit with timber cribbing excavated through unidentified schist (as WP83). Schist cobbles stockpiled adjacent to pit are mineralized with light green/blue mineral (malachite and chrysocolla (?)).
	WP85	917422	841183	Yp	Photo II-95	Intersection of mapped faults in Yp. Small drainage formed along east-west fault trace with grey, oxidized cobbles of Yp in bottom of depression.
	WP86	917410	840420	Yp/Tal	n/a	Contact between Yp and Tal
	WP87	917490	840453	Yp	Photo II-96	Intersection of mapped fault in Yp with drainage. 40 ft wide disturbed rock mass exposed in drainage bank. Red, R1/R2 (R0 in heavily oxidized and disturbed areas), calcite veining throughout, in heavily disturbed areas dark black fine grained rock clasts are floating in oxidized silty sand composed of weathered rock.
	WP88	917111	839735	Xpm	Photo II-97	Xpm in channel bottom.
	WP89	916800	839904	Yp	n/a	Surface exposures of Yp sandstone.
	WP90	916645	840069	Xpm	n/a	Xpm exposed.
	WP91	916315	840049	Tal/Xpm	n/a	Tal/Xpm contact
	WP92	915973	839928	Tal/Xpm	n/a	Tal/Xpm contact
	WP93	915548	840063	Tal/Yp	n/a	Tal/Yp contact
	WP94	915274	840241	Xpm	n/a	Traverse enters Xpm
	WP95	915424	840899	Xpm	n/a	Traverse still in Xpm. Tal observed to the north across small drainage.
	WP96	915554	840798	Xpm	n/a	***Orientation of dominant Xpm foliations: 053/57.***
	WP97	915559	840797	Xpm	Photo II-98	Small scale folding observed in small outcrop.
	WP98	915857	840515	Xpm	Photo II-99	Xpm exposed in drainage bottom.
	WP99	915908	840676	Xpm	Photo II-100 to Photo II-102	Large exposure of Xpm in drainage bank – mapped as Yp. ***Foliation cleavage orientation: 040/44***
January 22, 2017	WP100	920800	834060	Xpm	n/a	***Strike of dominant Xpm foliation in ridge: 094***
	WP101	920636	834049	Xpm	Photo II-103	***Xpm foliation cleavage orientation: 115/55***
	WP102	920072	834472	Xpm	Photo II-104	***Xpm foliation cleavage orientation: 074/52***

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP103	919942	834770	Xpm	n/a	***Xpm foliation cleavage orientation: 075/72***
	WP104	919708	835176	Xpm	Photo II-105	Xpm outcrops exposed in ridge. General trend in strike of foliation cleavage but variable dip with small scale folding. ***Xpm foliation cleavage orientation: 98/60***
	WP105	920793	836196	Tb	Photo II-106	Northern end of mapped fault. Tb exposed in both sides of drainage.
	WP106	920247	836088	Tcg/Tb	n/a	Narrow “finger” of Tcg exposed surrounded by Tb.
	WP107	920230	836005	Tcg/Xpm	n/a	Tcg pinches out across mapped fault into Xpm.
	WP108	920168	835876	Xpm	n/a	Xpm outcrops near mapped fold. Strike/drip of foliation highly variable on top of ridge. ***General large-scale strike of Xpm foliation cleavage 220.***
	WP109	919453	835869	Xpm	n/a	Sub-vertical foliation cleavage in small Xpm outcrops. ***Xpm foliation cleavage strike: 100***
	WP110	919221	836248	Xpm	n/a	***Xpm foliation cleavage orientation: 118/75***
	WP111	918525	835999	Xpm	n/a	***Xpm foliation cleavage orientation: 075/60***
	WP112	918460	836442	Xpm	Photo II-107 and Photo II-108	Xpm outcrop in bottom of drainage. ***Foliation cleavage orientation: 075/67*** ***Parallel surfaces (joint surfaces?) cross cutting foliation cleavage: 175/69***
	WP113	918029	836903	Xpm	n/a	***Cleavage face/joint orientation: 140/40***
	WP114	917618	837119	Xpm	Photo II-109	Intensely folded Xpm exposed at top of ridge ***Foliation cleavage orientation: 342/70*** ***Cleavage face/joint orientation: 238/11***
	WP115	917100	837611	Xpm	n/a	Small outcrop of Tb surrounded by Xpm – very limited in extent.
	WP116	916881	838032	Xpm	n/a	Xpm outcrop in Bear Tank Canyon. Some sub-parallel cleavage faces apparent (cutting across dominant foliation orientation), however orientation too variable to get a reliable orientation. ***Foliation cleavage orientation: 009/40*** ***Foliation cleavage orientation (just downstream): 020/44***
	WP117	915985	838179	Xpm	Photo II-110	***Xpm foliation cleavage orientation: 040/45***
	WP118	915498	838398	Xpm	n/a	***Xpm foliation cleavage orientation: 009/38***
	WP119	915000	838586	Xpm	n/a	***Xpm foliation cleavage orientation: 065/59***
	WP120	914345	838155	Xpm	n/a	Small outcrop on top of ridge. ***Xpm foliation cleavage orientation: 067/56***
	WP121	913736	837855	Xpm	Photo II-111 and Photo II-112	Folding visible in Xpm outcrop. ***Fold trend/plunge: 085/25*** ***Foliation cleavage orientation: 060/41*** ***Strike of parallel cleavage faces cutting across foliations: 000***
	WP122	913165	838570	Xpm	n/a	***Xpm foliation cleavage orientation: 055/43***
	WP123	912462	839483	Xpm/Tal	n/a	Xpm/Tal contact.
	WP124	912177	839564	Xpm	Photo II-113 and Photo II-114	Xpm exposed in small drainage. Schist, fresh, two distinct rock properties in outcrop: Bluish grey, R3, heavily foliated, sub-vertical foliations; and light grey, R4, foliation cleavage less dominant, disturbed rock mass, heavily jointed/folded. ***Strike of foliation cleavage in bluish-grey rock mass: 080***
	WP125	911934	840459	Xpm	Photo II-115	Xpm exposed in drainage bottom: Schist, brownish grey, fresh, R3/R4, foliated, less friable than most other outcrops observed during today’s traverse (increasing metamorphic grade?), shiny micaceous surfaces less prevalent.
	WP126	912180	841274	Xpm	Photo II-116	Xpm exposed in channel bottom. Schist, bluish grey, fresh, R3, disturbed rock mass, one dominant joint set (~ 1” spacing) appears aligned with foliations, second dominant set perpendicular to foliations. ***Orientation of joint set following foliations: 280/64***
	WP127	912108	842087	Xpm	n/a	***Strike of sub-vertical Xpm foliation cleavage: 105***

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP128	913198	841501	Xpm/Tal	n/a	Xpm/Tal contact.
	WP129	917394	838530	Xpm	Photo II-117	***Xpm foliation cleavage orientation: 040/40*** ***Xpm fold trend/plunge: 085/15***
January 24, 2017	WP130	925779	838615	Tcg	Photo II-118	Tcg outcrops in drainage banks and bottom. Outcrop on east bank: GRAVEL and SAND (GW), some cobbles, well graded, max. particle size = 10”, sub-angular to angular, clast supported, various lithology (tuff, quartz, schist, basalt, sandstone), moderate to strong acid reaction, dominantly R2/R3 with some more competent ledges (beds) with similar gradation to weaker beds above and below.
	WP131	925782	838684	Tcg	Photo II-119 and Photo II-120	Small Tcg ledge in drainage bottom with water flowing over. Typical bed gradation as WP130. Layer of poorly welded tuff below Tcg ledge: SAND (SP), poorly graded, pinkish brown, no acid reaction, quartz and biotite grains visible, R0 (soil-like).
	WP132	925745	838748	Tcg	Photo II-121	Tcg outcrop on west drainage bank. Layer of poorly welded tuff exposed in outcrop with Tcg above and below: Tcg: SAND (SW), some gravel, well graded, max. particle size = 2”, sub-angular to angular, pinkish brown, sand supported, various lithology, moderate acid reaction, R3. Poorly Welded Tuff (Tt?): 1 ft thick bed. Pinkish white, fresh, biotite and quartz grains visible, no acid reaction, some small voids/vugs along margins with Tcg, weaker than Tcg, R3.
	WP133	925754	839098	Tcg	n/a	Tcg outcrop high on east bank of drainage. Gravelly SAND (SW), some cobbles, well graded, mac. particle size = 8”, sub-angular to angular, clast supported, various lithology (tuff, basalt, sandstone dominate), brown, R1.
	WP134	925721	839242	Tcg	Photo II-122	8 ft high Tcg outcrop in east channel bank. Top half of outcrop: SAND and GRAVEL (SW), some cobbles, well graded, max. particle size = 8”, typically clast supported with some sandy areas, various lithology, weak to strong acid reaction, R2. Bottom half of outcrop: SAND (SW), some silt, trace gravel, well graded, sand supported, max. particle size = 1”, reddish brown, trace calcareous silt stringers, R0/R1.
	WP135	925885	839575	Tcg	Photo II-123	Tcg outcrops in drainage bottom. Well graded (gravel, sand and cobbles), outcrops span the drainage bottom, preferential erosion of weaker beds result in sub-horizontal overhangs in channel bank.
	WP136	930623	837273	Tcg	Photo II-124	Tcg outcrop in drainage bank. BOULDERS, COBBLES and GRAVEL, some sand, max. particle size = 24”, sub-rounded to angular, clast supported, various lithology, weak to moderate acid reaction, sub-horizontal ft-scale beds.
	WP137	930989	837831	Tcg	Photo II-125 and Photo II-126	Tcg outcrop in drainage bank. Sub-horizontally bedded with beds typically > 1ft thick. Variability in bed weathering susceptibility with finer, matrix supported beds least resistant. Bed at base of outcrop: Gravelly SAND (SW), some silt, some cobbles, well graded, max. particle size= 8”, sub-rounded to angular, reddish brown, various lithology dominated by schist, weak to moderate acid reaction, R1. ***Orientation of beds: 160/15***
	WP138	931342	838051	Tcg	Photo II-127	Large Tcg outcrop with consistent bedding orientation. ***Orientation of beds: 180/22***
	WP139	931495	838406	Tcg	Photo II-128 and Photo II-129	Tcg outcrop with consistent bed gradation from top to bottom. Beds typically > 1ft thick mixtures of sand, gravel and cobbles. ***Orientation of beds: 185/25***
	WP140	931642	839063	Tcg	Photo II-130	***Orientation of Tcg beds: 200/16***
	WP141	932097	839606	Tcg	Photo II-131	Typical bedded Tcg on outside of channel meander. SAND, GRAVEL and COBBLES (SW), well graded, weak acid reaction, R1.
	WP142	932509	839976	Tcg	n/a	15 ft high Tcg outcrop. SAND, GRAVEL and COBBLES (SW), well graded, max. particle size = 18” boulder, variably clast to matrix supported, various lithology but dominated by schist, moderate acid reaction, most beds are > 1f thick, some sandy beds are inch-scale, R1/R2.
	WP143	932934	841058	Tcg	Photo II-132	15 ft high exposure of Qoa overtop of Tcg. Qoa: SAND and GRAVEL (SW), some cobbles, some clay, well graded, brown, moist, no acid reaction
	WP144	933417	842307	Tt	Photo II-133	Tt outcrop. Some lithic clasts floating in tuff matrix, no acid reaction, R1.
	WP145	933961	842390	Tt	Photo II-134	Shallow exposure of Tt. White, fresh, R1/R2, quartz and biotite crystals visible, low density. Tt surrounded by surface exposures of Yd. ***Orientation of “layering”: 105/37.***
	WP146	933981	842472	Yd	Photo II-135	Test pit in Yd. Dark black (mafic) with white feldspar crystals, slightly weathered with orangey surface oxidation, R3/R4, heavily fractured/disturbed, some calcite infilling on fracture surfaces.
	WP147	934219	842667	Yd	Photo II-136	2 ft high exposure of Yd in road cut. Dark grey, shallow weathering (oxidation), fresh below, disturbed with joints throughout, no infill on joint surfaces, joint spacing typically <1”. ***Strike of dominant joint set: 065***

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP148	934268	842700	Yd	Photo II-137	3 ft wide zone of completely disintegrated Yd (broken down to sand-sized particles) with disturbed Yd rock mass on either side. Some sub-vertical calcite veins cross cutting the disintegrated zone.
	WP149	934335	842794	Yd	Photo II-138	Completely weathered Yd in channel bottom. Rock disintegrated to sand-sized particles, oxidized, some calcite veins cross cutting exposures.
	WP150	934396	843137	Yd	Photo II-139	Yd outcrop. Greyish green, fresh, R3, disturbed rock mass. Completely disintegrated Yd exposed upstream and downstream of this outcrop.
	WP151	934905	844006	Yd	Photo II-140	Intact Yd exposed in drainage bottom. Dark grey with white feldspar crystals, fresh to slightly weathered (surface oxidation), R3, very blocky to disturbed, two dominant joint sets apparent, joint spacing typically < 1", aperture variable with some closed joints, some open with trace evidence of calcite on surfaces.
	WP152	935118	844831	Ym/Yd	n/a	Ym/Yd contact.
	WP153	934831	844872	Ym/Yd	n/a	Ym/Yd contact.
January 25, 2017	WP154	918613	841436	Tcg	Photo II-141	Tcg exposed in drainage banks and bottom. SAND, GRAVEL and COBBLES (SW), well graded, various lithology (siltstone, sandstone, diabase dominate), moderate acid reaction, R0/R1 in drainage banks, R1/R2 in drainage bottom.
	WP155	918558	841362	Tcg	Photo II-142	3 sub-vertical joints in sandy Tcg observed below sub-horizontally bedded Tcg in drainage bank. Joints open at surface of the outcrop but seem to close off in the bank, joint spacing 6" to 12", rough surfaces. ***Orientation of joints: 153/74***
	WP156	918610	841267	Tcg/Ym/Tal	n/a	Contact between Tcg, Ym and tuff. Tcg exposed in outcrop overlying poorly welded tuff and adjacent to Ym. Tuff adjacent to Ym is disturbed (R1). ***Orientation of Ym beds: 007/42***
	WP157	918496	841267	Ym/Ydsu	Photo II-143	Ym/Ydsu contact in drainage. Ydsu description: Sandstone, pinkish red to grey, fresh, bedded, R4, blocky, one set of joints parallel to bedding and one perpendicular, joint spacing < 1" to > 1 ft, joint surfaces rough and planar, some areas of outcrop disturbed. ***Orientation of beds: 003/50***
	WP158	918258	841201	Ydsu	Photo II-144	Heavily fractured/disintegrated outcrop of Ydsu bracketed by more intact, blocky rock mass. Rock in the disintegrated zone has thin beds of light grey siltstone.
	WP159	918152	841114	Yd/Ydsu	Photo II-145	Black, completely disintegrated mafic rock adjacent to Ydsu in drainage bottom. Some relict structure and calcite veins visible. Yd? ***Orientation of Ydsu beds: 016/30***
	WP160	917749	840704	Yp	n/a	Small outcrop of black, very blocky, oxidized fine grained rock, R2. Yp siltstone?
	WP161	917687	840621	Yp	Photo II-146 and Photo II-147	Outcrop of Yp. Siltstone, black, oxidized, R2, very blocky/disturbed, tilted blocks displaying sub-horizontal bedding visible in more intact sections of outcrop, disintegrated zones contain gravel sized particles of siltstone floating in a black, oxidized sandy matrix of disintegrated rock, one sub-vertical joint approximately 3" wide with clay and calcite infill. ***Orientation of beds: 330/26*** ***Strike of sub-vertical joint: 130***
	WP162	917516	840613	Yp/Tal	n/a	Yp/Tal contact.
	WP163	917677	840160	Tcg	n/a	Tcg exposed in drainage bank along mapped fault.
	WP164	917932	840321	Tcg/Tal	n/a	Tcg/Tal contact in bottom of small drainage.
	WP165	917606	840027	Tcg	Photo II-148 and Photo II-149	20 ft high Tcg outcrop in drainage bank. Mixture of boulders, cobbles, gravel, sand and silt, sub-angular to angular, beige/brown, variably clast to matrix supported (mostly matrix), various lithology, no to weak acid reaction, R0 to R2. One sub-vertical joint cutting through outcrop. 3" wide with calcareous silt and sand infill, roots penetrating full length, fresh, rough, stepped surfaces. ***Orientation of joint: 160/68***
	WP166	917522	839781	Tcg/Tal	Photo II-150	Tal exposed in drainage banks. Tcg exposed overtop of Tal.
	WP167	917443	839708	Tal	n/a	Small depression visible along mapped fault perpendicular to drainage. Massive schist boulder suspended in Tal outcrop.
	WP168	917232	839477	Yd	n/a	Yd exposed in drainage bottom immediately adjacent to Xpm outcrop. Black with some white feldspar crystals, fresh, R5, very blocky/disturbed, some calcite veins, one 3" wide sub-vertical joint infilled with silty sand.
	WP169	917517	840740	Yd	Photo II-151	Yd exposed in drainage bottom and banks, black with oxidized surfaces, R4.
	WP170	917566	840985	Yd	Photo II-152	Outcrops of Yd. Black to dark grey/orange, oxidized throughout, R3, very blocky, cubed at surface into gravel sized pieces.
	WP171	917533	841117	Yp	Photo II-153	Annealed fault zone in Yp. Gravel to cobble size pieces of Yp floating in a lithified matrix, R4. Intact Yp just upstream of fault zone. ***Orientation of beds in intact outcrop: 355/37***

Mapping Date	Waypoint ID	Easting (ft)[1]	Northing (ft)[1]	Unit(s) Described	Photograph (See Appendix II)	Observations
	WP172	917398	841506	Yp/Tal	n/a	Intersection of mapped fault between Yp and Tal. Contact between two units along a small, shallow drainage. No outcrops.
	WP173	917378	841445	Xpm	n/a	Xpm outcrops and cobbles visible at surface.
	WP174	916443	841206	Xpm	Photo II-154	Xpm outcrops in drainage bottom.
	WP175	916294	839971	Xpm	n/a	Traverse in Xpm.
	WP176	915129	839334	Xpm	n/a	Traverse in Xpm.
	WP177	915149	839608	Xpm/Tal	Photo II-155	Xpm/Tal contact.
	WP178	915003	840022	Tal	Photo II-156	Typical Tal outcrop in bottom of drainage. Pinkish white, fresh, R4, quartz grains and biotite visible in felsic matrix, several joint sets with different orientations, joint surfaces are rough and planar, aperture difficult to determine, ranges from closed to ~ 1/8" open with sand infill (may close off below surface), some small air voids visible in fresh surfaces.
	WP179	914985	840321	Xpm/Tal	n/a	Tal/Xpm contact
	WP180	914731	840782	Xpm/Tal	n/a	Xpm/Tal contact
	WP181	915454	841238	Xpm/Tal	Photo II-157	Xpm outcrop along contact with Tal. Dark grey to orangey red, oxidized, R4/R5.
	WP182	916253	841288	Xpm/Tal	n/a	Traverse following Tal/Xpm contact between WP181 and WP182
	WP183	916472	841119	Xpm	Photo II-158	***Xpm foliation cleavage orientation: 040/36***
	WP184	917104	840998	Xpm/Yp	n/a	Contact between Xpm and Yp siltstone in bottom of small drainage. ***Orientation of Yp beds: 190/48.***
	WP185	917274	840337	Xpm/Yp	n/a	Traverse following Xpm/Yp contact between WP184 and WP185.
	WP186	917220	841196	Xpm/Yp	Photo II-159	Traverse following Xpm/Yp contact between WP185 and WP186. At WP186 the contact becomes obscured at top of ridge.

Notes: 1. Coordinates measured with a handheld GPS and given in Arizona State Plane Central; NAD83 Datum.

APPENDIX II

Photographs

Appendix II
Photographs

2016 FIELD MAPPING

Photo II-1 WP3 – 2016

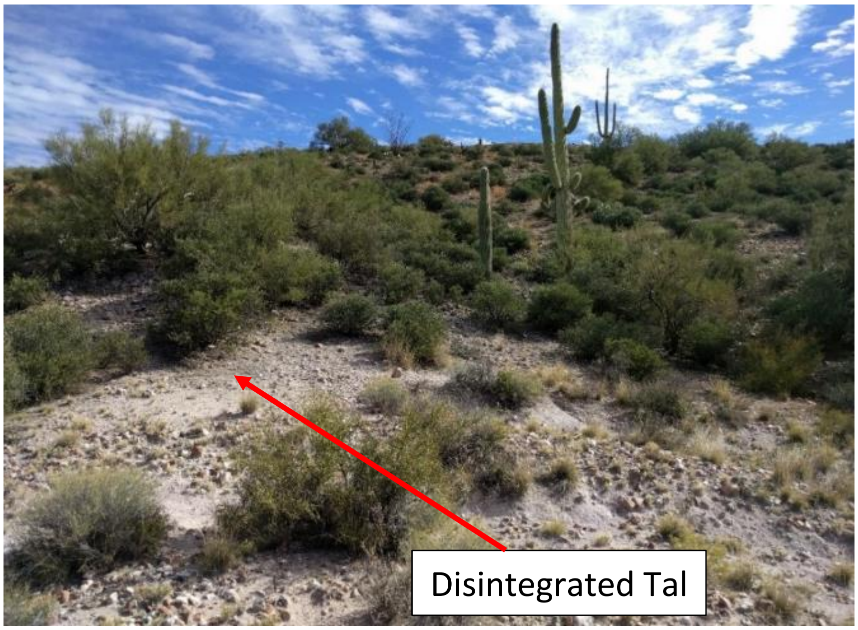


Photo II-2 WP3 – 2016

Photo II-3   WP5 - 2016

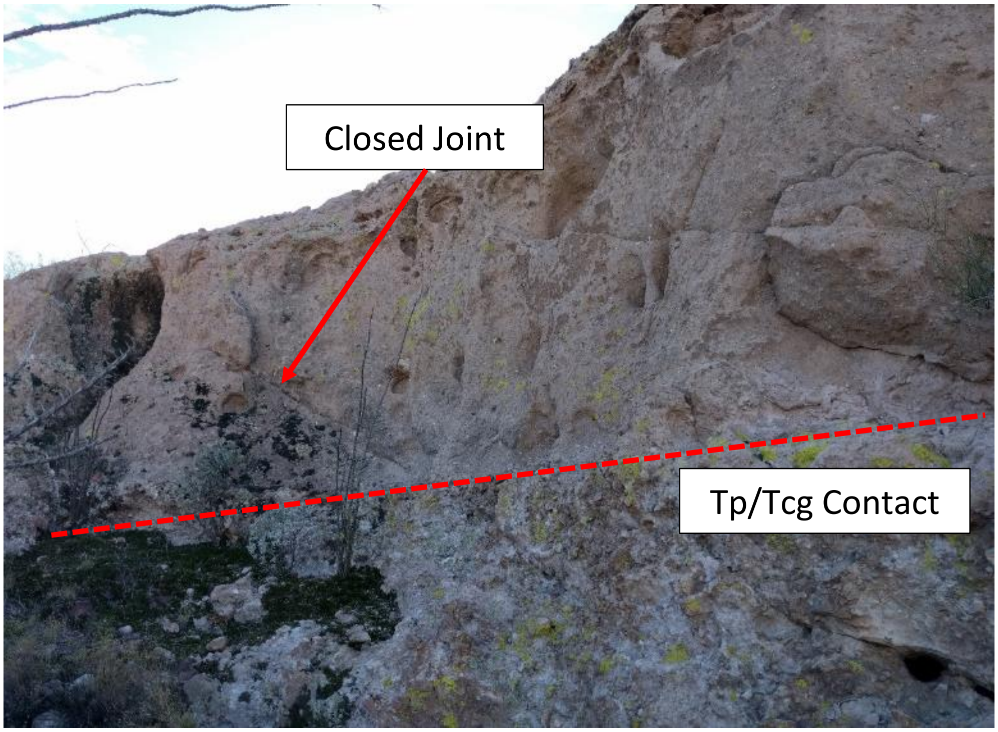


Photo II-4   WP5 - 2016

2017 FIELD MAPPING

Photo II-5 WP1

Photo II-6 WP2

Photo II-7 WP3

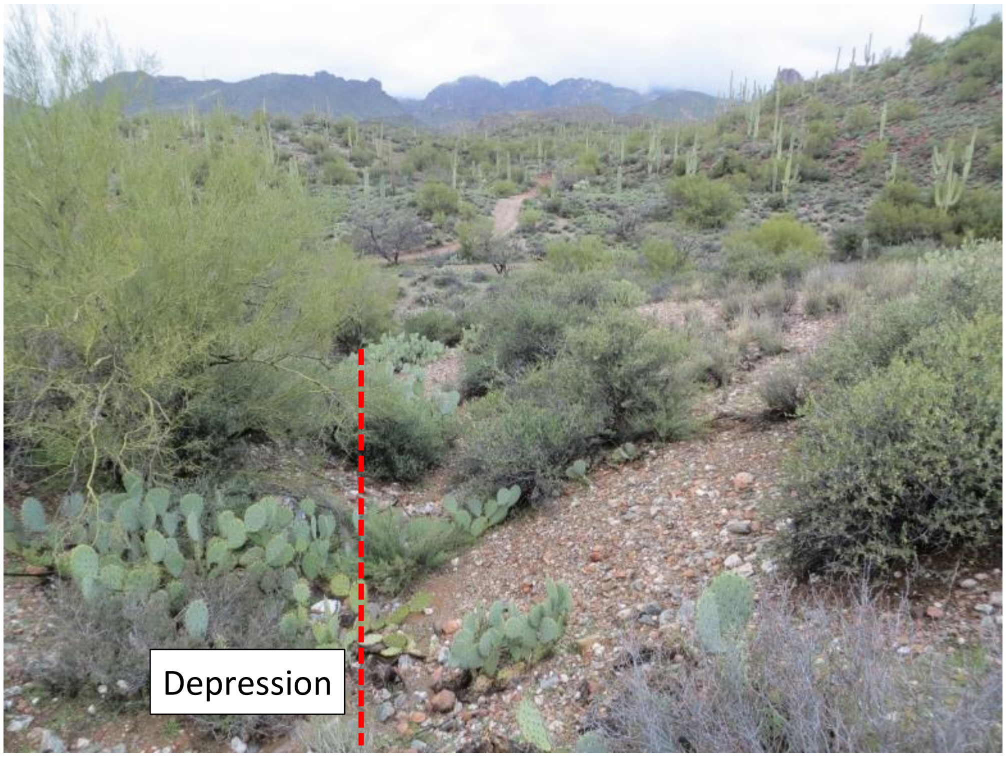
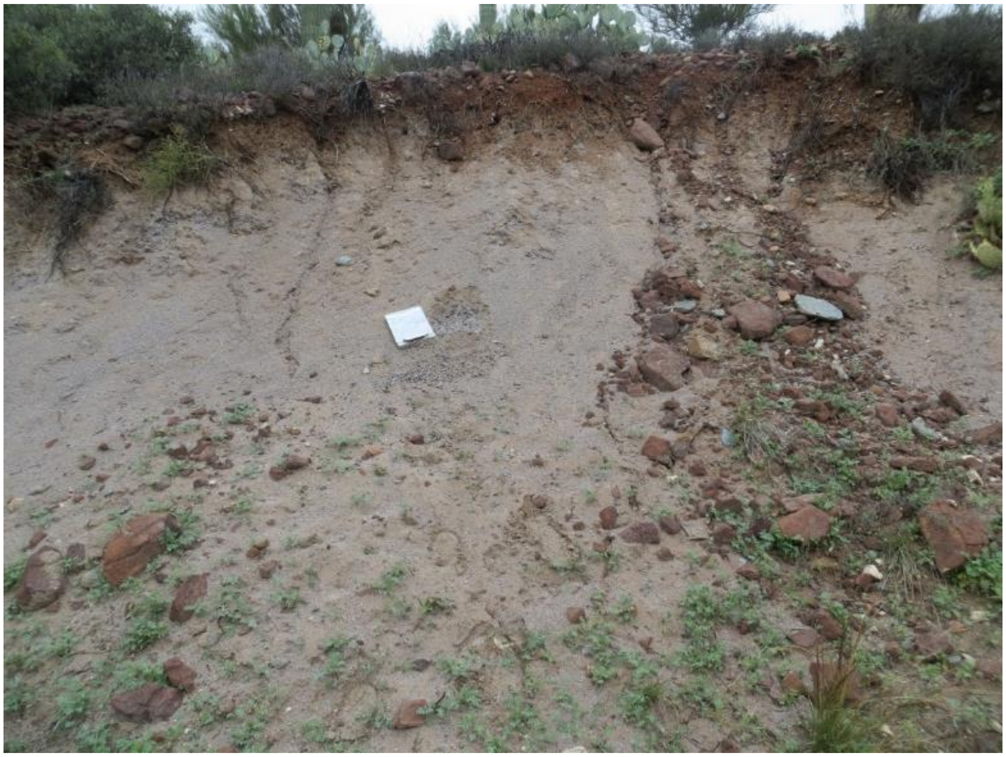


Photo II-8 WP4

Photo II-9 WP5



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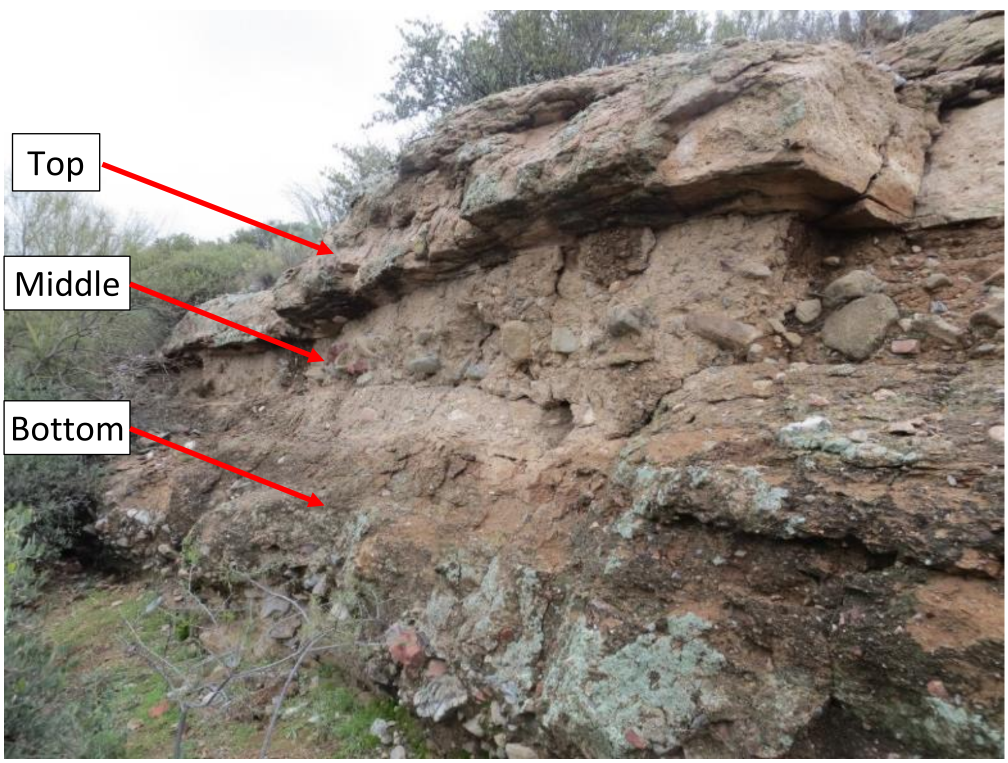

Photo II-11 WP7

Photo II-12 WP8

Photo II-13 WP9

Photo II-14 WP10

Photo II-15 WP12

Photo II-16 WP13

Photo II-17 WP14

Photo II-18 WP15

Photo II-19 WP16

Photo II-20 WP17

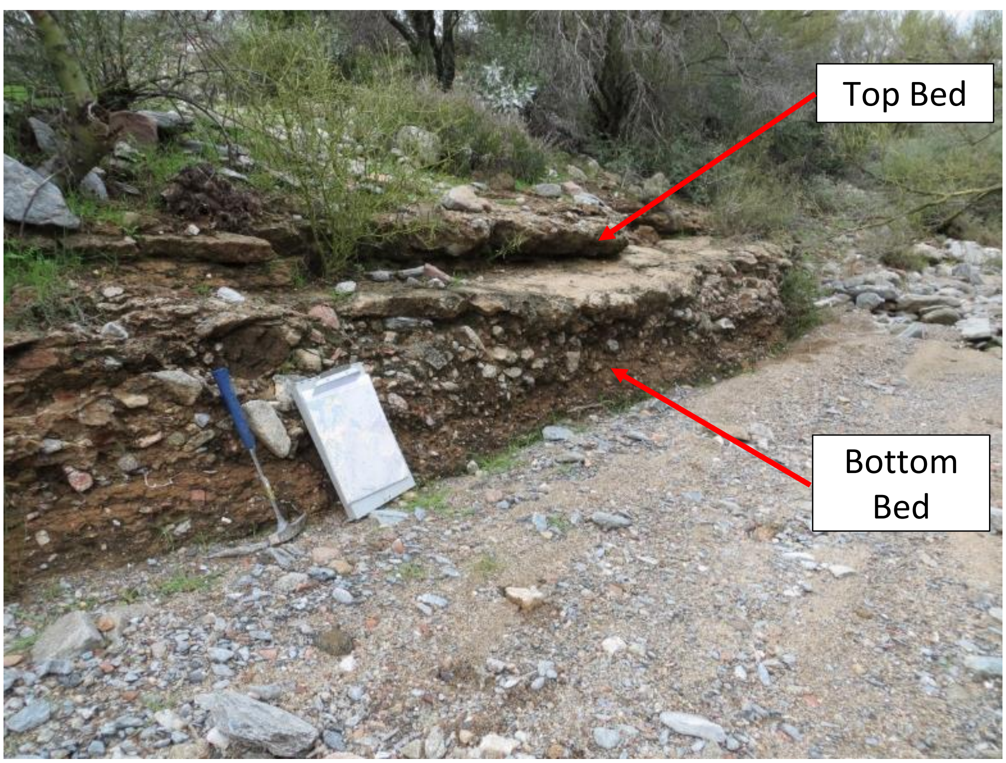

Photo II-21 WP18

Photo II-22 WP19

Photo II-23 WP19

Photo II-24 WP20

Photo II-25 WP21

Photo II-26 WP22

Photo II-27 WP23

Photo II-28 WP24

Photo II-29 WP25

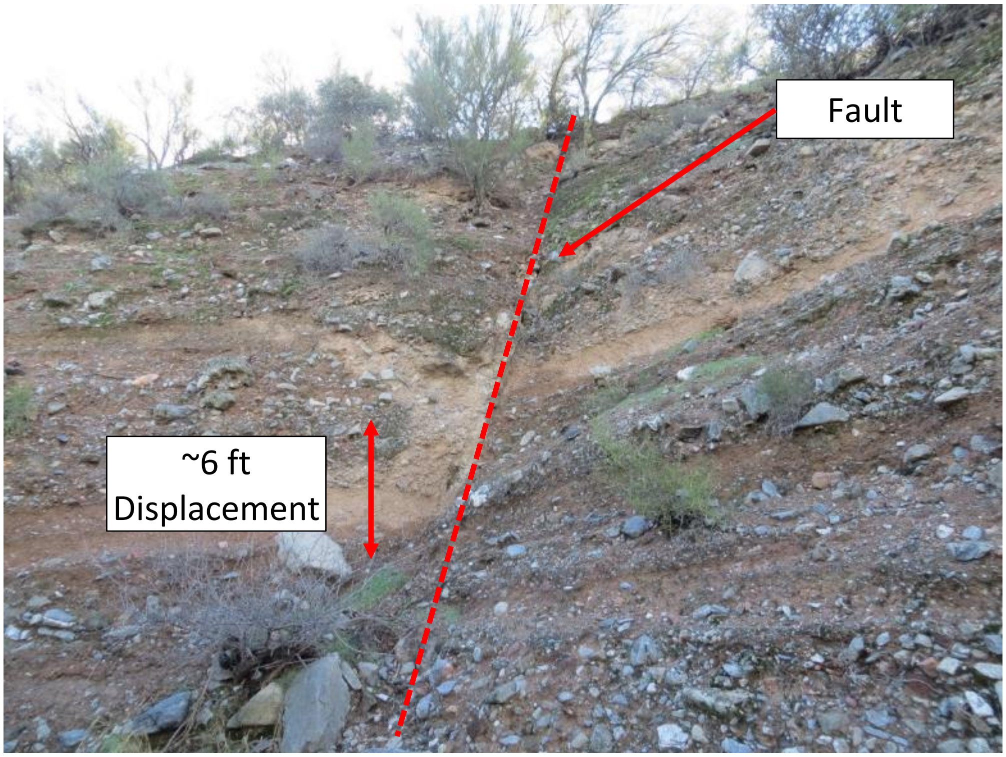

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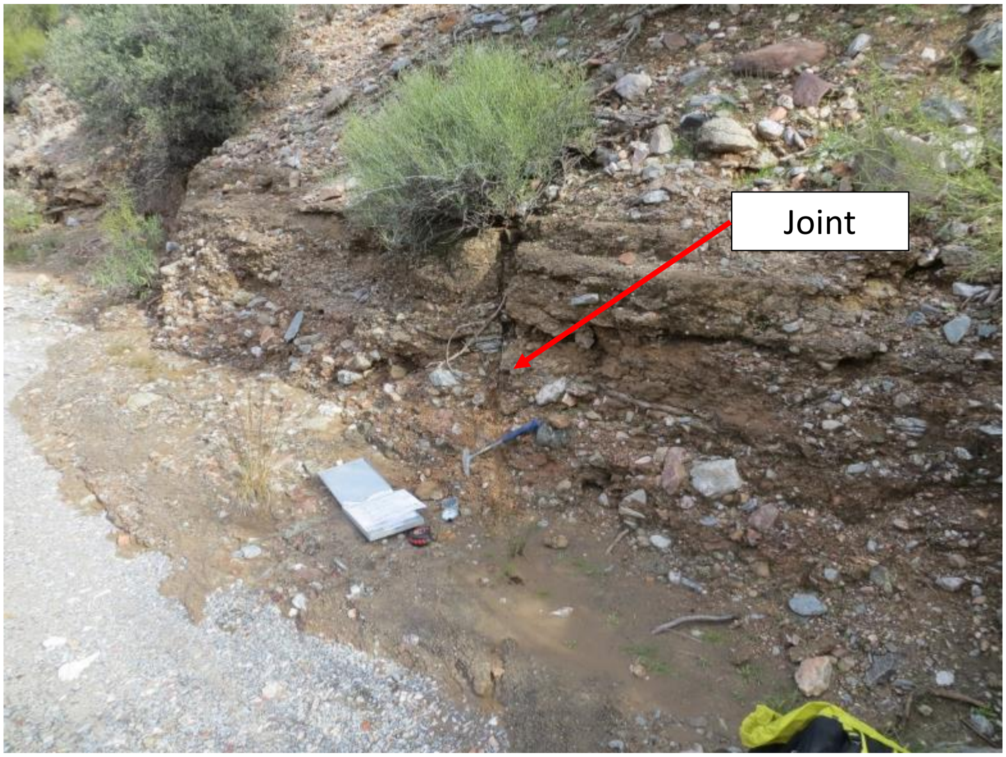
Photo II-31 WP28



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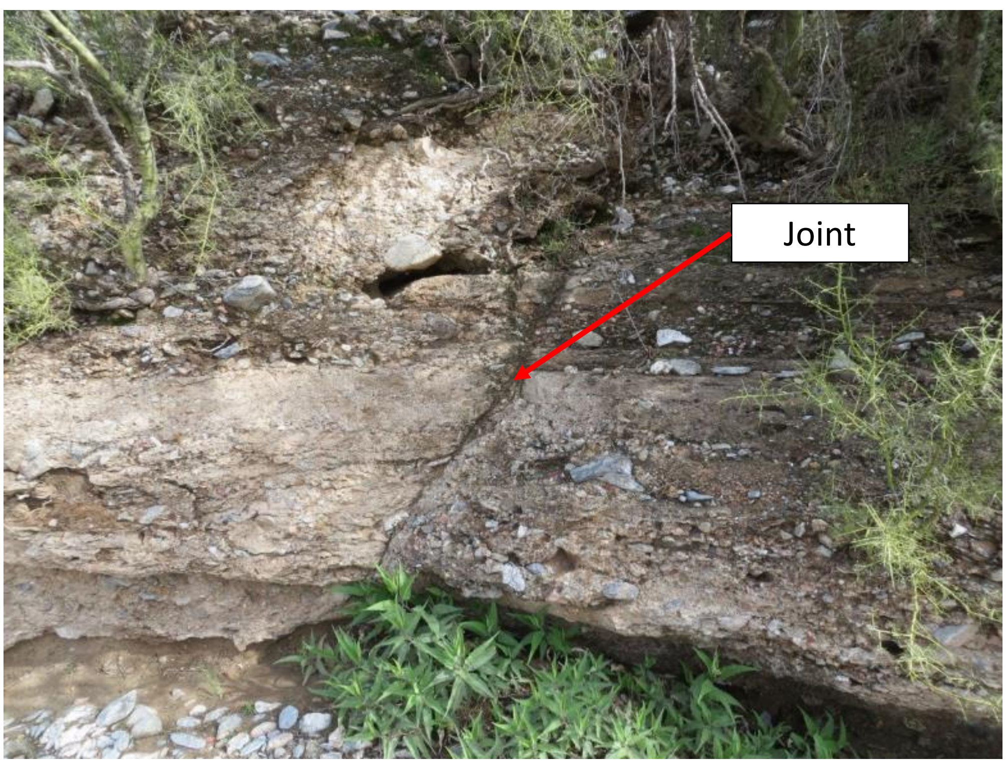

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Photo II-34 WP31

Photo II-35 WP32

Photo II-36 WP33

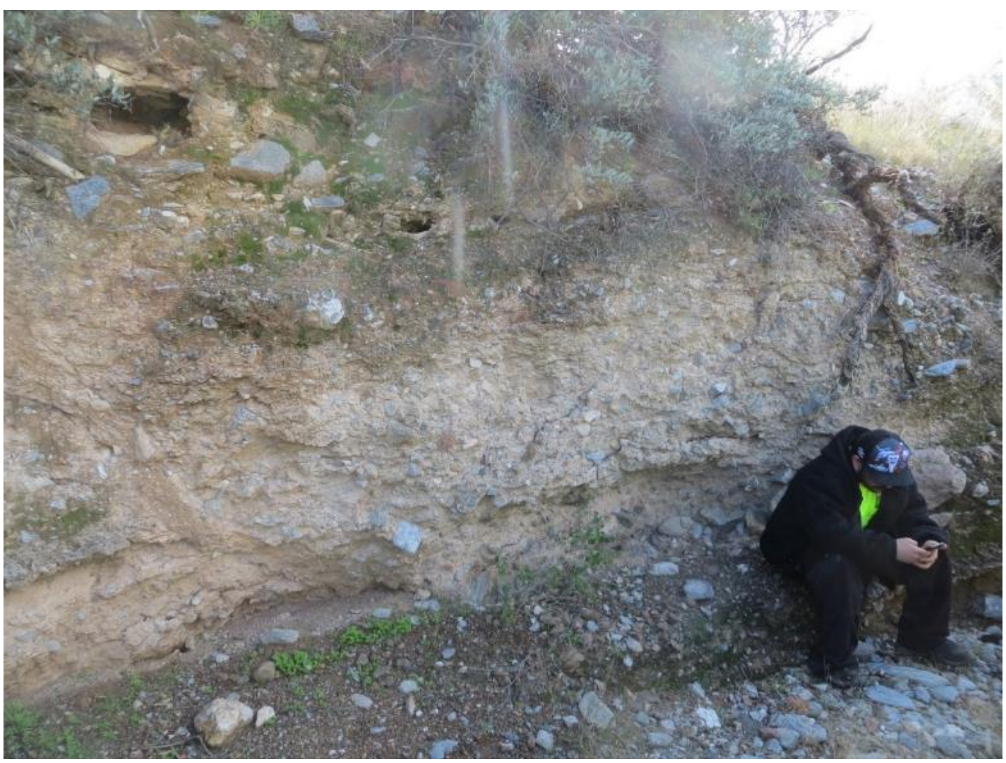

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Photo II-38 WP35

Photo II-39 WP36

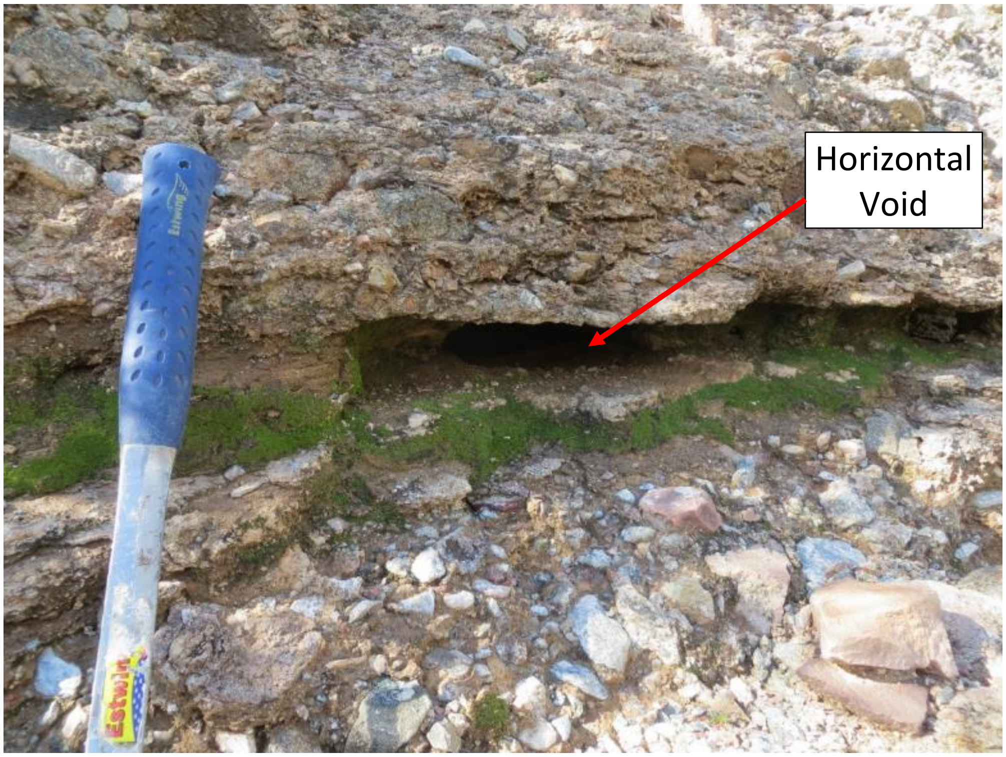

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Photo II-42 WP38

Photo II-43 WP39

Photo II-44 WP40

Photo II-45 WP41

Photo II-46 WP42

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Photo II-48 WP44

Photo II-49 WP45

Photo II-50 WP46

Photo II-51 WP47

Photo II-52 WP48

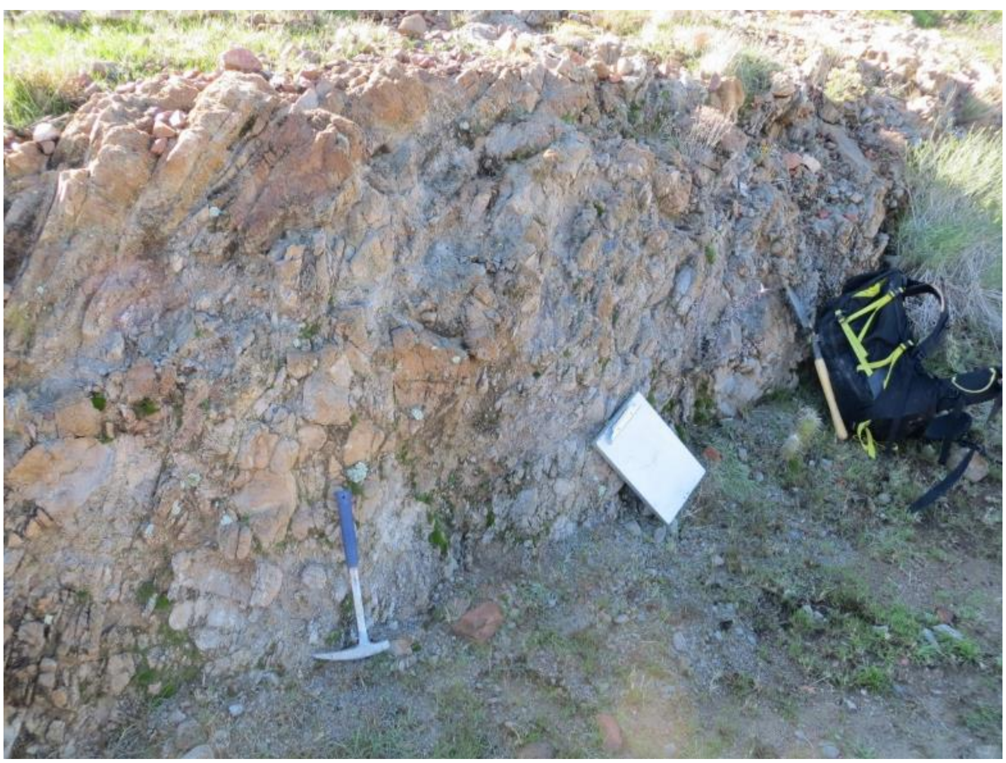

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Photo II-56 WP52

Photo II-57 WP53

Photo II-58 WP54

Photo II-59 WP55

Photo II-60 WP56

Photo II-61 WP57

Photo II-62 WP58

Photo II-63 WP59

Photo II-64 WP60

Photo II-65 WP61

Photo II-66 WP62

Photo II-67 WP63

Photo II-68 WP64

Photo II-69 WP65

Photo II-70 WP66

Photo II-71 WP66

Photo II-72 WP68

Photo II-73 WP69

Photo II-74 WP69

Photo II-75 WP70

Photo II-76 WP71

Photo II-77 WP71

Photo II-78 WP72

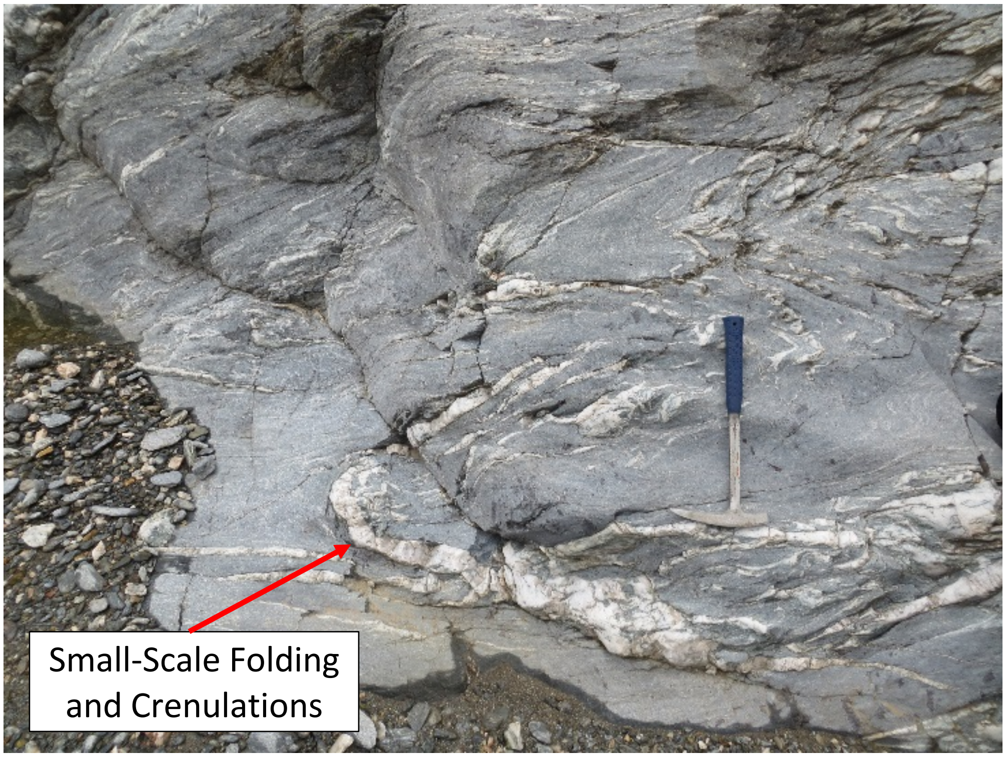
Photo II-79 WP73

Photo II-80 WP73

Photo II-81 WP74

Photo II-82 WP74

Photo II-83 WP74



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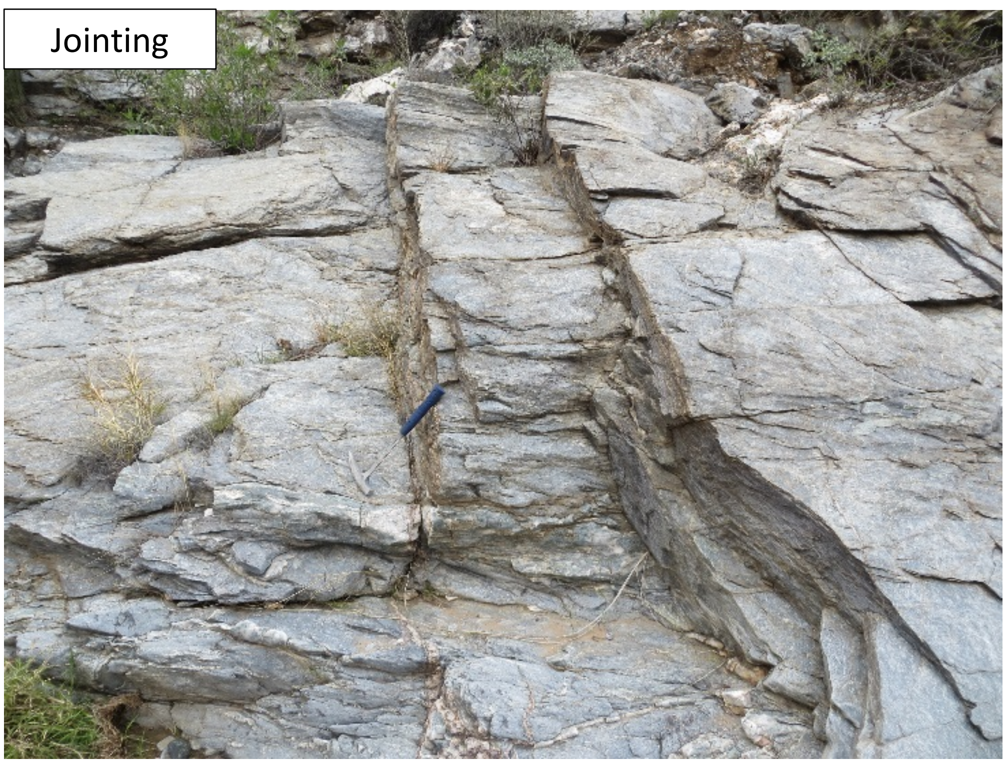

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Photo II-86 WP76

Photo II-87 WP77

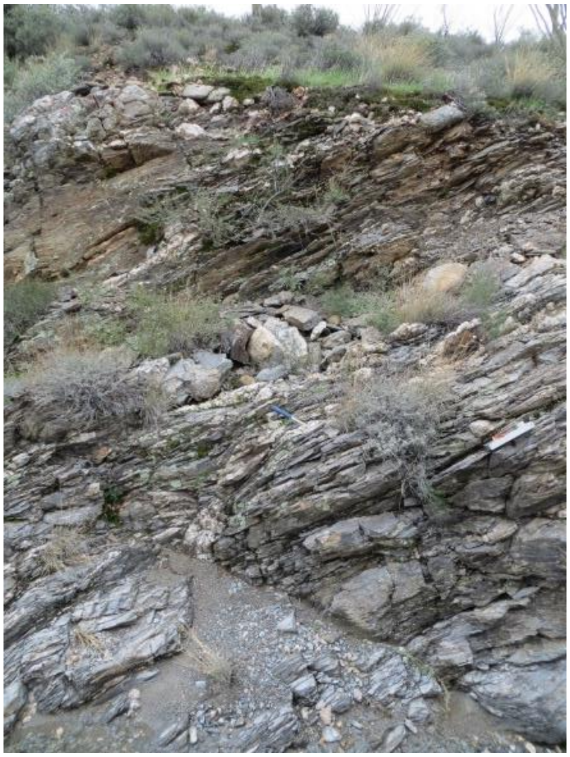

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Photo II-89 WP79

Photo II-90 WP81

Photo II-91 WP82

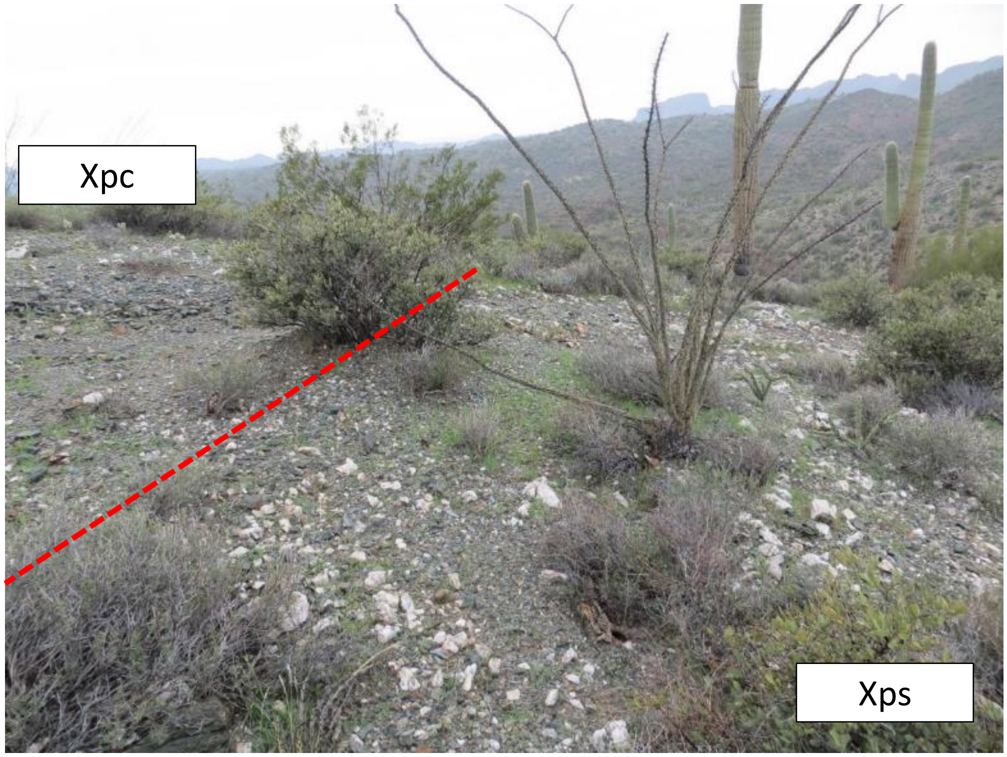

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Photo II-93 WP84

Photo II-94 WP84

Photo II-95 WP85

Photo II-96 WP87

Photo II-97 WP88

Photo II-98 WP97

Photo II-99 WP98

Photo II-100 WP99

Photo II-101 WP99

Photo II-102 WP99

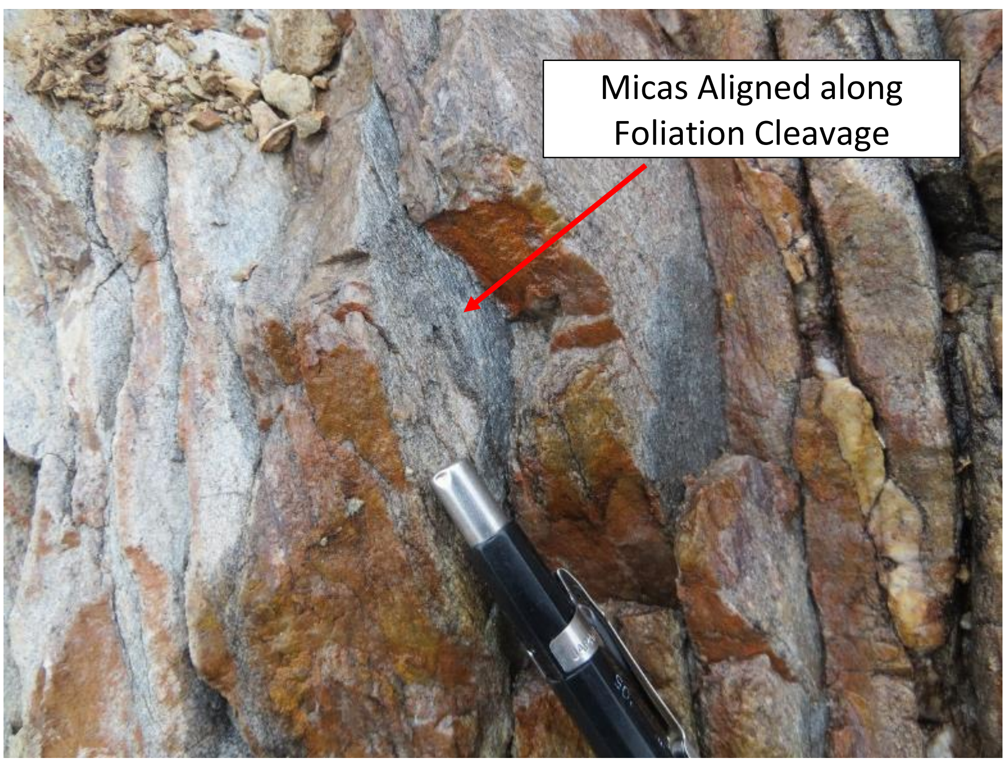

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Photo II-105 WP104

Photo II-106 WP105

Photo II-107 WP112

Photo II-108 WP112

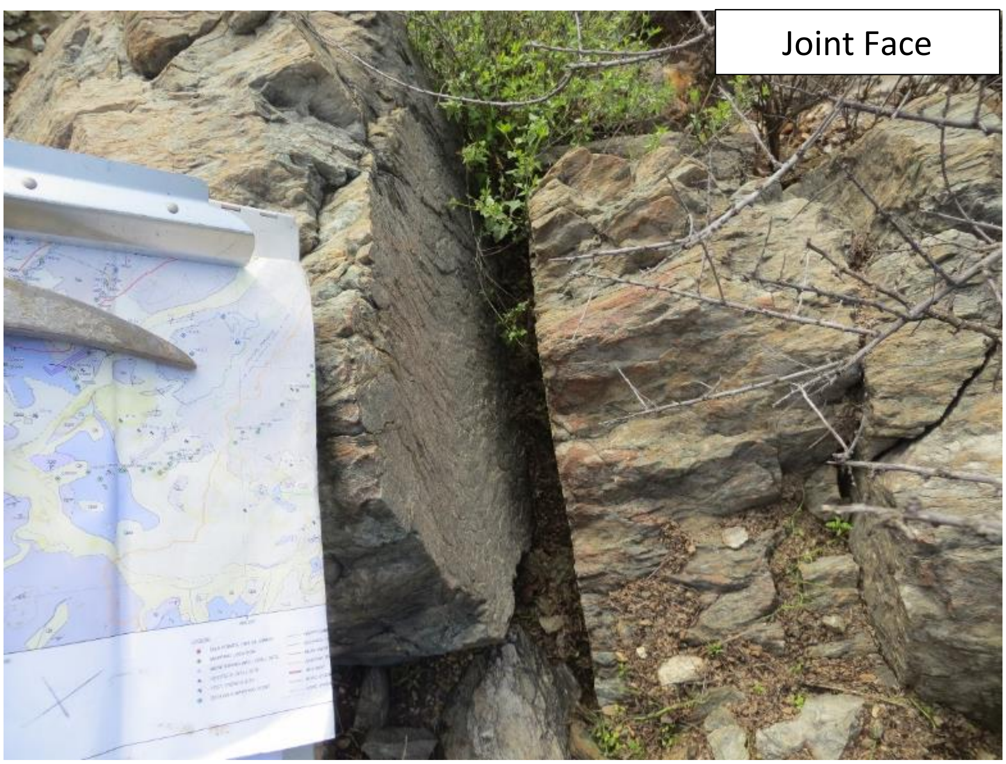

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Photo II-111 WP121

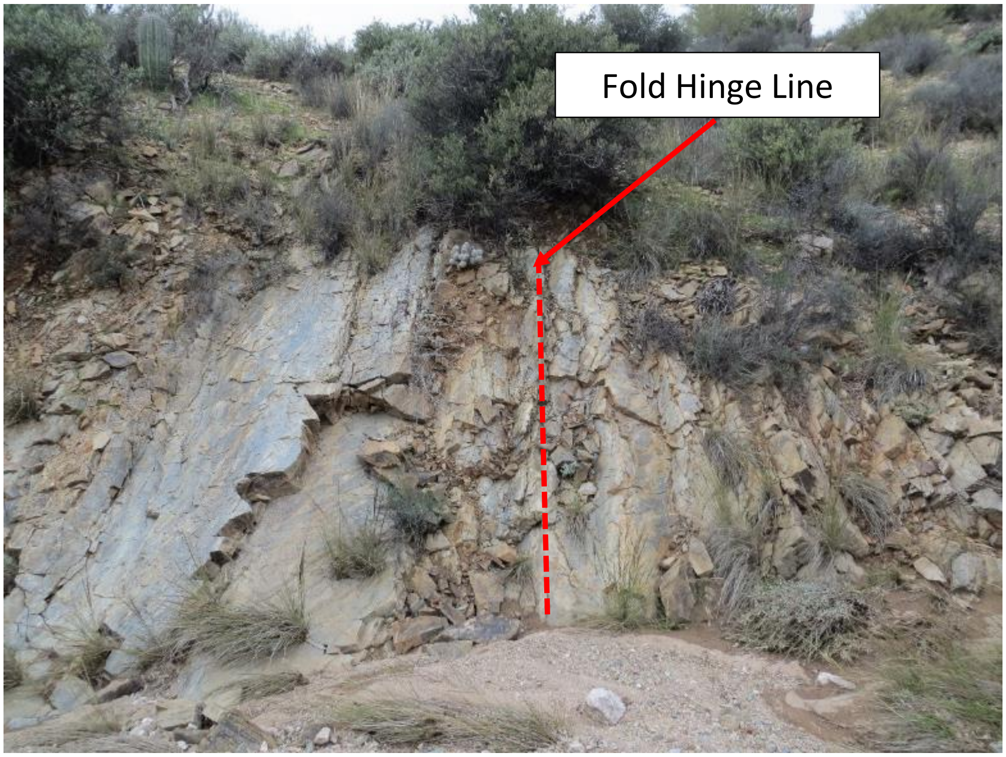

Photo II-112 WP121

Photo II-113 WP124

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Photo II-115 WP125

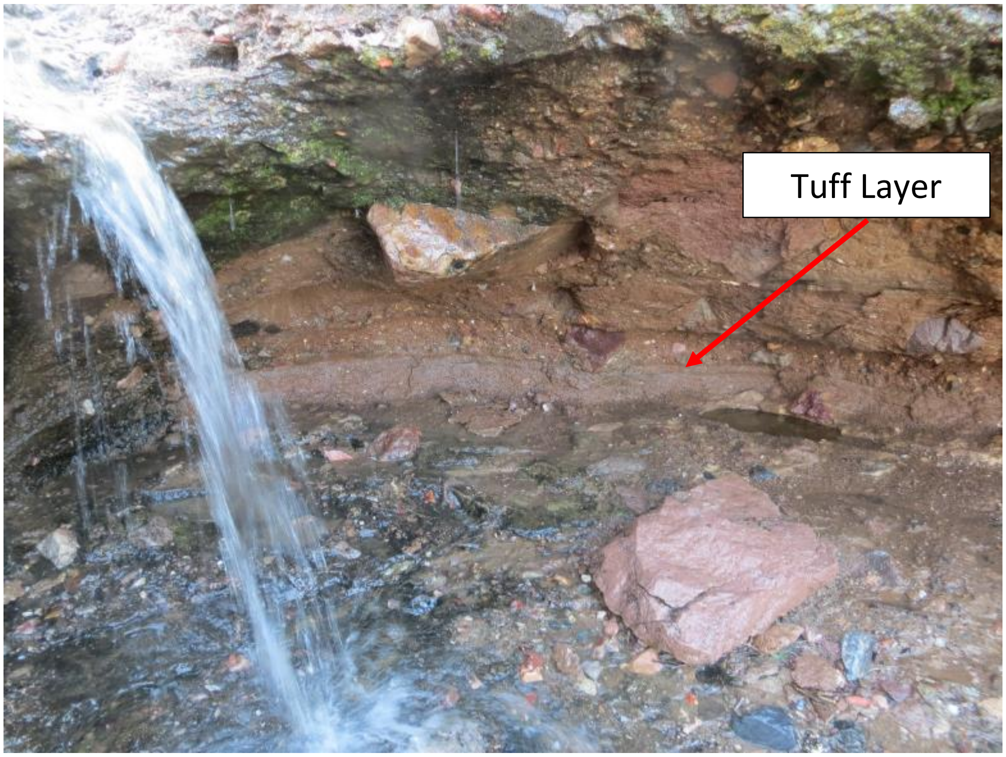
Photo II-116 WP126

Photo II-117 WP129

Photo II-118 WP130

Photo II-119 WP131

Photo II-120 WP131



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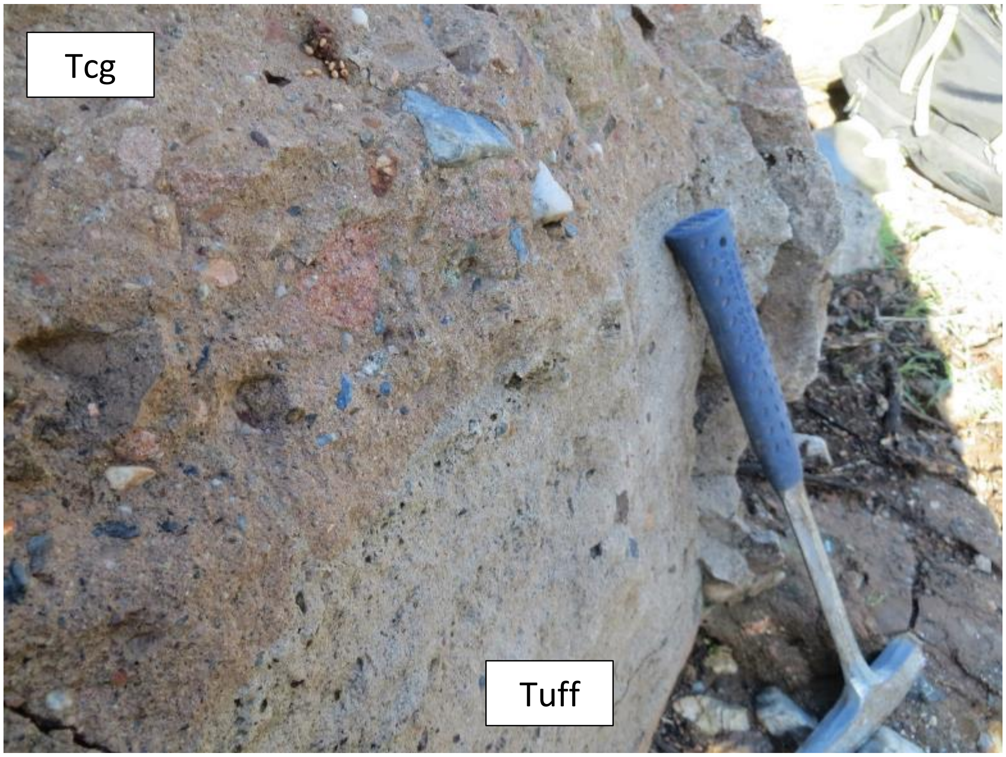

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Photo II-124 WP136

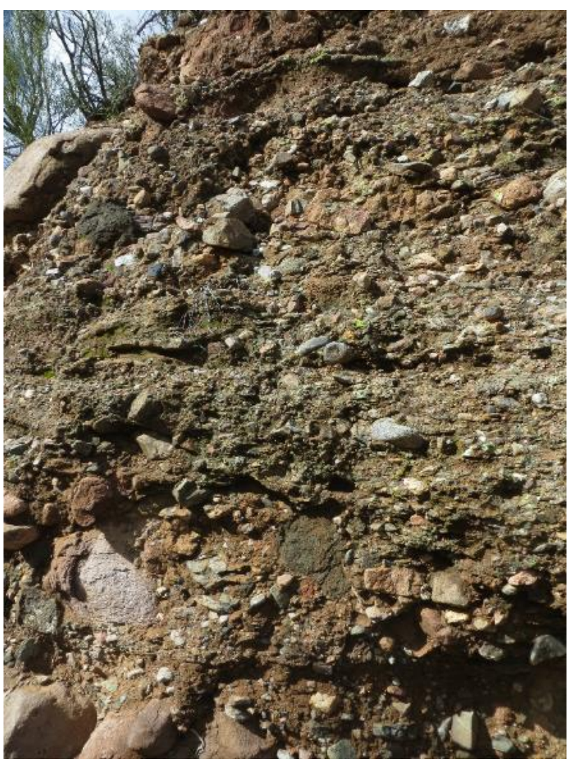

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Photo II-126 WP137

Photo II-127 WP138

Photo II-128 WP139

Photo II-129 WP139

Photo II-130 WP140

Photo II-131 WP141

Photo II-132 WP143

Photo II-133 WP144

Photo II-134 WP145

Photo II-135 WP146

Photo II-136 WP147

Photo II-137 WP148

Photo II-138 WP149

Photo II-139 WP150

Photo II-140 WP151

Photo II-141 WP154

Photo II-142 WP155

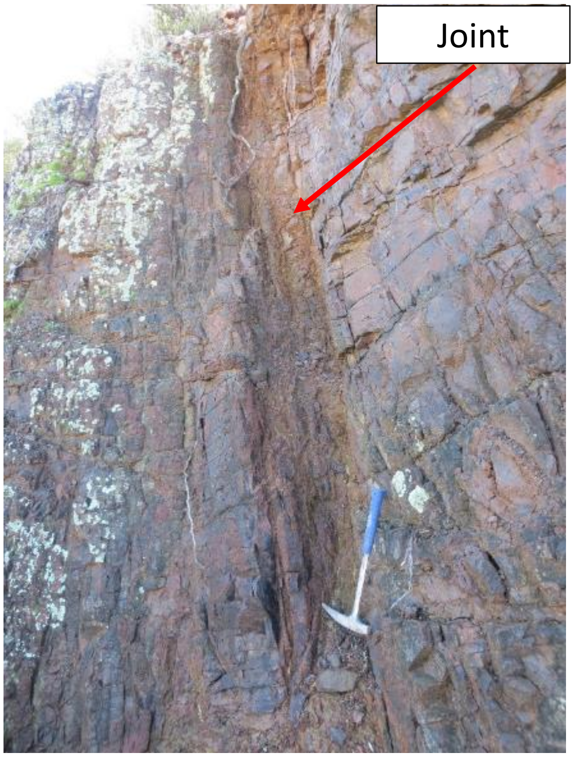
Photo II-143 WP157

Photo II-144 WP158

Photo II-145 WP159

Photo II-146 WP161

Photo II-147 WP161



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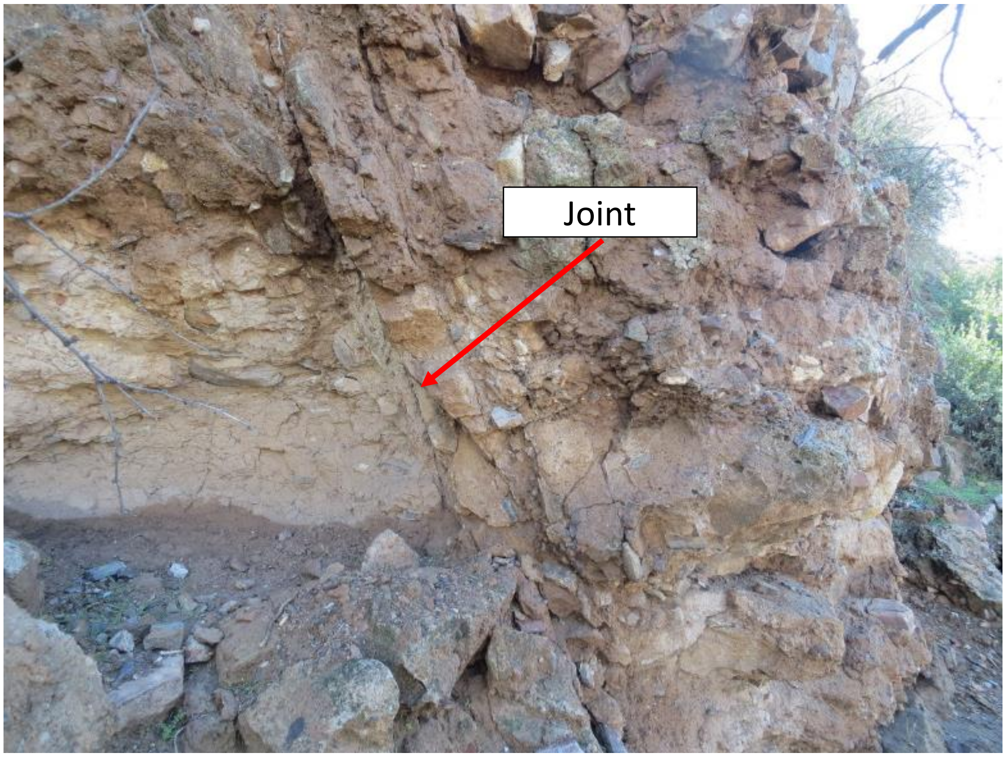

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Photo II-152 WP170

Photo II-153 WP171

Photo II-154 WP174

Photo II-155 WP177

Photo II-156 WP178

Photo II-157   WP181

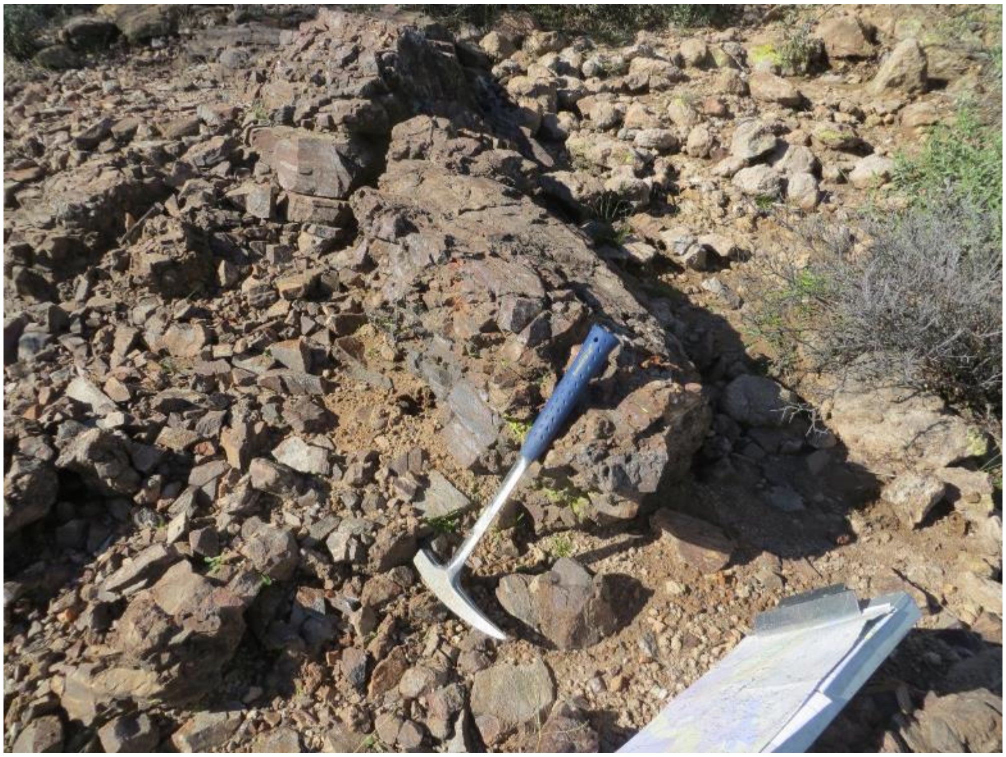
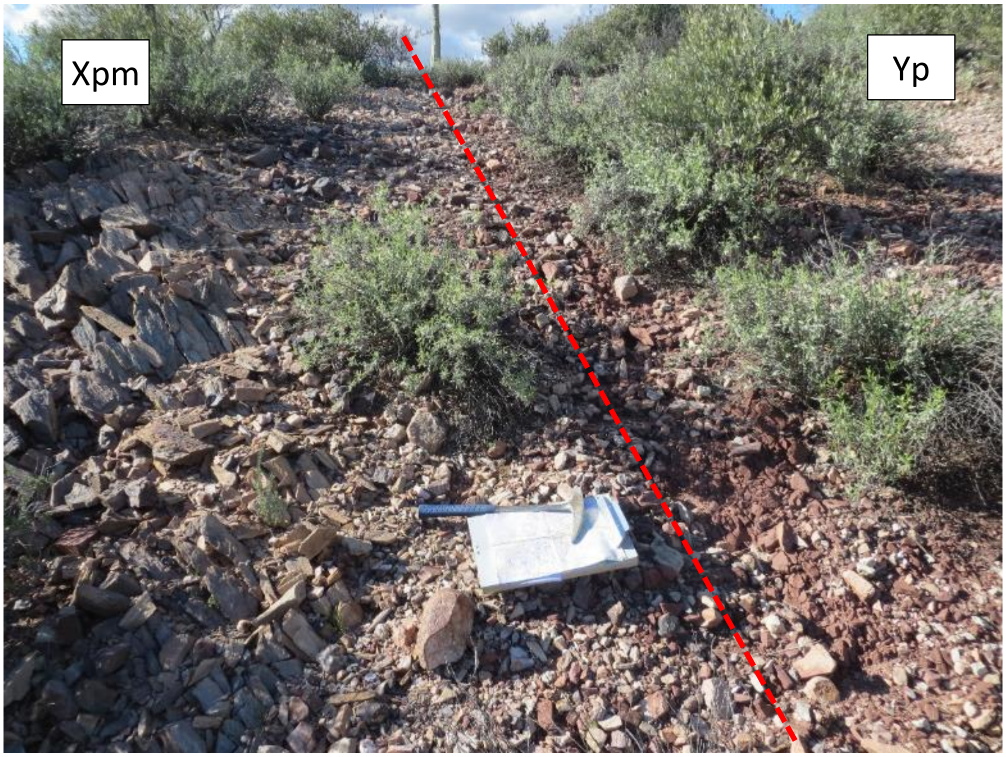


Photo II-158   WP183

Photo II-159 WP186



APPENDIX V

KCB Test Trenching Report

Klohn Crippen Berger

Resolution Copper Mining LLC

Resolution Copper Project

Near West Tailings Storage Facility

2017 Gila Test Trenching

CANADA'S BEST MANAGED COMPANIES Platinum member

ISO 9001
ISO 14001
OHSAS 18001

M09441A18.730

October 2017

October 20, 2017

Resolution Copper Mining LLC
P.O. Box 1944
Superior, Arizona
85273

Ms. Kim Huether
General Manager - Studies

Dear Ms. Huether:

Resolution Copper Project
Near West Tailings Storage Facility
2017 Gila Test Trenching

We are pleased to provide a summary of the 2017 Gila Test Trenching.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Kate Patterson, P.E., M.Eng.
Project Manager

CK:dl

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Resolution Copper Mining LLC

Resolution Copper Project

Near West Tailings Storage Facility

2017 Gila Test Trenching

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) were onsite to observe and document nine test trench excavations in Gila Conglomerate and Gila Sandstone on drill pads within the footprint of the proposed Near West Tailings Storage Facility (TSF). Test trenching was carried out as part of the pre-feasibility study (PFS) for Resolution Copper Mining LLC's (RCM) proposed TSF at the Near West site in Pinal County, Arizona. The trenches were completed from February 27 to March 2, 2017 by DalMolin Excavating of Globe, Arizona. Mr. Chris Kowalchuk, P.Geo. was the KCB representative on site.

A separate program of thirty-two test trenches in recent alluvium, old alluvium, and undifferentiated overburden was completed by Golder Associates, and is reported in Golder (2017).

2 OBJECTIVES

The main objectives of the test trenching program were:

1. To collect bulk samples of Gila Conglomerate to determine its suitability and properties as a construction material.
2. To characterize surface features of the Gila Conglomerate, i.e., depth of weathering, gradation, cementation, strength, and variability.
3. To identify, if possible, any structural features within Gila Conglomerate, such as any clay filled bedding planes within the sandstone facies, or openings that may serve as conduits for fluid flow.
4. To complete infiltration tests in Gila Conglomerate as a semi-quantitative estimate of hydraulic conductivity.

3 TEST TRENCHING PROGRAM

Nine trenches were excavated using a 9 ton 308C Caterpillar excavator with a 24" wide toothed bucket, except at TP17-34 where a larger 24 ton Komatsu 220 was brought in to attempt to excavate to a greater depth. Test trench locations are shown on Figure 1, and details are outlined in Table 3.1. Stratigraphic logs for the trenches are included in Appendix I.

Infiltration testing was carried out at TP17-32, TP17-36 and TP17-37 to provide a semi-quantitative assessment of hydraulic conductivity. The tests were carried out in open pits excavated into the Gila Conglomerate by the excavator about 4 ft deep, roughly 4 ft x 4 ft in area, with between 6" and 8" of water. The water level was then monitored over 1 to 4 hours. The duration of the tests may not have been long enough to allow full saturation of the rock surrounding the pit. The results of the infiltration tests are shown on Figure 2 and Table 3.2. The infiltration rates are the falling head velocity averaged over the final three time steps at the end of the test period, and have not been transformed to an equivalent saturated hydraulic conductivity.

Table 3.1 2017 Test Trenching Summary

Test Trench No.	Drill Pad	Depth (ft)	Northing[1,2] (ft)	Easting[1,2] (ft)	Ground Elevation (ft)[2]	Date	Comments
TP17-31	GT-15	7.5	842237	922823	2441.4	27-Feb-17	No bedrock encountered.
TP17-32	GT-20	3.5	843668	926165	2498.5	27-Feb-17	Refusal at 3.5 ft. Falling head infiltration test conducted; see Figure 2.
TP17-33	GT-21	3.5	841667	924850	2568.5	28-Feb-17	Refusal at 3.5 ft.
TP17-34	GT-14	3.0	838469	923191	2407.9	28-Feb-17	Refusal at 3.0 ft with larger Komatsu 220 excavator (24 US tons).
TP17-35	GT-8	4.5	840639	919194	2391.3	01-Mar-17	Refusal at 4.5 ft.
TP17-36	GT-7	2.5	842616	918064	2488.1	01-Mar-17	Refusal at 2.5 ft. Falling head infiltration test conducted; see Figure 2.
TP17-37	GT-16	3.5	845108	920153	2665.6	01-Mar-17	Refusal at 3.5 ft. Falling head infiltration test conducted; see Figure 2. Approximately 0.5 ft of capillary zone noted in the trench.
TP17-38	GT-19	3.5	846998	923369	2671.3	02-Mar-17	Refusal at 3.5 ft.
TP17-39	GT-17	3.0	849377	921436	2735.9	02-Mar-17	Refusal at 3.0 ft.

Notes:
1. Coordinates are presented in Arizona State Plane system, NAD 83 datum.
2. Locations were surveyed with a handheld GPS. Elevations were obtained from a digital terrain model based on GPS coordinates.

Table 3.2 Falling Head Infiltration Test Results

Test Trench	Description	Location	Infiltration Rate (cm/s)
TP17-32 (GT-20)	Unweathered conglomerate with medium gravel sized clasts and a strong acid reaction.	Bear Tank tributary floor.	7.6×10^{-5}
TP17-36 (GT-7)	Unweathered conglomerate with fine gravel sized clasts and a weak acid reaction.	Ridge crest east of Bear Tank near southern contact of Gila.	1.3×10^{-5}
TP17-37 (GT-16)	Unweathered conglomerate with coarse gravel sized clasts and a strong acid reaction.	Ridge crest east of Bear Tank in center of TSF.	1.6×10^{-4}

Notes:
1. Infiltration rate is the falling head velocity averaged over the final three time steps at the end of the test period, and has not been transformed to an equivalent saturated hydraulic conductivity

4 SUMMARY OF TEST TRENCHING OBSERVATIONS

Figure 1 shows test trench locations. Test trench logs are included in Appendix I. General photographs of the test trenching program are included Appendix II.

Laboratory testing is planned to assess the suitability of Gila Conglomerate as a potential construction material, and will be reported the PFS site characterization report for the TSF.

Observations from the test trenching indicate:

- Gila Conglomerate is very difficult to rip, with refusal being met at less than 5 ft, even with a toothed bucket on the excavators.
- Based on acid reaction in the field, carbonate content is variable, and is generally higher west of Bear Tank Canyon (Table 4.1).
- Increased carbonate content seemed to correlate to increasing excavation difficulty due to a higher degree of cementation.
- Depth of weathering is typically 2 ft or less. Weathering products are typically weakly cemented silty sand with some gravel (Table 4.2).
- Gravel and cobble content decreases to the south (Table 4.1).
- Ripping with a toothed excavator bucket yields a variable grainsize distribution of coarse gravel to cobble sized cemented fragments, individual liberated clasts, and pulverized sand.
- Infiltration rates vary with grainsize, and are an order of magnitude greater in coarse northern facies than in finer southern facies (Table 3.2).
- No groundwater was observed in any pits.

Table 4.1 Spatial Variation in Grainsize of Gila Conglomerate

Test Trench	Acid Reaction[1]	Description of Grain Size of Gila Conglomerate Constituents	Location	Comment
TP17-31 (GT-15)	N/A	N/A	Bear Tank Canyon floor upstream of proposed cleaner cell starter dam.	No Gila Conglomerate.
TP17-32 (GT-20)	Strong	Fine to coarse gravel, some sand to sandy, some cobbles, trace silt.	Bear Tank tributary floor near northern contact of Gila Conglomerate.	Overlain by 2.5 ft of alluvium.
TP17-33 (GT-21)	None	Fine to coarse gravel, and sand, trace cobbles, trace silt.	Ridge crest east of Bear Tank.	1 ft of completely weathered Conglomerate.
TP17-34 (GT-14)	Strong	Sand, some fine gravel, trace silt.	Flat area at south edge of TSF.	Carbonate accumulation from surface precipitation.
TP17-35 (GT-8)	Weak	Fine to coarse gravel, mostly fine, sandy to and sand, no cobbles, trace silt.	Hillside west of Bear Tank near southern contact of Gila Conglomerate.	-
TP17-36 (GT-7)	Weak	Sand, and gravel to gravelly, trace to some cobbles.	Ridge crest east of Bear Tank near southern contact of Gila Conglomerate.	-
TP17-37 (GT-16)	Weak	Fine to coarse gravel, sandy, some cobbles.	Ridge crest east of Bear Tank in center of TSF.	-
TP17-38 (GT-19)	Strong	Fine to coarse gravel, sandy, some cobbles, trace boulders.	Ridge crest east of Bear Tank near northern contact of Gila Conglomerate.	Limestone exposed to the north.
TP17-39 (GT-17)	Strong	Fine to coarse gravel, sandy, some cobbles.	Ridge crest east of Bear Tank near northern contact of Gila Conglomerate.	Limestone exposed to the north.

Notes:

1. Weak acid reaction is a few bubbles. Strong acid reaction is vigorous foaming.

Table 4.2 Depth of Weathering at Test Trenches

Test Trench	Depth and Degree of Weathering	Location	Comment
TP17-31 (GT-15)	N/A.	Bear Tank Canyon floor.	No Gila Conglomerate.
TP17-32 (GT-20)	Little to no weathering.	Bear Tank tributary floor.	2.5 ft of alluvium overlying Gila Conglomerate.
TP17-33 (GT-21)	0 ft to 1 ft Completely weathered, compact 1 ft to 2 ft Highly weathered, R0-R2.	Ridge crest.	1 ft of completely weathered Gila Conglomerate.
TP17-34 (GT-14)	0 ft to 1 ft Moderately to highly weathered, R0-R2 1 ft to 2 ft Slightly to moderately weathered, R2.	Flat area at south edge of TSF.	Up to 2 ft of material removed during pad preparation.
TP17-35 (GT-8)	0 ft to 0.8 ft Completely weathered, compact 0.8 ft to 1.5 ft Slightly to moderately weathered, R1-R2.	Hillside west of Bear Tank.	-
TP17-36 (GT-7)	No weathered horizon remaining.	Ridge crest east of Bear Tank near southern contact of Gila.	Up to 3 ft of material removed during pad preparation.
TP17-37 (GT-16)	0 ft to 1 ft Completely weathered, compact to dense.	Ridge crest east of Bear Tank in center of TSF.	-
TP17-38 (GT-19)	No weathered horizon remaining.	Ridge crest east of Bear Tank near northern contact of Gila.	Up to 2 ft of material removed during pad preparation.
TP17-39 (GT-17)	No weathered horizon remaining.	Ridge crest east of Bear Tank near northern contact of Gila.	Up to 2 ft of material removed during pad preparation.

5 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Resolution Copper Mining LLC (Client) for the specific application to the Resolution Copper Project. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavored to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

KLOHN CRIPPEN BERGER LTD.

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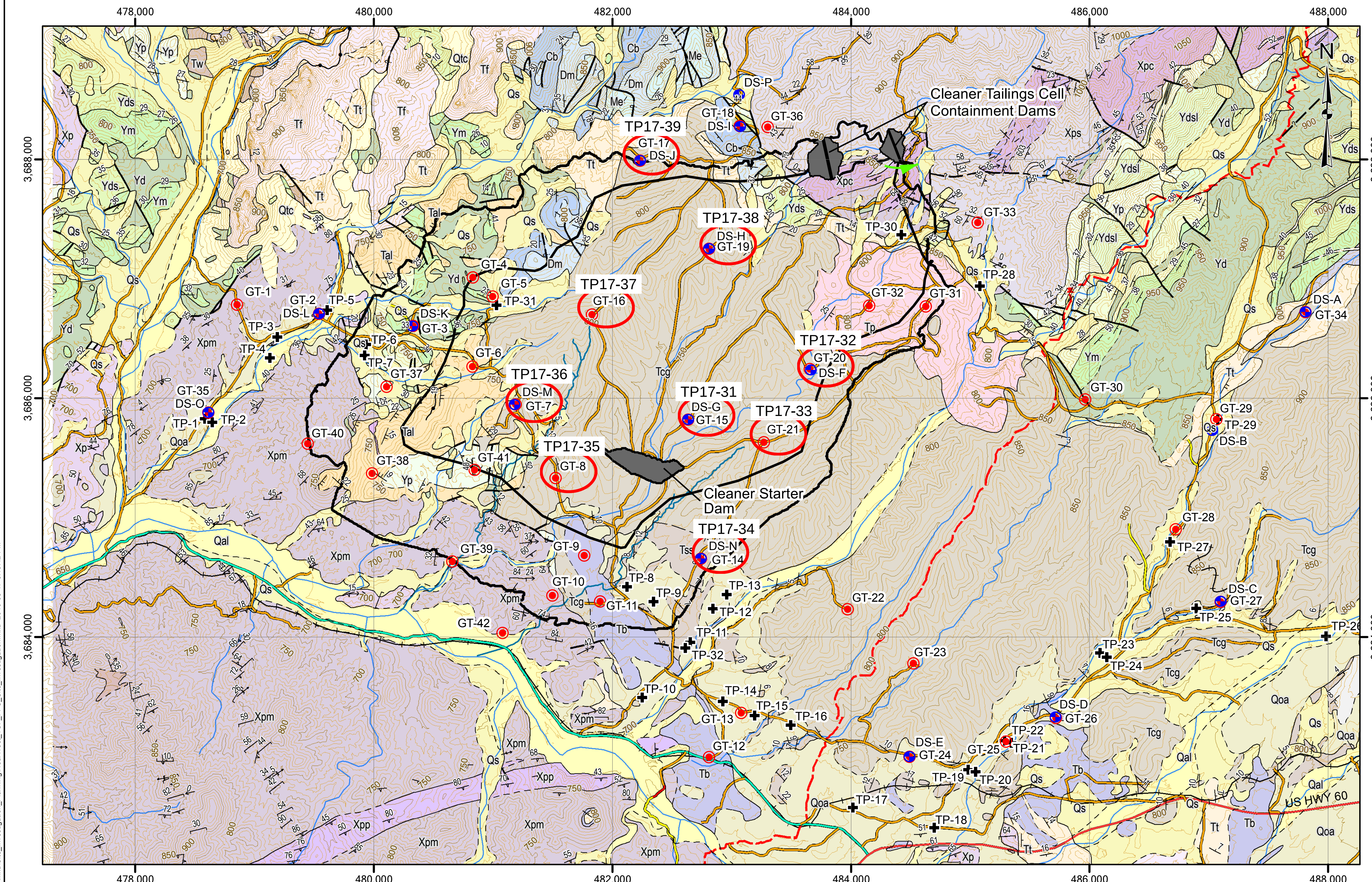
Engineering Geologist

Kate Patterson, P.E., M.Eng.
Project Manager

REFERENCES

Golder Associates Ltd. 2017. Near West TSF Geotechnical Investigation – Field Summary Report (Draft). Submitted to Resolution Copper Mining, March 27.

FIGURES



Qs	Undivided Surficial Deposits (Quaternary)
Qtd	Disturbed Surficial Deposits (Holocene)
Qtc	Talus and Colluvium (Quaternary)
Qal	Unconsolidated Alluvium (Quaternary)
Qoa	Old Alluvium (Quaternary)
QTs	Older Alluvium (Early Quaternary to Late Tertiary)
Tcg	Conglomerate (Pliocene to Late Miocene)
Tss	Sandstone (Pliocene to late Miocene)
Tb	Basalt (Mid-Miocene to Early Miocene)
Tp	Perlitic Aphyric Rhyolite (Middle Tertiary)
Tal	Apache Leap Tuff (Early Miocene)
Tt	Tuff (poorly welded) (Miocene)
Tf	Felsic Volcanic Rocks, undivided (Middle Tertiary)
Tbl	Lower Basalt (Middle Tertiary)
Tx	Rock Avalanche or Talus Breccia (Middle Tertiary)
Tw	Whitetail Conglomerate
Tdb	Basaltic Dikes (Middle Tertiary)
Kd	Quartz Diorite (Latest Cretaceous)
Me	Escabrosa Limestone (Mississippian)
Dm	Martin Limestone (Devonian)
Cb	Bolsa Quartzite (Cambrian)
Yd	Diabase (Middle Proterozoic)
Ym	Mescal Limestone (Middle Proterozoic)
Yds	Dripping Spring Quartzite, undivided (Middle Proterozoic)
Ydsu	Dripping Spring Quartzite, Upper Unit (Middle Proterozoic)
Ydsl	Dripping Spring Quartzite, Lower Unit (Middle Proterozoic)
Yp	Pioneer Shale (Middle Proterozoic)
Ypt	Pioneer Shale, Tuff Unit (Middle Proterozoic)
YXd	Diorite (Early or Middle Proterozoic)
Xp	Pinal Schist, undivided (Early Proterozoic)
Xpc	Pinal Schist, Calc-silicate Facies (Early Proterozoic)
Xpcs	Pinal Schist, Calc-silicate and Schist Facies (Early Proterozoic)
Xpm	Pinal Schist, Psammite Facies (Early Proterozoic)
Xpp	Pinal Sctist, Phyllite Facies (Early Proterozoic)
Xpq	Pinal Schist, Quartzite Layers (Early Proterozoic)
Xps	Pinal Schist, Pelitic Schist (Early Proterozoic)

0 2,500 Feet

0 1 km

LEGEND

- GEOTECHNICAL DRILL SITE (GT-1 THROUGH GT-41)
- HYDROLOGIC DRILL SITE (DS-A THROUGH DS-P)
- TEST TRENCH SITE (TP-1 THROUGH TP-32)
- NEAR WEST TAILINGS SITE
- SPILLWAY
- TP17-36 DS-M GT-7 GILA TEST TRENCH

TRANSPORTATION

- BASIC CUSTODIAL CARE (CLOSED)
- HIGH CLEARANCE VEHICLES
- MODERATE DEGREE OF USER COMFORT
- PRIVATE ROAD
- HIGHWAY
- RAILROAD
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)

- FELSIC DYKE
- FAULT
- FAULT - APPROXIMATE
- FAULT - CONCEALED
- MARKER HORIZON (LOCAL)

- CONTACT (BETWEEN GEOLOGIC UNITS)
- CONTACT - APPROXIMATE
- CONTACT - INFERRED
- CONTACT BETWEEN PINAL SCHIST
  CLAST-RICH CONGOMERATE BELOW AND DRIPPING SPRING QUARTZITE CLAST-RICH CONGLOMERATE ABOVE

- STREAM

NOTES:
1. NAD27 UTM12N
2. REFER TO MAIN REPORT FOR SOURCE OF GEOLOGIC DATA.

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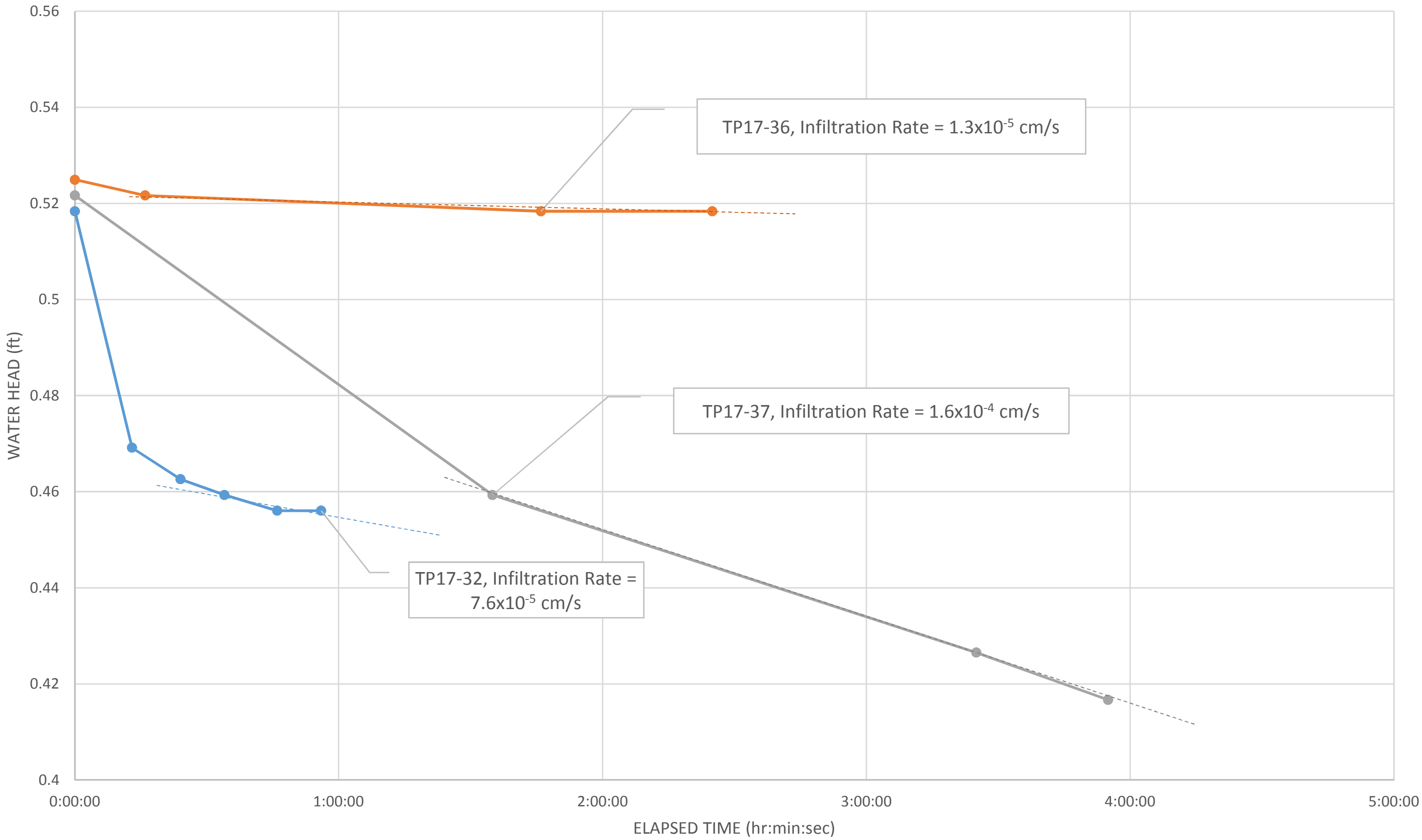
Klohn Crippen Berger

PROJECT
NEAR WEST TAILINGS STORAGE FACILITY

TITLE
GILA TEST TRENCHING LOCATION PLAN

PROJECT No. M09441A18

FIG No. 1



CLIENT

Resolution Copper Mining

Klohn Crippen Berger

PROJECT

NEAR WEST TAILINGS STORAGE FACILITY

TITLE

FALLING HEAD INFILTRATION TEST SUMMARY

PROJECT No.	FIG. No.
M09441A18	2

Date & Time: 2017-04-26 9:59
Figure File: Z:\M\VCR\M09441A18 - RES-Near West PFS\300 Design\320 Site Investigation\Test Pitting\[Falling head tests.xlsx]Sheet1

APPENDIX I

Test Trench Logs

TEST PIT LOG TP17-31

STARTED: 17-2-27	**FINISHED:** 17-2-27
EXCAVATOR TYPE: Komatsu 220	
GROUND ELEV. (ft): 2441.4	
COORDINATES (ft): N 842237	E 922823

Su - ksf: 1, 2, 3, 4

VANE: FIELD, LAB — PEAK ◆ ■; REMOLD ◇ □; ▲ UC/2; △ P.PEN/2

★ % FINES

W_P% — W% — W_L%: 20, 40, 60, 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0 – 7.50	Bucket	S1 S2		GRAVEL (GC), fine to coarse, some clay to clayey, some sand, trace cobbles, fines of intermediate plasticity, compact, sub-angular to sub-rounded, reddish brown, moist, diabase clasts completely weathered to sand. [COLLUVIUM/ALLUVIUM]	
7.50 2433.9				End of Pit at 7.50 feet	

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Coordinates are in Arizona State Plane, NAD 83.

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

KCBL_TEST_PIT-IMP 170317 GILA TEST PITS.GPJ KC_DATA.GDT 5-4-17

Klohn Crippen Berger

PROJECT NO.: M09441A18	
PROJECT: Near West Tailings Storage Facility	
LOCATION: Superior, Arizona	
LOGGED BY: CK	**CHECKED BY:** NG
SHEET 1 **OF** 1	**HOLE NO.:** TP17-31

TEST PIT LOG TP17-32

STARTED: 17-2-27 **FINISHED:** 17-2-27
EXCAVATOR TYPE: Komatsu 220
GROUND ELEV. (ft): 2498.5
COORDINATES (ft): N 843668 E 926165

Su - ksf: 1, 2, 3, 4
VANE: PEAK (FIELD ◆, LAB ■); REMOLD (FIELD ◇, LAB □); ▲ UC/2; △ P.PEN/2
★ % FINES
W_P% — W% — W_L%: 20, 40, 60, 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0–2.50	Bucket	S1 S2 S3 S4		GRAVEL (GM), fine to coarse, some sand, some silt, compact to loose, sub-angular, brown, moist, no obvious structure. [ALLUVIUM]	
2.50 (2496.0)–3.50				GILA CONGLOMERATE, brown, moderately weathered, weak rock (R2), very crude sub-horizontal bedding, composed of gravel (GW), fine to coarse, some sand to sandy, some cobbles, no to trace silt, angular to sub-angular, strong reaction to hydrochloric acid.	
3.50 (2495.0)				End of Pit at 3.50 feet	

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 3.5 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Depth scale (feet): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

KCBL_TEST_PIT-IMP 170317 GILA TEST PITS.GPJ KC_DATA.GDT 5-4-17

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Near West Tailings Storage Facility
LOCATION: Superior, Arizona
LOGGED BY: CK **CHECKED BY:** NG
SHEET 1 **OF** 1 **HOLE NO.:** TP17-32

TEST PIT LOG TP17-33

STARTED: 17-2-28 **FINISHED:** 17-2-28
EXCAVATOR TYPE: Komatsu 220
GROUND ELEV. (ft): 2568.5
COORDINATES (ft): N 841667 E 924850

Su - ksf: 1 2 3 4
VANE: FIELD / LAB — PEAK ◆ ■ — REMOLD ◇ □ — ▲ UC/2 — △ P.PEN/2
★ % FINES
$W_P\%$ — W% — $W_L\%$: 20 40 60 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	Depth / Elev.	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0 – 1				1.00	SAND (SM), and silt to silty, some gravel (fine), compact, reddish brown, moist (completely weathered rock; diabase clasts weathered to micaceous sand and silt; relict structure crude horizontal bedding; no reaction to hydrochloric acid). [RESIDUAL SOIL]	
1 – 2	Bucket	S1 S2		2567.5 / 2.00	GILA CONGLOMERATE, reddish brown, highly weathered, extremely weak to very weak rock (R0 to R1), crude horizontal bedding, composed of gravel (GW), and sand, silty, moist, no reaction to hydrochloric acid.	
2 – 3.5	Bucket	S3 S4 S5 S6		2566.5 / 3.50	GILA CONGLOMERATE, reddish brown, rusty mottling, moderate cementation, highly weathered, extremely weak to weak rock (R0 to R2), crude horizontal stratification, breaks into tabular pieces with an excavator, composed of gravel (GW), fine to coarse, and sand to sandy, trace silt, trace cobbles, well-graded, no reaction to hydrochloric acid.	
				2565.0	End of Pit at 3.50 feet	

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 3.5 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Near West Tailings Storage Facility
LOCATION: Superior, Arizona
LOGGED BY: CK **CHECKED BY:** NG
SHEET 1 **OF** 1 **HOLE NO.:** TP17-33

TEST PIT LOG TP17-34

STARTED: 17-2-28 **FINISHED:** 17-2-28

EXCAVATOR TYPE: Komatsu 220

GROUND ELEV. (ft): 2407.9

COORDINATES (ft): N 838469 E 923191

Su - ksf: 1, 2, 3, 4

VANE PEAK / REMOLD — FIELD, LAB; UC/2; P.PEN/2

% FINES

W_P% W% W_L%: 20, 40, 60, 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	Depth / Elev.	DESCRIPTION OF MATERIALS
0–1			1.00 / 2406.9	GILA SANDSTONE, highly weathered, extremely weak to weak rock (R0-R2), horizontal stratification, roots appear to have sprung open bedding which has subsequently infilled with carbonate, composed of sand (SP), fine to medium, some gravel (fine), poorly-graded, angular to sub-angular, strong reaction to hydrochloric acid. At 0.8 ft, interlayered with 1/4" to 1" thick layers of carbonate were noted.
1–2	Bucket	S1, S2	2.00 / 2405.9	GILA SANDSTONE, slightly weathered, weak rock (R2), horizontal stratification, roots appear to have sprung open bedding which has subsequently infilled with carbonate 1/5" thick, no sign of clay beds, composed of sand (SP), fine to medium, some gravel (fine), poorly-graded, angular to sub-angular, strong reaction to hydrochloric acid.
2–3	Bucket	S3, S4	3.00 / 2404.9	GILA SANDSTONE, slightly weathered, medium strong rock (R3), no signs of sprung bedding and carbonate layers, composed of sand (SP), fine to medium, some gravel (fine), poorly-graded, angular to sub-angular, strong reaction to hydrochloric acid.

End of Pit at 3.00 feet

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 3.0 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Depth scale (feet): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Klohn Crippen Berger

PROJECT NO.: M09441A18

PROJECT: Near West Tailings Storage Facility

LOCATION: Superior, Arizona

LOGGED BY: CK **CHECKED BY:** NG

SHEET 1 **OF** 1 **HOLE NO.:** TP17-34

TEST PIT LOG TP17-35

STARTED: 17-3-01	**FINISHED:** 17-3-01
EXCAVATOR TYPE:	Komatsu 220
GROUND ELEV. (ft):	2391.3
COORDINATES (ft):	N 840639 E 919194

Su - ksf: 1, 2, 3, 4
VANE: FIELD, LAB
PEAK ◆ ■
REMOLD ◇ □
▲ UC/2
△ P.PEN/2
★ % FINES
W_P% W% W_L%
20 40 60 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	DEPTH / ELEV.	DESCRIPTION OF MATERIALS
0 – 0.80			0.80 / 2390.5	SAND (SM), gravelly, some silt, trace cobbles, compact to dense, brown, dry-moist, weak to no reaction to hydrochloric acid. [RESIDUAL SOIL]
0.80 – 1.50			1.50 / 2389.8	GILA CONGLOMERATE, reddish brown, slightly to moderately weathered, very weak to weak rock (R1 to R2), composed of gravel (GW), sandy to and sand, trace cobbles, trace silt, well-graded, sub-angular, weak to no reaction to hydrochloric acid.
1.50 – 4.50	Bucket	S1 S2 S3 S4	4.50 / 2386.8	GILA CONGLOMERATE, reddish brown, slightly weathered with extremely weathered clasts, weak to medium strong rock (R2 to R3), composed of gravel (GW), sandy to and sand, trace cobbles, trace silt, trace roots, well-graded, dense, sub-angular, moist to wet, weak to no reaction to hydrochloric acid.
				End of Pit at 4.50 feet

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 4.5 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Depth scale (feet): 1 2 3 4 5 6 7 8 9 10 11 12

INSTRUMENT DETAILS

Klohn Crippen Berger

PROJECT NO.: M09441A18	
PROJECT: Near West Tailings Storage Facility	
LOCATION: Superior, Arizona	
LOGGED BY: CK	**CHECKED BY:** NG
SHEET 1 **OF** 1	**HOLE NO.:** TP17-35

TEST PIT LOG TP17-36

STARTED: 17-3-01 **FINISHED:** 17-3-01
EXCAVATOR TYPE: Komatsu 220
GROUND ELEV. (ft): 2488.1
COORDINATES (ft): N 842616 E 918064

Su - ksf: 1 2 3 4

VANE: FIELD, LAB — PEAK ◆ ■ — REMOLD ◇ □ — ▲ UC/2 — △ P.PEN/2
★ % FINES
W_P% W% W_L%
× — — — — o — — — — ×
20 40 60 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0 – 2.50	Bucket	S1, S2, S3, S4		GILA CONGLOMERATE, light brown, fresh to slightly weathered, medium strong rock (R3), no obvious structure, composed of sand (SW), fine to coarse, and fine to coarse gravel to gravelly, trace to some cobbles up 12", well-graded, sub-angular, dry, weak to no reaction to hydrochloric acid.	
2.50 / 2485.6				End of Pit at 2.50 feet	

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 2.5 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Near West Tailings Storage Facility
LOCATION: Superior, Arizona
LOGGED BY: CK **CHECKED BY:** NG
SHEET 1 **OF** 1 **HOLE NO.:** TP17-36

TEST PIT LOG TP17-37

STARTED: 17-3-01 **FINISHED:** 17-3-02
EXCAVATOR TYPE: Komatsu 220
GROUND ELEV. (ft): 2665.6
COORDINATES (ft): N 845108 E 920153

Su - ksf: 1, 2, 3, 4
VANE: FIELD, LAB — PEAK ◆ ■; REMOLD ◇ □; ▲ UC/2; △ P.PEN/2
★ % FINES
W_P% W% W_L%: 20 40 60 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	Depth / Elev.	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0 – 1.00				1.00	GRAVEL (GM), fine to coarse, sandy, some silt, trace cobbles up to 6", compact to dense, sub-angular, dark brown, moist, strong reaction to hydrochloric acid. [RESIDUAL SOIL]	
1.00 – 3.50	Bucket	S1 S2		2664.6 / 3.50	GILA CONGLOMERATE, light brown, slightly weathered, weak rock (R1), some clasts weathered to very weak rock, no obvious structure, composed of gravel (GW), fine to coarse, sandy, some cobbles, trace silt, well-graded, angular, dry, weak to no reaction to hydrochloric acid. At 1.0 ft, several 1/4" thick layers of carbonate were noted.	
3.50		S3 S4		2662.1	End of Pit at 3.50 feet	

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 3.5 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates ara in Arizona State Plane, NAD 83.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Near West Tailings Storage Facility
LOCATION: Superior, Arizona
LOGGED BY: CK **CHECKED BY:** NG
SHEET 1 **OF** 1 **HOLE NO.:** TP17-37

TEST PIT LOG TP17-38

STARTED: 17-3-02 **FINISHED:** 17-3-02
EXCAVATOR TYPE: Komatsu 220
GROUND ELEV. (ft): 2671.3
COORDINATES (ft): N 846998 E 923369

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0–3.50	Bucket	S1 S2 S3 S4		GILA CONGLOMERATE, reddish brown, moderately weathered, weak rock (R2), some diabase clasts are weathered to extremely weak rock (R0), no obvious structure, composed of gravel (GW), fine to coarse, and sand, some cobbles, trace limestone boulders up to 18", trace silt, well-graded, sub-angular, dry, strong reaction to hydrochloric acid.	
3.50 2667.8				End of Pit at 3.50 feet	

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 3.5 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Su - ksf: 1 2 3 4
VANE FIELD LAB
PEAK ◆ ■ ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES
W_P% W% W_L%
× — — — — o — — — — ×
20 40 60 80

Klohn Crippen Berger

PROJECT NO.: M09441A18
PROJECT: Near West Tailings Storage Facility
LOCATION: Superior, Arizona
LOGGED BY: CK **CHECKED BY:** NG
SHEET 1 **OF** 1 **HOLE NO.:** TP17-38

TEST PIT LOG TP17-39

STARTED: 17-3-02	**FINISHED:** 17-3-02
EXCAVATOR TYPE: Komatsu 220	
GROUND ELEV. (ft): 2735.9	
COORDINATES (ft): N 849377	E 921436

Su - ksf: 1, 2, 3, 4

VANE: PEAK (FIELD ◆, LAB ■); REMOLD (FIELD ◇, LAB □); ▲ UC/2; △ P.PEN/2; ★ % FINES

W_P% — W% — W_L%: 20, 40, 60, 80

DEPTH (feet)	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0–3	Bucket	S1, S2, S3, S4		GILA CONGLOMERATE, reddish brown, strong cementation, moderately weathered, weak to medium strong rock (R2-R3), no obvious structure, composed of gravel (GP), fine to coarse, some sand, some cobbles, trace silt, poorly-graded, maximum particle size 14", angular, dry, strong reaction to hydrochloric acid.	
3.00 (2732.9)				End of Pit at 3.00 feet	

1. Test pit was backfilled with excavated material and compacted in 1 ft lifts.
2. No groundwater was noted.
3. Refusal at 3.0 ft. Gila Conglomerate, and was difficult to excavate.
4. Coordinates are in Arizona State Plane, NAD 83.

Depth scale (feet): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Klohn Crippen Berger

PROJECT NO.: M09441A18	
PROJECT: Near West Tailings Storage Facility	
LOCATION: Superior, Arizona	
LOGGED BY: CK	**CHECKED BY:** NG
SHEET 1 **OF** 1	**HOLE NO.:** TP17-39

APPENDIX II

Test Trench Photos

Appendix II
Test Trench Photos

2017 GILA TEST TRENCHING

Photo II-1 TP17-31 - Drill pad prior to test trenching. (Feb. 27, 2017)

Photo II-2 TP17-31 - Clayey gravel alluvium/colluvium. (Feb. 27, 2017)

Photo II-3 TP17-31 - Clayey gravel alluvium/colluvium excavated from the trench. (Feb. 27, 2017)

Photo II-4 TP17-32 - Drill pad prior to excavation. (Feb. 27, 2017)

Photo II-5 TP17-32 - 2.5 ft of alluvium composed of gravel, some sand, some silt, overlying Gila Conglomerate in base of trench. (Feb. 27, 2017)

Photo II-6 TP17-32 - Gila Conglomerate excavated from base of trench. (Feb. 27, 2017)

Photo II-7 TP17-32 - Cemented fragment of moderately weathered Gila Conglomerate from 2 ft depth. (Feb. 27, 2017)

Photo II-8 TP17-32 - Infiltration test in test trench. (Feb. 27, 2017)

Photo II-9 TP17-33 - Drill pad on ridge prior to test trenching. (Feb. 28, 2017)

Photo II-10 TP17-33 - 1 ft of compact residual soil overlying highly weathered Gila Conglomerate with rusty mottling. (Feb. 28, 2017)

Photo II-11 TP17-33 - Gila Conglomerate excavated from trench, forming gravel size cemented fragments. (Feb. 28, 2017)

Photo II-12 TP17-33 - Gila Conglomerate at 2.5 ft depth. (Feb. 28, 2017)

Photo II-13 TP17-34 - Drill pad on broad flat area before excavation. (Feb. 28, 2017)

Photo II-14 TP17-34 - Initial test trench excavation. (Feb. 28, 2017)

Photo II-15 TP17-34 - Carbonate layer with plant root at 1 ft depth. (Feb. 28, 2017)

Photo II-16 TP17-34 - Gila Sandstone with 1 ft of highly weathered sandstone with carbonate accumulation along sprung bedding, overlying slightly weathered sandstone. (Feb. 28, 2017)

Photo II-17 TP17-34 - Gravel sized fragments of cemented sandstone excavated from trench. (Feb. 28, 2017)

Photo II-18 TP17-34 - Gravel sized fragments of cemented sandstone excavated from trench. (Feb. 28, 2017)

Photo II-19 TP17-35 - Drill pad on hill side before excavation. (Mar. 1, 2017)

Photo II-20 TP17-35 - 0.8 ft of residual soil overlying slightly weathered Gila Conglomerate. (Mar. 1, 2017)

Photo II-21 TP17-35 - Fine grained facies of Gila Conglomerate. (Mar. 1, 2017)

Photo II-22 TP17-35 - Pile of excavated material and buckets being filled with sample. (Mar. 1, 2017)

Photo II-23 TP17-36 - Drill pad before excavation. (Mar. 1, 2017)

Photo II-24 TP17-36 - Pit excavated in Gila Conglomerate, with 1 foot diameter cobble of schist in right hand corner. (Mar. 1, 2017)

Photo II-25 TP17-36 - Close up of face excavated in Gila Conglomerate. (Mar. 1, 2017)

Photo II-26 TP17-36 - Infiltration test in test trench. (Mar. 1, 2017)

Photo II-27 TP17-37 - Pit excavated in Gila Conglomerate, with 1 foot of residual soil slightly weathered Gila Conglomerate. (Mar. 1, 2017)

Photo II-28 TP17-37 - Pit excavated in Gila Conglomerate, with 1 foot of residual soil slightly weathered Gila Conglomerate. (Mar. 1, 2017)

Photo II-29 TP17-37 - Pit excavated in Gila Conglomerate, with 1 foot of residual soil slightly weathered Gila Conglomerate. (Mar. 1, 2017)

Photo II-30 TP17-37 - Close up of texture of intact Gila Conglomerate. (Mar. 1, 2017)

Photo II-31 TP17-37 - Material excavated from test trench. (Mar. 1, 2017)

Photo II-32 TP17-37 - Infiltration test in test trench. (Mar. 2, 2017)

Photo II-33 TP17-38 - Drill pad on ridge prior to excavation. Pad is wet from rain 2 days prior. (Mar. 2, 2017)

Photo II-34 TP17-38 - Gila Conglomerate exposed in wall of trench. (Mar. 2, 2017)

Photo II-35 TP17-38 - Excavated material from test trench. (Mar. 2, 2017)

Photo II-36 TP17-39 - Drill pad on ridge prior to excavation. (Mar. 2, 2017)

Photo II-37 TP17-39 - Gila Conglomerate exposed in wall of trench. (Mar. 2, 2017)

Photo II-38 TP17-39 - Test trench with excavated material. (Mar. 2, 2017)

APPENDIX VI

HGI Shear Wave Report

RPT-2016-051

DOWNHOLE SEISMIC INVESTIGATION – RESOLUTION COPPER MINE, AZ

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Date Published
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Prepared for Resolution Copper Mining Ltd (RCML)

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

This report documents the results of a downhole seismic investigation conducted at the Near West Site, in February 2017, under contract to Resolution Copper Mining Ltd (RCML) by hydroGEOPHYSICS, Inc. (HGI).

The downhole seismic investigation consisted of measuring the shear-wave and p-wave velocities in six boreholes across the Near West Site, chosen to investigate the varying geological units across the site.

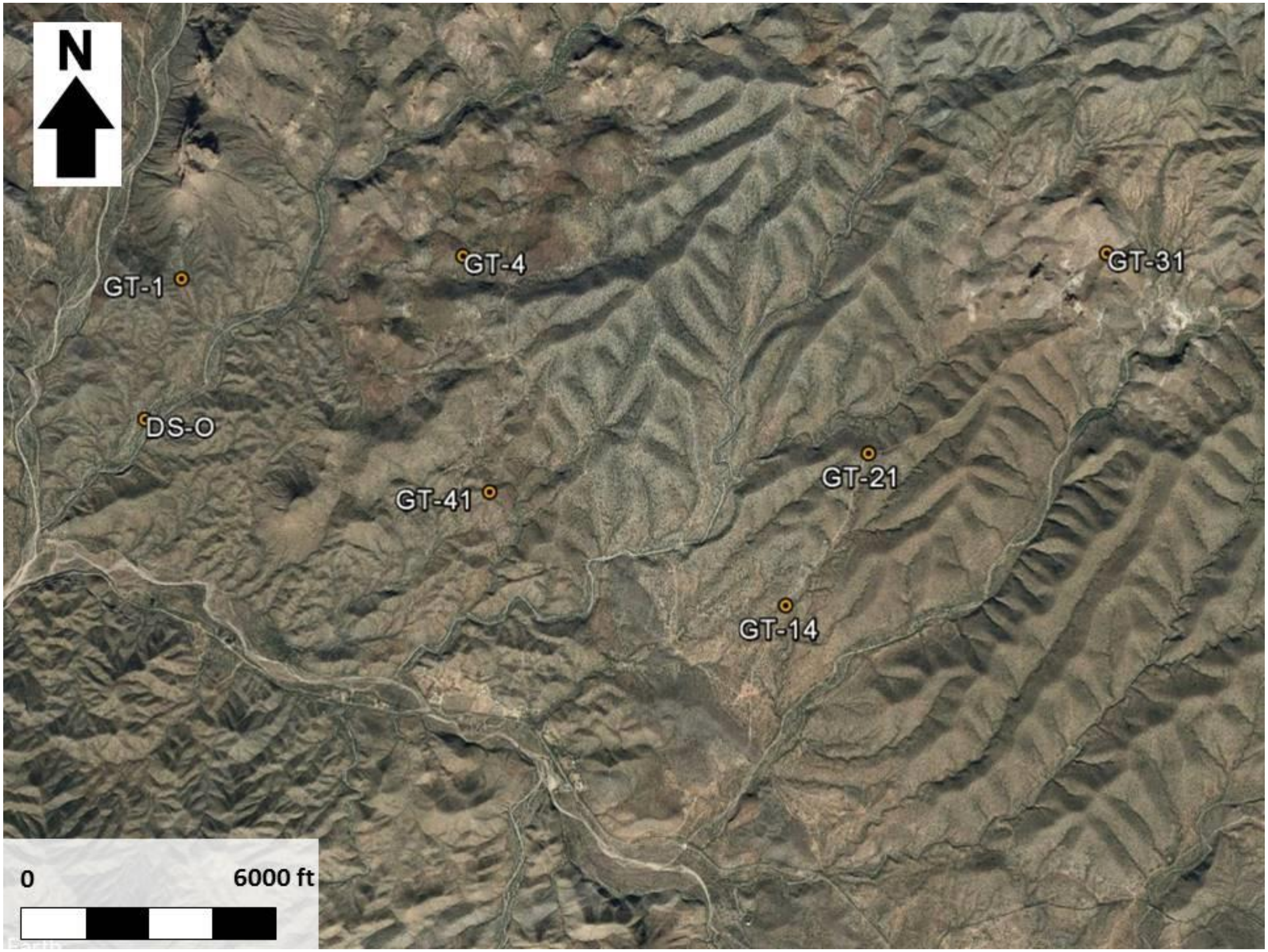
1.2 SITE LOCATION

The Near West Site is located adjacent to the town of Superior, AZ, approximately 70 miles east of Phoenix in Pinal County. The geophysical characterization was conducted at seven separate sites across the Near West Site, which are highlighted in Figure 1.

1.3 OBJECTIVE OF INVESTIGATION

The objective of the downhole seismic investigation is to provide one-dimensional (1D) shear-wave velocity profiles to determine the V_s30 values, to feed into the seismic hazard analysis for the site. In addition, 1D p-wave profiles will be collected to assist with the rippability assessment of the geological materials in the near surface.

Figure 1. General Location Map of the Six Boreholes of the Downhole Seismic Investigation.



2.0 METHODOLOGY

2.1 SURVEY AREA AND LOGISTICS

A downhole seismic investigation, consisting of shear-wave and p-wave measurements, was completed down six boreholes across the Near West Site, between the 11th and 14th February 2017. Table 1 provides a summary of the investigation parameters, and Figure 1 indicates the locations of the seven boreholes/areas surveyed. In addition, a multi-channel analysis of surface waves (MASW) profile was collected at the ground surface, to provide a comparison 1D shear-wave interval velocity profile – further details of the MASW method are provided in Appendix A.

Table 1. Downhole Seismic Investigation Survey Details.

Site #	Acquisition date	Measurement Spacing	Survey Length	PVC Casing Stick-up (Above ground surface)	Borehole Location (UTM, NAD 83, Zone 12N)
GT-1	2/12/17	5 feet	50 feet	2 feet 4 inches	478778, 3686973
GT-4	2/13/17	5 feet	110 feet	1 feet 11 inches	480603, 3687110
GT-14	2/10/17	5 feet	125 feet	3 feet 9 inches	482671, 3684873
GT-21	2/11/17	5 feet	110 feet	2 feet 9 inches	483200, 3685834
GT-31	2/14/17	5 feet	125 feet	2 feet 6 inches	484722, 3687098
GT-41	2/12/17	5 feet	125 feet	3 feet 2 inches	480780, 3685596
DS-O	1/21/17	n/a	MASW Only	1 feet 8 inches	478549, 3686081

2.2 EQUIPMENT

2.2.1 Equipment for Downhole Seismic Investigation

Data were collected using a Geode Ultra-Light Exploration 24–Channel Seismograph (Geometrics, Inc. - San Jose, CA), providing a total of 24-channels. A BHG-2 triaxial borehole geophone (Geostuff - Lincoln, CA) was used to detect the arrival times of the surface generated shear-waves and p-waves at 5 foot intervals along the surveyed depth of each borehole (Figure 2). The BHG-2 borehole geophone was manually lowered to the desired depth, the clamping mechanism was then engaged to physically lock the geophone against the pvc casing and ensure good coupling to the surrounding formations. **All depths are measured from the top of the 2 inch diameter pvc casing in each borehole (the stick-up lengths of the casings are listed in Table 1).**

Figure 2. The Triaxial Borehole Geophone prior to Deployment down the Borehole Casing.

Figure 3. Photograph of the Shear-Wave Pendulum Sledgehammer and Weighted Beam Source System, with the Field Vehicle used to Weight Down the Beam. The Monitoring Geophones for the Shear-Wave Source can be Seen in the Foreground.

The shear-waves were generated using a pendulum sledgehammer and weighted beam source system (Figure 3). The p-waves were generated using a sledgehammer and plate system, similar to typical surface based seismic refraction surveys. The weighted beam and hammer plate were typically positioned between 10 and 15 feet from the borehole, depending on access and terrain at each of the borehole locations. A number of additional surface based horizontal and vertical geophones were used to provide a check on the timing of the shear-wave and p-wave source triggers, to enable corrections for any inconsistencies in the trigger timing at each measurement depth interval in the boreholes. These monitoring geophones can be observed installed at the ground surface in the foreground of Figure 3 for the shear-wave monitoring. In this case, two horizontal geophones (orange geophones) and one vertical geophone (blue geophone) were used to monitor and correct trigger timing errors and provide a quality control check on shear-wave generation.

The Geode Seismograph was connected to a laptop in order to view each record, to ensure acceptable data quality, and record and process the data. Additional hammer blows forming a new "stack" of data were added until the desired data quality is achieved.

2.3 DATA PROCESSING

2.3.1 Quality Control – Onsite

Data from the shear-wave and p-wave collections were given a preliminary assessment for quality control (QC) in the field to assure quality of data before progressing the survey. Following onsite QC, the data were transferred to the HGI server for storage and detailed data processing and analysis.

2.3.2 Downhole Seismic Processing

The data processing flow for the downhole seismic used the SeisImager/DH (Geometrics Inc., San Jose, CA) downhole seismic processing software. Any geometry changes to correct for errors made during the field acquisition were conducted within the SeisImager software called PickWin (Version 4.2.0.0).

SeisImager's PickWin was then used to create data file lists for the shear-wave and p-wave data and assign each file to a particular receiver depth in the borehole. In the case of the p-wave results, the vertical component of the triaxial borehole geophone was selected and the first arrivals for each receiver depth are picked. If a monitoring geophone was used, as in this case, the first arrivals are picked for this channel and the PickWin software automatically corrects for any offset in the timing of the borehole geophone arrivals. In the case of the shear-wave results, the two horizontal components of the triaxial borehole geophone are first selected. Again, if a monitoring geophone was used, as in this case, the first arrivals are picked for this channel and the PickWin software automatically corrects for any offset in the timing of the two horizontal components of the borehole geophone arrivals. The two horizontal components are then polarized; this rotates the two components to direction of particle motion essentially correcting the horizontal geophone to the same plane as the surface beam source. The first arrivals of the shear-wave for each receiver depth are then picked.

SeisImager's PSLog module then calculates the traveltime curve and interval velocity model for each of the p-wave and shear-wave depth profiles based on the first arrival picks. The geometry of the downhole seismic survey was incorporated into the PSLog module to correct for the source offset from the borehole and difference in elevation between the borehole casing and source (plate or weighted beam).

2.3.3 Downhole Seismic Plotting

The interval velocity model results for each borehole were output from SeisImager's PSLog into an .XYZ data file and were then plotted as a step plot in Grapher 7 (Golden Software, Inc.).

3.0 RESULTS & INTERPRETATION

The interval velocity model results for the downhole seismic investigation are presented in Figures 4 through 9. The shear-wave and p-wave interval velocity profiles are included together with the interval velocity profiles for the surface based MASW method. We have included the latter for comparison as this method has a significantly larger sampling volume providing an additional assessment of the calculated V_s30 value.

Borehole GT-1

Shear-wave and p-wave measurements were collected at 5-foot intervals, to a depth of 50 feet below casing level (bcl) in this borehole, presented as 1-D interval velocity profiles in Figure 4. Borehole GT-1 was a replacement for GT-40, which proved to be inaccessible by vehicle and hence could not be surveyed. In addition, the topography at the location of GT-1 was not conducive for the surface based MASW method (labeled as S-Wave (surface) in Figure 4) and so the interval velocity profile from the MASW survey at the nearby borehole DS-O (Figure 1) is presented in Figure 4.

Geological logs from GT-1 indicate Pinal Schist along the entirety of the surveyed depth of the borehole. In general, the borehole shear-wave and p-wave interval velocity profiles display a gradual increase in velocity with depth, until approximately 30 feet (bcl) when we observe a sharp increase in velocity in both seismic waves. The shear-wave and p-wave interval velocity profiles then remain relatively constant until 50 feet (bcl), the final depth of the downhole seismic measurements. The shear-wave interval velocity profile for the surface based MASW method displays a similar gradual increase in velocity with depth. Below approximately 20 feet (bcl), the overall velocity tends to be significantly lower than the downhole shear-wave profile. This is unusual, as published investigations have shown the surface and downhole shear-wave profiles typically agree to within 15-20%. This discrepancy is reflected in many of the surface versus downhole shear-wave profiles within this study. One possible explanation for this particular case is the difference in the locations of the surface versus the downhole locations. The DS-O borehole is located in the valley floor, next to a major drainage, where the bedrock could be more weathered than the hill slope location of borehole GT-1, resulting in lower seismic velocities. However, it was communicated to HGI, by Klohn Crippen Berger, that the borehole logs indicating a similar degree of weathering in both boreholes. Hence, there is potential for a problem with either the surface based shear-wave profiles or downhole seismic profiles, in terms of the seismic velocities being too high or low. In addition, the Poisson's Ratio profile, calculated using the downhole shear-wave and p-wave results, is shown in Figure 5. This ratio displays a gradual decrease between the ground surface and approximately 30 feet (bcl), where we observe a significant decrease to negative or near zero values. The negative and near zero values are unrealistic for geological materials and this leads us to conclude that a problem exists with this depth interval of the downhole shear-wave and p-wave results. There are a number of explanations for the low to negative Poisson's Ratio including:

- Potential errors relating to the equipment used, either the downhole geophone or timing issues with the seismograph.
- Potential errors resulting from the coupling between the grouting and both the casing and formation, potentially related to highly weathered or fractured regions of the borehole.

An initial survey attempt in January 2017, where this problem was first identified, led to a number of changes in the equipment used to collect the downhole seismic profiles. A different downhole geophone model was used that was potentially better suited to the small diameter borehole casing, a new mechanical surface shear-wave source was constructed to improve consistency of the shot points (highlighted in Figure 3), and the surface based monitoring geophone network was improved upon to better assess quality of shear-waves and correct any source triggering timing errors. These changes allow for the assessment of the quality of the generated shear-waves and correction of any timing issues, which may lead to errors in the shear-wave and p-wave arrival times at the borehole geophone. Thus, it is unlikely equipment related problems would cause the issues relating to the low or negative Poisson's Ratio, which is essentially caused by the modeled shear-wave and p-wave velocities being too high or low respectively.

Another cause for the problems observed in the Poisson's Ratio profile could be related to the coupling between the grouting and both the casing and formation. This could be associated with highly weathered and/or fractured regions of the bedrock formations surrounding the borehole. Poor coupling can affect the seismic velocities around the borehole casing and the quality of the shear-wave and p-wave arrivals; which can make it difficult to accurately pick the arrival times at the borehole geophone and subsequently affect the resulting modeled velocity profiles. Since the poor coupling, and possibly degree of fracturing and weathering, can vary along the depth of the boreholes this affect may only be apparent along discreet zones, especially if caused by zones of highly weathered or fractured bedrock.

Based on the limited grouted depth in this borehole we would suggest using the surface shear-wave survey model results in calculations of the V_s30 velocity for site classification. The calculated V_s30 velocity for the surface shear-wave survey is 2982 ft/sec, which places this location in Site Class B – Rock based on the International Building Code (IBC) 2009 site class definitions.

Figure 4. Borehole GT-1 – Interval Velocity Models for the Downhole Shear-Wave and P-Wave Surveys and the Surface Based MASW Survey.

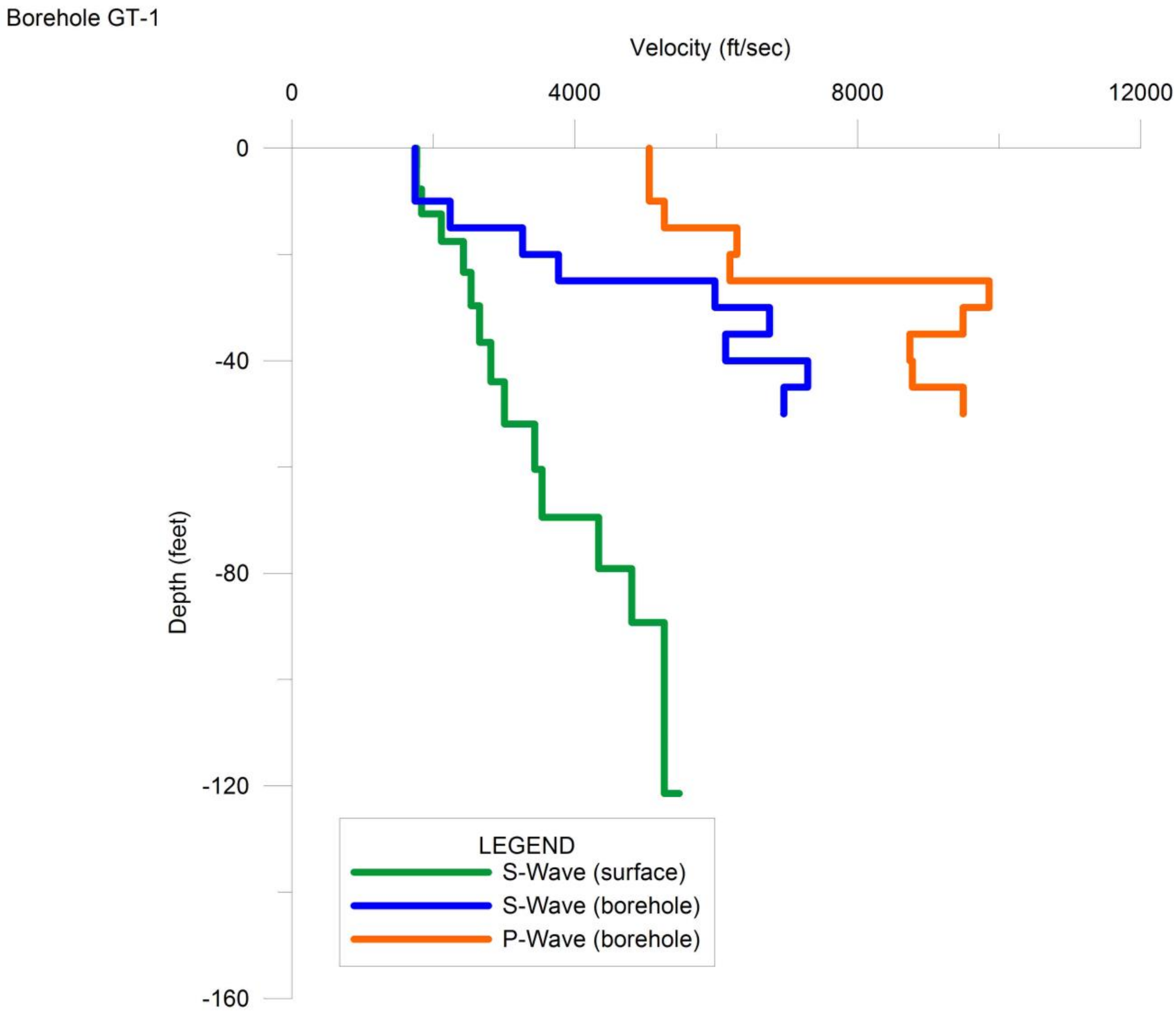
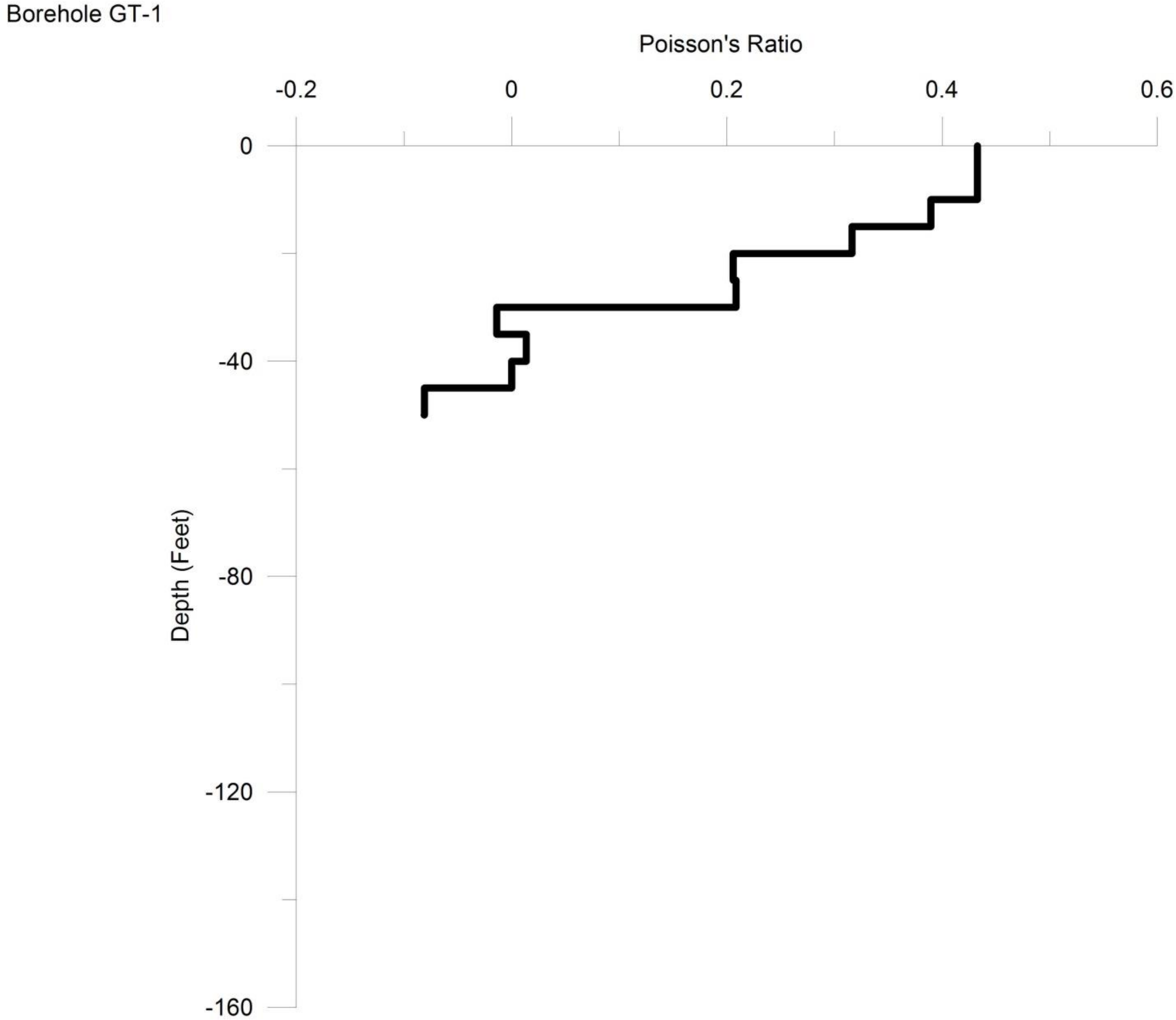


Figure 5. Borehole GT-1 – Calculated Poisson's Ratio for the Downhole Shear-Wave and P-Wave Results.



Borehole GT-4

Shear-wave and p-wave measurements were collected at 5-foot intervals, to a depth of 110 feet (bcl) in this borehole, presented as 1-D interval velocity profiles in Figure 6.

Geological logs from GT-4 indicate an interval of Basalt between approximately 0 and 42 feet below ground surface (bgs). A thin limestone layer was encountered between approximately 42 and 50 feet (bgs), which transitions into Diabase along the remaining surveyed depth of the borehole. In general, the borehole shear-wave and p-wave interval velocity profiles display a gradual increase in velocity with depth, until approximately 50 feet (bcl) when we observe a sharp increase in velocity in both seismic waves, likely a response to the transition to Diabase. The shear-wave interval velocity profile then remains relatively constant until 110 feet (bcl), the final depth of the downhole seismic measurements. In contrast, the p-wave interval velocity profile increases gradually between approximately 55 and 85 feet (bcl). Velocity then decreases sharply between approximately 85 and 100 feet (bcl), before remaining relatively constant until 110 feet (bcl), the final depth of the downhole seismic measurements. The shear-wave interval velocity profile for the surface based MASW method, displays a similar gradual increase in velocity with depth. There is a good agreement between the surface and downhole shear-wave interval velocity profiles to approximately 50 feet (bcl); below 50 feet (bcl) the surface shear-wave interval velocity tends to be significantly lower than the downhole shear-wave profile to approximately 90 feet (bcl).

This significant discrepancy between the surface and downhole shear-wave between approximately 50 and 90 feet (bcl) could indicate a problem with one of these profiles. Although we expect some variation in the two profiles, because the MASW method in reality measures the surface wave velocity, which can vary by up to 10% of the shear-wave velocity, and the difference in sampling volume of the two methods, this should be within the range of 15-20%. The calculated Poisson's Ratio profile (Figure 7) again indicates a number of regions where negative and near zero values are observed along the borehole. This could indicate a problem with the downhole seismic profiles in this interval, potentially related to the coupling between the casing and formation as discussed previously and the resulting uncertainty in arrival times of the borehole shear-waves and p-waves. Below 90 feet (bcl) the surface and downhole shear-wave interval velocity profiles again display a good agreement.

Based on the potential errors associated with the downhole shear-wave profile results we would recommend using the surface shear-wave profile to calculate the Vs30 velocity for use in subsequent analysis of seismic hazards for the site. The calculated V_s30 velocity for the surface shear-wave survey is 2837 ft/sec, which places this borehole in Site Class B – Rock, based on the International Building Code (IBC) 2009 site class definitions.

Figure 6. Borehole GT-4 – Interval Velocity Models for the Downhole Shear-Wave and P-Wave Surveys and the Surface Based MASW Survey.

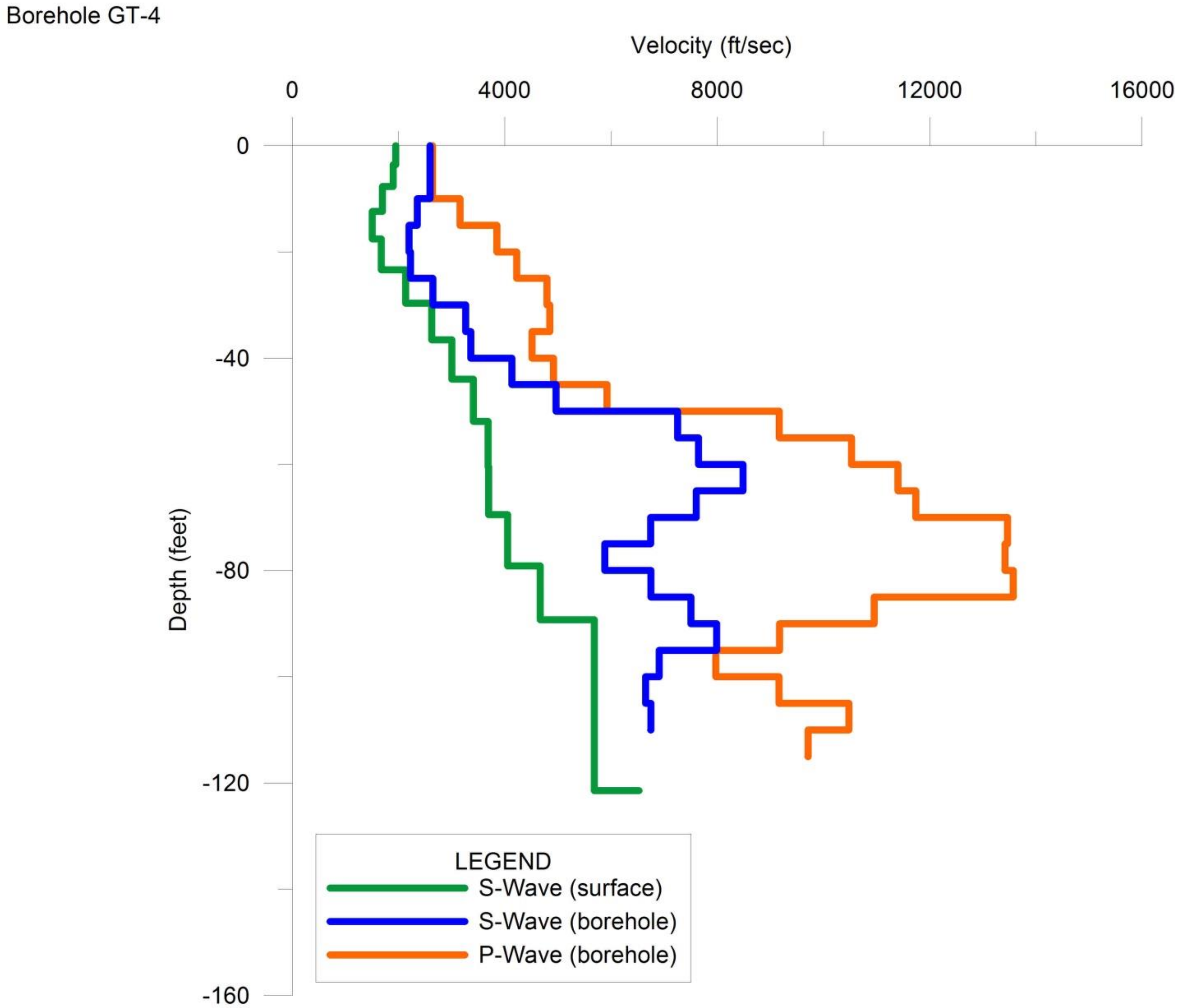
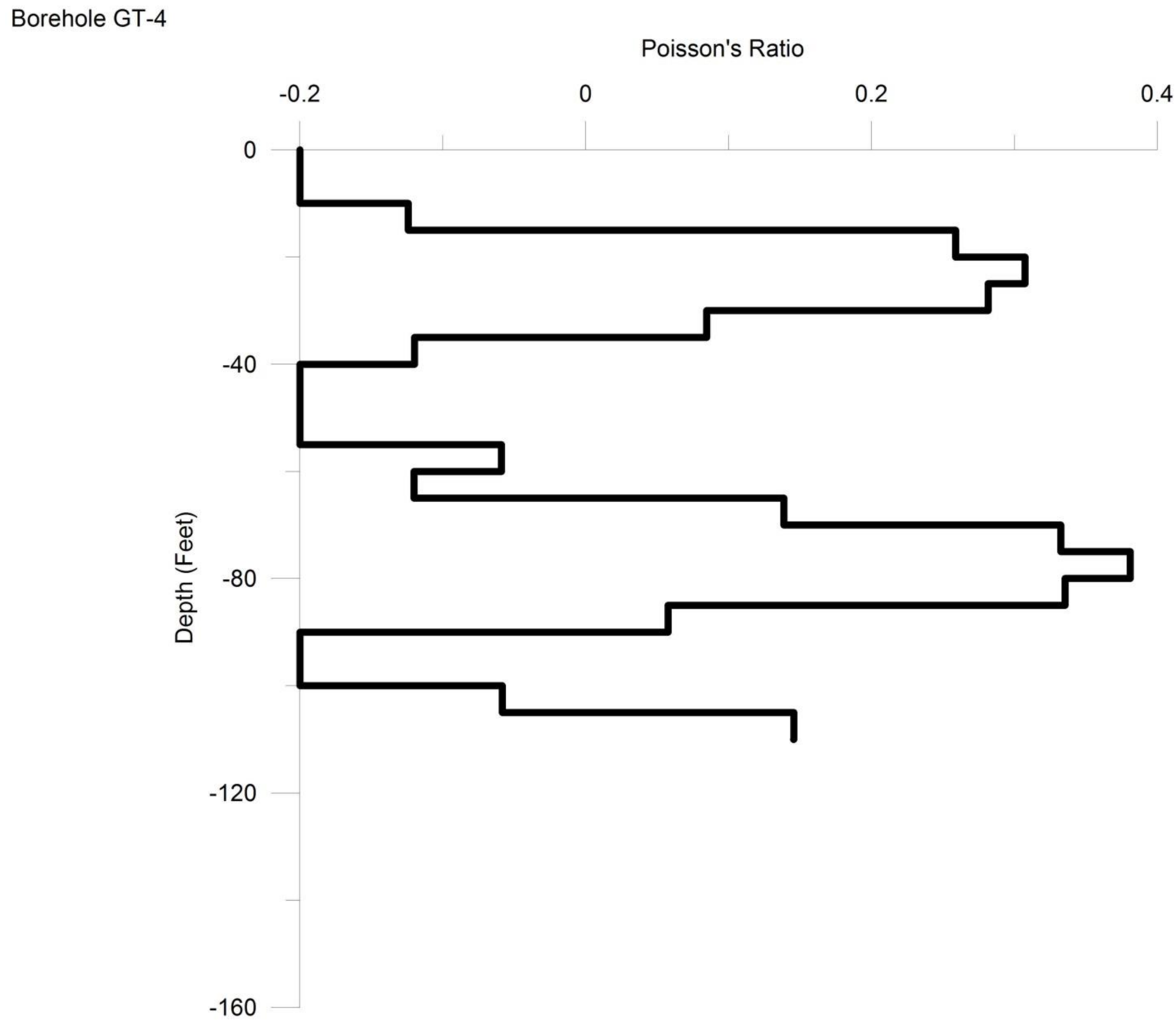


Figure 7. Borehole GT-4 – Calculated Poisson's Ratio for the Downhole Shear-Wave and P-Wave Results.



Borehole GT-14

Shear-wave and p-wave measurements were collected at 5-foot intervals, to a depth of 125 feet (bcl) in this borehole, presented as 1D interval velocity profiles in Figure 8.

Geological logs from GT-14 indicate Gila Conglomerate along the entirety of the surveyed depth of the borehole. In general, the borehole shear-wave and p-wave interval velocity profiles display a degree of overlap in the upper 20 feet of the borehole. This is likely a result of the data being noisy in this zone, producing a lower confidence in the identification of the first arrival times. This could be a result of increased weathering in the near-surface leading to poor coupling between the formation and the grout surrounding the borehole casing, or the grout installation not being consistent around the casing in this zone due to the weathering and small annulus between casing and formation. This is reflected in the calculated Poisson's Ratio profile for this borehole, with negative and near zero values in upper 20 feet (Figure 9).

Below 20 feet (bcl), the borehole shear-wave interval velocity profile displays a gradual increase in velocity with depth until approximately 40 feet (bcl). Below 40 feet (bcl) the two profiles remain relatively constant until 125 feet (bcl), the final depth of the downhole seismic measurements. There is a small decrease in borehole shear-wave interval velocity, between approximately 65 and 90 feet (bcl), which could reflect an increase in weathering within this zone. In contrast, the borehole p-wave interval velocity profile displays a much sharper increase in velocity down to 40 feet (bcl), after which it reflects the shear-wave profile and remains relatively constant until 125 feet (bcl), the final depth of the downhole seismic measurements. We do not observe any significant decrease in p-wave interval velocity between approximately 65 and 90 feet (bcl), which only appears to affect the shear-wave velocities in this zone. The shear-wave interval velocity profile for the surface based MASW method, displays a similar gradual increase in velocity with depth to the downhole shear-wave profile. There is a general good agreement between the surface and borehole shear-wave interval velocity profiles along the entirety of the surveyed length of the borehole. There are several zones where the downhole shear-wave velocities increase compared to the surface shear-wave, which potentially reflects the difference in resolution between the two methods.

Based on the general good agreement between the surface and downhole shear-wave profiles, and the realistic Poisson's Ration values below 20 feet (bcl), we have confidence in the downhole seismic profiles in this borehole. The calculated V_s30 velocity for the downhole shear-wave survey is 4584 ft/sec, which places this borehole in Site Class B – Rock based on the International Building Code (IBC) 2009 site class definitions. The calculated V_s30 velocity for the surface shear-wave survey is 3333 ft/sec, which again places this location in Site Class B – Rock.

Figure 8. Borehole GT-14 – Interval Velocity Models for the Downhole Shear-Wave and P-Wave Surveys and the Surface Based MASW Survey.

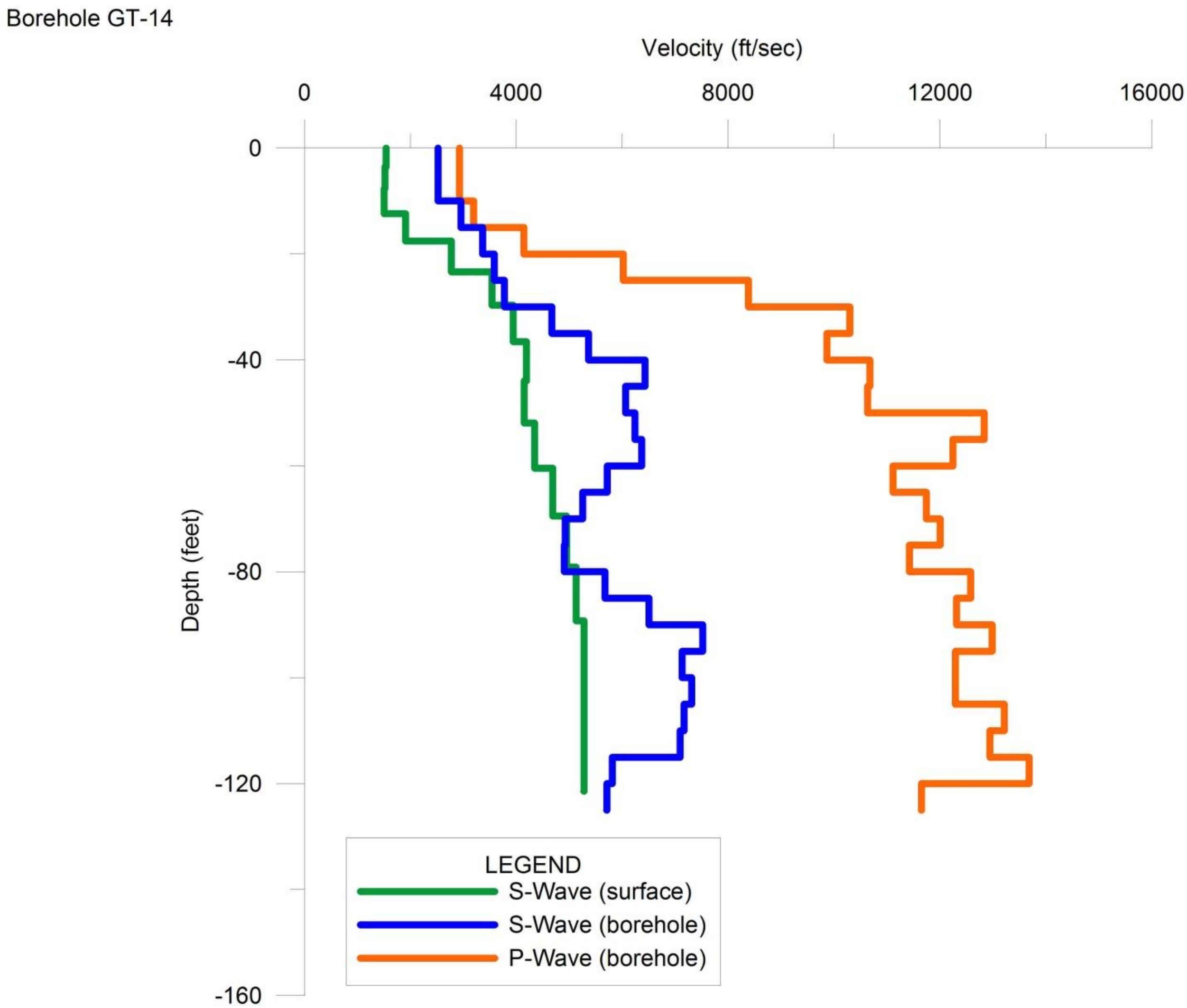
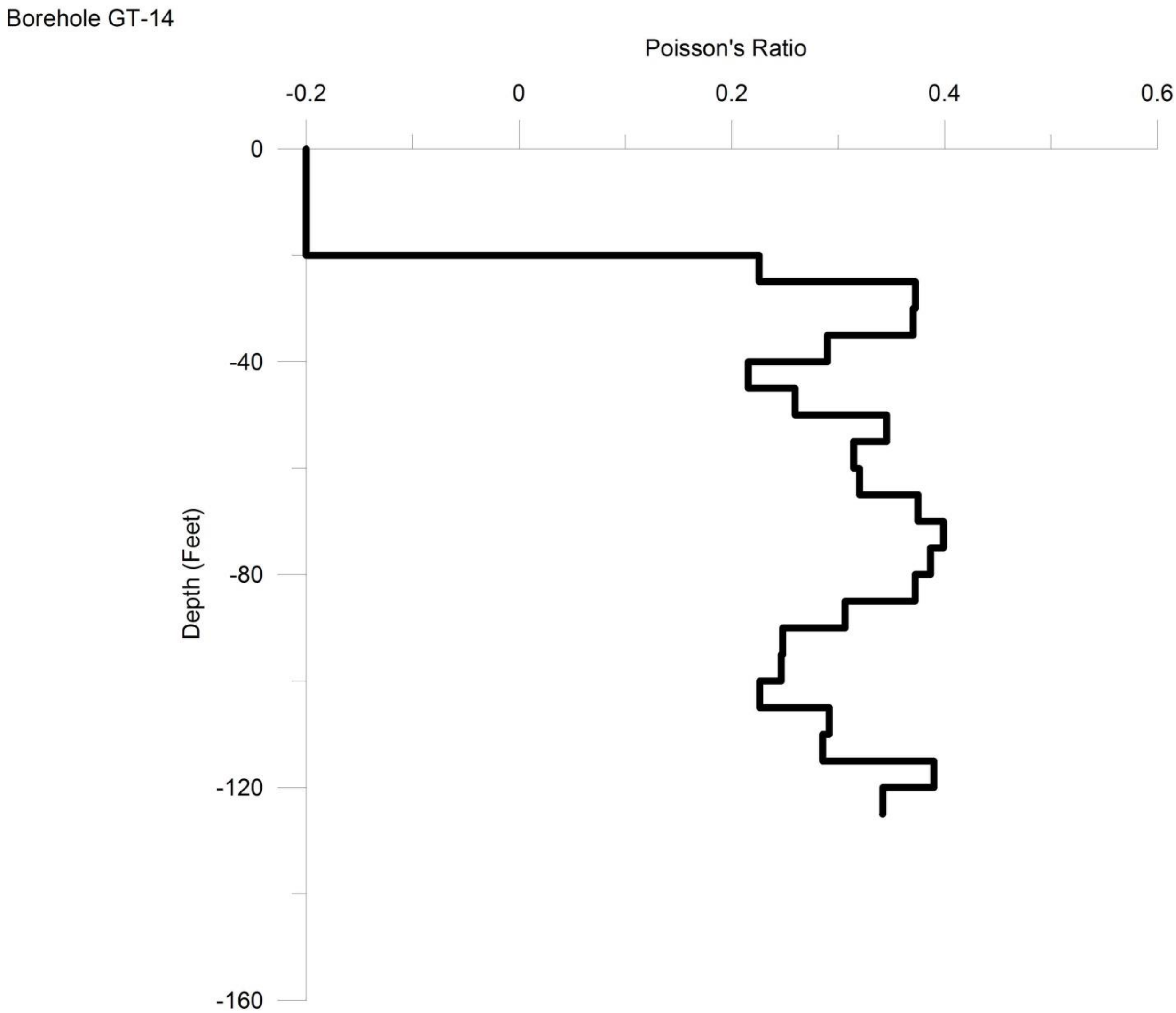


Figure 9. Borehole GT-14 – Calculated Poisson's Ratio for the Downhole Shear-Wave and P-Wave Results.



Borehole GT-21

Shear-wave and p-wave measurements were collected at 5-foot intervals, to a depth of 110 feet (bcl) in this borehole, presented as 1-D interval velocity profiles in Figure 10.

Geological logs from GT-21 indicate Gila Conglomerate along the entirety of the surveyed depth of the borehole. In general, the borehole shear-wave and p-wave interval velocity profiles display a degree of overlap in the upper 35 feet of the borehole. This is likely a result of the data being noisy in this zone, producing a lower confidence in the identification of the first arrival times. This could be a result of poor coupling between the formation and the grout surrounding the borehole casing, or the grout installation not being consistent around the casing in this zone due to the weathering and small annulus between casing and formation. This is reflected in the calculated Poisson's Ratio profile for this borehole, with negative and near zero values in upper 40 feet (Figure 11).

Below 35 feet (bcl), the borehole shear-wave interval velocity profile displays a gradual increase in velocity with depth until 110 feet (bcl), the final depth of the downhole seismic measurements. The borehole p-wave interval velocity profile displays a much sharper increase in velocity between approximately 35 and 60 feet (bcl), and then remains relatively constant until 110 feet (bcl), the final depth of the downhole seismic measurements. The shear-wave interval velocity profile for the surface based MASW method, displays a similar gradual increase in velocity with depth to the borehole shear-wave profile, to approximately 90 feet (bcl) after which the interval velocity profile remains relatively constant to 120 feet (bcl). The surface shear-wave interval velocity profile is consistently lower than the borehole profile, as mentioned previously this could indicate a problem with either the surface or downhole profiles. Based on the unrealistic Poisson's Ratio values between approximately 0 and 45 feet (bcl) and below 90 feet (bcl), it is likely that errors exist in intervals of the downhole seismic profiles, potentially relating to the coupling between the casing and formations.

Based on the potential errors associated with the downhole shear-wave profile results we would recommend using the surface shear-wave profile to calculate the Vs30 velocity for use in subsequent analysis of seismic hazards for the site. The calculated V_s30 velocity for the surface shear-wave survey is 2470 ft/sec, which places this borehole on the border of Site Classes C and B – Very dense soil or soft rock or Rock respectively, based on the International Building Code (IBC) 2009 site class definitions.

Figure 10. Borehole GT-21 – Interval Velocity Models for the Downhole Shear-Wave and P-Wave Surveys and the Surface Based MASW Survey.

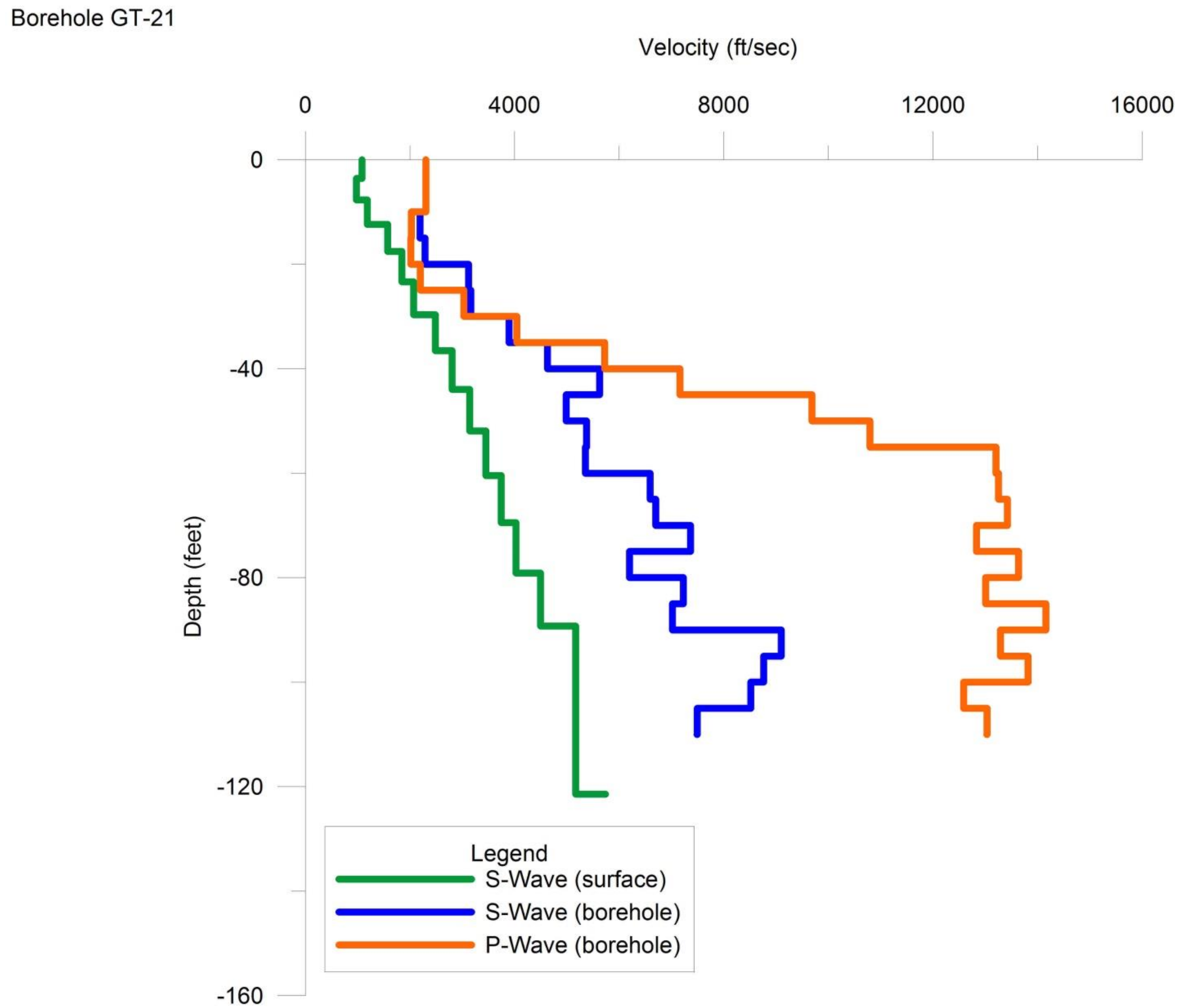
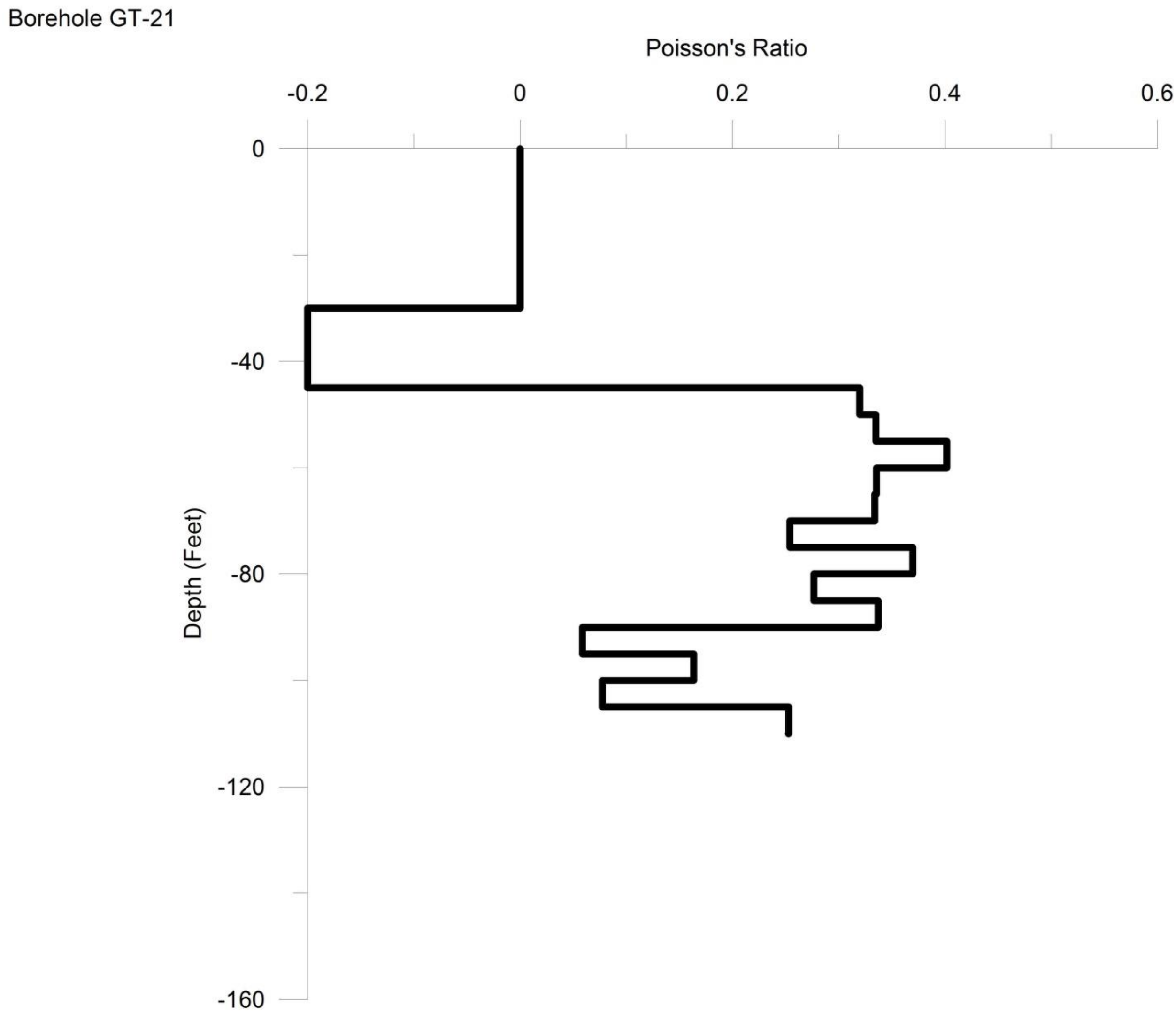


Figure 11. Borehole GT-21 – Calculated Poisson's Ratio for the Downhole Shear-Wave and P-Wave Results.



Borehole GT-31

Shear-wave and p-wave measurements were collected at 5-foot intervals, to a depth of 125 feet (bcl) in this borehole, presented as 1D interval velocity profiles in Figure 12.

Geological logs from GT-31 indicate Rhyolite along the entirety of the surveyed length of the borehole. In general, the borehole shear-wave and p-wave interval velocity profiles display a gradual increase in velocity over the upper 35 feet of the borehole. Between approximately 35 and 80 feet (bcl) the interval velocity profiles remain relatively constant, before both display a sharp increase in velocity between approximately 80 and 100 feet (bcl). Both the borehole shear-wave and p-wave profiles then remain relatively constant once again until 125 feet (bcl), the final depth of the downhole seismic measurements. The surface shear-wave interval velocity profile, for the MASW method, displays a similar gradual increase in velocity to a depth of approximately 35 feet (bcl) to the downhole profile. Below 35 feet (bcl), the velocity remains relatively constant down to 120 feet (bcl). The shear-wave interval velocity profile for the surface based MASW method, displays a good agreement with the borehole profile between approximately 35 and 80 feet (bcl). Outside of this interval, the surface shear-wave velocities are consistently lower than the borehole profile, as mentioned previously this could indicate a problem with either the surface or downhole profiles. Based on the unrealistic Poisson's Ratio values along the majority of the calculated profile in Figure 13, it is likely that errors exist in intervals of the downhole seismic profiles, potentially relating to the coupling between the casing and formations. In fact, the only realistic Poisson's Ration values are in the interval where the surface and downhole shear-wave profiles display good agreement, namely between 50 and 60 feet (bcl).

Based on the potential errors associated with the downhole shear-wave profile results we would recommend using the surface shear-wave profile to calculate the Vs30 velocity for use in subsequent analysis of seismic hazards for the site. The calculated V_s30 velocity for the surface shear-wave survey is 4961 ft/sec, which places this borehole in Site Class B – Rock based on the International Building Code (IBC) 2009 site class definitions.

Figure 12. Borehole GT-31 – Interval Velocity Models for the Downhole Shear-Wave and P-Wave Surveys and the Surface Based MASW Survey.

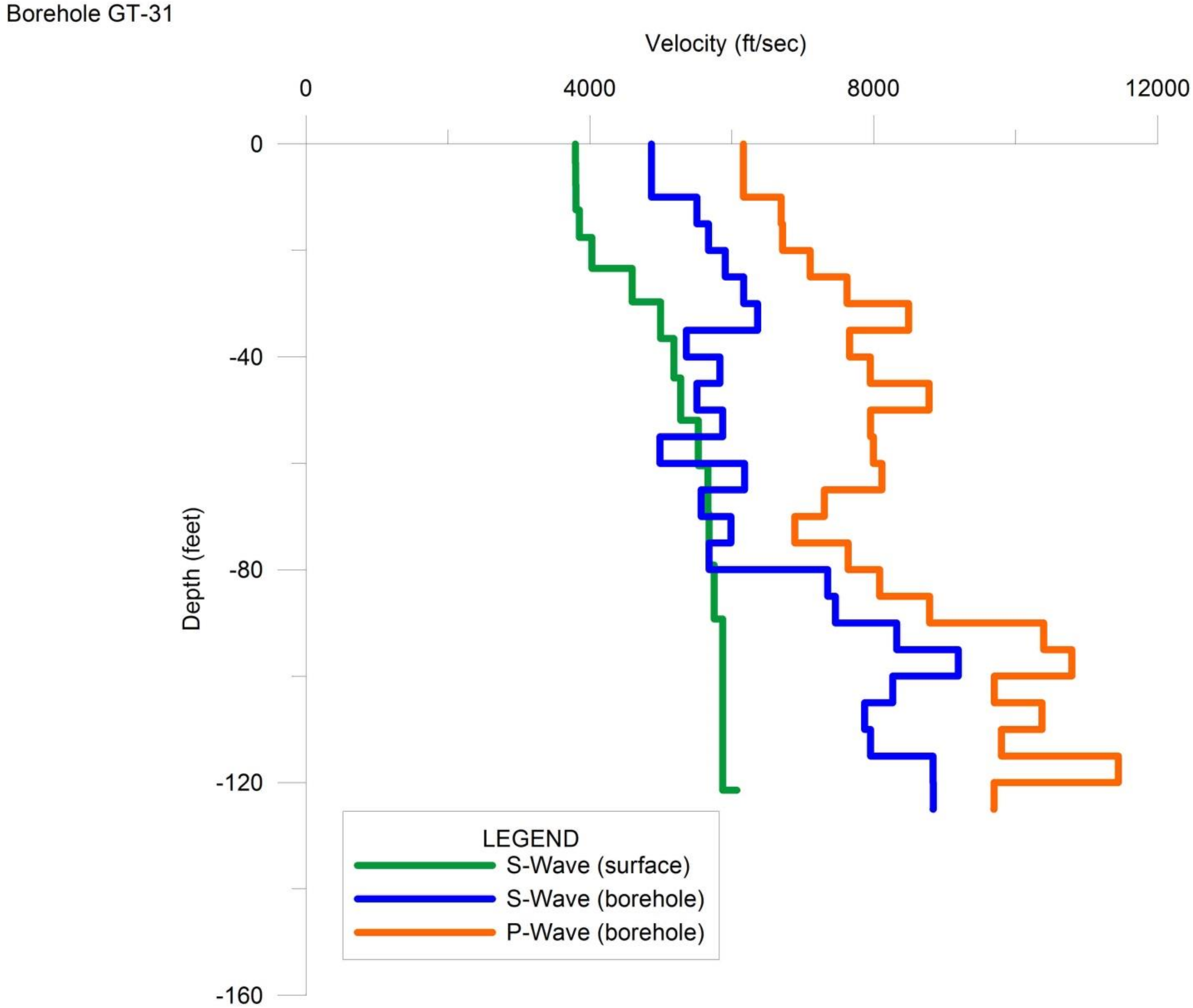
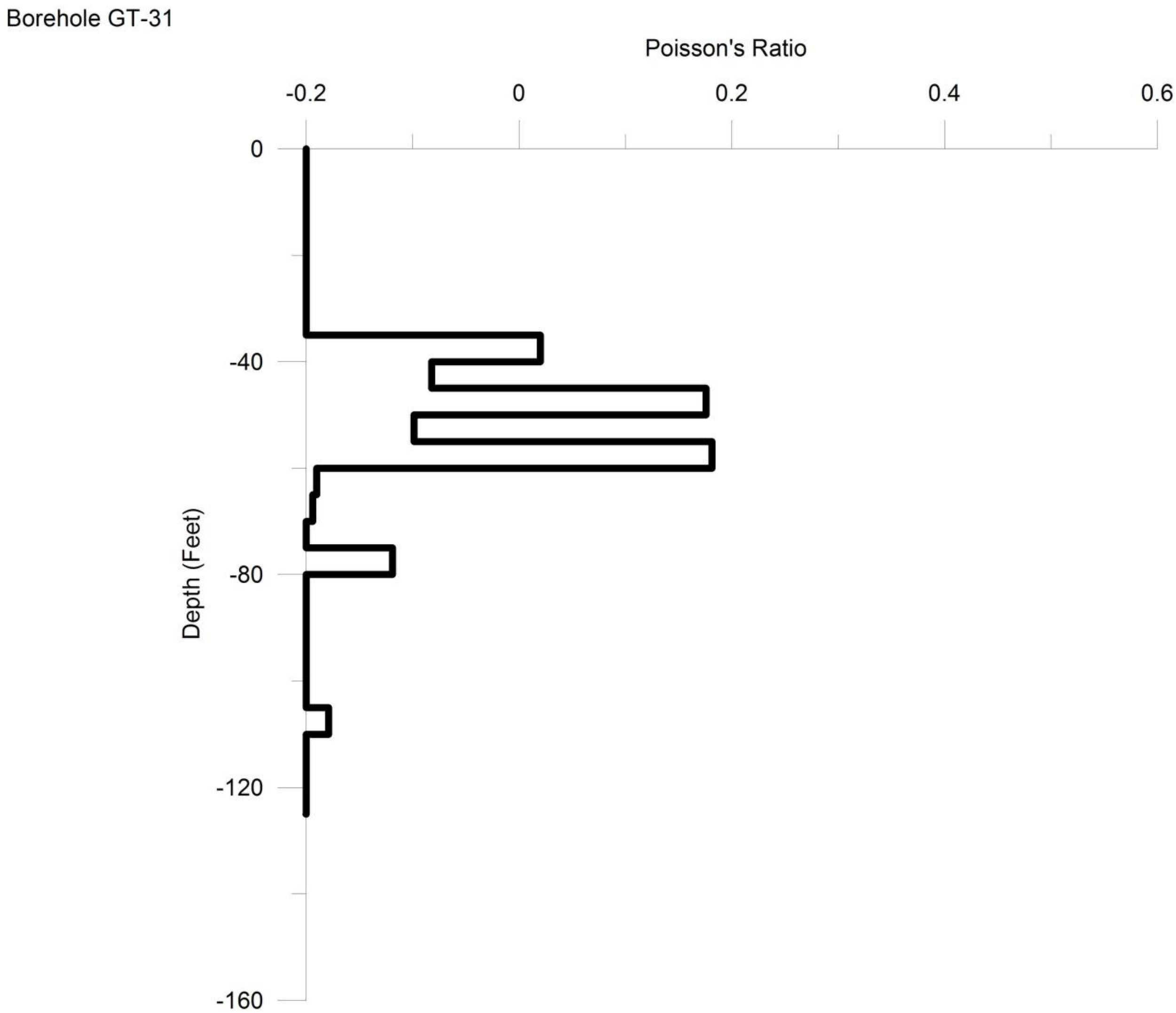


Figure 13. Borehole GT-31 – Calculated Poisson's Ratio for the Downhole Shear-Wave and P-Wave Results.



Borehole GT-41

Shear-wave and p-wave measurements were collected at 5-foot intervals, to a depth of 125 feet (bcl) in this borehole, presented as 1D interval velocity profiles in Figure 14.

Geological logs from GT-41 indicate Pinal Schist between approximately 0 and 103 feet (bgs), transitioning to a mafic intrusive along the remaining surveyed depth of the borehole, to 125 feet (bcl). While there are a number of small fluctuations in the borehole shear-wave and p-wave interval velocity profiles over the upper 85 feet of the borehole, in general the profiles display a relatively constant velocity over this interval. Both borehole interval velocity profiles then display a sharp increase in velocity between approximately 85 and 110 feet (bcl), before the velocity decreases slightly in both the shear-wave and p-wave profiles to 125 feet (bcl), the final depth of the downhole seismic measurements. The surface shear-wave interval velocity profile, for the MASW method, displays a similar relatively constant velocity along the entirety of the profile, to 120 feet (bcl). The shear-wave interval velocity profile for the surface based MASW method, displays a good agreement with the borehole profile between approximately 70 and 85 feet (bcl). Outside of this interval, the surface shear-wave velocities are consistently lower than the borehole profile, apart from the upper 10 feet of the borehole where the surface shear-wave velocities are higher. As mentioned previously this could indicate a problem with either the surface or downhole profiles. Based on the unrealistic Poisson's Ratio values along the majority of the calculated profile in Figure 15, it is likely that errors exist in intervals of the downhole seismic profiles, potentially relating to the coupling between the casing and formations.

Based on the potential errors associated with the downhole shear-wave profile results we would recommend using the surface shear-wave profile to calculate the Vs30 velocity for use in subsequent analysis of seismic hazards for the site. The calculated V_S30 velocity for the surface shear-wave survey is 2626 ft/sec, which places this borehole in Site Class B – Rock based on the International Building Code (IBC) 2009 site class definitions.

Figure 14. Borehole GT-41 – Interval Velocity Models for the Downhole Shear-Wave and P-Wave Surveys and the Surface Based MASW Survey.

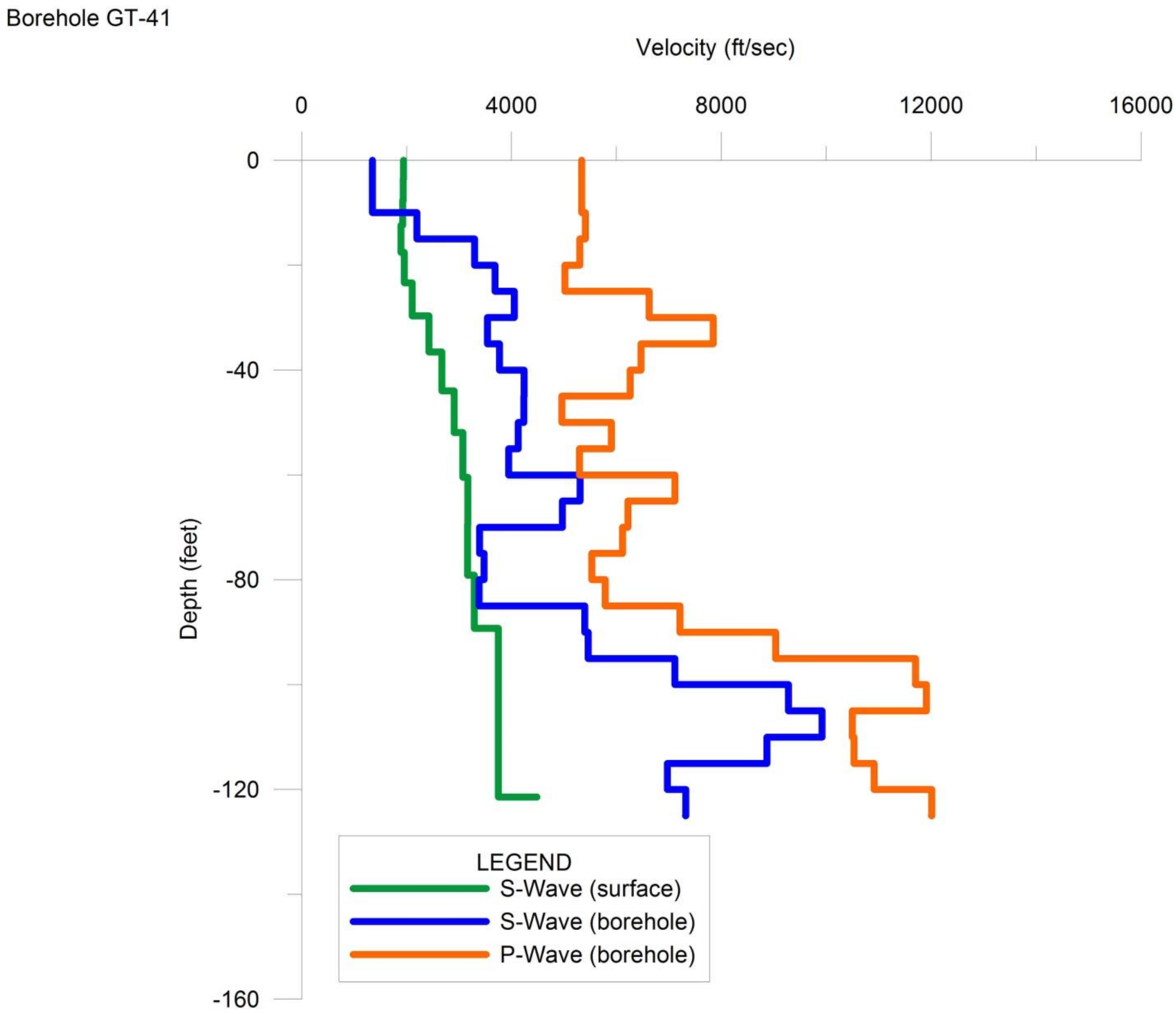
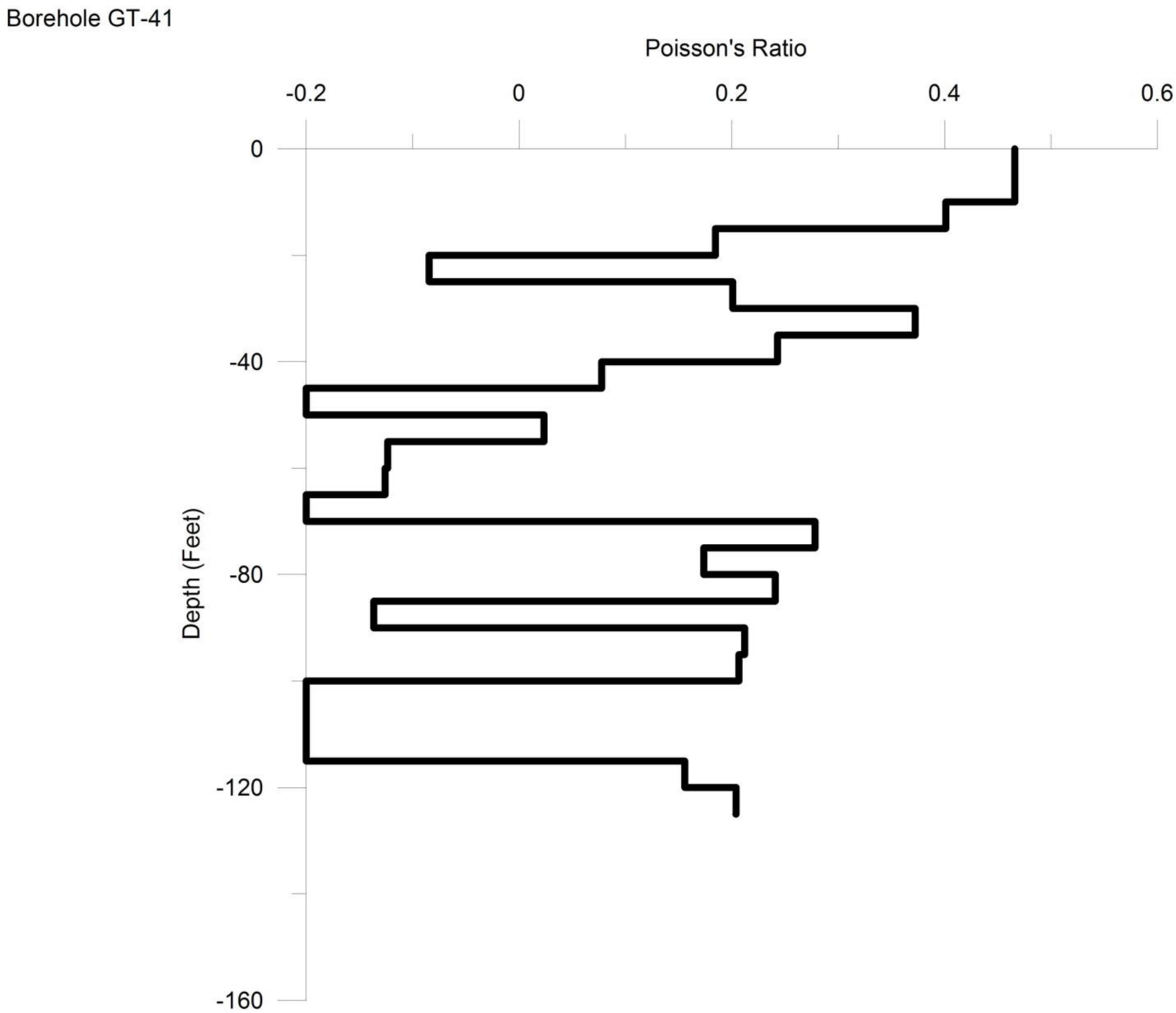


Figure 15. Borehole GT-41 – Calculated Poisson's Ratio for the Downhole Shear-Wave and P-Wave Results.



4.0 SUMMARY

A downhole seismic investigation, which included collecting shear-wave and p-wave interval velocity profiles in a total of six boreholes, was completed at the Near West Site for RCML. Data was acquired between 11th and 15th February, 2017.

The calculated V_s30 values together with the IBC 2009 Seismic Site Classification are summarized in the table below for each borehole. As discussed, there appears to be a significant discrepancy between the seismic velocities of a number of the downhole shear-wave profiles when compared to the surface shear-wave profile results. When combined with the Poisson's Ratio profiles, which display a number of intervals where the values are unrealistic for geological materials, it would appear to indicate the downhole shear-wave profiles are likely overestimated. This could be related to errors in identifying the downhole seismic wave arrival times, potentially a result of the coupling between the casing and formation along these intervals. Therefore, we have recommended using the surface shear-wave profiles to calculate the V_s30 velocity for use in subsequent analysis of seismic hazards for the site.

We have also calculated a similar value for the p-wave interval velocities over the upper 10 meters (30 feet) and used that value to assess the rippability of the near-surface materials using the Caterpillar Handbook, based on a D9R Ripper.

In summary:

Borehole	Survey Depth	Downhole V_s30	Profile Used	IBC 2009 Classification	Downhole V_p10	Rippability
	ft (bcl)	ft/sec			ft/sec	Based on D9R Ripper – Caterpillar Handbook
GT-1	50	**2982**	Surface	B	**6175**	Yes
GT-4	110	**2837**	Surface	B	**3572**	Yes
GT-14	125	**4584**	Borehole	B	**4234**	Yes
GT-21	110	**2470**	Surface	B / C	**2265**	Yes
GT-31	125	**4961**	Surface	B	**6828**	Marginal
GT-41	125	**2626**	Surface	B	**5487**	Yes

APPENDIX A

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW) - METHOD

Multi-Channel Analysis of Surface Waves (MASW)

Dispersion, or change in phase velocity with frequency, is the fundamental property utilized in surface-wave methods. Phase velocity of surface-wave is sensitive to the shear wave velocity (Vs); phase velocity of surface-wave is typically 90-95% that of the shear wave velocity. Surface wave dispersion can be significant in the presence of velocity layering, which is common in the near-surface environment. There are other types of surface waves, or waves that travel along a surface, but in this application we are concerned with the Rayleigh wave, which is also called "ground roll" since the Rayleigh wave is the dominant component of ground roll.

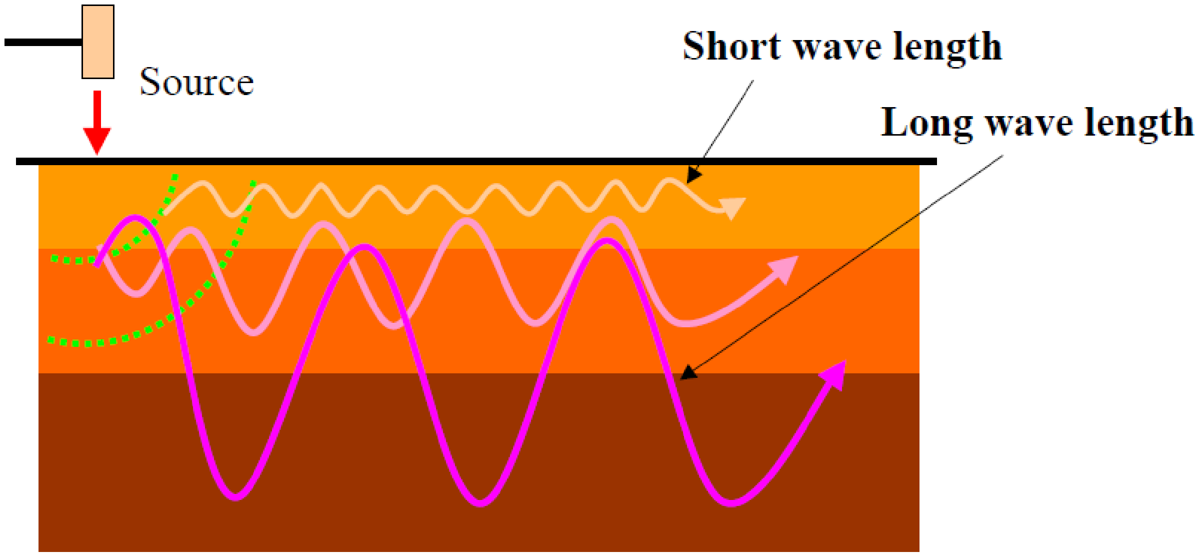
"Active source" surface-wave surveying means that seismic energy is intentionally generated at a specific location relative to the geophone spread and recording begins when the source energy is imparted into the ground. This is in contrast to "passive source" surveying, also called "microtremor" surveying, or sometimes referred to as "refraction microtremor" (or the commercial term "ReMi") surveying, where there is no time break and motion from ambient energy generated by cultural noise, wind, wave motion, etc. at various, and usually unknown, locations relative to the geophone spread is recorded.

Surface-wave energy decays exponentially with depth beneath the surface. Longer wavelength (that is, longer-period and lower-frequency) surface waves travel deeper and thus contain more information about deeper velocity structure (Figure A1). Shorter wavelength (that is, shorter-period and higher-frequency) surface waves travel shallower and thus contain more information about shallower velocity structure. In this context, by their nature and proximity to the geophone spread, it can be said that higher frequency active source surface waves resolve the shallower velocity structure and lower frequency passive source surface waves resolve the deeper velocity structure.

MASW surveys are conducted using the same source and seismograph equipment as the more common P-wave seismic refraction surveys, requiring only a change to lower frequency geophones (typically 4.5Hz). They are much easier to conduct than shear wave surveys, and benefit from increasing source power efficiency (for each sledgehammer blow 67% of the energy produced is in the form of surface-waves, 26% shear waves, and 7% P-waves) and consequently improved signal to noise.

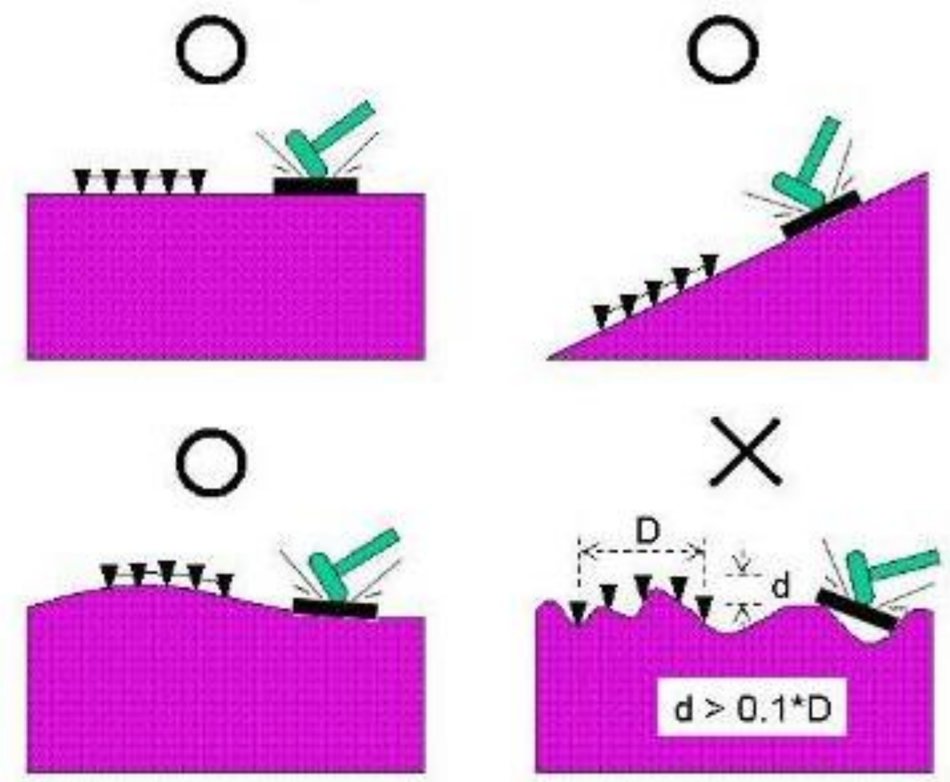
Minimal or constant topography change across the spread is required for the technique to produce meaningful results. As demonstrated in Figure A2, slopes of constant gradient or smoothly varying changes over distance do not significantly affect the results. However, significantly undulating topography will impact the technique and care must be taken to minimize such topographic variations. The technique works best in soft rock geology conditions and care should be taken in hard rock geological areas that a sufficient depth of cover / weathered material exists for good surface wave generation. Often in hard rock geological areas the generation of higher modes in the dispersion curve analysis are observed.

Figure A1. Example of surface wave dispersion produce During Multi-Channel Analysis of Surface Wave Surveying



Shear wave velocity is one of the elastic constants and closely related to Young's modulus. Under most circumstances, shear wave velocity is a direct indicator of the ground strength (stiffness) and therefore can be used to derive load-bearing capacity.

Figure A2. Acceptable topographic conditions for multichannel analysis of surface wave surveying.



MASW Equipment

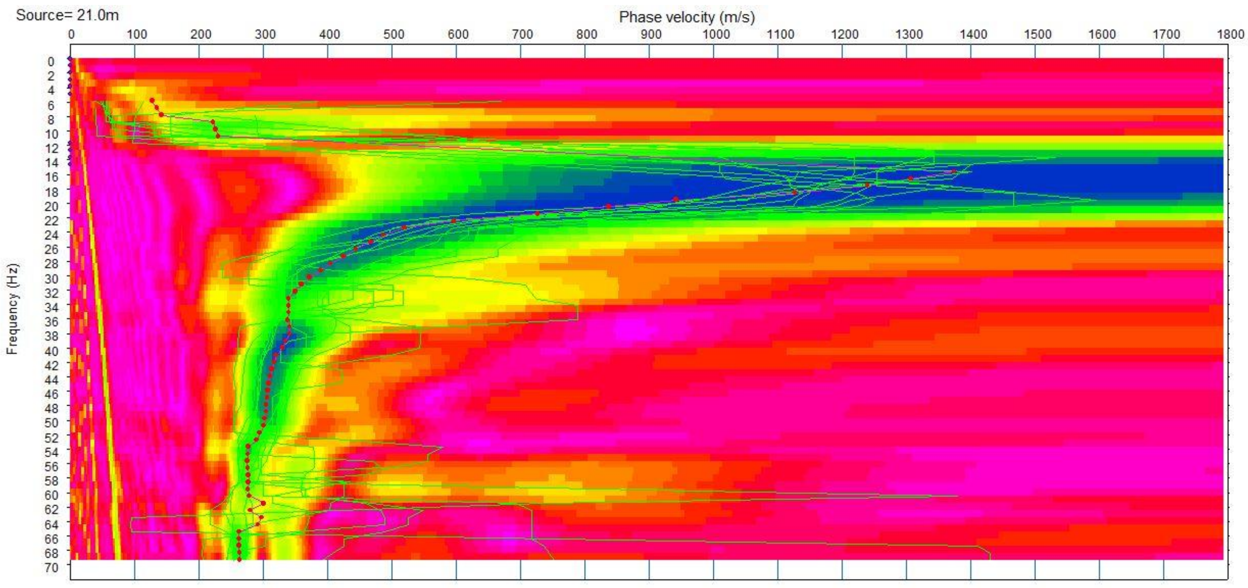
A Geode Ultra-Light Exploration 24 –Channel Seismograph (Geometrics Inc., San Jose, CA) was used for MASW surveying, providing a total of 24-channels. 4.5Hz geophone placement was every 10 feet (3 meters), off-end shot points were collected on either end of the spread beyond the first and last geophones, at distances of 20 and 40 feet (6 and 12 meters). The seismic source consisted of a 16-lb sledgehammer and polyethylene strike plate. The Geode ran from a laptop in order to view each shot to ensure acceptable data quality. Additional hammer blows forming a new "stack" of data were added until the desired data quality was achieved. The shot record (seismogram) was also saved to the computer and stored for subsequent processing. A real-time noise monitor showing all geophones was carefully scrutinized during shots to ensure that noise levels were at a minimum for each shot. This included waiting for breaks in wind noise, traffic, and other sources of noise.

MASW Processing and Plotting

The data processing flow for the MASW used the SeisImager (Geometrics Inc., San Jose, CA) seismic processing software. Any geometry changes to correct for errors made during the field acquisition were conducted within the SeisImager software called Pickwin (Version 4.2.0.0).

SeisImager's Pickwin was then used to calculate the Common Mid-Point (CMP) cross-correlation gathers, a bin size of 6 feet was used for the three profiles. SeisImager's WaveEq module was used to generate the dispersion curves and run the inversion to produce the shear wave velocity profile. A multichannel field record is first decomposed via Fast Fourier Transformation (FFT) into individual frequency component, and then amplitude normalization is applied to the each component. Then, for a given testing phase velocity in a certain range, the necessary amount of phase shifts are calculated to compensate for the time delay corresponding to a specific offset, applied to individual components, and all of them are summed together. This is repeated for different frequency components. Display of all summed energy in frequency-phase velocity space will show patterns of energy accumulation that represents the dispersion curve as shown in Figure A3.

Figure A3. Example dispersion curves for a typical MASW profile.



The inversion is then performed within SeisImager's WaveEq module using a non-linear least square method to iteratively seek the 2D shear wave velocity profile, with the goal of minimizing the root-mean squared (RMS) error between the observed and calculated velocity curves. Convergence of the inversion was judged whether the model achieved an RMS of less than 5% within six iterations.

The inverted data were output from SeisImager's WaveEq into an .XYZ data file and were then plotted as a step plot in Grapher 7 (Golden Software, Inc.).

APPENDIX VII

Optical and Acoustic Televiewer Results

See Volume 4

APPENDIX VIII

Geological Conceptual Model

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Near West 2017 Leapfrog Model Development
Model Edits from April to May 2017

MODEL UPDATE SUMMARY

I. Planned Model Updates

This document describes model updates made since the Leapfrog Model Review Meeting on April 25, 2017. The following model updates were requested during the meeting and previously shared in the Meeting Summary provided on April 28, 2017:

A. Relink the model to acQuire to update 2017 wells to their surveyed coordinates
B. Edits based on unresolved issues discussed in the meeting summarized as:
    i. Add buried fault below TSF
    ii. Change Trdt contact from Tt to Tal. Review results and edit Tt and Tal units.
    iii. Change Quaternary units to use only the Qal contact.
C. Prepare the geologic volumes west of Hewitt Canyon Fault.
D. Prepare the pCdiab as a refined model of the pCy.
E. Prepare Tw, Trdt, TKg, and pCgu volumes which were excluded earlier due to time restrictions and their distance from the TSF.
F. Review unit contacts between fault blocks. Add more control points where necessary.
G. Review unit thicknesses and adjust where necessary.
H. Final review of the model to address any outstanding issues.

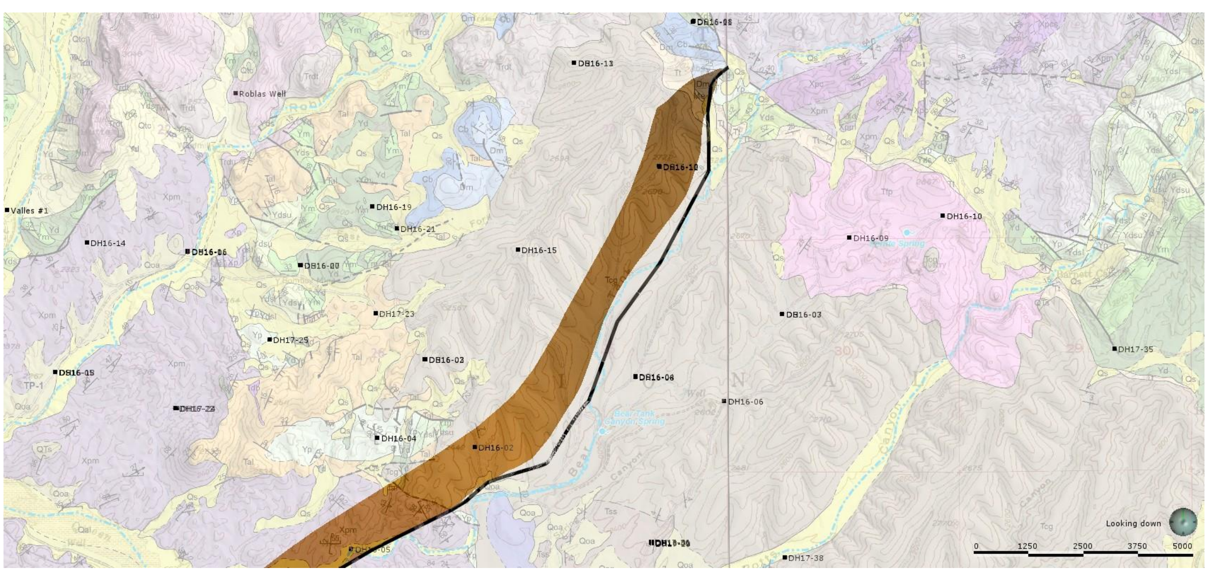
II. Summary and Comments for Model Update

The model updates are considered to be complete and are summarized as:

A. Wells were updated to 2017 survey coordinates.
B. Added a fault below the TSF to improve unit relationships below the Tg
    i. The previous model version showed evidence of a fault by developing a syncline in the Tal and Pz due to the model rectifying well logs and bedding. The mapped bedding at surface resulted in the units dipping east-southeast below the Tg west of Bear Tank Canyon. The well log for DS16-04, which is east of Bear Tank Canyon in the middle of the Tg, showed the Tal and Pz were missing and the pCy is high.
    ii. The fault was prepared in Leapfrog with the following steps:

1. The volumes for the Tertiary units younger than the Tal were reviewed to ensure they honored well lithology, geologic contacts at surface, and bedding. These units were then merged and the base was used as the top boundary for the inferred Bear Tank Canyon fault.
2. The inferred Bear Tank Canyon fault was delineated based on well lithology, the previous model version extent of the Tal and Pz, faults mapped at the surface in older units near the Tg contact, and along Qal in the pCpi south of the TSF.
3. The dip of the fault is approximately 36-40º and is based on the Roblas Canyon Fault angle which was modified to the pCy bedding
4. The offset for the fault is based on the unit thicknesses established in the Tal and Pz by the well logs and interpolation of geologic contacts at surface and bedding.
5. The fault extends south to DH17-32 which had some faults distinguished in the televiewer data; however these faults dip between 33 and 56º to the south instead. Although the fault direction is different, the inferred Bear Tank Canyon Fault was connected to at least correspond with a faulted area as it terminated at the model boundary.

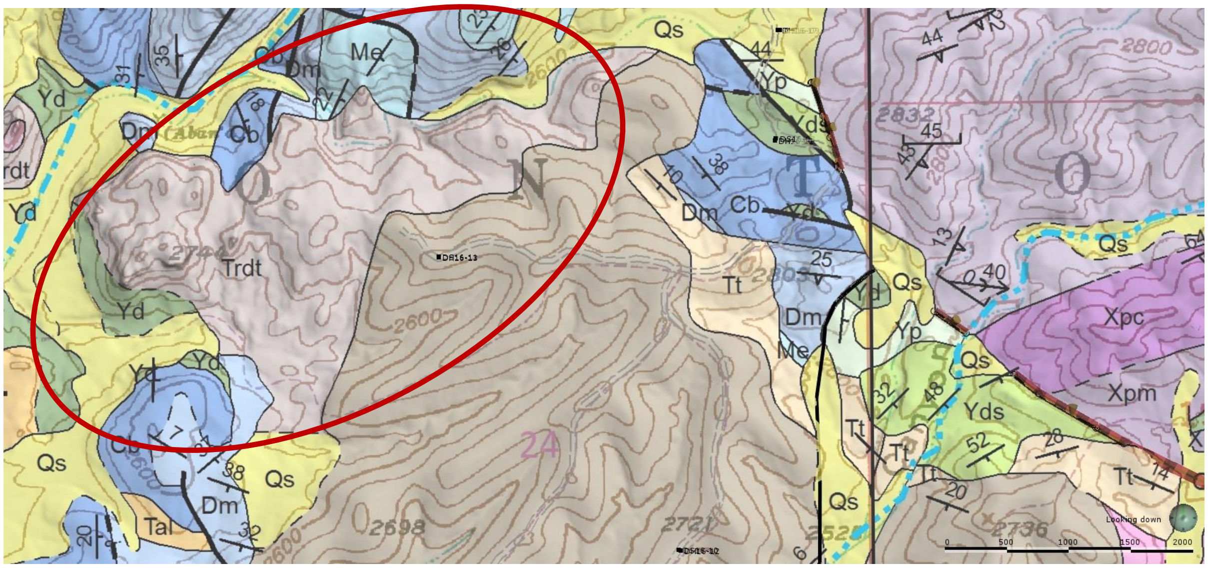
iii. The image below shows the location of the inferred Bear Tank Canyon fault surface (in orange) and the extension of the fault to land surface as a polyline (in black). The gap between the surface and the polyline shows where the fault surface does not reach land surface due to younger Tertiary units.



C. Changed the Trdt outcrop in the northwest portion of the TSF to Tt

   i. There is a discrepancy in the northwest portion of the TSF area between the Tt, Trdt, and Tal. The discrepancy occurs between the: Trdt outcrop mapped by AZGS, the same outcrop was mapped as Tt by KCB, and nearby boreholes log only Tal. The previous version of the model included the mapped Trdt as Tt.

   ii. Changed the mapped Trdt to Tal to correspond with Tal logged in nearby wells. The image below shows the Trdt outcrop circled in red.



D. Limit Quaternary units to the Qal mapped by AZGS

   i. The previous model version had volumes for all mapped Quaternary units. Many of these outcrops are thought to be veneers or in the case of the TSF area will be scraped away. The model is limited to a minimum resolution of 20 feet, which resulted in the thickness of Quaternary units often being overestimated. The decision was made to not overestimate the Quaternary units and limit them to the AZGS mapped Qal.

      1. The digitized AZGS Qal contact was used where available and the M&A generalized geology contact was used in the Whitlow Dam area.

      2. The Qal in Queen Creek was given a thickness of 100 feet based on drill logs from Rose Well, Berry Well, and Schepers Well.

E. Prepared the units west of Hewitt Canyon

   i. The previous model version did not have any volumes prepared west of Hewitt Canyon due to time constraints.

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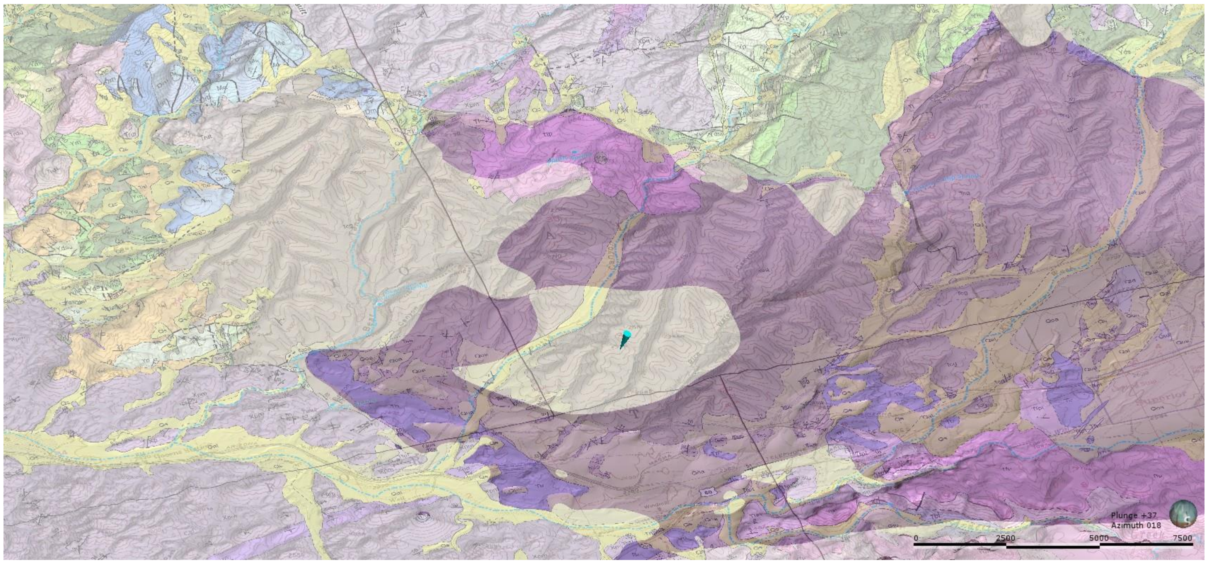
   ii. The volumes were prepared and reviewed. Some contacts and bedding were digitized from the AZGS Florence Junction quad to help with accuracy.

F. Prepared the refined model of the pCy to include two volumes: the Apache Group and the pCdiab
   i. The previous model version had one volume for the pCy with the intention of delineating the pCdiab after the initial review of the unit
   ii. The volume for the pCy was refined to pCdiab and pCy (Apache Group)
   iii. Because it is intrusive, the location of the pCdiab is poorly understood below land surface. Multiple iterations of the pCdiab were prepared and are still available in the model for verification. The pCdiab ultimately was built using the following factors due to the result showing intrusive behavior and tilting as observed by bedding measured in the pCy:
      1. Bedding measured in the pCy
      2. Geologic contacts with the pCy at surface.
         a. The contacts in the Hewitt Canyon area are mostly obscured by Quaternary deposits. The pCdiab outcrops were connected through the Quaternary deposits and were conservative.
         b. The contact plunge was ultimately assigned 60º.
      3. An overall surface trend between 70-80º with an azimuth following the trend of the pCy in the given fault block. Lower angles did not aid the pCdiab to extend to the bottom model boundary.
   iv. Altogether, the pCdiab volume matches the pCdiab mapped at surface and the overall lithology in the well logs. The minimum thickness of the pCdiab is currently set to 100 feet and could be refined for this unit to capture smaller intervals, if needed.

G. Prepared the Tw, Tvu, TKy, and pCgu volumes

H. Reviewed the unit contacts between fault blocks and unit thicknesses.

I. Reviewed the model to address any outstanding issues
   i. Upon review with M&A staff, the decision was made to add the Qoa in between Berry Well and Happy Camp Canyon.
   ii. The previous model version had a few issues with the Tb that have been fixed. The image below shows the previous model Tb (purple) underneath the geologic map.



1. In the previous model version, the Tb had a hole underneath the middle of the Tg due to Tg eroding Tb. The Tg surface has more data control and is thought to better reflect the shape of the basin the Tb or volcanics deposited on. The update added control points for the Tb to dip below the Tg in the middle. In the image above, the blue arrow shows the hole in the Tb.
2. In the previous model version, the volcanics near the Roblas Canyon Fault were not being fully integrated: the Tt was a veneer at the surface, the ashflow tuff at the bottom of DS16-03 was included as perlite, and the Tb was allowed to fill in to the Roblas Canyon Fault when there is no evidence of Tb. The updated model addressed these issues by: assigning the ashflow tuff at the bottom of DS16-03 as Tt and extending the Tt below land surface along the Roblas Canyon Fault. The contact between the Tt and Tb is considered to be simplified and likely includes some interfingering. The image below shows the Tb (purple), Tt (yellow), and perlite (pink).

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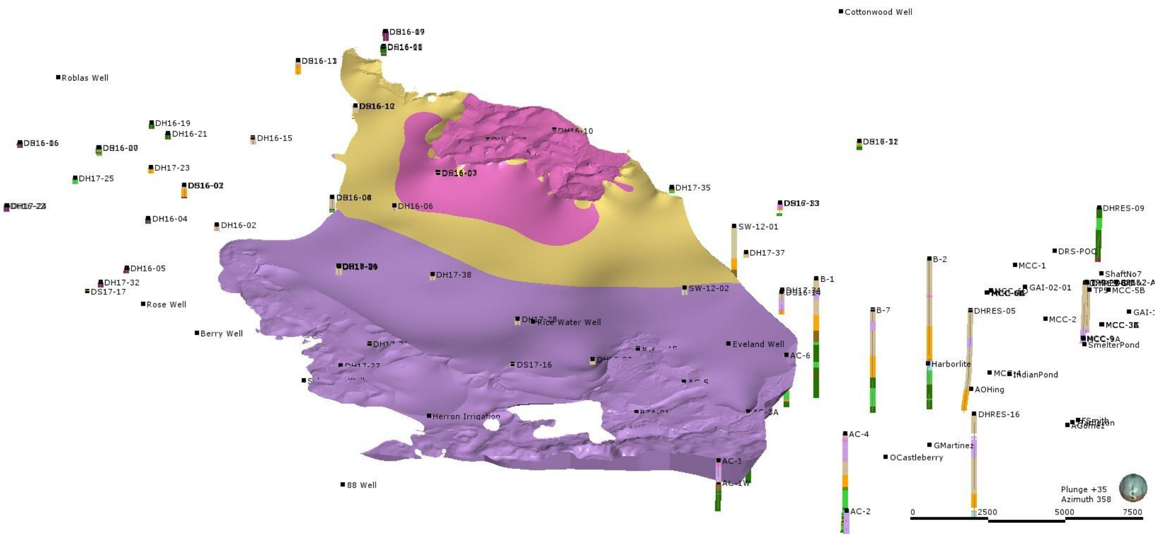


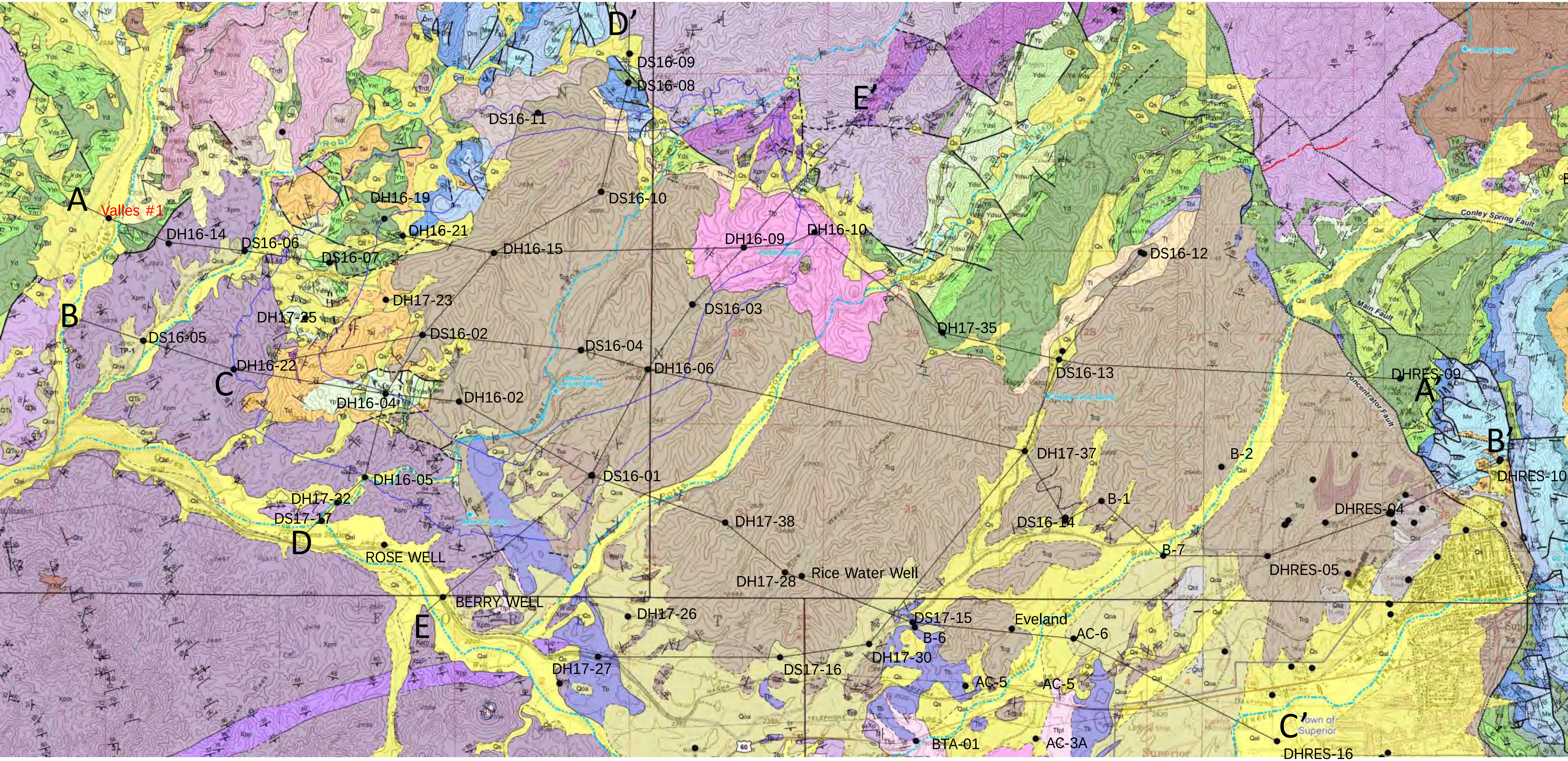
3. The previous model version labelled the Tertiary volcanics in the Superior fault block as Tb. This was changed to Tvy to show the Tertiary volcanics are grouped.

III. Model Sections

Attached are two sets of Sections A-A’, B-B’, C-C’, D-D’, and E-E’. The first set displays all five sections on one page with 1x vertical exaggeration and the second set shows each section with 5x vertical exaggeration.

IV. Update on project tasks (and target completion dates) (M&A)

A. *Edit the model (**May 26**) Complete; may need to revisit the resolution of certain volumes depending on numerical model needs.*
B. *Update and redistribute cross-sections A-A’, B-B’, C-C’, D-D’, and E-E’ (**May 29**) Complete*
    a. Prepare any additional sections requested by May 29th (**May 31**)
C. Tech Memo (**June 9th**)



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Section Locations

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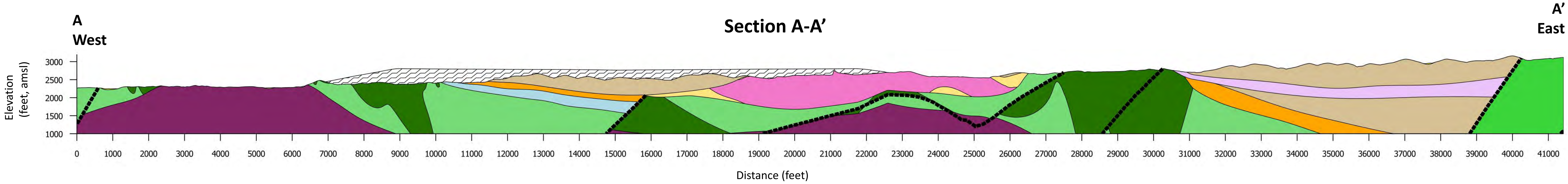
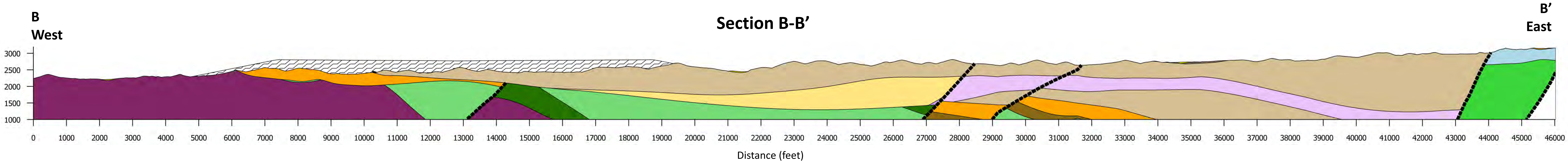
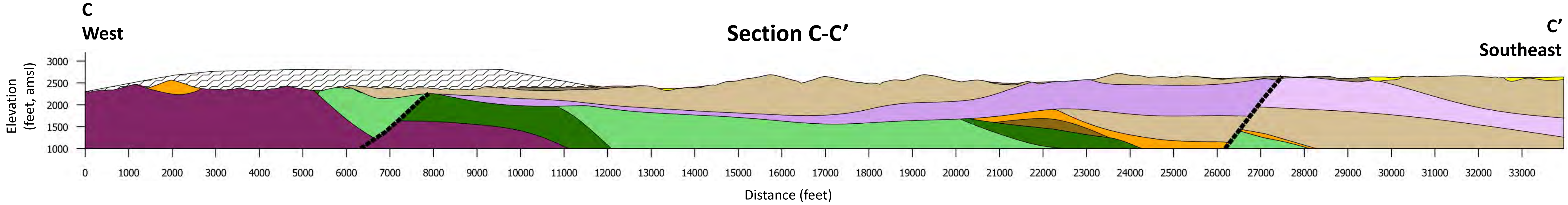
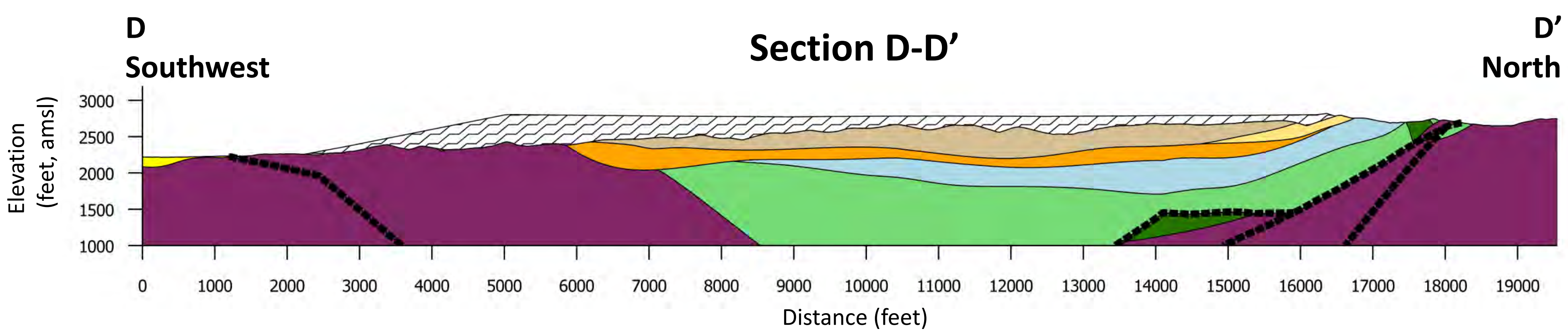
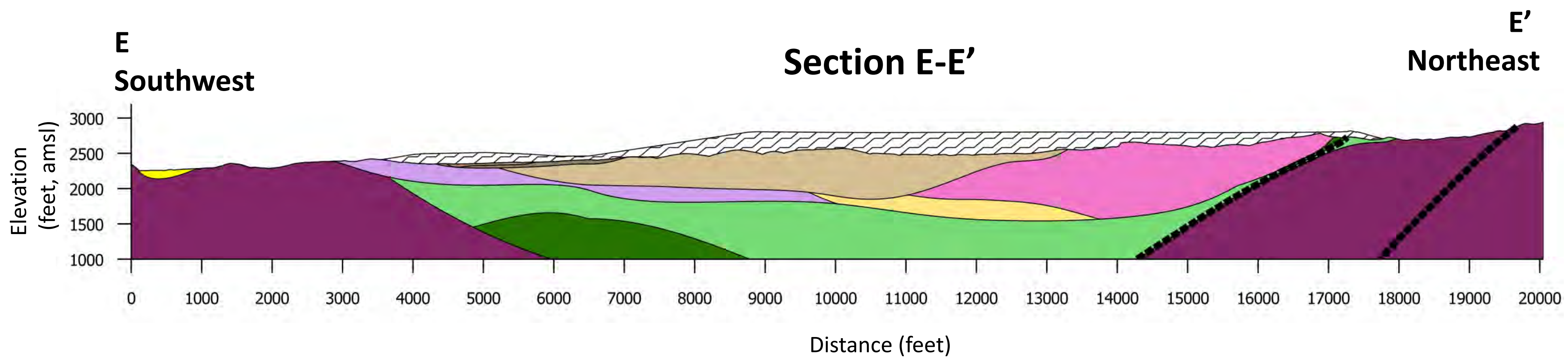
All Sections – Vertical Exaggeration 1x











Explanation

- Qal
- Qoa
- Tss
- Tg
- Tr
- Tt
- Tb
- Tvy (undivided)
- Tvu
- Tal
- Tw
- Pz
- pCdiab
- pCy
- pCpi

Scale: 1:20,000
Vertical exaggeration: 1x

0ft 7000ft

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ALL SECTIONS
VERTICAL EX. 1

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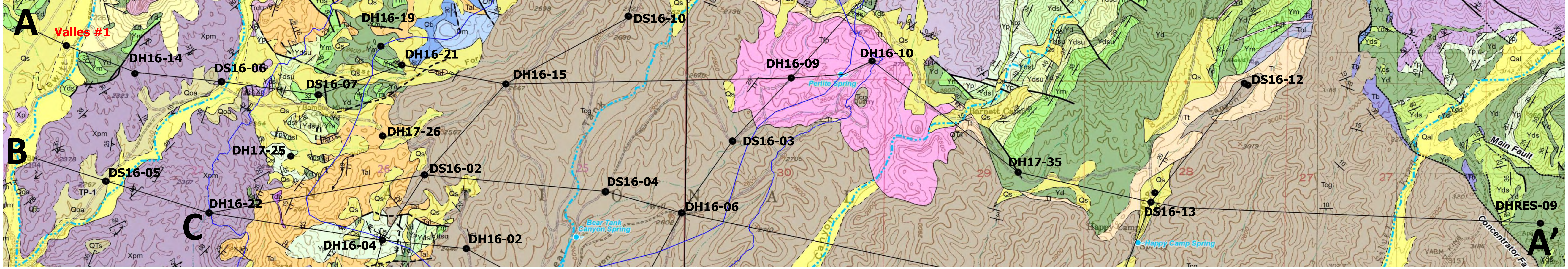

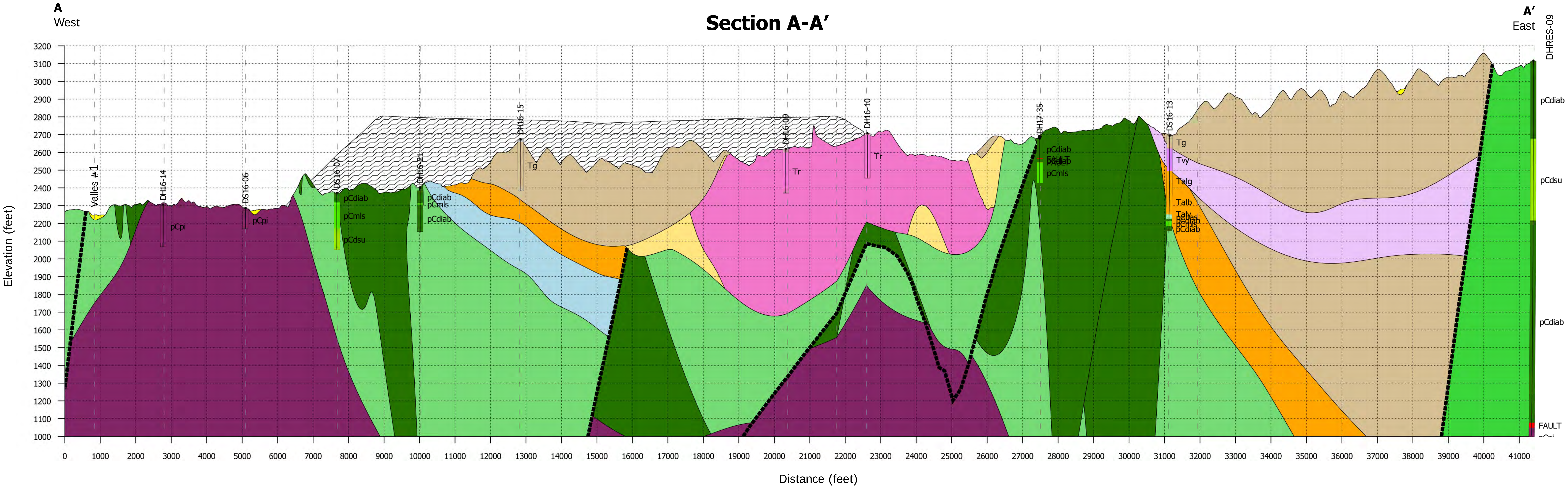

Explanation

Qal	Tal
Qoa	Tw
Tss	Pz
Tg	pCdiab
Tr	pCy
Tt	pCpi
Tb	
Tvy (undivided)	
Tvu	

N
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S

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SECTION A-A'

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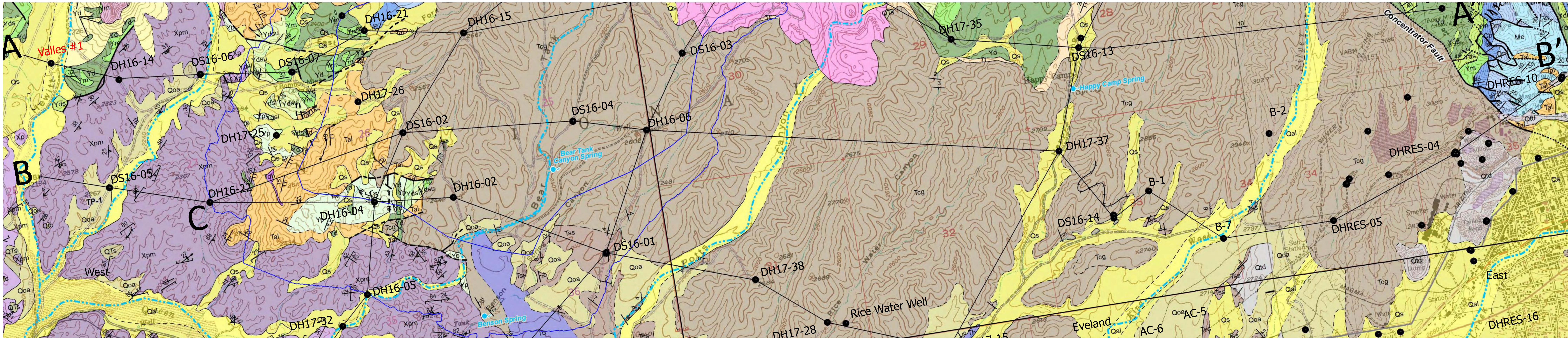
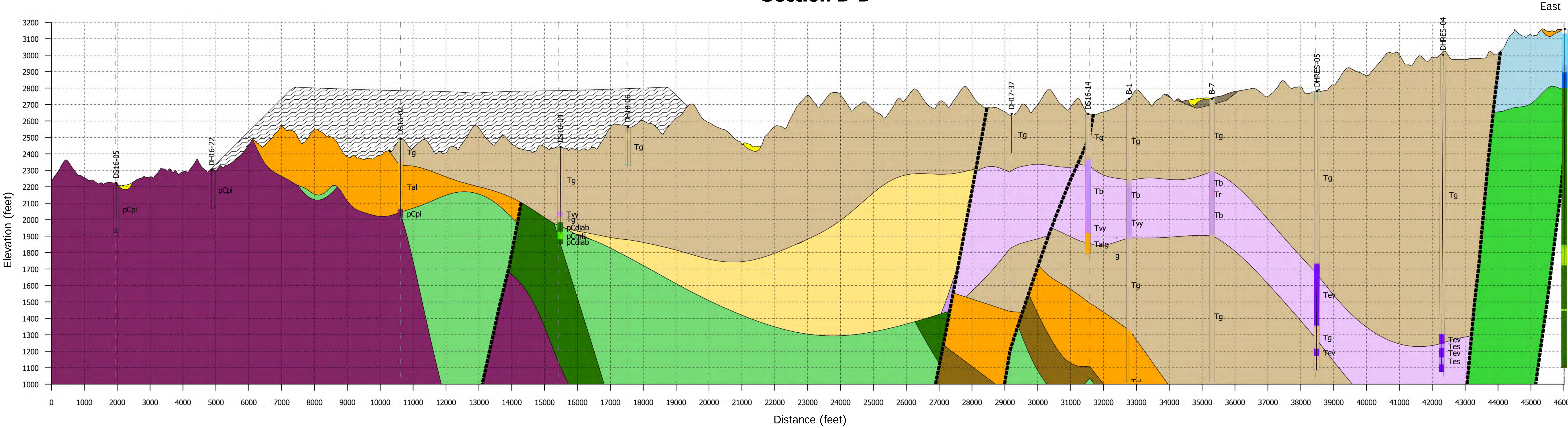


B
West

Section B-B'

B'
East



Explanation

- Qal
- Qoa
- Tss
- Tg
- Tr
- Tt
- Tb
- Tvy (undivided)
- Tvu
- Tal
- Tw
- Pz
- pCdiab
- pCy
- pCpi

N
W E
S

Scale: 1:20,000

Vertical exaggeration: 5x

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RESOLUTION COPPER

SECTION B-B'

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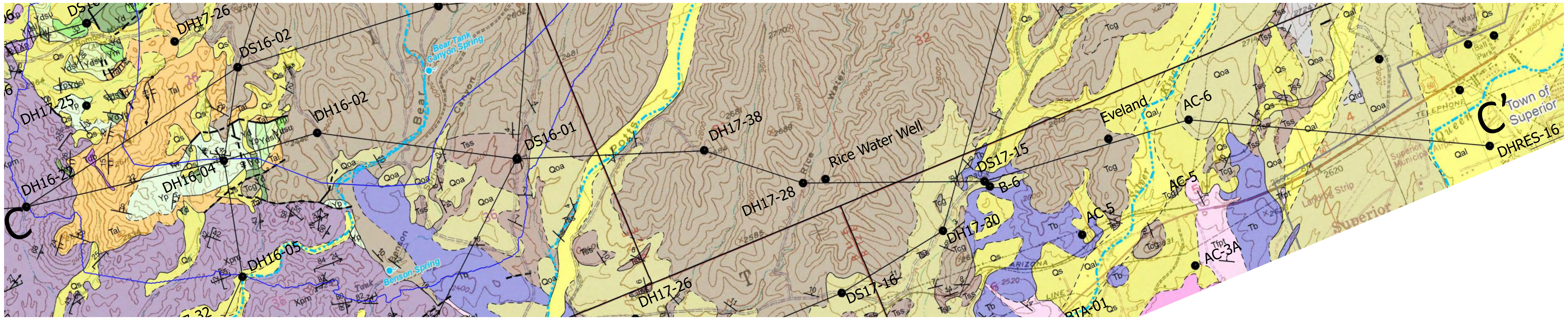

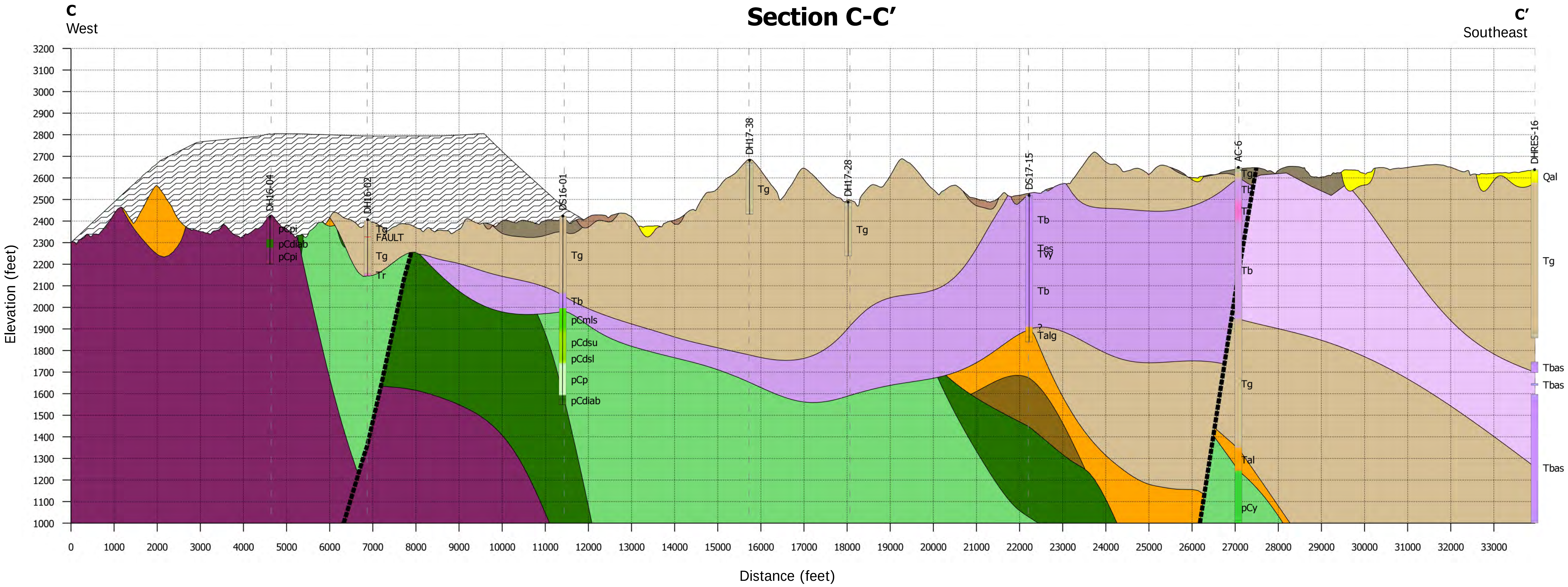

Explanation

- Qal
- Qoa
- Tss
- Tg
- Tr
- Tt
- Tb
- Tvy (undivided)
- Tvu
- Tal
- Tw
- Pz
- pCdiab
- pCy
- pCpi

N
W E
S

Scale: 1:20,000

Vertical exaggeration: 5x

0ft 7000ft

RESOLUTION COPPER

SECTION C-C'

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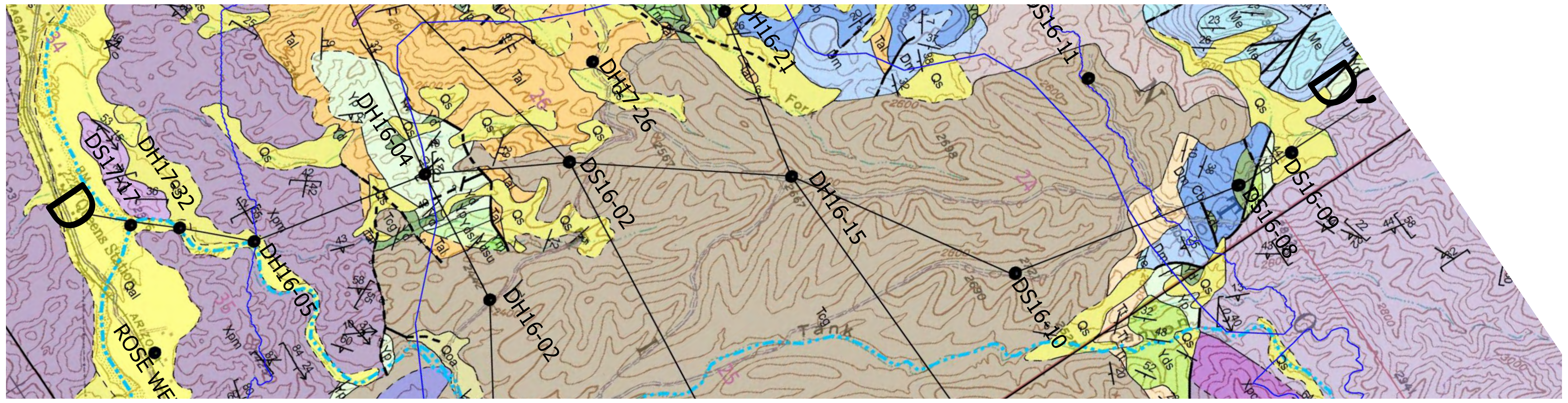
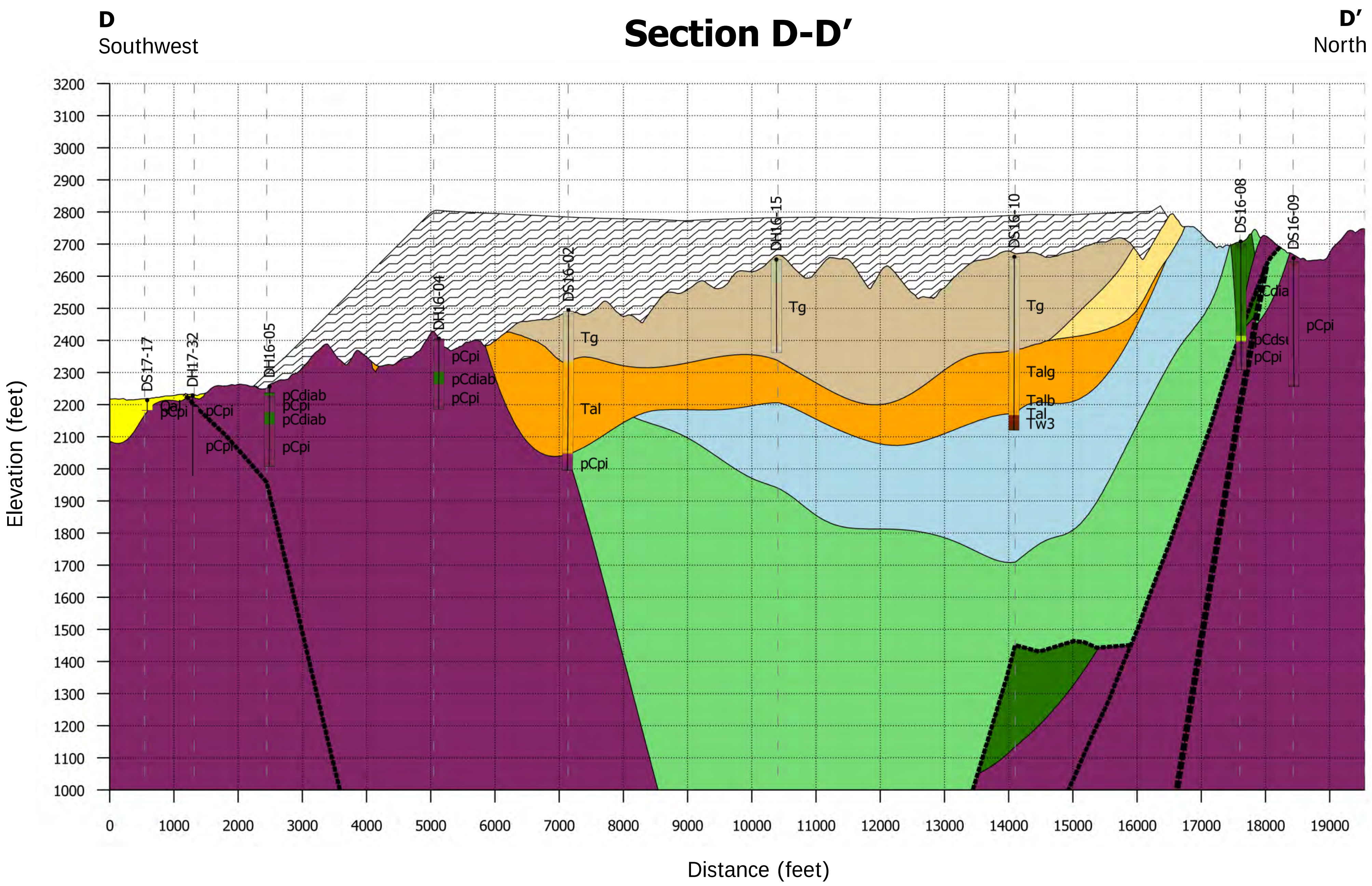




Explanation

Qal	Tal
Qoa	Tw
Tss	Pz
Tg	pCdiab
Tr	pCy
Tt	pCpi
Tb	
Tvy (undivided)	
Tvu	

W N S E

Scale: 1:20,000

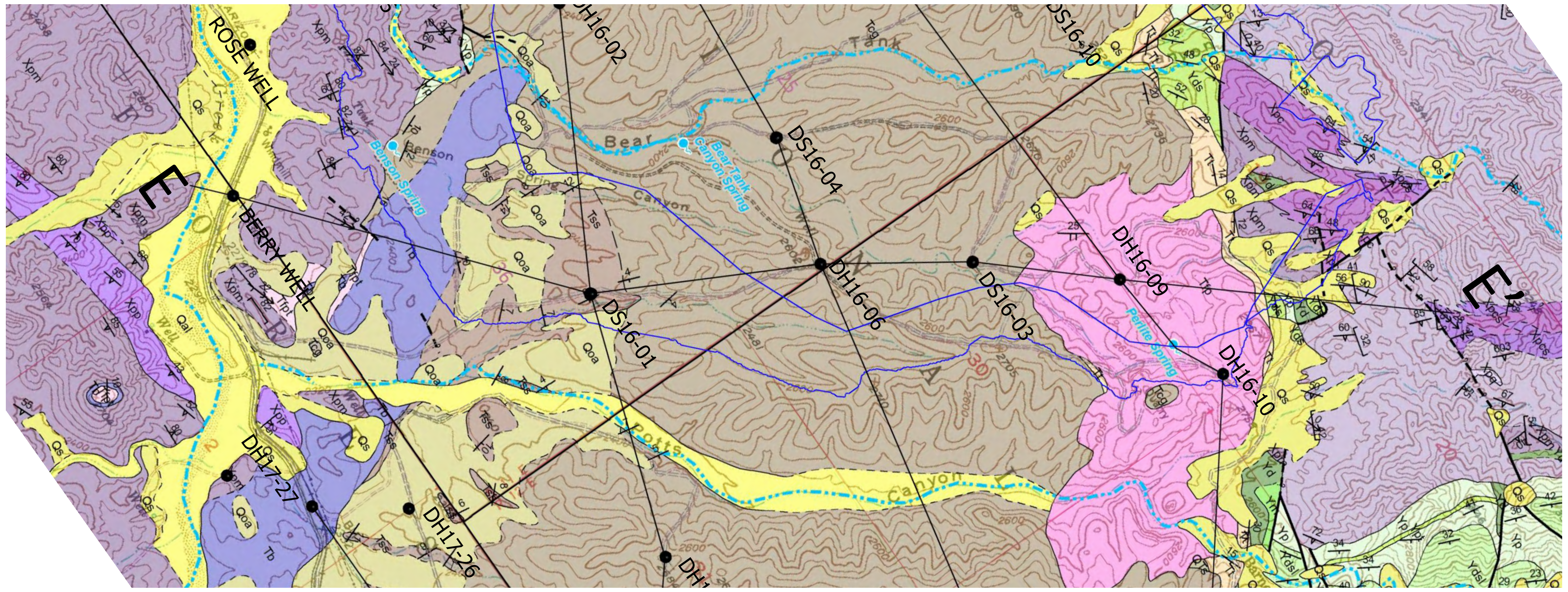
Vertical exaggeration: 5x

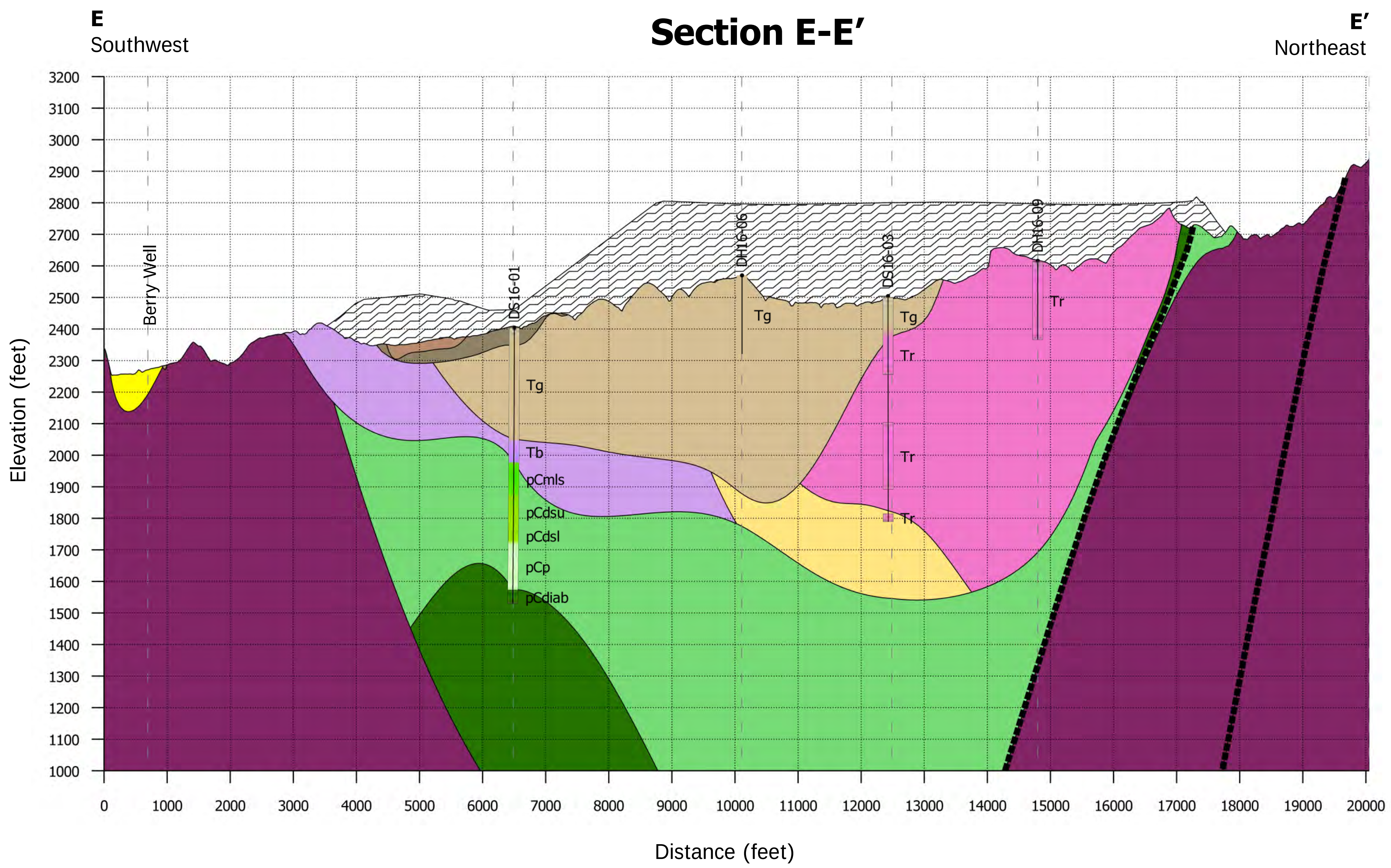
0ft 7000ft

RESOLUTION COPPER

SECTION D-D'

MONTGOMERY & ASSOCIATES





Explanation

Qal	Tal
Qoa	Tw
Tss	Pz
Tg	pCdiab
Tr	pCy
Tt	pCpi
Tb	
Tvy (undivided)	
Tvu	

W N S E

Scale: 1:20,000

Vertical exaggeration: 5x

0ft 7000ft

RESOLUTION COPPER

SECTION E-E'

MONTGOMERY & ASSOCIATES