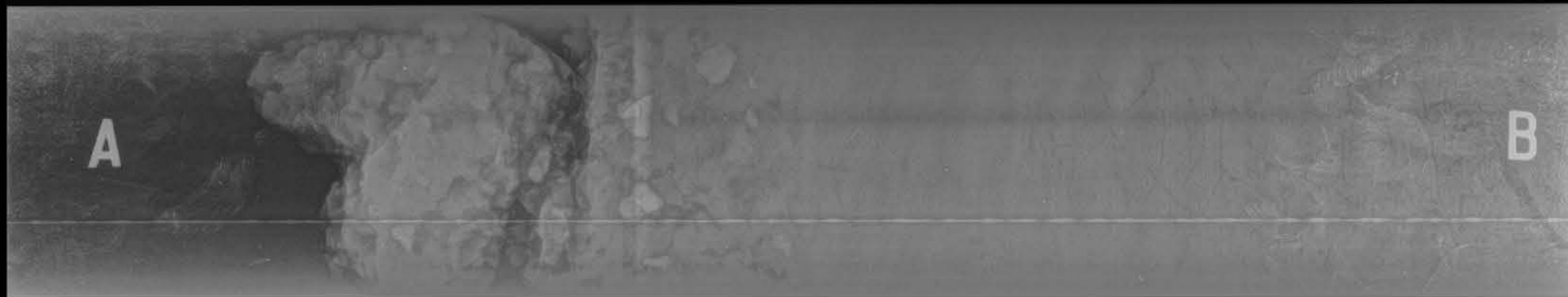


BC-02 S06 @ 19.5'



BC-02 S08 @ 34.5'



CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-02 S06 @ 19.5'



CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-03 S06 @ 39.5'

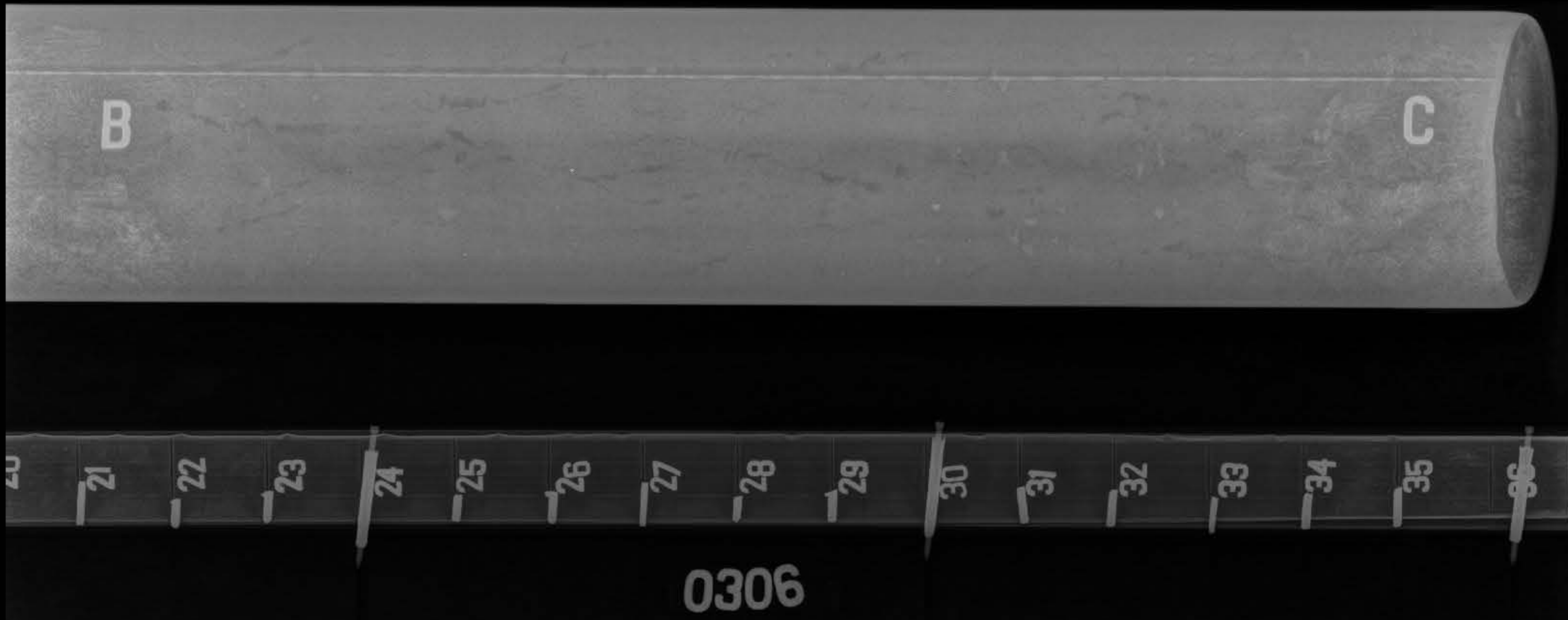




CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-03 S06 @ 39.5'

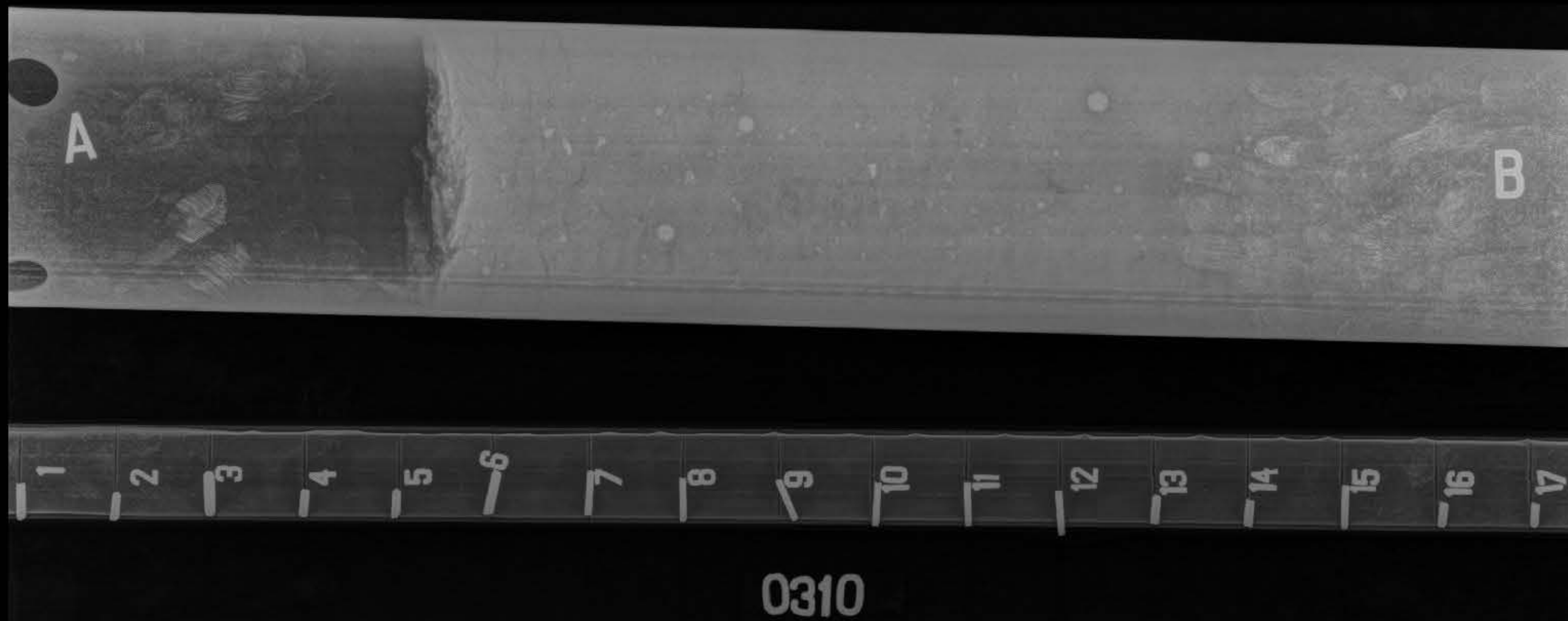




CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

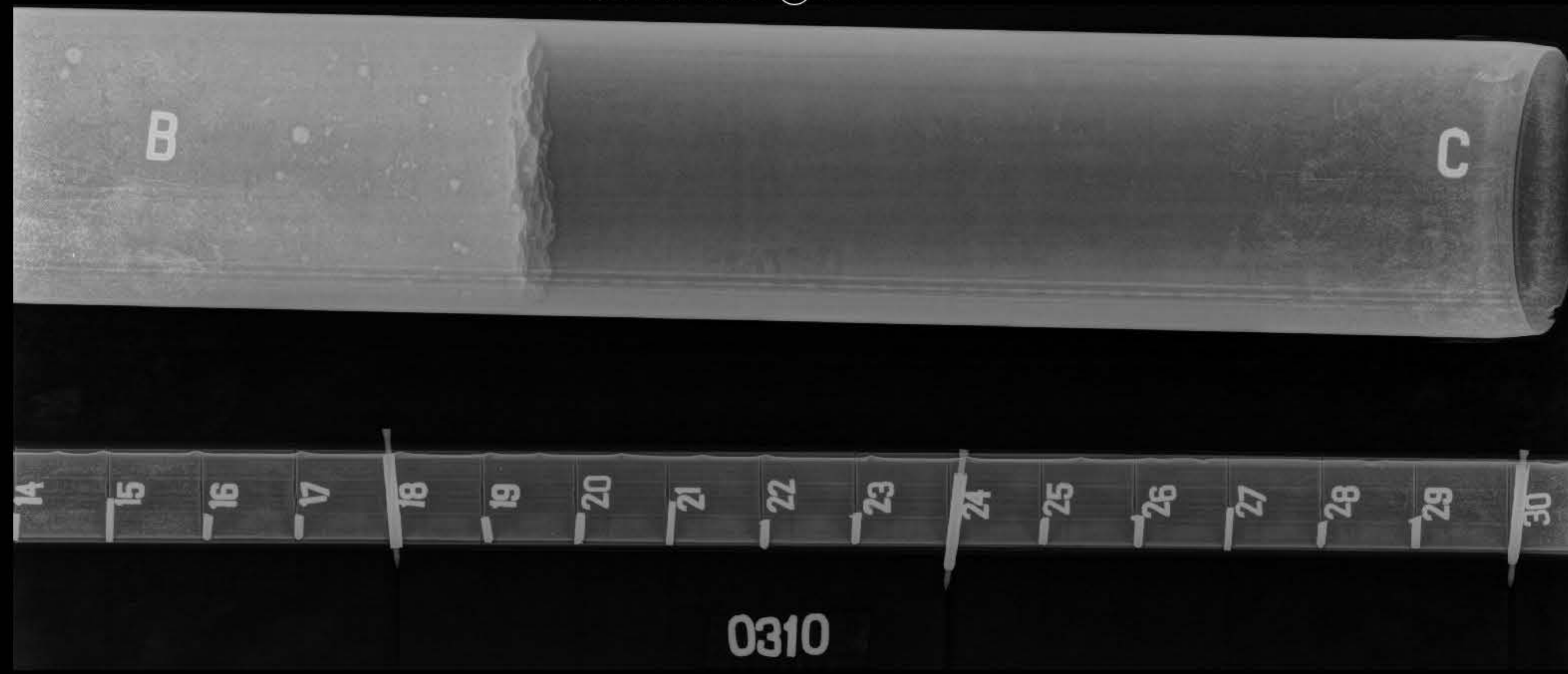
BC-03 S10 @ 90'



CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-03 S10 @ 90'



BC-04 S04 @ 12.5'



0404



0405

BC-04 S05 @ 17.5'

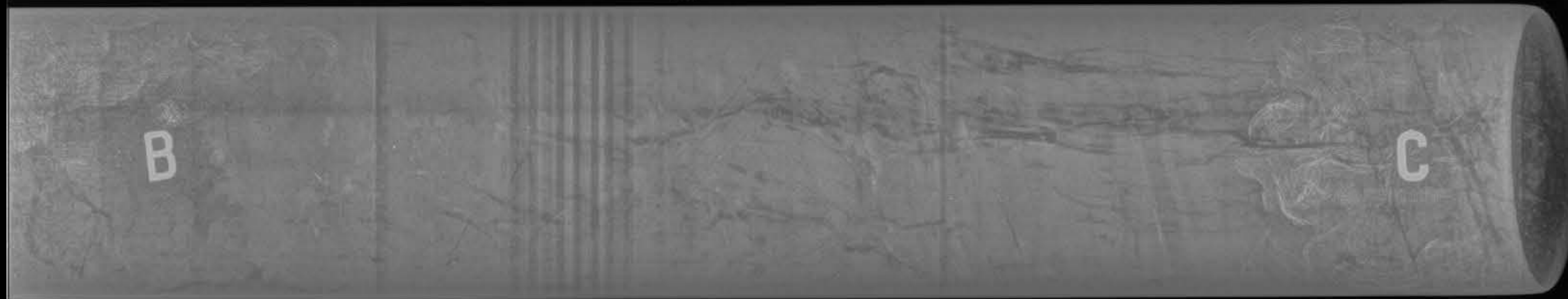




BC-04 S04 @ 12.5'



BC-04 S05 @ 17.5'



BC-04 S06 @ 22.5'

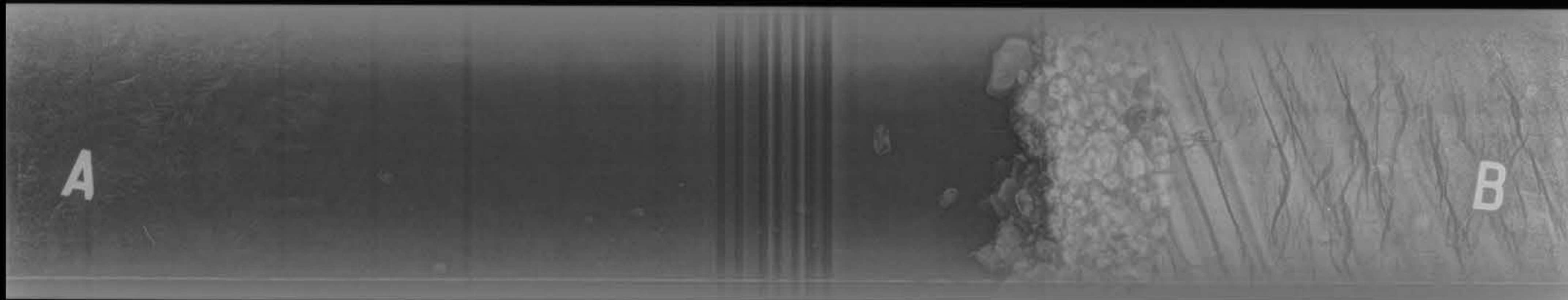


0406



0408

BC-04 S08 @ 32.5'

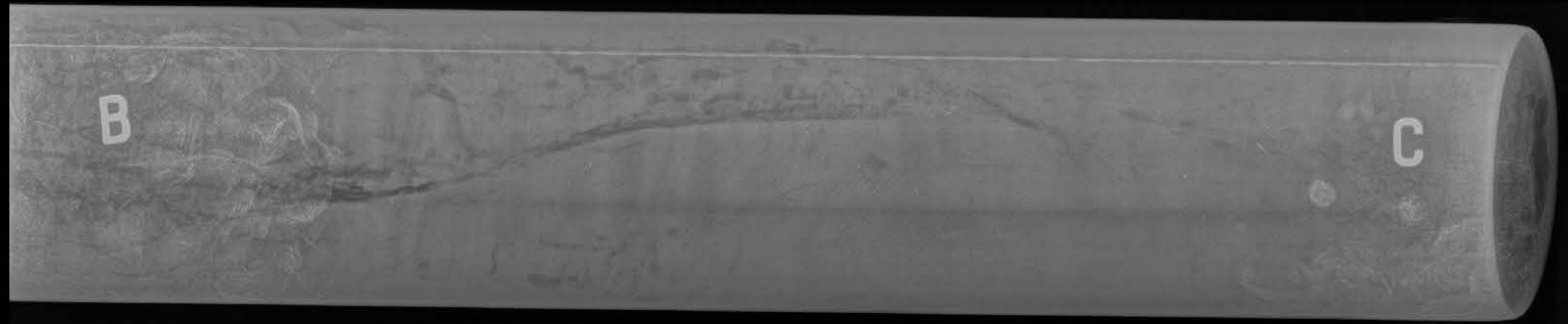




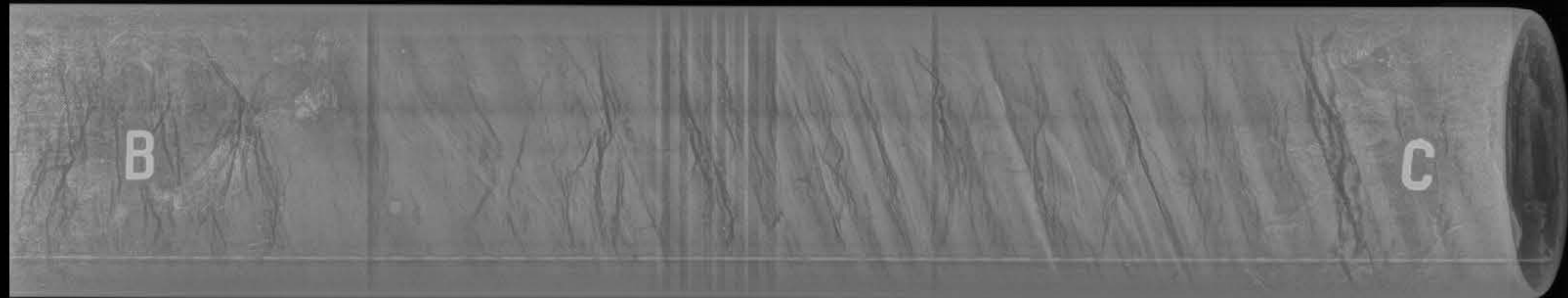
CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-04 S06 @ 22.5'

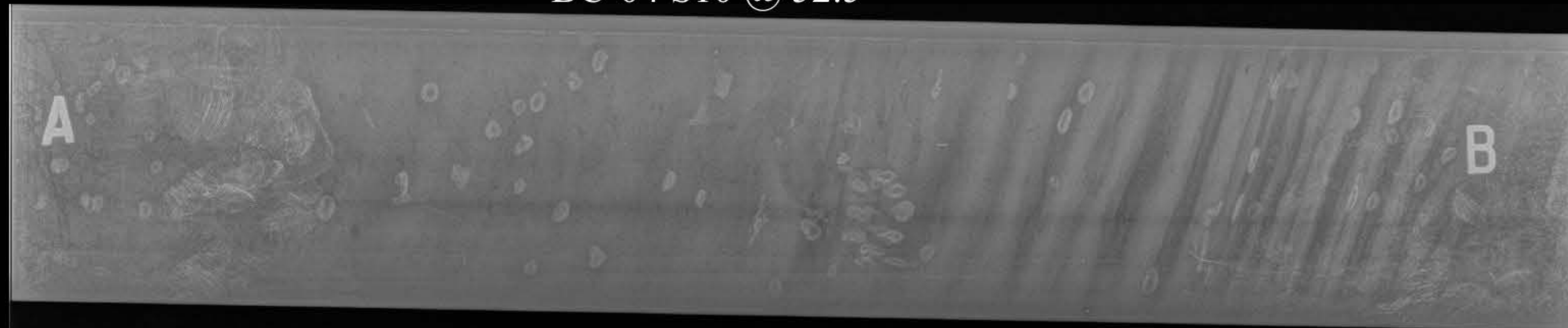


BC-04 S08 @ 32.5'





BC-04 S10 @ 52.5'



0410



0504

BC-05 S04 @ 14.5'



CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-04 S10 @ 52.5'

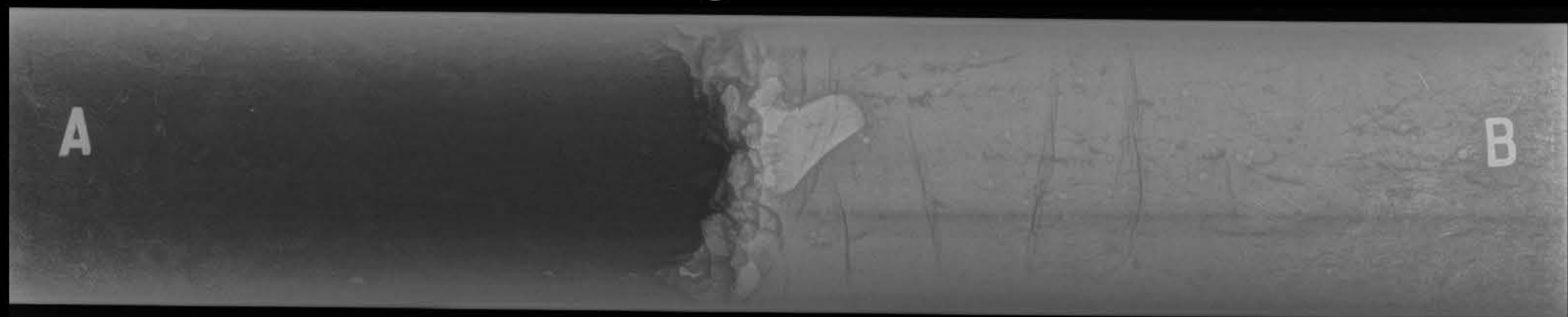


BC-05 S04 @ 14.5'





BC-09 S05 @ 23'



BC-09 S09 @ 68'





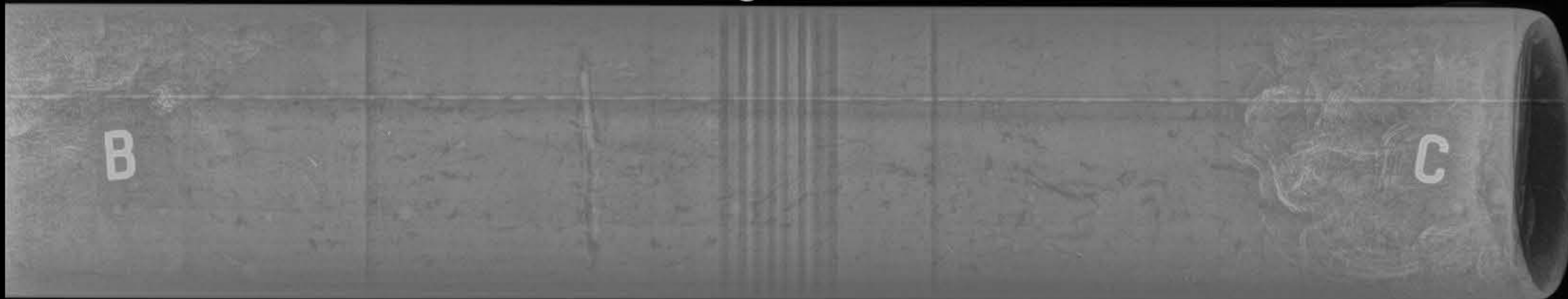
CTL# 020-251  
AECOM  
Klamath River Dam Removal  
60537920

Scale in inches  
0 = Top of Tube

BC-09 S05 @ 23'



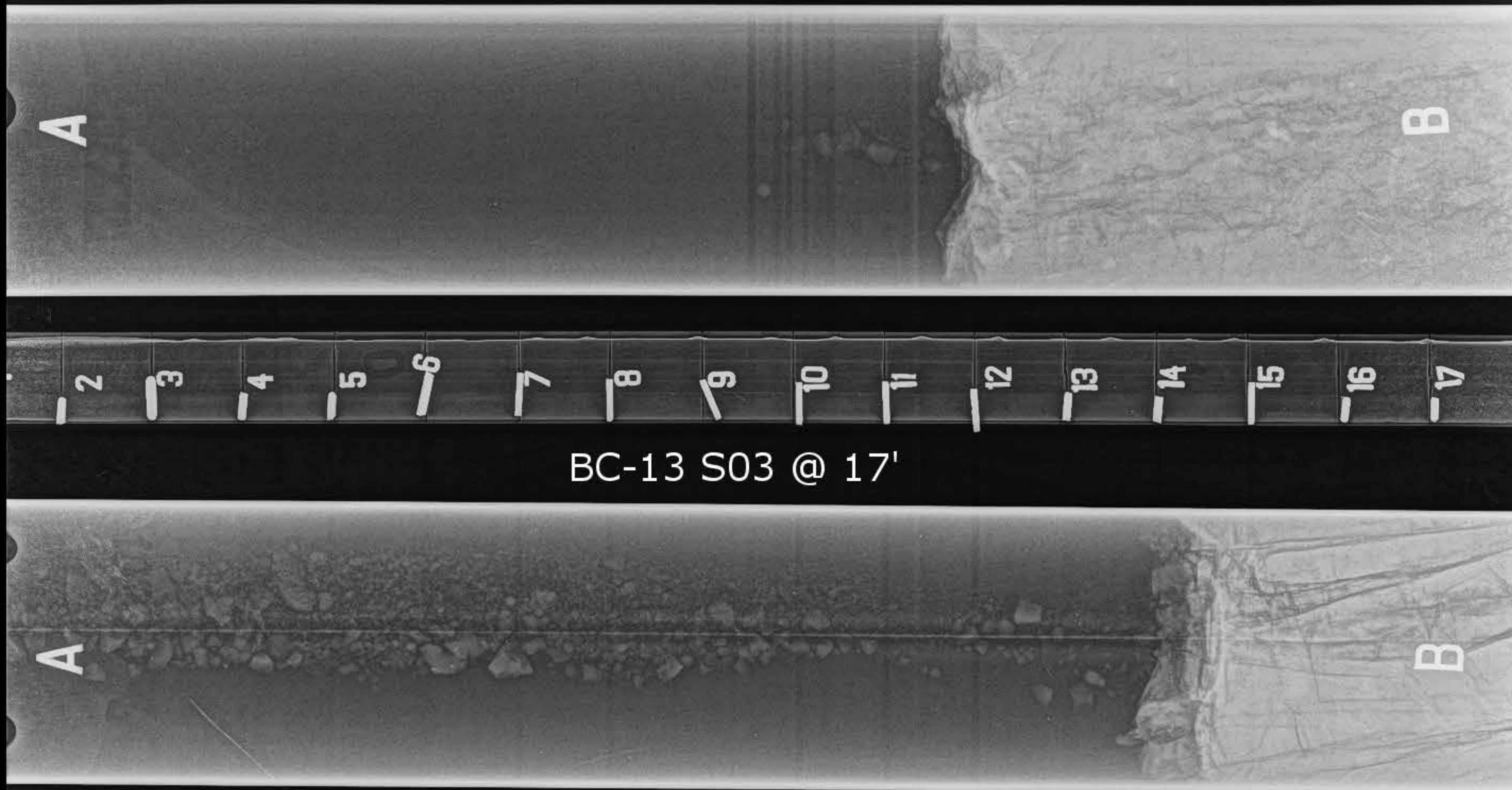
BC-09 S09 @ 68'



CTL# 020-271  
AECOM  
Klamath River Dam  
Removal Project  
60537920

Scale in inches  
0 = Top of Tube

BC-13 S02 @ 12'

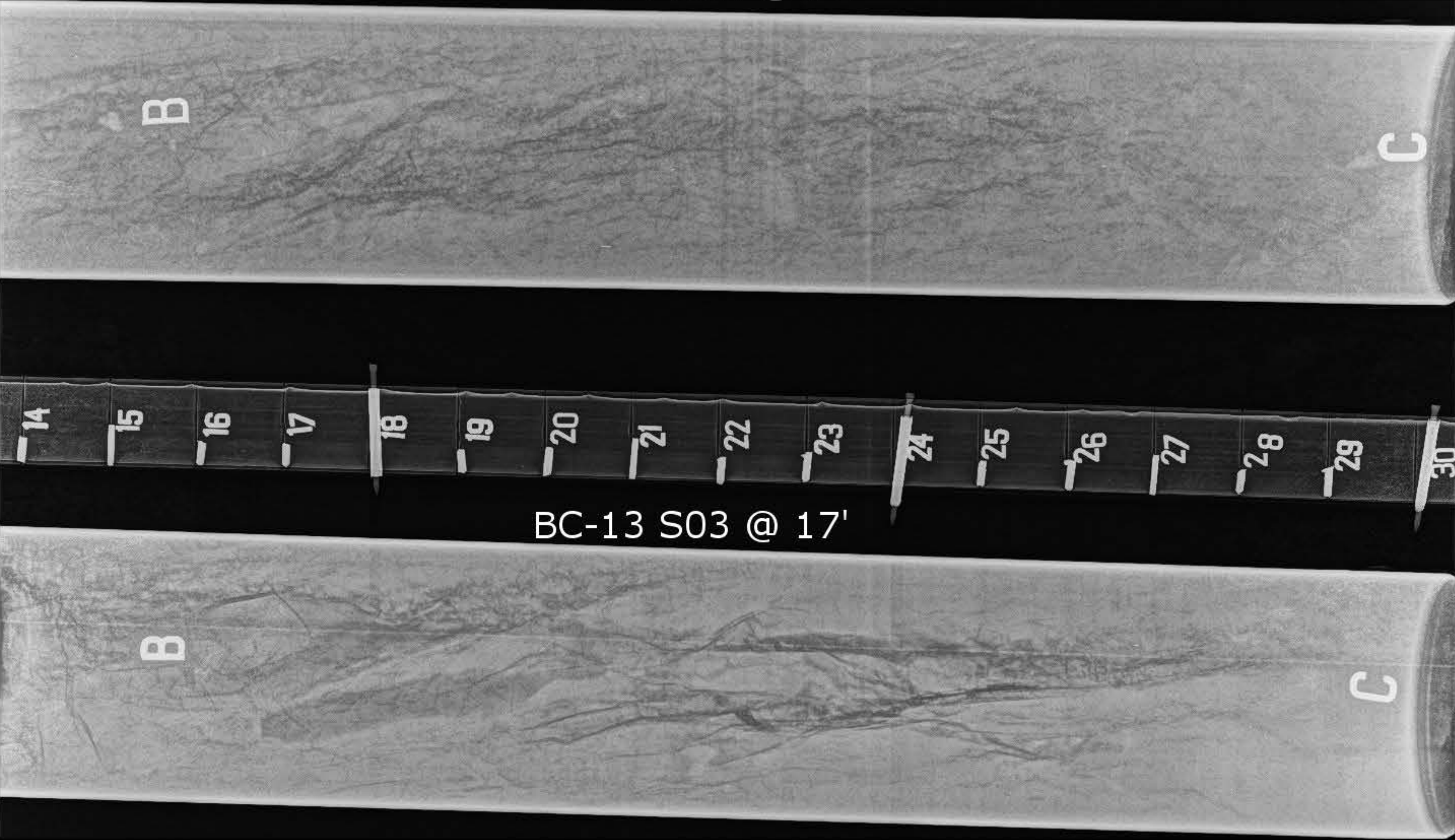




CTL# 020-271  
AECOM  
Klamath River Dam  
Removal Project  
60537920

Scale in inches  
0 = Top of Tube

BC-13 S02 @ 12'

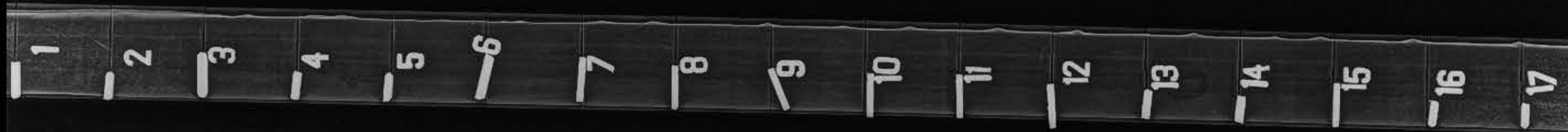
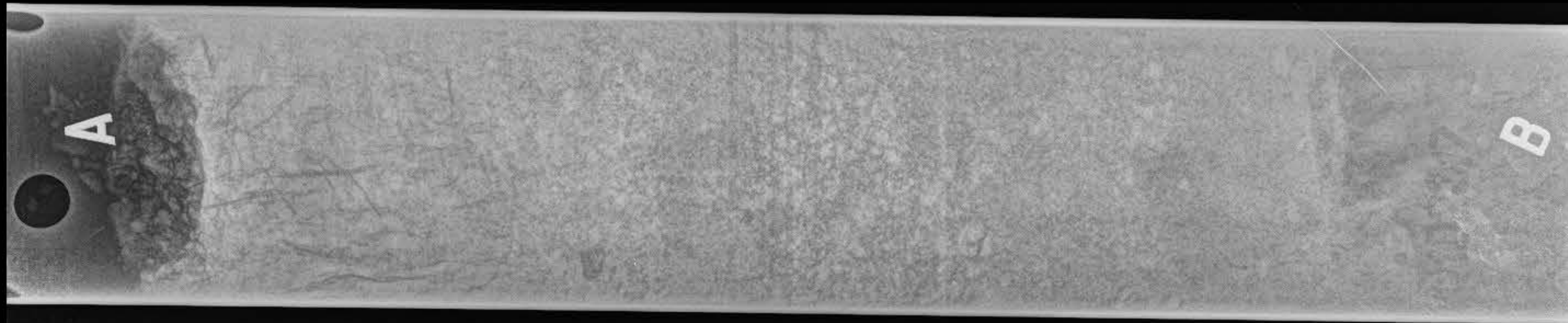




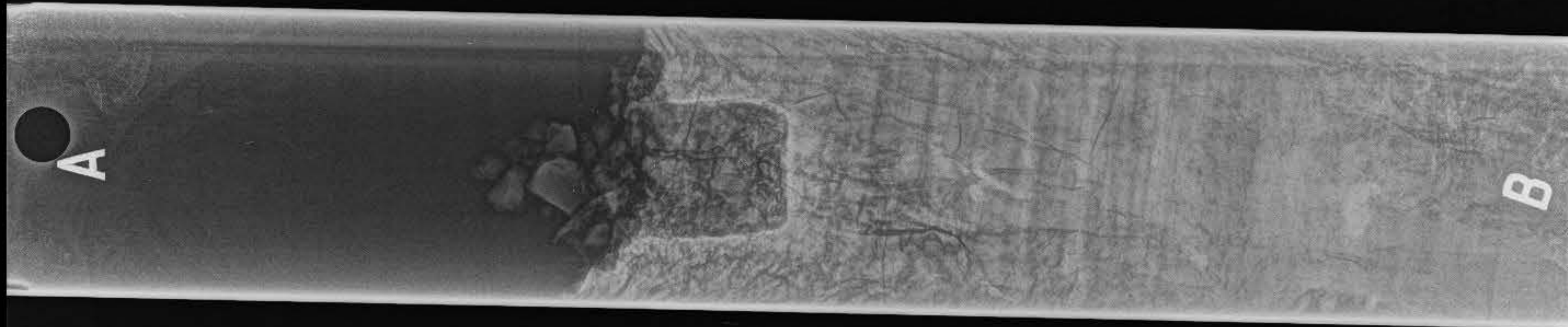
CTL# 020-271  
AECOM  
Klamath River Dam  
Removal Project  
60537920

Scale in inches  
0 = Top of Tube

BC-13 S04 @ 22'



BC-13 S05 @ 30.5'





CTL# 020-271  
AECOM  
Klamath River Dam  
Removal Project  
60537920

Scale in inches  
0 = Top of Tube

BC-13 S04 @ 22'



BC-13 S05 @ 30.5'

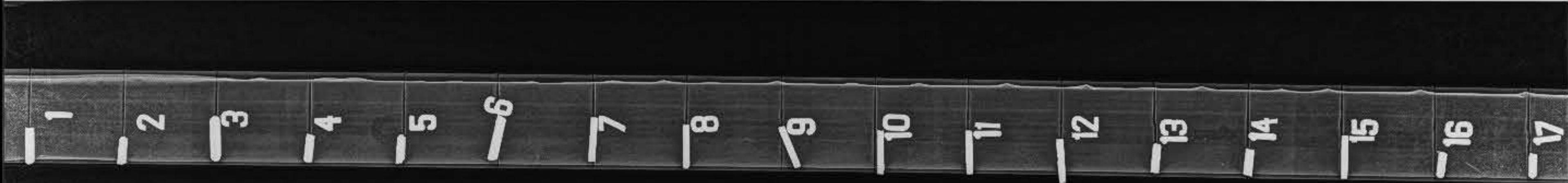
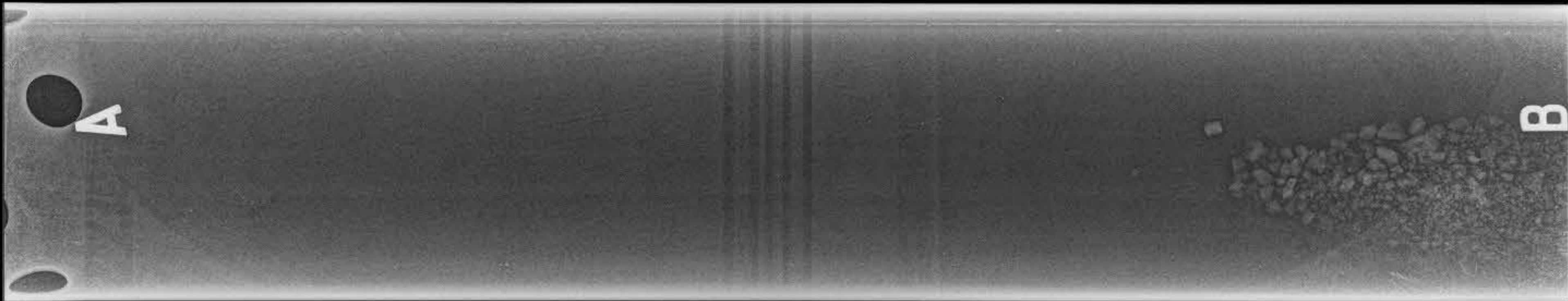




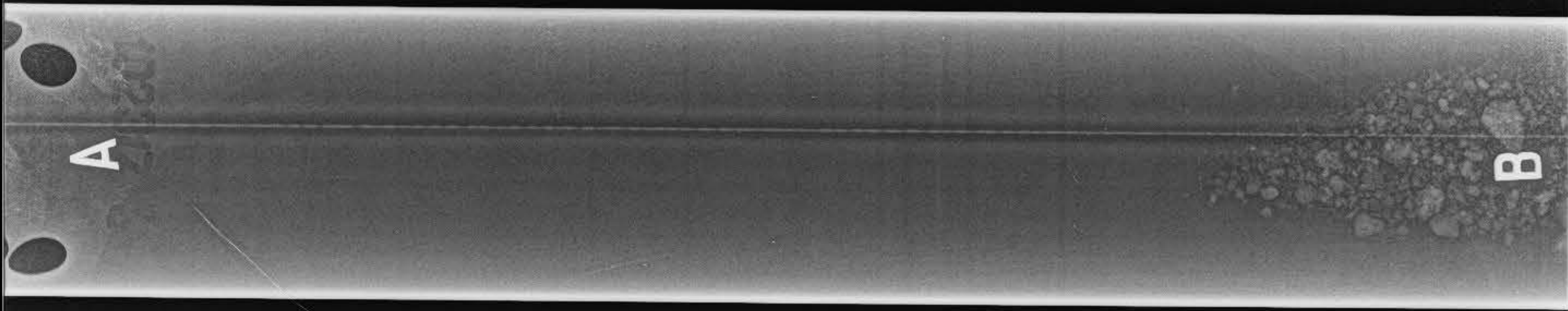
CTL# 020-271  
AECOM  
Klamath River Dam  
Removal Project  
60537920

Scale in inches  
0 = Top of Tube

BC-14 S01 @ 5'



BC-14 S04 @ 12'

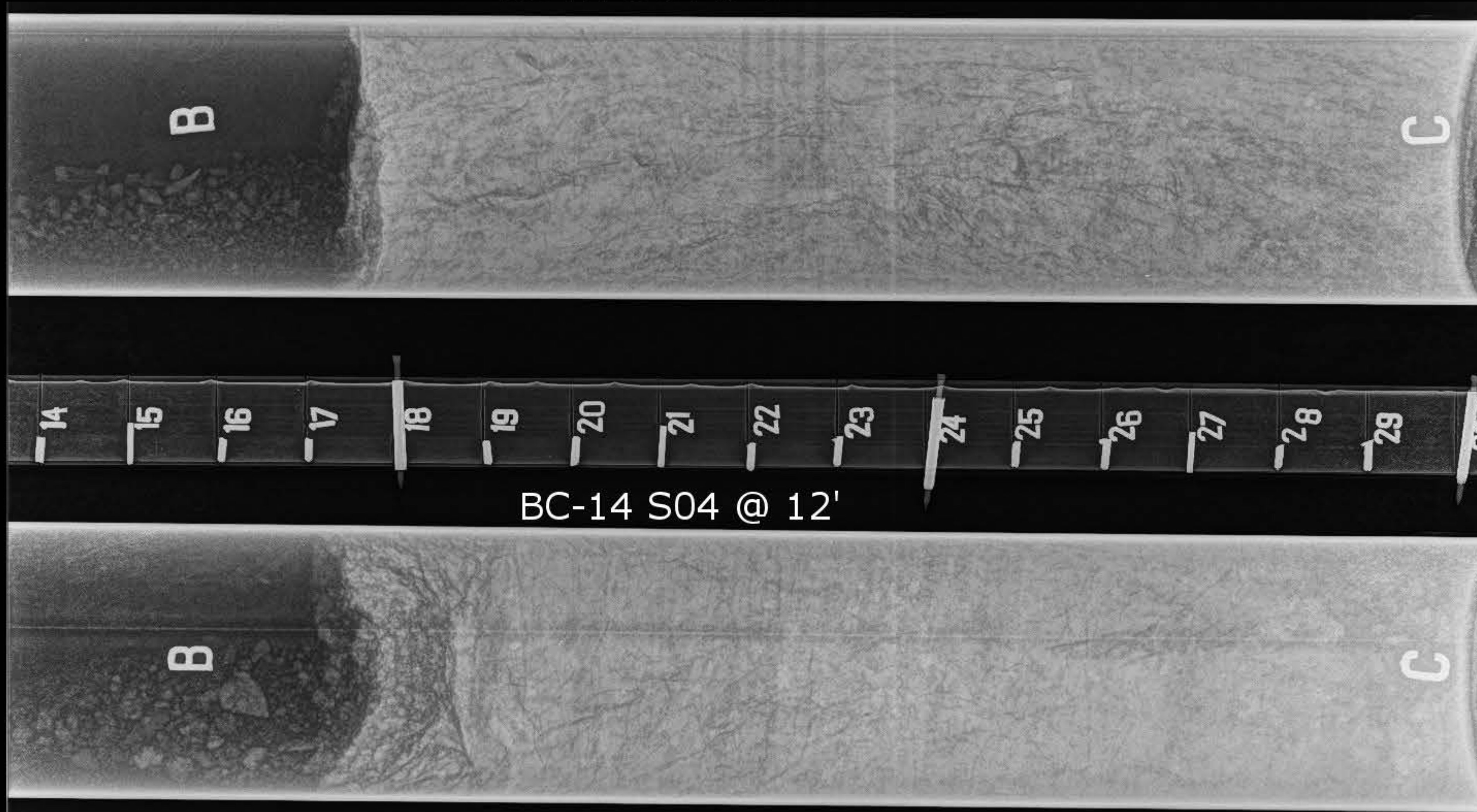




CTL# 020-271  
AECOM  
Klamath River Dam  
Removal Project  
60537920

Scale in inches  
0 = Top of Tube

BC-14 S01 @ 5'





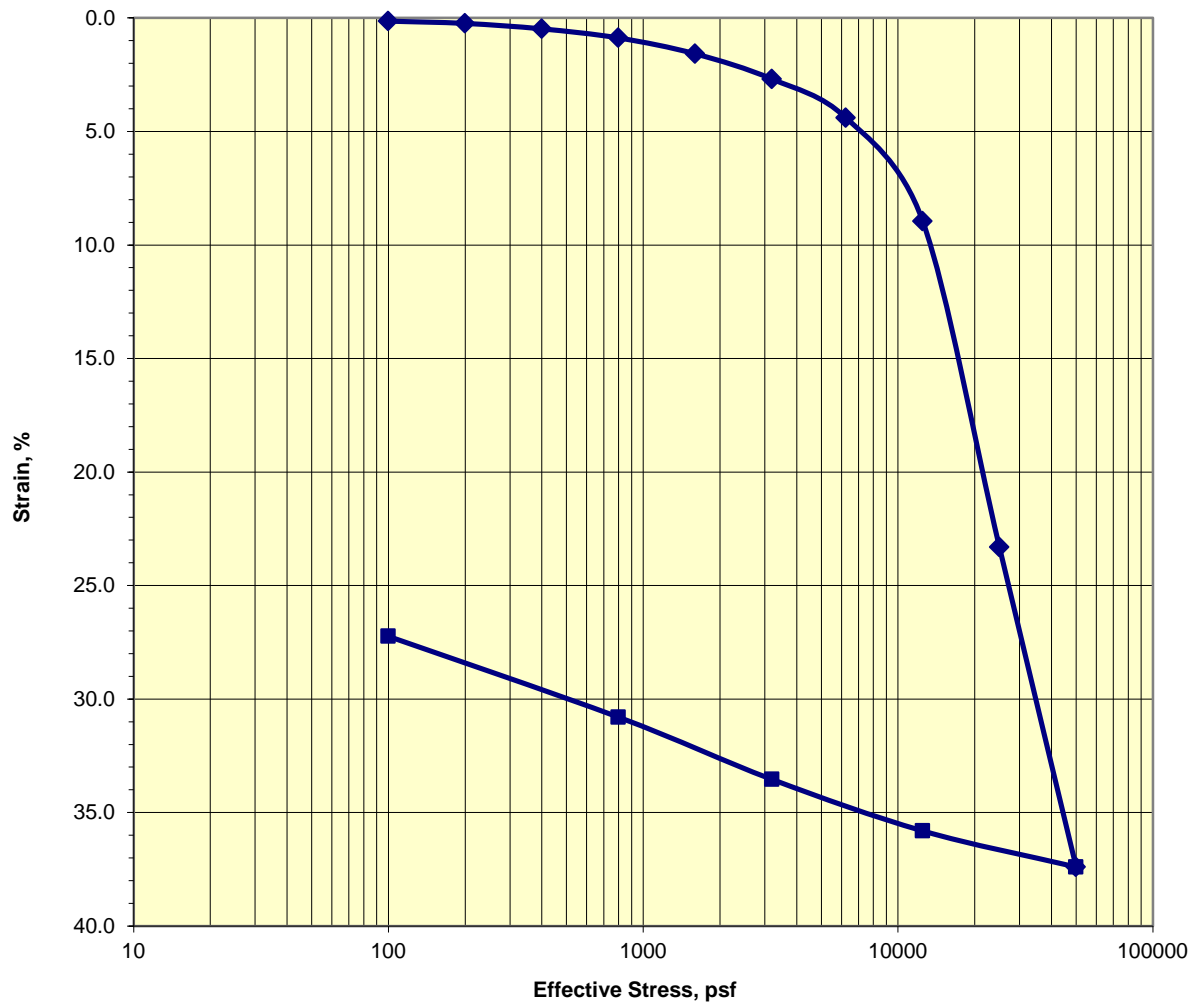


# Consolidation Test

## ASTM D2435

Job No.:	020-251	Boring:	BC-04	Run By:	MD
Client:	AECOM	Sample:	S-08	Reduced:	PJ
Project:	60537920	Depth, ft.:	32.5(Tip-2")	Checked:	PJ/DC
Soil Type:	Pale Brown Mottled Gray Elastic SILT		Date:	6/1/2018	

### Strain-Log-P Curve



Assumed Gs	2.6	Initial	Final
Moisture %:		149.5	104.4
Dry Density, pcf:		32.1	43.7
Void Ratio:		4.058	2.715
% Saturation:		95.8	100.0

Remarks:

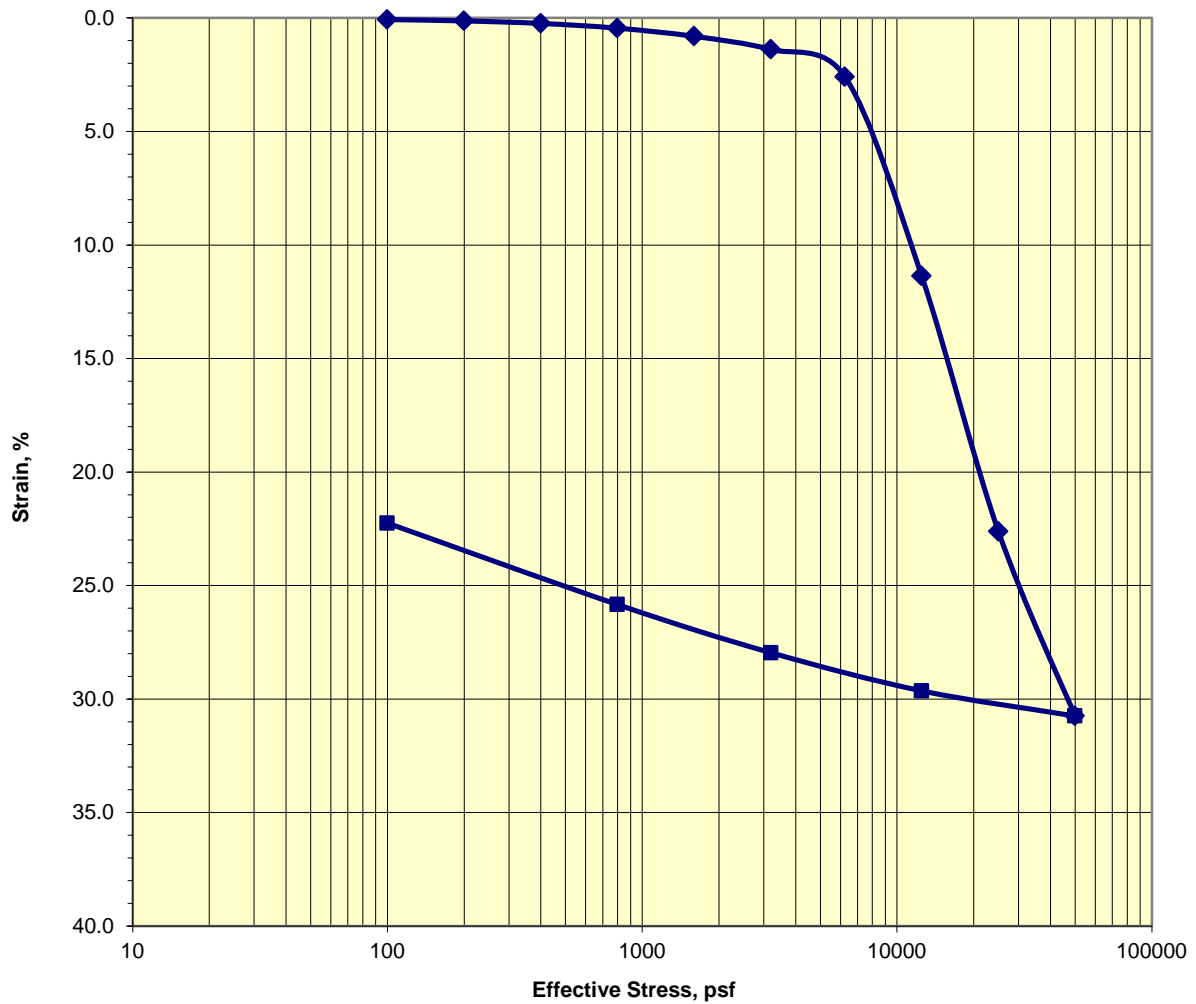


# Consolidation Test

## ASTM D2435

Job No.:	020-251	Boring:	BC-09	Run By:	MD
Client:	AECOM	Sample:	S-09	Reduced:	PJ
Project:	60537920	Depth, ft.:	68-70.5(Tip-20")	Checked:	PJ/DC
Soil Type:	Dark Greenish Gray CLAY (Silty)	Date:	6/1/2018		

### Strain-Log-P Curve



Assumed Gs	2.6	Initial	Final
Moisture %:		88.4	60.3
Dry Density, pcf:		48.6	63.2
Void Ratio:		2.340	1.568
% Saturation:		98.2	100.0

Remarks:



22 February, 2019

Job No. 1902023  
Cust. No. 12259

Mr. John Hunt  
Inspection Services Inc.  
1798 University Avenue  
Berkeley, CA 94703-1514

Subject: Project No.: 60537920  
Project Name: Klamath River Dam Removal Project  
Corrosivity Analysis – CalTrans Test Methods

Dear Mr. Hunt:

Pursuant to your request, CERCO Analytical has analyzed the soil samples submitted on February 05, 2019. Based on the analytical results, this brief corrosivity evaluation is enclosed for your consideration.

Based upon the resistivity measurements, Sample No.003 is classified as “severely corrosive” and the remaining samples are classified as “corrosive”. All buried iron, steel, cast iron, ductile iron, galvanized steel and dielectric coated steel or iron should be properly protected against corrosion depending upon the critical nature of the structure. All buried metallic pressure piping such as ductile iron firewater pipelines should be protected against corrosion.

The chloride ion concentrations reflect none detected with a reporting limit of 15 mg/kg.


The sulfate ion concentrations reflect none detected & 26 mg/kg and are determined to be insufficient to damage reinforced concrete structures and cement mortar-coated steel at these locations.

The pH of the soils ranged from 7.84 to 8.97, which does not present corrosion problems for buried iron, steel, mortar-coated steel and reinforced concrete structures.

This corrosivity evaluation is based on general corrosion engineering standards and is non-specific in nature. For specific long-term corrosion control design recommendations or consultation, please call *JDH Corrosion Consultants, Inc. at (925) 927-6630*.

We appreciate the opportunity of working with you on this project. If you have any questions, or if you require further information, please do not hesitate to contact us.

Very truly yours,  
**CERCO ANALYTICAL, INC.**

  
J. Darby Howard, Jr., P.E.  
President

JDH/jdl  
Enclosure



Date of Report: 22-Feb-2019

**PRIVILEGED AND CONFIDENTIAL**

\* Results Reported on an "As Received" Basis  
N.D. - None Detected

**Quality Control Summary - All laboratory quality control parameters were found to be within established limits**





## APPENDIX D3

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### **Rock Lab Testing Results**

(Pages D3-1 to D3-139)

**Moisture Content**  
 ASTM D2216-10

 COMPANY WITH  
 QUALITY SYSTEM  
 CERTIFIED BY DNV GL  
 = ISO 9001 =

 Tonon USA  
 Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-4-1
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 27-27.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/27-30/2018
--------------------------	------------------------	---------------------------

## Method A: Caliper

Diameter (mm)	Length (mm)	Initial Weight (g)	Dry Weight (g)
		202.50	193.13

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)
4.85				

## Method B: Buoyancy

Weight (g)	Saturated Weight (g)	Suspended Weight (g)	Dry Weight (g)

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 2028 E Ben White BLVD #240-2660  
 Austin, TX 78741

 Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
 Phone: +1-512-200-3051  
 E-mail: fulvio@tononeng.com



**Moisture Content**  
 ASTM D2216-10

 COMPANY WITH  
 QUALITY SYSTEM  
 CERTIFIED BY DNV GL  
 = ISO 9001 =

 Tonon USA  
 Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-4-2
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 48.9-50.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/27-30/2018
--------------------------	------------------------	---------------------------

Method A: Caliper

Diameter (mm)	Length (mm)	Initial Weight (g)	Dry Weight (g)
		180.47	169.63

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)
6.39				

Method B: Buoyancy

Weight (g)	Saturated Weight (g)	Suspended Weight (g)	Dry Weight (g)

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
 Phone: +1-512-200-3051  
 E-mail: fulvio@tononeng.com

**Moisture Content**  
 ASTM D2216-10

 COMPANY WITH  
 QUALITY SYSTEM  
 CERTIFIED BY DNV GL  
 = ISO 9001 =

 Tonon USA  
 Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-4-3
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 55.4-56.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/27-30/2018
--------------------------	------------------------	---------------------------

## Method A: Caliper

Diameter (mm)	Length (mm)	Initial Weight (g)	Dry Weight (g)
		175.36	165.73

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)
5.81				

## Method B: Buoyancy

Weight (g)	Saturated Weight (g)	Suspended Weight (g)	Dry Weight (g)

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
 Phone: +1-512-200-3051  
 E-mail: fulvio@tononeng.com



**Moisture Content**  
 ASTM D2216-10

 COMPANY WITH  
 QUALITY SYSTEM  
 CERTIFIED BY DNV GL  
 = ISO 9001 =

 Tonon USA  
 Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-4-4
Report Date	5/17/2018
Drill Hole and Depth	BI-03; 17.4-18.4 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/27-30/2018
--------------------------	------------------------	---------------------------

Method A: Caliper

Diameter (mm)	Length (mm)	Initial Weight (g)	Dry Weight (g)
		84.27	74.93

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)
12.46				

Method B: Buoyancy

Weight (g)	Saturated Weight (g)	Suspended Weight (g)	Dry Weight (g)

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 Austin, TX 78741

 Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
 Phone: +1-512-200-3051  
 E-mail: fulvio@tononeng.com

**Moisture Content**  
 ASTM D2216-10

 COMPANY WITH  
 QUALITY SYSTEM  
 CERTIFIED BY DNV GL  
 = ISO 9001 =

 Tonon USA  
 Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-4-5
Report Date	5/17/2018
Drill Hole and Depth	BI-03; 21.5-22.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/27-30/2018
--------------------------	------------------------	---------------------------

## Method A: Caliper

Diameter (mm)	Length (mm)	Initial Weight (g)	Dry Weight (g)
		177.06	160.77

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)
10.13				

## Method B: Buoyancy

Weight (g)	Saturated Weight (g)	Suspended Weight (g)	Dry Weight (g)

Moisture Content (%)	Unit Weight (kN/m <sup>3</sup> )	Unit Weight (pcf)	Dry Unit Weight (kN/m <sup>3</sup> )	Dry Unit Weight (pcf)

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 Austin, TX 78741

 Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
 Phone: +1-512-200-3051  
 E-mail: fulvio@tononeng.com



**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/24/2018****Colorado School of Mines****Mining Engineering Department****ASTM D2216**

Sample ID	Weight as Received	Weight After Drying	Weight of Moisture	Percent Moisture
	(gr)	(gr)	(gr)	
B-202 @ 56.2-57.5	289.66	256.46	33.20	12.9%
B-202 @ 82.0-82.8	402.18	343.52	58.66	17.1%
B-206 @ 47.4-48.7	434.16	423.74	10.42	2.5%
B-206 @ 65.2-66.5	459.22	453.96	5.26	1.2%

**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath Rive****Date: 10/3/2018****Colorado School of Mines****Mining Engineering Department****ASTM D2216**

Sample ID	Weight as Received	Weight After Drying	Weight of Moisture	Percent Moisture
	(gr)	(gr)	(gr)	
B-207 @ 74.5-75.5	549.94	522.26	27.68	5.3%



**Bulk Density**

ISRM Suggested Methods 1977



Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-3-1
Report Date	5/17/2018
Drill Hole and Depth (ft)	BI-02; 27-27.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/30/2018
--------------------------	------------------------	------------------------

Diameter	Length	Weight	Bulk Density	Bulk Density
(mm)	(mm)	(g)	(kN/m <sup>3</sup> )	(pcf)
60.54	97.72	637.28	22.22	141.42

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Bulk Density**  
 ISRM Suggested Methods 1977



Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-3-2
Report Date	5/17/2018
Drill Hole and Depth (ft)	BI-02; 48.9-50.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/30/2018
--------------------------	------------------------	------------------------

Diameter	Length	Weight	Bulk Density	Bulk Density
(mm)	(mm)	(g)	(kN/m <sup>3</sup> )	(pcf)
60.85	127.87	891.59	23.51	149.67

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Bulk Density**  
 ISRM Suggested Methods 1977



Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-3-3
Report Date	5/17/2018
Drill Hole and Depth (ft)	BI-02; 55.4-56.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/30/2018
--------------------------	------------------------	------------------------

Diameter	Length	Weight	Bulk Density	Bulk Density
(mm)	(mm)	(g)	(kN/m <sup>3</sup> )	(pcf)
60.68	128.33	882.58	23.32	148.46

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Bulk Density**

ISRM Suggested Methods 1977



Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-3-4
Report Date	5/17/2018
Drill Hole and Depth (ft)	BI-03; 17.4-18.4 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/30/2018
--------------------------	------------------------	------------------------

Diameter	Length	Weight	Bulk Density	Bulk Density
(mm)	(mm)	(g)	(kN/m <sup>3</sup> )	(pcf)
60.59	129.81	830.07	21.75	138.44

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Bulk Density**

ISRM Suggested Methods 1977



Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-3-5
Report Date	5/17/2018
Drill Hole and Depth (ft)	BI-03; 21.5-22.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/30/2018
--------------------------	------------------------	------------------------

Diameter	Length	Weight	Bulk Density	Bulk Density
(mm)	(mm)	(g)	(kN/m <sup>3</sup> )	(pcf)
60.58	125.67	783.13	21.20	134.96

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Brazilian Tensile Strength Test**  
**ASTM D3967 - 16**

 COMPANY WITH  
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 = ISO 9001 =

 Tonon USA:  
 Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal	Rate of loading (0.05-0.35 MPa/s or 500-3,000 psi/min)	0.11 MPa/sec	957 psi/min
Location	Klamath River	Diameter (D)	60.94 mm	2.40 in
Client	Klamath River Renewal Corporation	Thickness (t)	22.88 mm	0.90 in
Client Project No.	60537920	Maximum Load (P)	6.53 kN	1,468 lbf
Registry No.	2018-22	Tensile strength (flat platens) $\sigma_t = 2P / \pi t D$	N/A	N/A
Report No.	2018-22-2-1	Tensile strength (curved platens) $\sigma_t = 1.272P / \pi t D$	1.90 MPa	275 psi
Report Date	5/17/2018	Direction of Loading	Orthogonal to the Borehole Axis	
Drill Hole and Depth	BI-02; 47-48.9 ft	Type of Failure	Non-Structural	
Rock Type	Volcanic Breccia	Conformance to dimensional Requirements $0.2 \leq \frac{t}{D} \leq 0.75$	$\frac{t}{D} = 0.38$	OK
Geologic Unit	N/A			
Moisture Condition	As-received			

Date Received : 4/24/2018

Date Opened : 4/24/2018

Date Tested: 4/30/2018



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 2028 E Ben White BLVD #240-2660  
 Austin, TX 78741

 Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
 Phone: +1-512-200-3051  
 E-mail: fulvio@tononeng.com

**Brazilian Tensile Strength Test**  
ASTM D3967 - 16

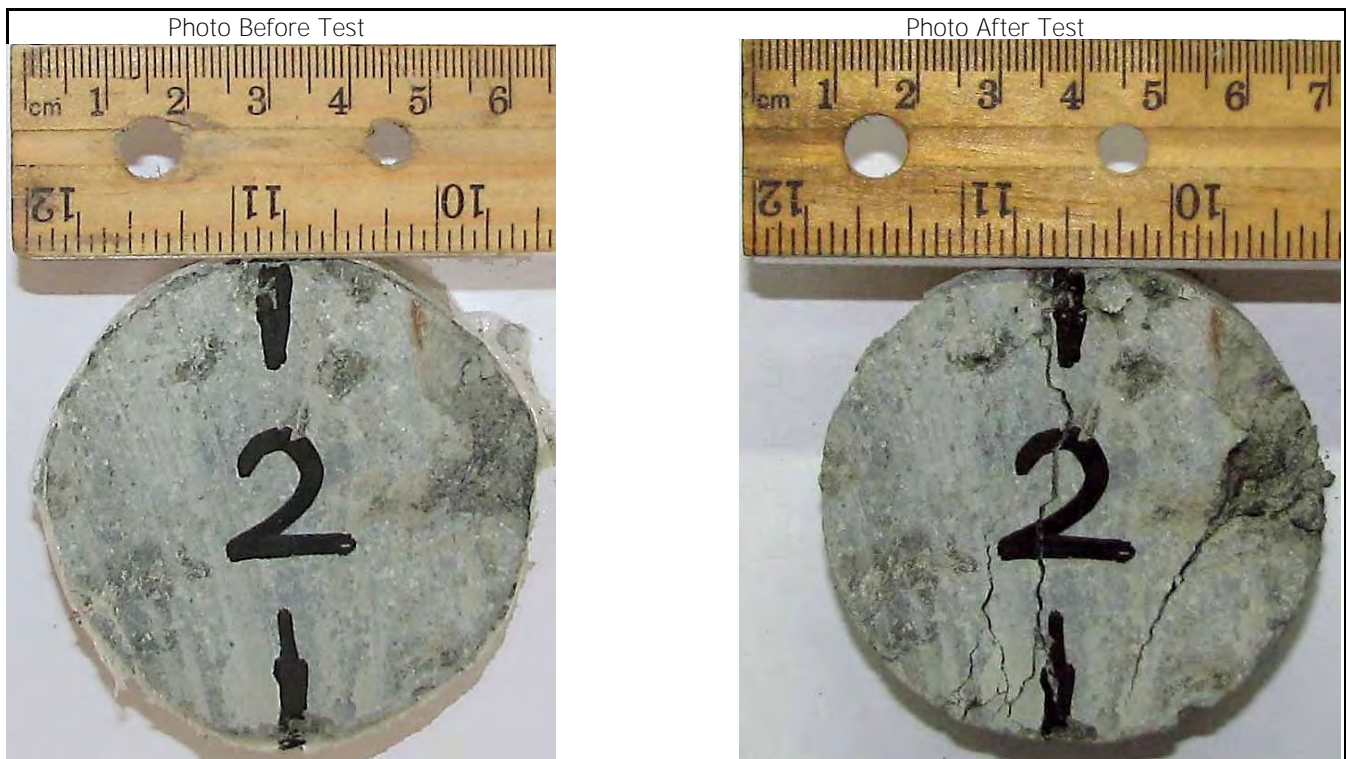
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Tonon USA:  
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Web: tononeng.com

Project Name	Klamath River Dam Removal	Rate of loading (0.05-0.35 MPa/s or 500-3,000 psi/min)	0.11 MPa/sec	957 psi/min
Location	Klamath River	Diameter (D)	60.84 mm	2.40 in
Client	Klamath River Renewal Corporation	Thickness (t)	24.67 mm	0.97 in
Client Project No.	60537920	Maximum Load (P)	5.25 kN	1,180 lbf
Registry No.	2018-22	Tensile strength (flat platens) $\sigma_t = 2P / \pi t D$	N/A	N/A
Report No.	2018-22-2-2	Tensile strength (curved platens) $\sigma_t = 1.272P / \pi t D$	1.42 MPa	206 psi
Report Date	5/17/2018	Direction of Loading	Orthogonal to the Borehole Axis	
Drill Hole and Depth	BI-02; 52-54.7 ft	Type of Failure	Non-Structural	
Rock Type	Volcanic Breccia	Conformance to dimensional Requirements $0.2 \leq \frac{t}{D} \leq 0.75$	$\frac{t}{D} = 0.41$	OK
Geologic Unit	N/A			
Moisture Condition	As-received			

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/30/2018
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Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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E-mail: fulvio@tononeng.com



**Brazilian Tensile Strength Test**  
ASTM D3967 - 16

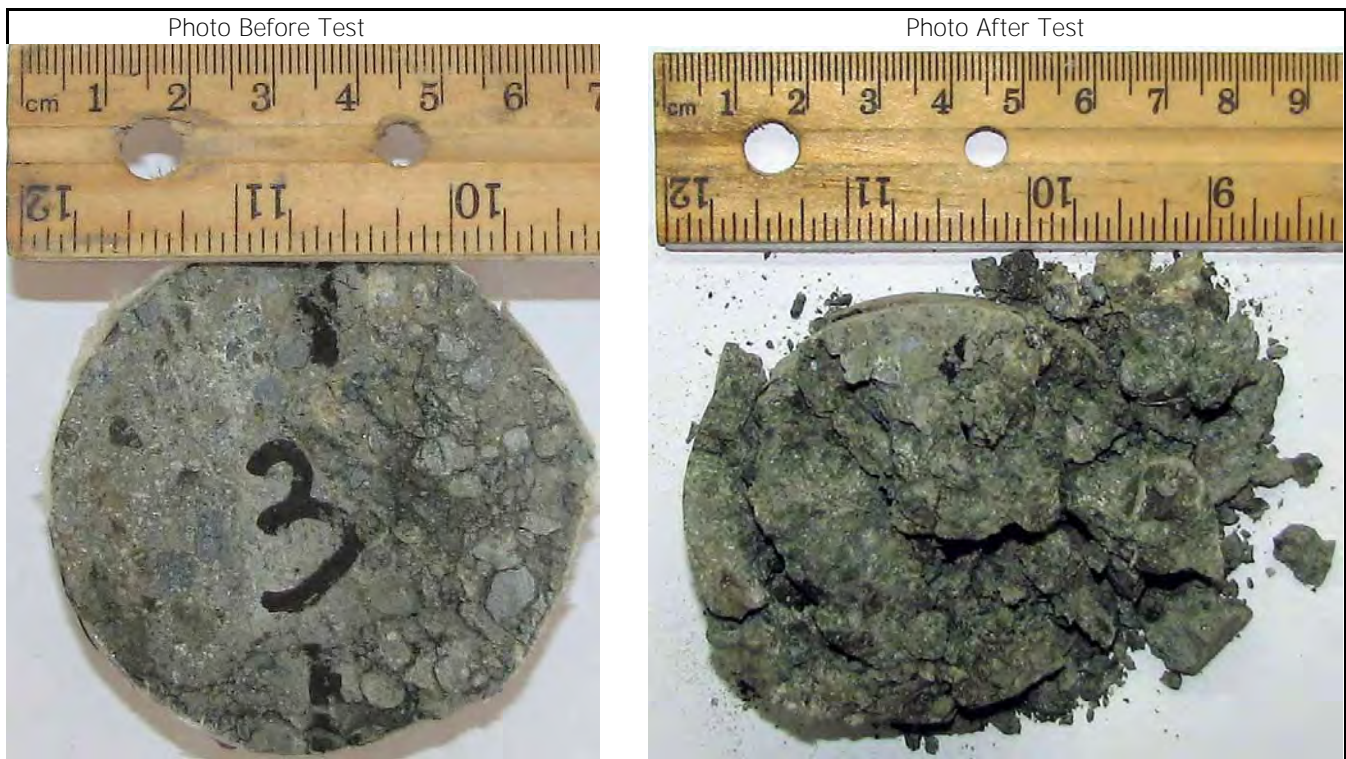
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Project Name	Klamath River Dam Removal	Rate of loading (0.05-0.35 MPa/s or 500-3,000 psi/min)	0.11 MPa/sec	957 psi/min
Location	Klamath River	Diameter (D)	60.74 mm	2.39 in
Client	Klamath River Renewal Corporation	Thickness (t)	26.84 mm	1.06 in
Client Project No.	60537920	Maximum Load (P)	1.51 kN	339 lbf
Registry No.	2018-22	Tensile strength (flat platens) $\sigma_t = 2P / \pi t D$	N/A	N/A
Report No.	2018-22-2-3	Tensile strength (curved platens) $\sigma_t = 1.272P / \pi t D$	0.38 MPa	54 psi
Report Date	5/17/2018	Direction of Loading	Orthogonal to the Borehole Axis	
Drill Hole and Depth	BI-03; 18.4-20.1 ft	Type of Failure	Non-Structural	
Rock Type	Volcanic Breccia	Conformance to dimensional Requirements $0.2 \leq \frac{t}{D} \leq 0.75$	$\frac{t}{D} = 0.44$	OK
Geologic Unit	N/A			
Moisture Condition	As-received			

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/30/2018
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Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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2018-22-2, R06, Brazilian Test, Tonon USA, AECOM Klamath River

**Brazilian Tensile Strength Test**  
**ASTM D3967 - 16**

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Project Name	Klamath River Dam Removal	Rate of loading (0.05-0.35 MPa/s or 500-3,000 psi/min)	0.11 MPa/sec	957 psi/min
Location	Klamath River	Diameter (D)	60.26 mm	2.37 in
Client	Klamath River Renewal Corporation	Thickness (t)	33.83 mm	1.33 in
Client Project No.	60537920	Maximum Load (P)	0.55 kN	124 lbf
Registry No.	2018-22	Tensile strength (flat platens) $\sigma_t = 2P / \pi t D$	N/A	N/A
Report No.	2018-22-2-4	Tensile strength (curved platens) $\sigma_t = 1.272P / \pi t D$	0.11 MPa	16 psi
Report Date	5/17/2018	Direction of Loading	Orthogonal to the Borehole Axis	
Drill Hole and Depth	BI-03; 22.9-24.2 ft	Type of Failure	Non-Structural	
Rock Type	Volcanic Breccia	Conformance to dimensional Requirements  $0.2 \leq \frac{t}{D} \leq 0.75$	$\frac{t}{D} = 0.56$	OK
Geologic Unit	N/A			
Moisture Condition	As-received			

Date Received : 4/24/2018

Date Opened : 4/24/2018

Date Tested: 4/30/2018



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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2018-22-2, R06, Brazilian Test, Tonon USA, AECOM Klamath River

**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/21/2018****Colorado School of Mines****Mining Engineering Department****ASTM D3967**

Sample ID	Average Length	Average Diameter	Failure Load	Indirect (Brazilian) Tensile Strength		Notes ( <i>Failure type</i> )
	(in)	(in)	(lbs)	(psi)	(MPa)	
B-206 @ 60.0-61.7	1.53	2.403	8,497	1,474	10.2	Non - Structural
B-206 @ 48.7-50.0	1.49	2.406	6,039	1,069	7.4	Non - Structural
B-202 @ 82.8-83.5	1.48	2.407	209	37	0.3	Non - Structural
B-202 @ 56.2-57.5	1.46	2.452	135	24	0.2	Non - Structural





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

"Brazilian" Indirect Tensile Strength - ASTM D3967

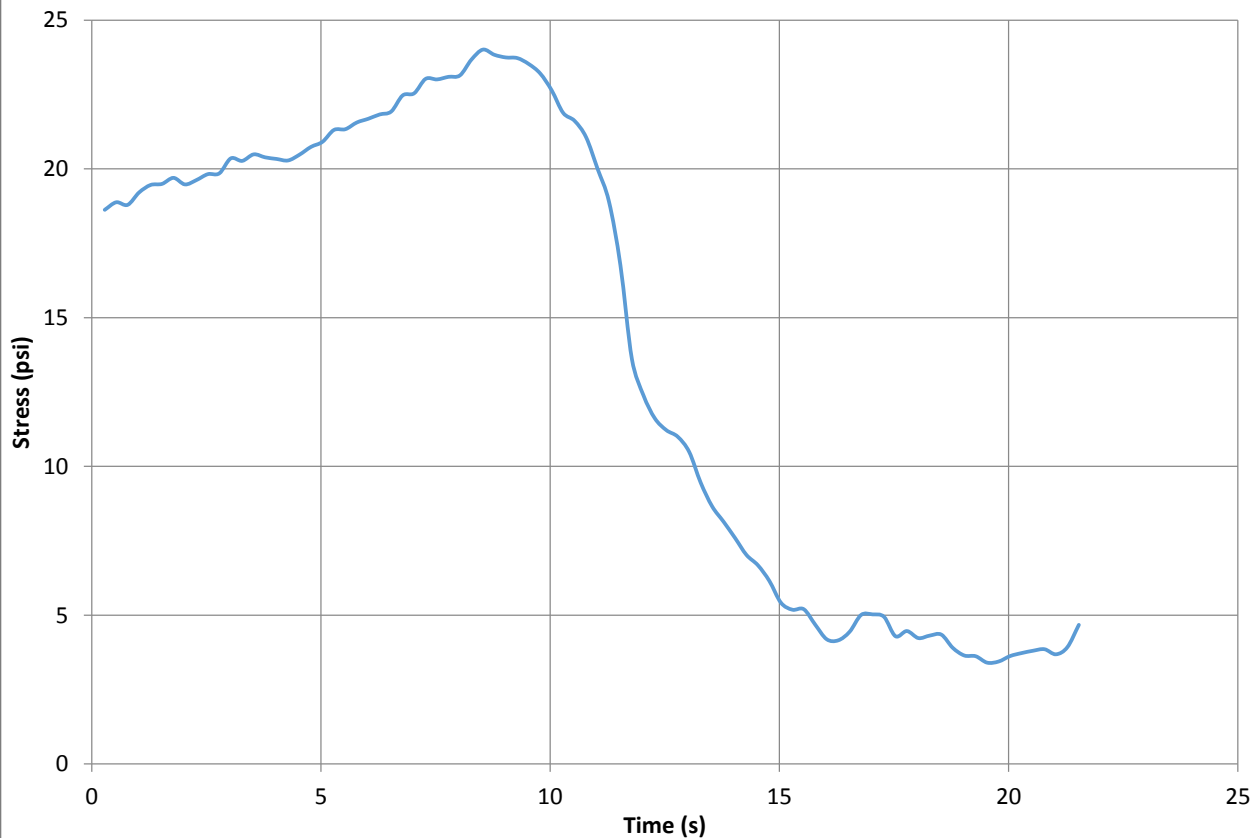


**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** N/A  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/21/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/21/2018  
**Core ID:** B-202 @ 56.2-57.5  
**File Name:** B-202 @ 56.2-57.5\_BTS  
**EMI Project No.:** 378



Disc Length		Disc Diameter		L/D Ratio
in	cm	in	cm	
1.46	3.7	2.452	6.23	0.60
Failure Load		BTS		Failure Mode
lbf	N	psi	MPa	
135	600	24	0.2	Non-Structural

**Note:** The sample was very soft and crushed within 10 seconds.





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

"Brazilian" Indirect Tensile Strength - ASTM D3967

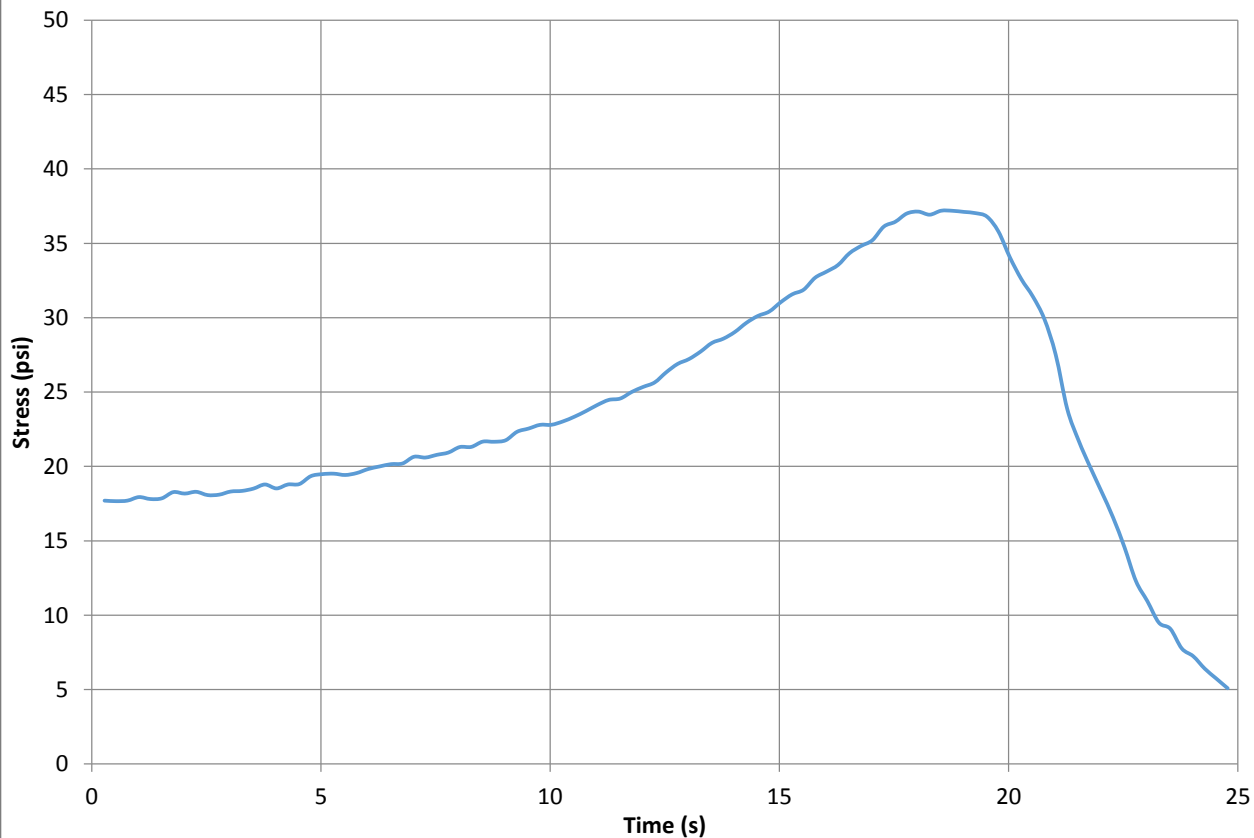


**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** N/A  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/21/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/20/2018  
**Core ID:** B-202 @ 82.8-83.5  
**File Name:** B-202 @ 82.8-83.5\_BTS  
**EMI Project No.:** 378



Disc Length		Disc Diameter		L/D Ratio
in	cm	in	cm	
1.48	3.8	2.407	6.11	0.62
Failure Load		BTS		Failure Mode
lbf	N	psi	MPa	
209	929	37	0.3	Non-Structural

**Note:** The sample was very soft and crushed within 20 seconds.





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

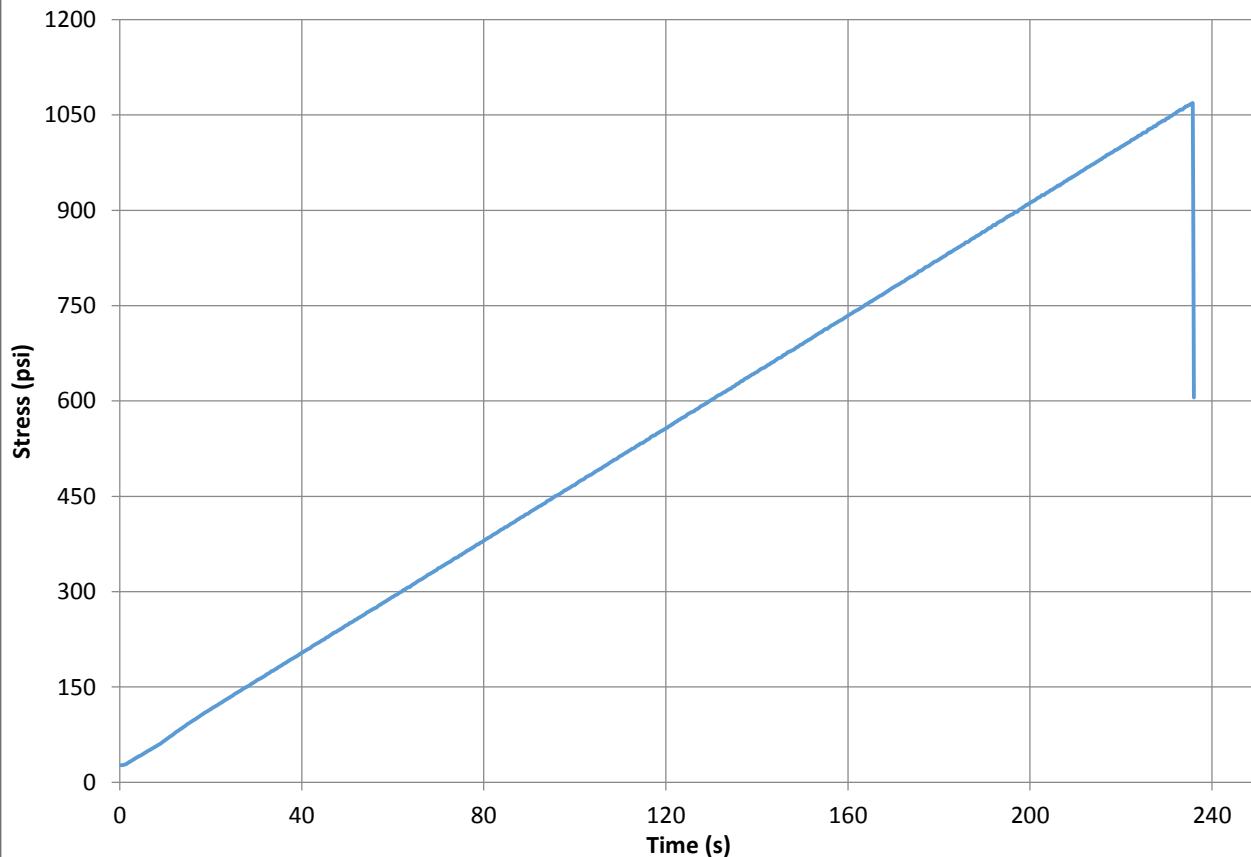
"Brazilian" Indirect Tensile Strength - ASTM D3967



**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** Igneous  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/20/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/20/2018  
**Core ID:** B-206 @ 48.7-50.0  
**File Name:** B-206 @ 48.7-50.0\_BTS  
**EMI Project No.:** 378



Disc Length		Disc Diameter		L/D Ratio
in	cm	in	cm	
1.49	3.8	2.406	6.11	0.62
Failure Load		BTS		Failure Mode
lbf	N	psi	MPa	
6,039	26,863	1,069	7.4	Non - Structural







# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

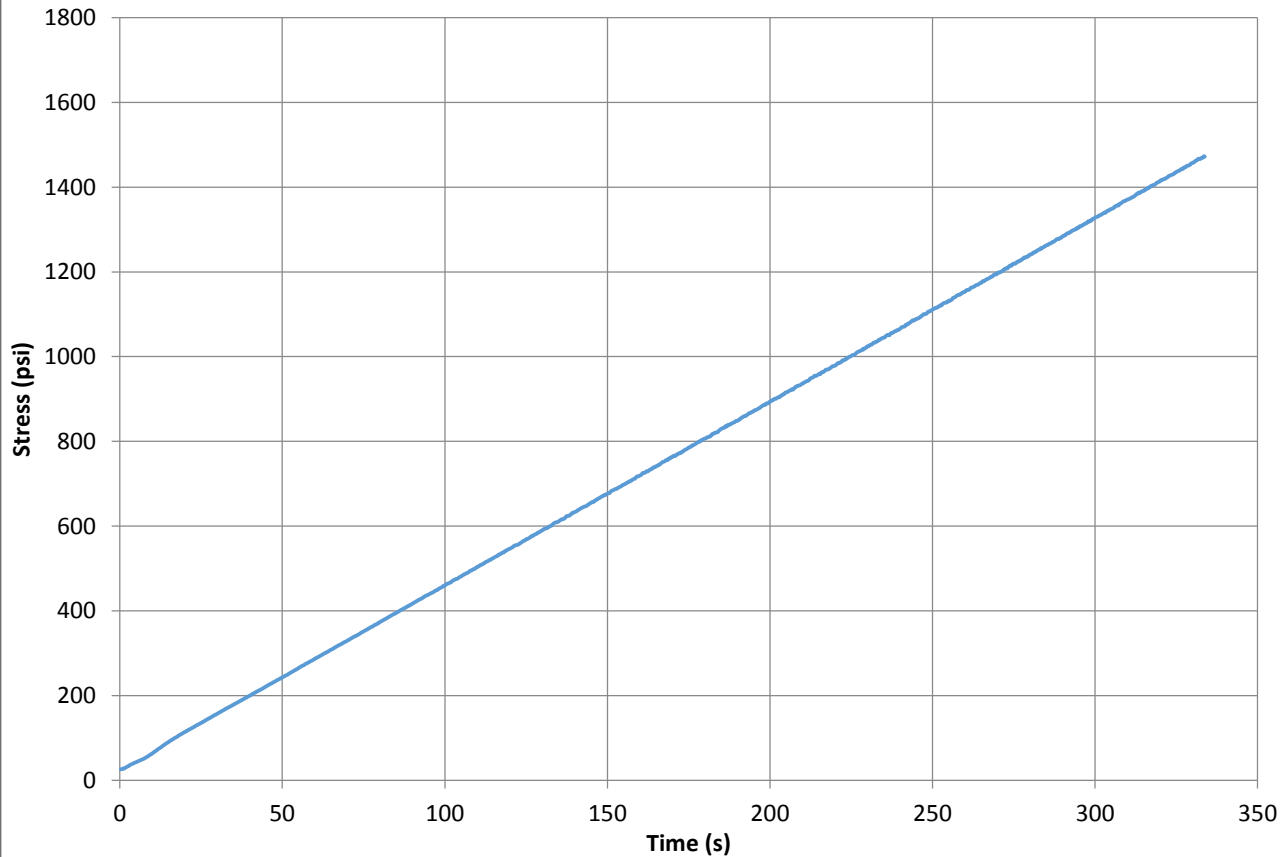
"Brazilian" Indirect Tensile Strength - ASTM D3967



**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** Igneous  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/20/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/20/2018  
**Core ID:** B-206 @ 60.0-61.7  
**File Name:** B-206 @ 60.0-61.7\_BTS  
**EMI Project No.:** 378



Disc Length		Disc Diameter		L/D Ratio
in	cm	in	cm	
1.53	3.9	2.403	6.10	0.64
Failure Load		BTS		Failure Mode
lbf	N	psi	MPa	
8,497	37,797	1,474	10.2	Non - Structural



**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/20/2018****Colorado School of Mines****Mining Engineering Department****ASTM D5731**

Sample ID	Loading Direction	Length (in)	Avg. Diameter (in)	Failure Load (N)	Point Load Index Strength				Notes
					Is		Is(50)		
					(psi)	(MPa)	(psi)	(MPa)	(Failure type)
B-201 @ 25.5-26.0	Diametric	3.60	2.337	25,815	1,063	7.33	1,148	7.91	Valid
B-201 @ 28.5-29.0	Diametric	3.58	2.391	3,910	154	1.06	168	1.16	Valid
B-202 @ 70.5-71.7	Diametric	3.53	2.365	560	23	0.16	24	0.17	Valid
B-202 @ 81.5-81.9	Diametric	3.49	2.408	140	5	0.04	6	0.04	Valid
B-206 @ 47.4-48.7	Diametric	3.55	2.402	17,725	691	4.76	756	5.21	Valid
B-206 @ 74.6-75.0	Diametric	3.48	2.402	21,370	833	5.74	911	6.28	Valid

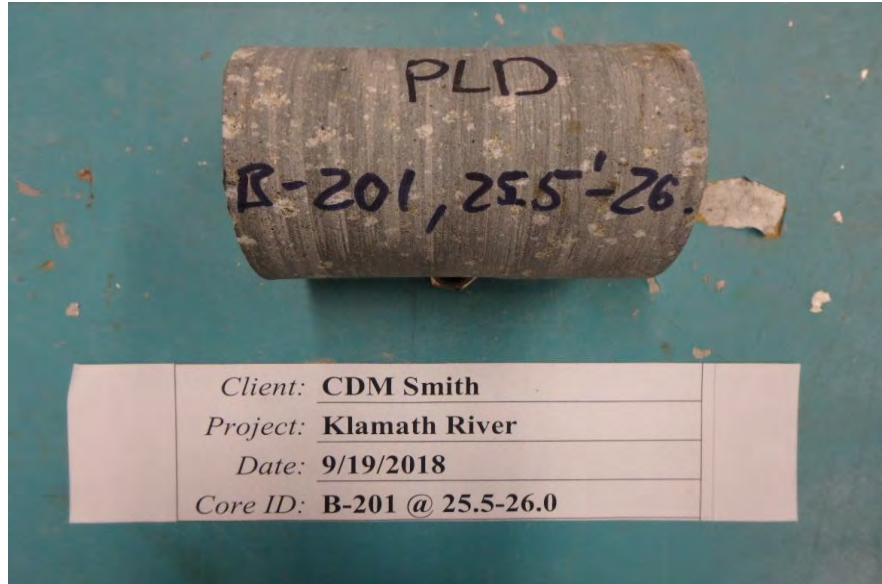
**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath Rive****Date: 10/3/2018****Colorado School of Mines****Mining Engineering Department****ASTM D5731**

Sample ID	Rock Type	Loading Direction	Length (in)	Avg. Diameter (in)	Failure Load (N)	Point Load Index Strength				Notes
						Is		Is(50)		
						(psi)	(MPa)	(psi)	(MPa)	(Failure type)
B-205 @ 22.7-23.6	Volcanic	Diametric	3.60	2.391	675	27	0.18	29	0.20	Valid
B-207 17.0-18.1	Volcanic	Diametric	3.57	2.399	13,205	516	3.56	564	3.89	Valid
B-208 @ 26.8-27.5	Volcanic	Diametric	3.51	2.405	18,940	736	5.08	806	5.56	Valid

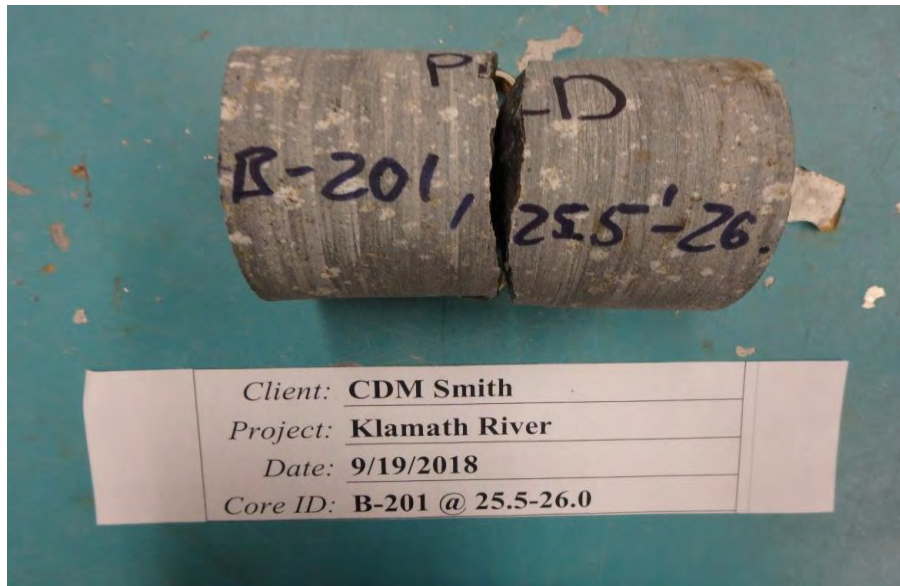


**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-201 @ 25.5-26.0



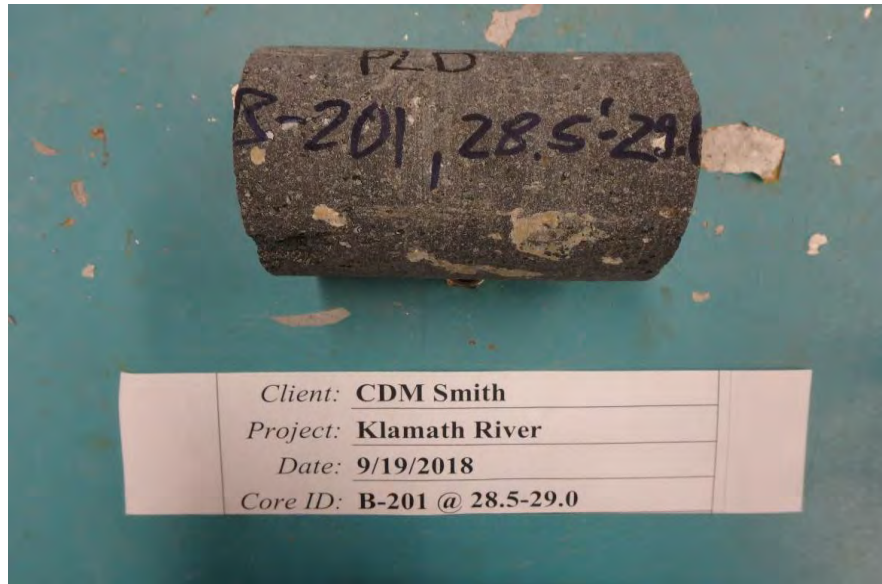
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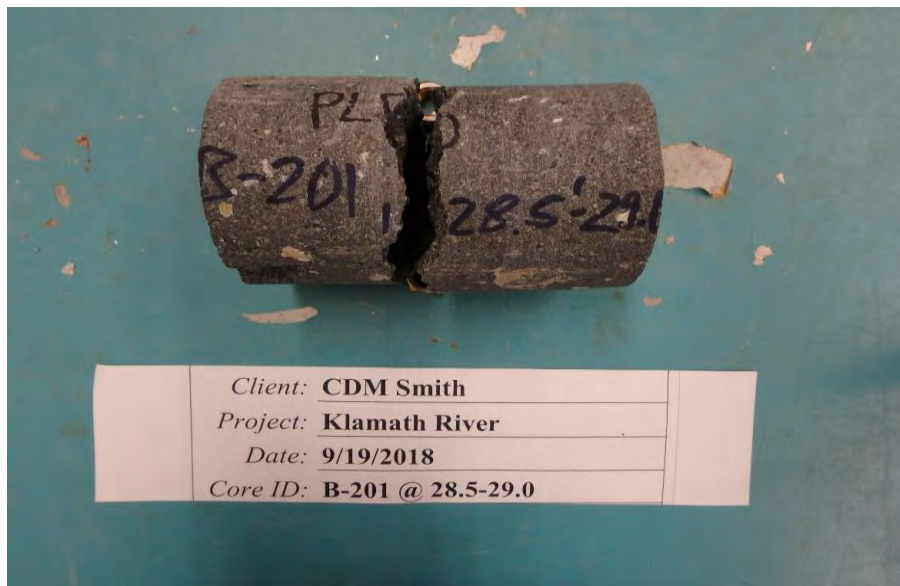
**After**

**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-201 @ 28.5-29.0



**Before**



**After**

**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-202 @ 70.5-71.7



**Before**

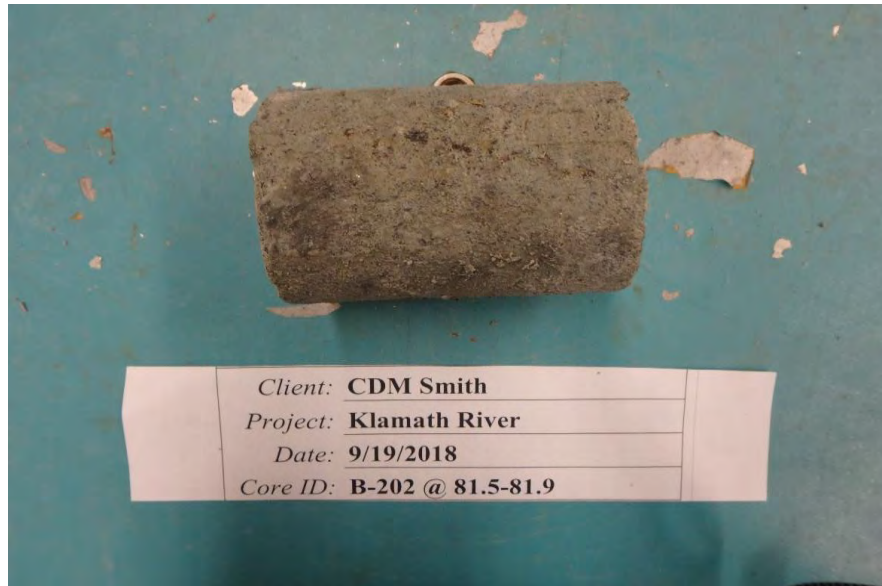


**After**



**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-202 @ 81.5-81.9



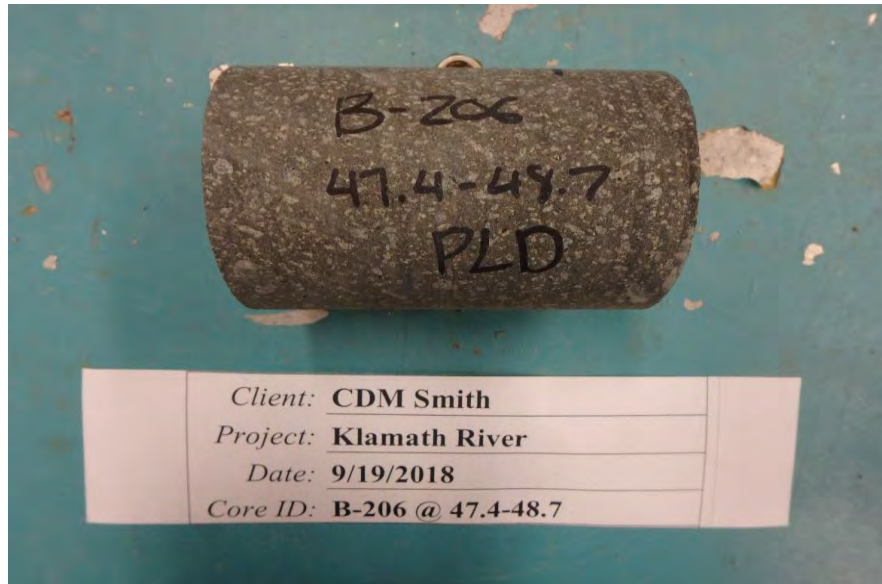
**Before**



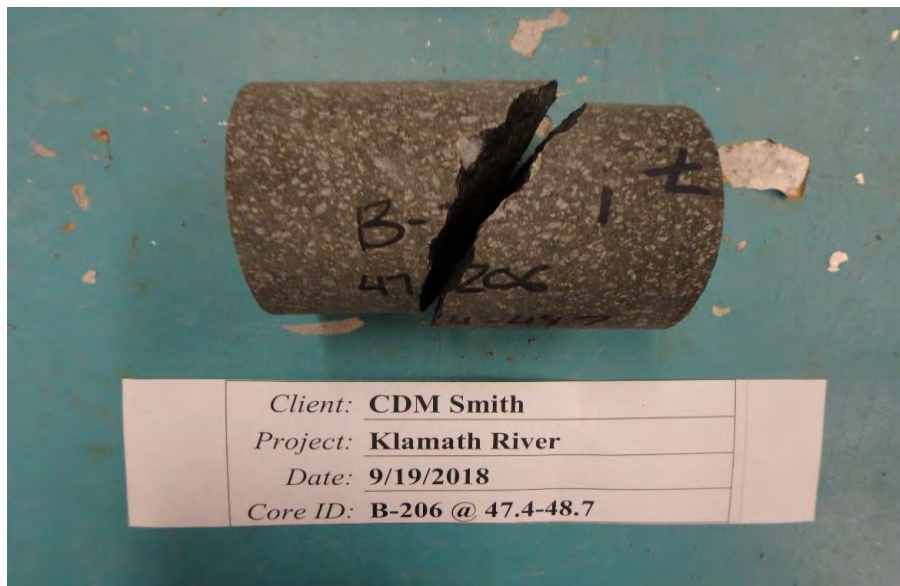
**After**

**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-206 @ 47.4-48.7



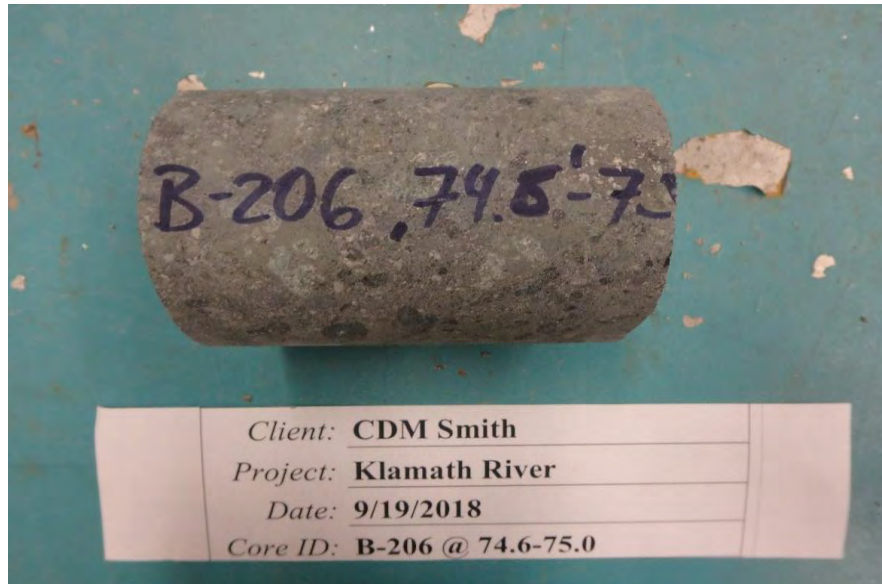
**Before**



**After**

**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-206 @ 74.6-75.0



**Before**

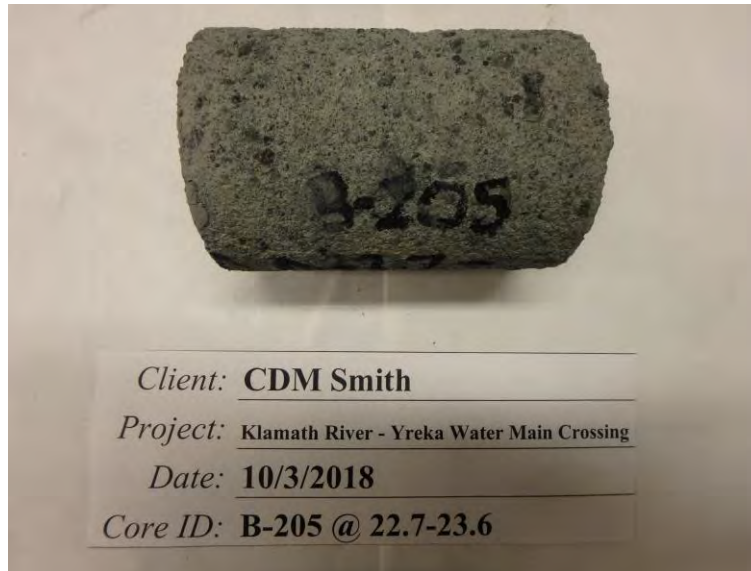


**After**

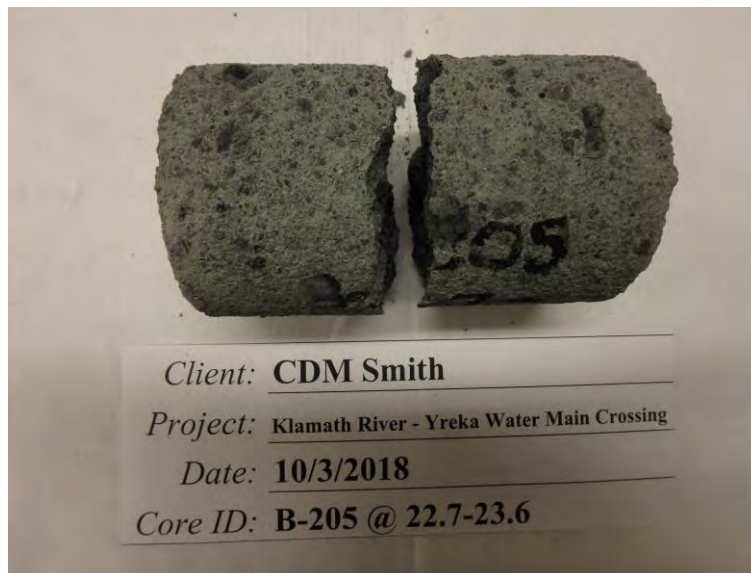


**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River - Yreka Water Main Crossing  
**Date:** 10/3/2018  
**Sample ID:** B-205 @ 22.7-23.6



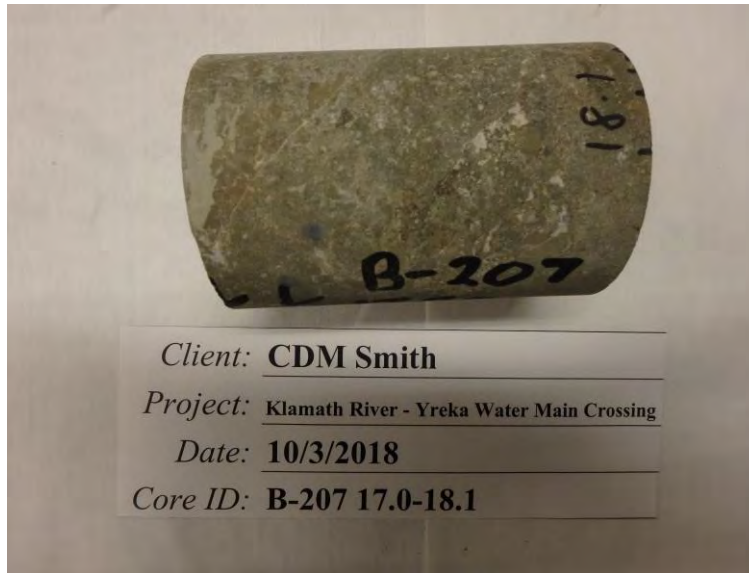
**Before**



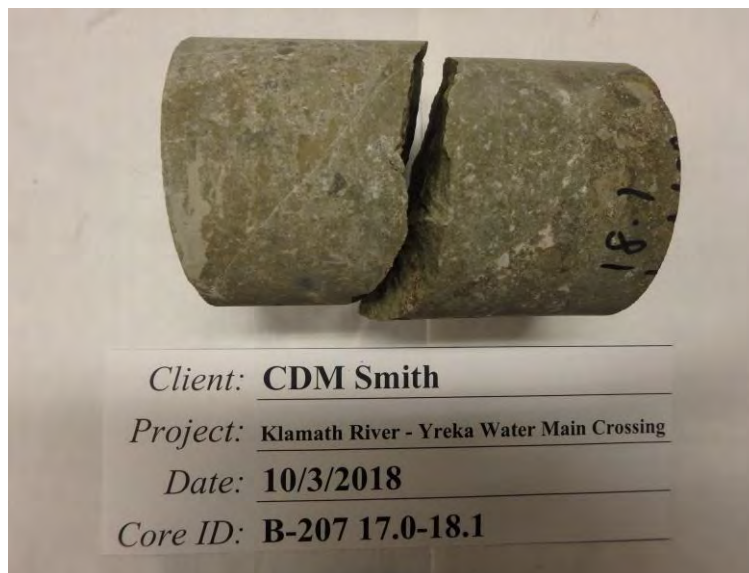
**After**

**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River - Yreka Water Main Crossing  
**Date:** 10/3/2018  
**Sample ID:** B-207 17.0-18.1



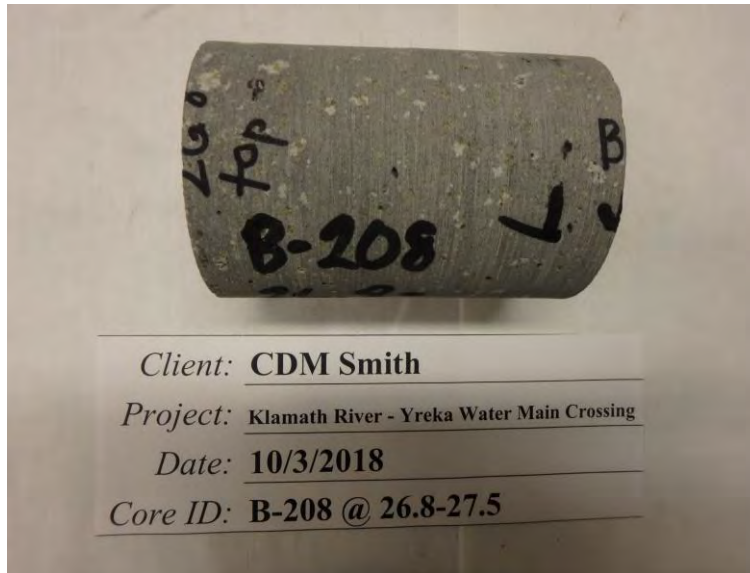
**Before**



**After**

**Pictures of Sample Before and After**  
**Point Load Index Strength**

**Client Name:** CDM Smith  
**Project Name:** Klamath River - Yreka Water Main Crossing  
**Date:** 10/3/2018  
**Sample ID:** B-208 @ 26.8-27.5



**Before**



**After**



# Point Load Strength Test

ASTM D 5731 - 08

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= ISO 9001 =

Tonon USA  
Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-1
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 48.9-50.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date Received: 4/24/2018	Date Opened: 4/24/2018	Date Tested: 4/30/2018
--------------------------	------------------------	------------------------

Distance, D		Load, P		Corrected Point Load Index		Direction of Loading	
				(D/50) <sup>0.45</sup> P/D <sup>2</sup>			
mm	in	kN	lbf	MPa	psi	A	B
60.86	2.40	0.74	166.352	0.22	31.66	1	
62.20	2.45	1.65	370.92	0.47	68.24		1
47.58	1.87	0.98	220.304	0.42	61.40	1	
79.15	3.12	3.23	726.104	0.63	91.95		1
82.44	3.25	3.00	674.4	0.55	80.18		1
39.71	1.56	0.86	193.328	0.49	71.31	1	

Average Point Load Strength in Direction A	0.38 MPa	54.79 psi
Average Point Load Strength in Direction B	0.55 MPa	80.12 psi

<b>Point Load Strength Anisotropy Index</b>
<b>1.46</b>

A = Parallel to core axis

B = Orthogonal to core axis

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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E-mail: fulvio@tononeng.com

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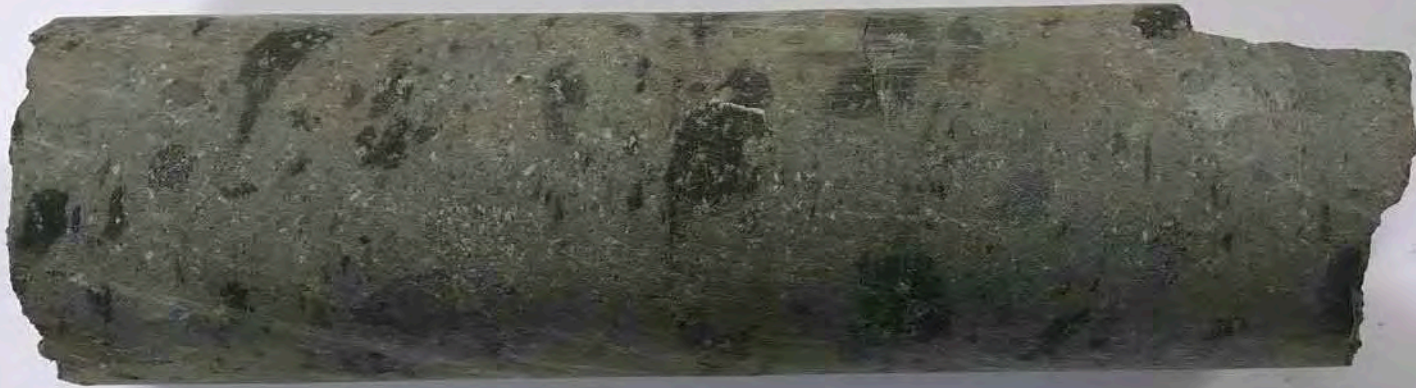
F	Fresh
SW	Slightly Weathered
MW	Moderately Weathered
HW	Highly Weathered
CW	Completely Weathered

← Top

Sample

4/11/18

BI-02 21.9-22.6



Klamath River Dam Removal





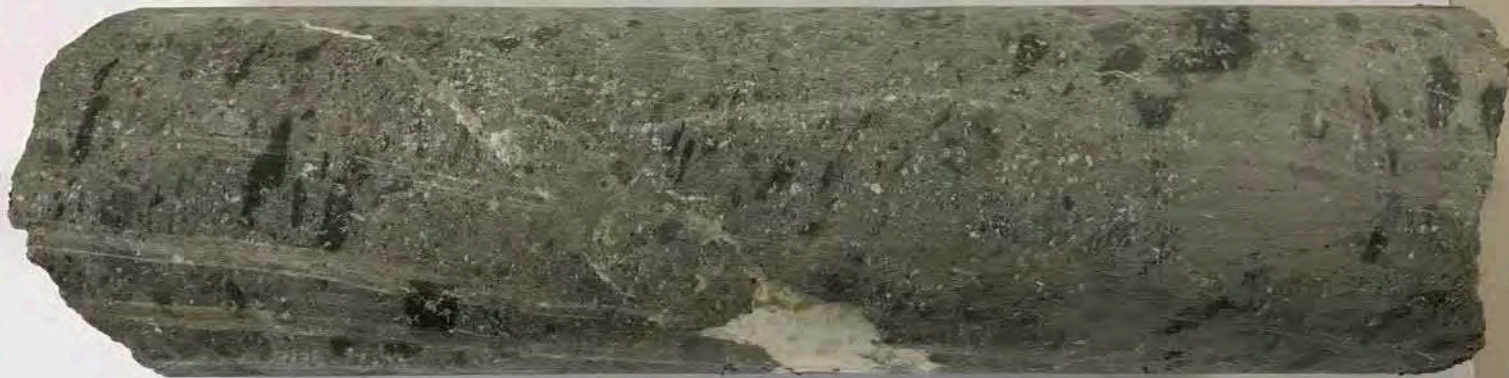
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Sample

4/11/18

BI-02

27.9 - 28.6



— Klamath River Dam Replacement Proj



← Top

Sample

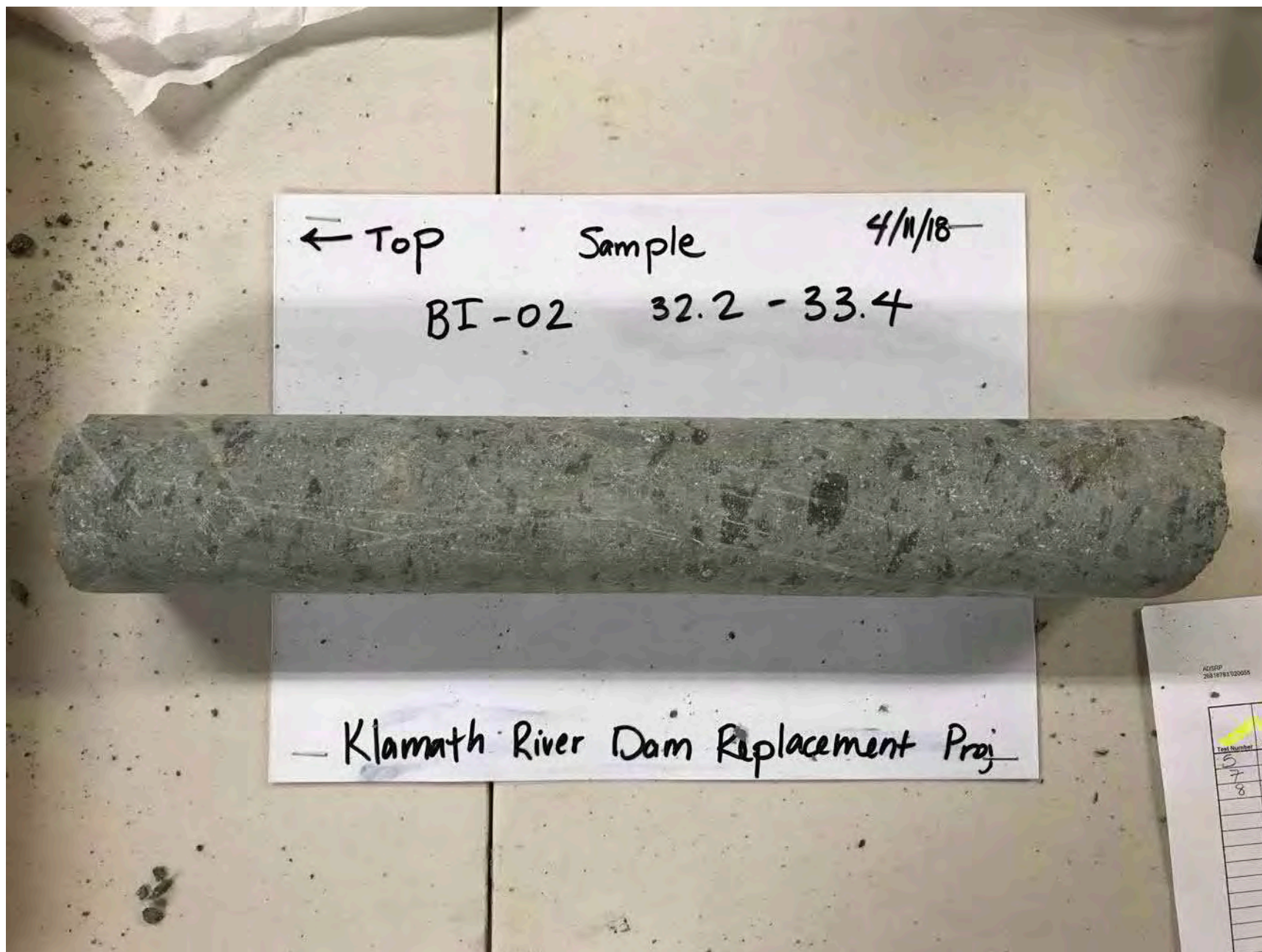
4/11/18

BI-02 27.9 - 28.6



Klamath River Dam Replacement Proj









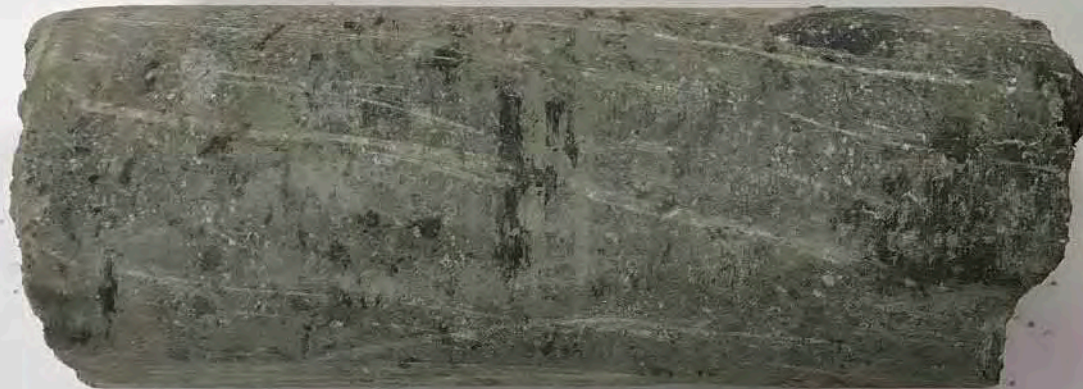
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Sample

4/11/18

BI-02

37.2 - 37.7



Klamath River Dam Replacement Proj



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Sample

4/11/18

BI-02 37.2 - 37.7



— Klamath River Dam Replacement Proj

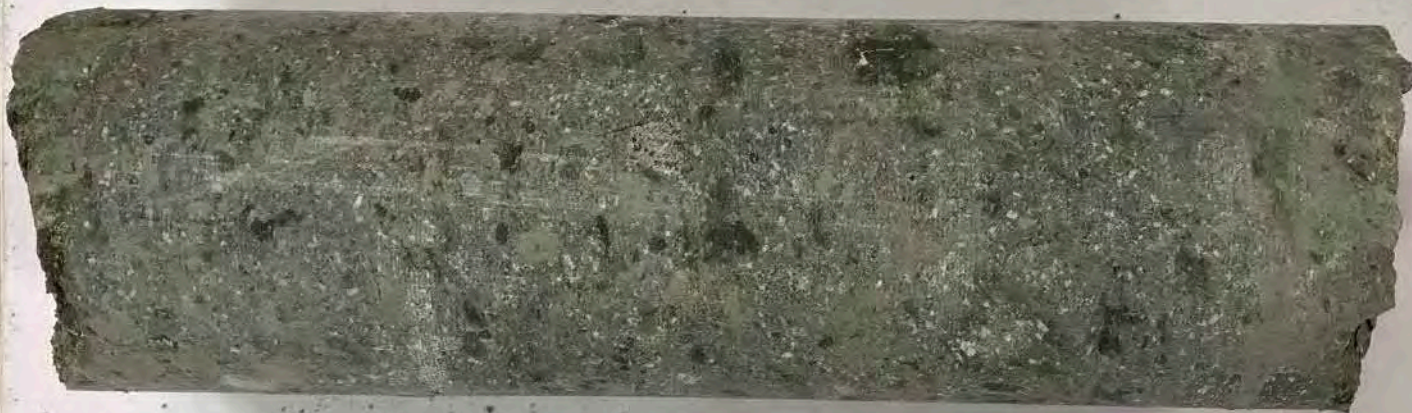
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Sample

4/11/18

BI-02

42.5 - 43.1



— Klamath River Dam Replacement Proj



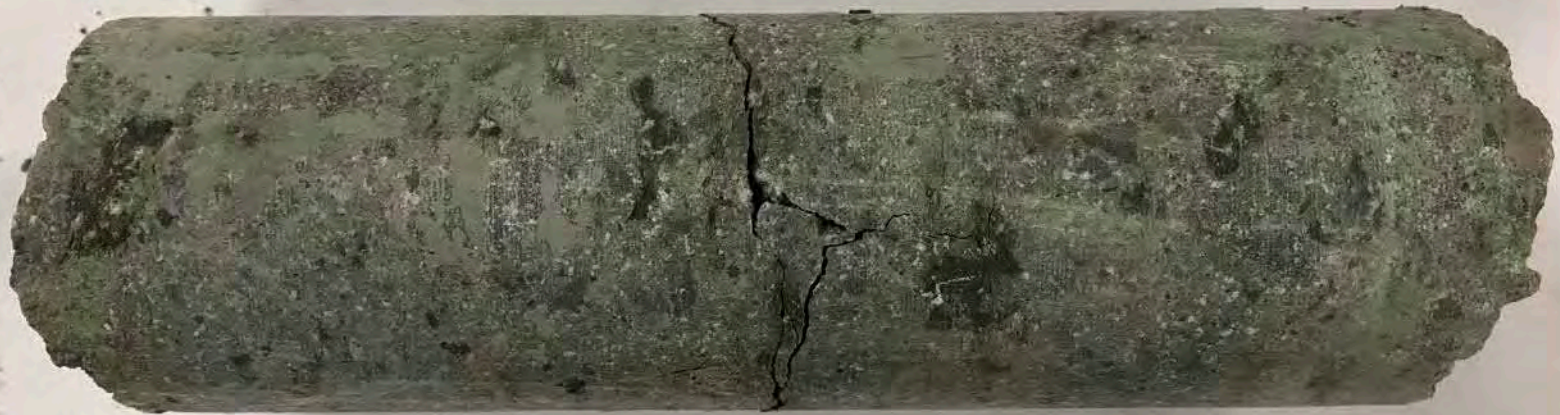
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Sample

4/11/18

BI-02

42.5 - 43.1



— Klamath River Dam Replacement Proj



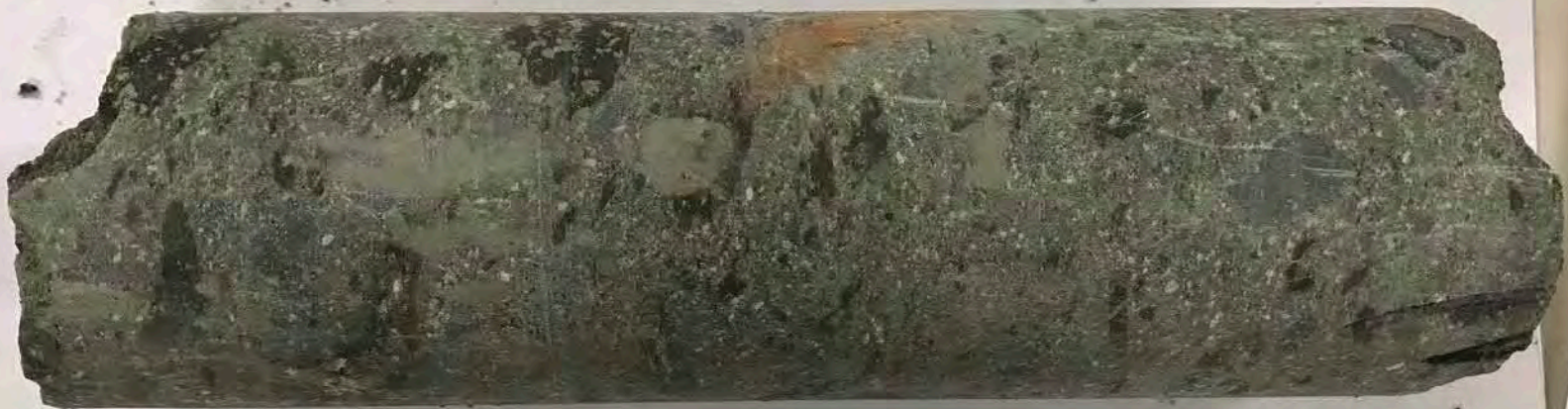
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Sample

4/11/18

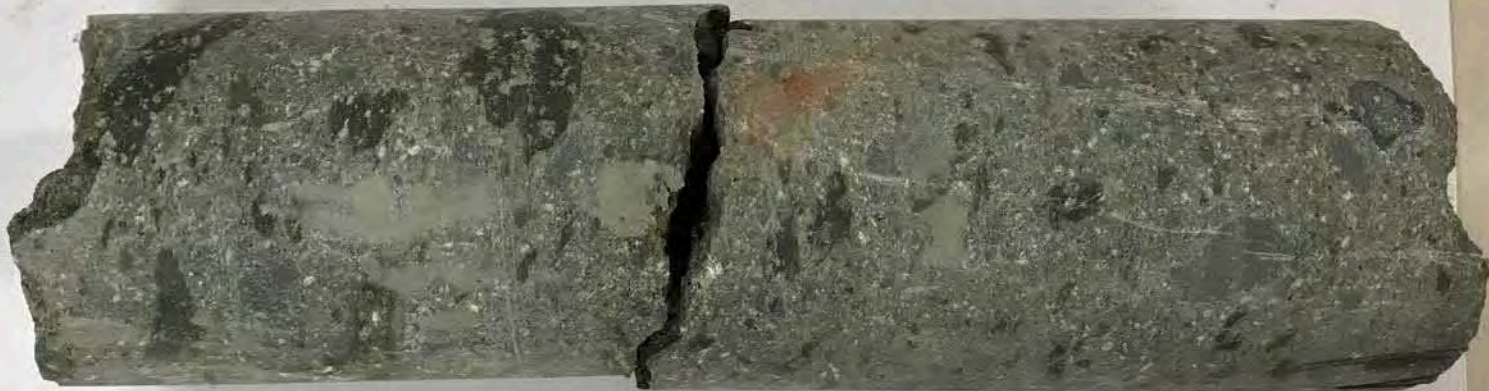
BI-02

54.7 - 55.4



Klamath River Dam Replacement Proj

← Top Sample 4/11/18  
BI-02 54.7 - 55.4



— Klamath River Dam Replacement Proj



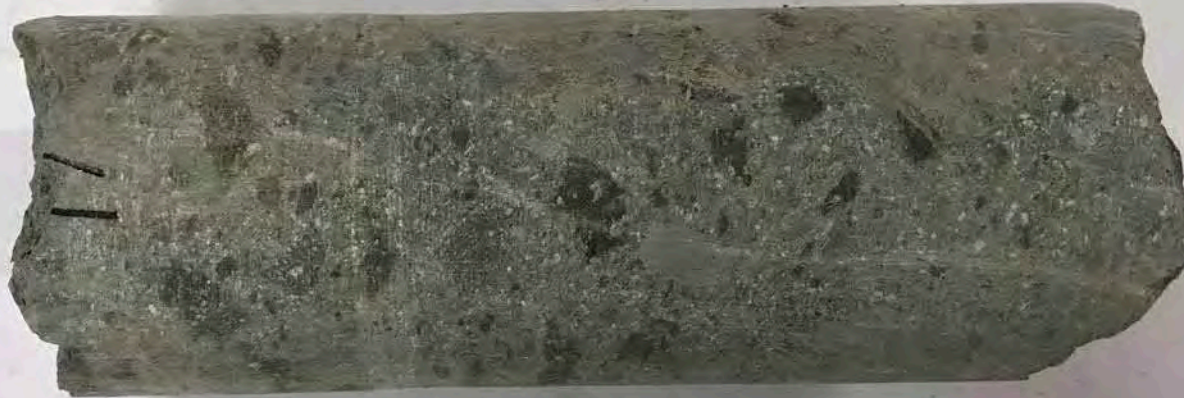
← Top

Sample

4/11/18

BI-02

57.0-57.6



— Klamath River Dam Replacement Proj



← Top

Sample

4/11/18

BI-02

57.0-57.6



— Klamath River Dam Replacement Proj

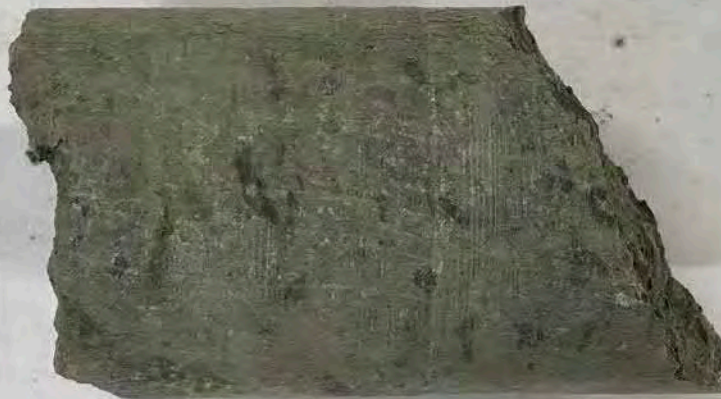
← Top

Sample

4/11/18

BI-02

57.0-57.6



— Klamath River Dam Replacement Proj



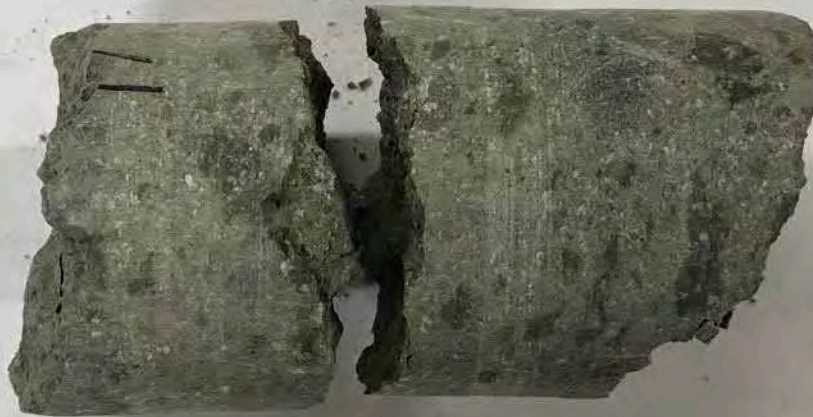
← Top

Sample

4/11/18

BI-02

57.0-57.6



— Klamath River Dam Replacement Proj



← Top

Sample

4/11/18

BI-02 63.7-64.7

— Klamath River Dam Replacement Proj

← Top

Sample

4/11/18

BI-02 63.7-64.7

— Klamath River Dam Replacement Proj

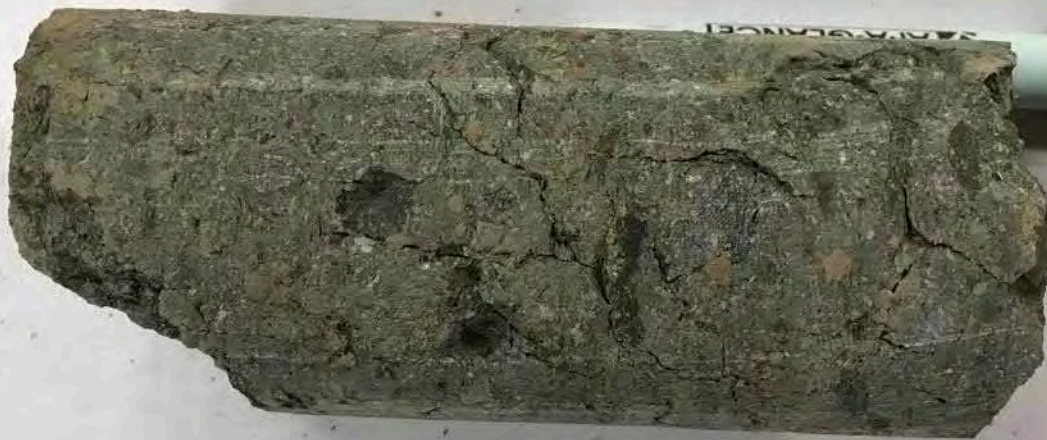


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Sample

4/11/18

BI-03 10.1 - 10.5



— Klamath River Dam Replacement Proj

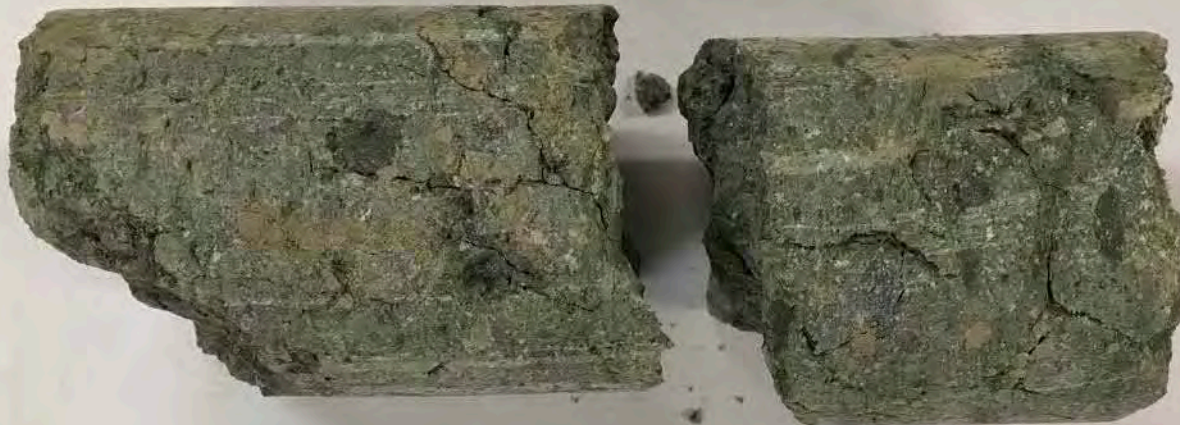


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Sample

4/11/18

BI-03 10.1-10.5



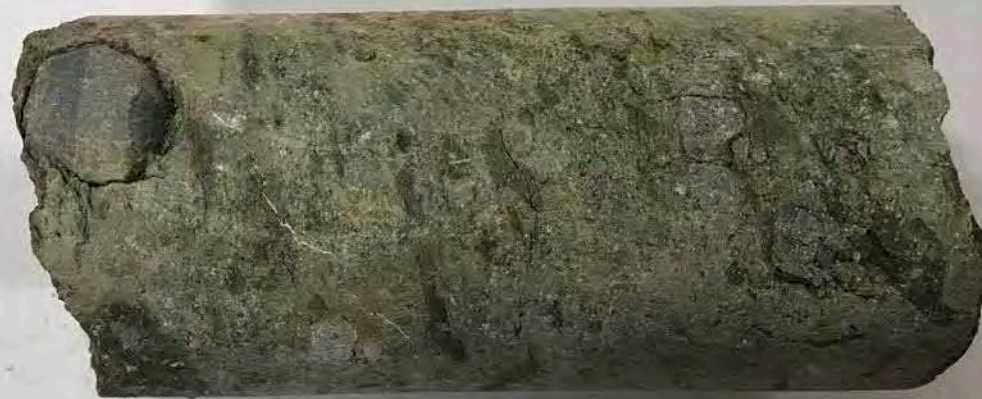
Klamath River Dam Replacement Project

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Sample

4/11/18

BI-03 17.0 - 17.4



— Klamath River Dam Replacement Proj



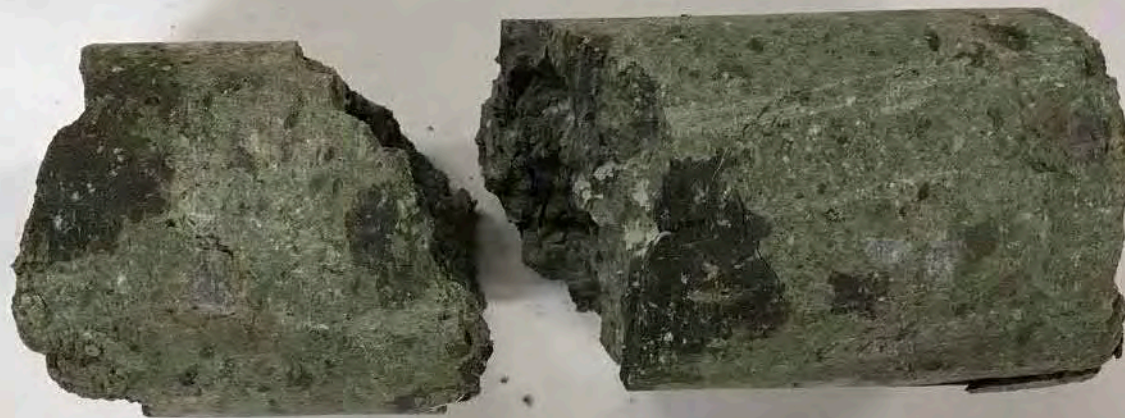
← Top

Sample

4/11/18

BI-03

17.0 - 17.4



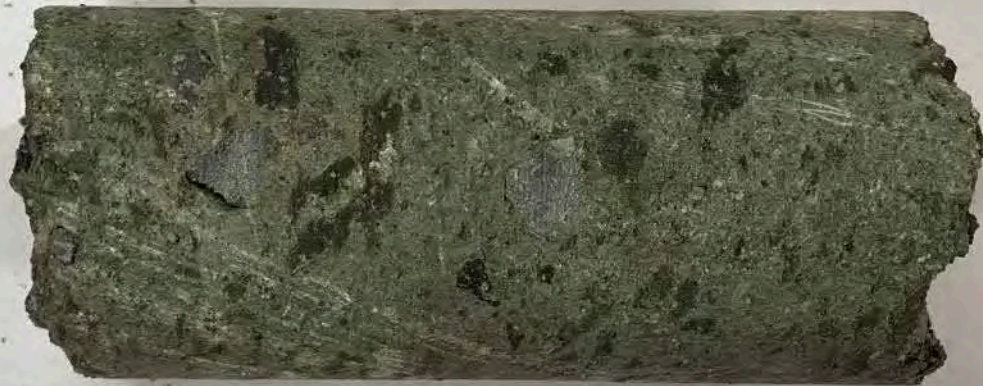
— Klamath River Dam Replacement Proj



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Sample  
BI-03 21.0 - 21.5

4/11/18



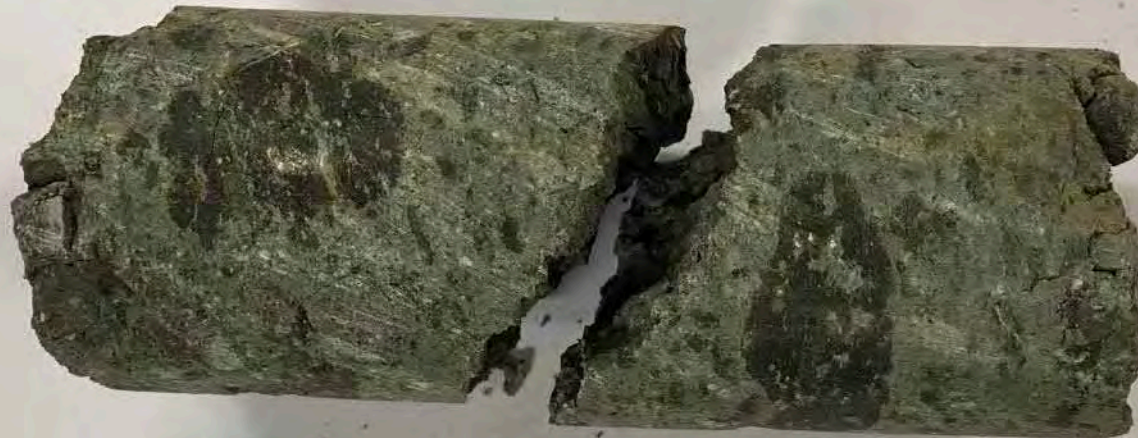
— Klamath River Dam Replacement Proj

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Sample

4/11/18

BI-03 21.0 - 21.5



— Klamath River Dam Replacement Proj

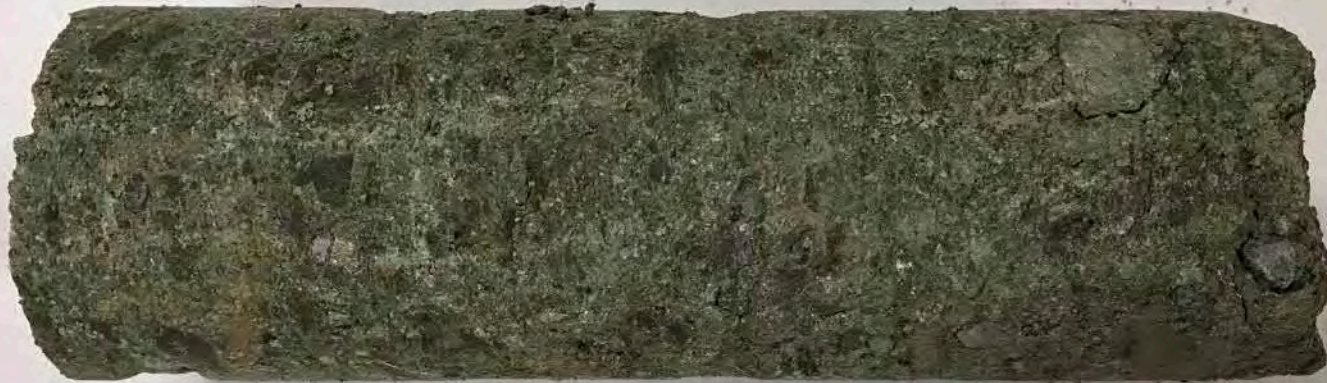


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Sample

4/11/18

BI-03 29.5 - 30.1



— Klamath River Dam Replacement Proj

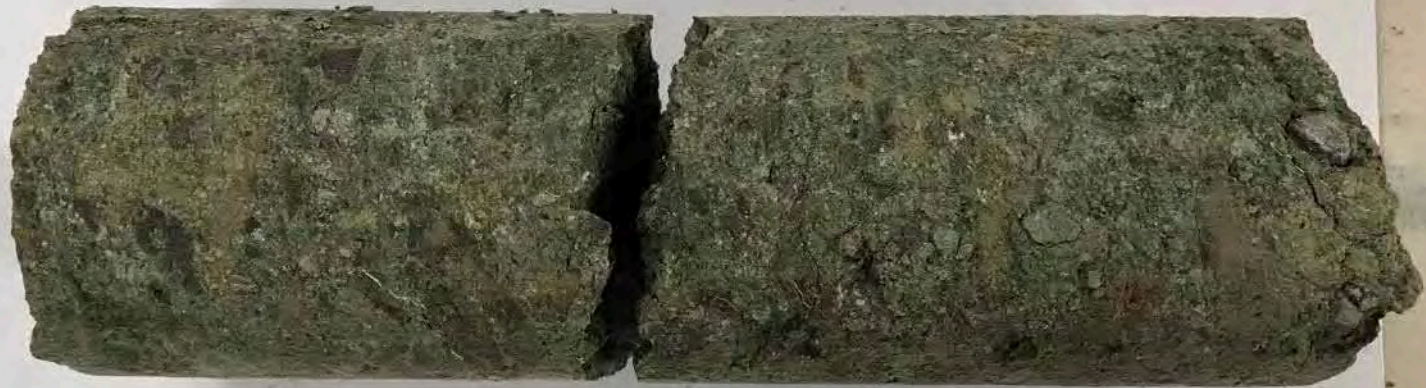


← Top

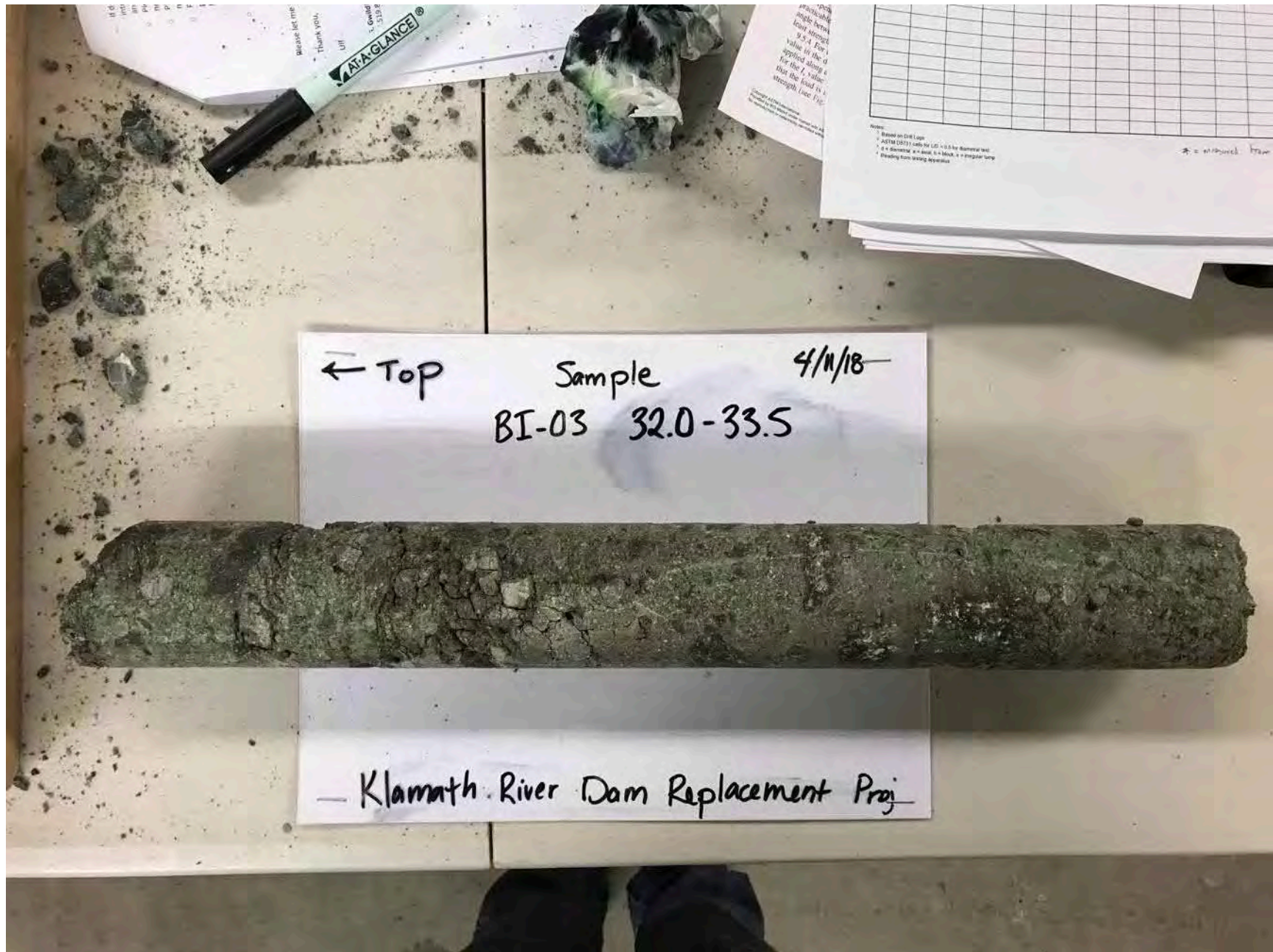
Sample

4/11/18

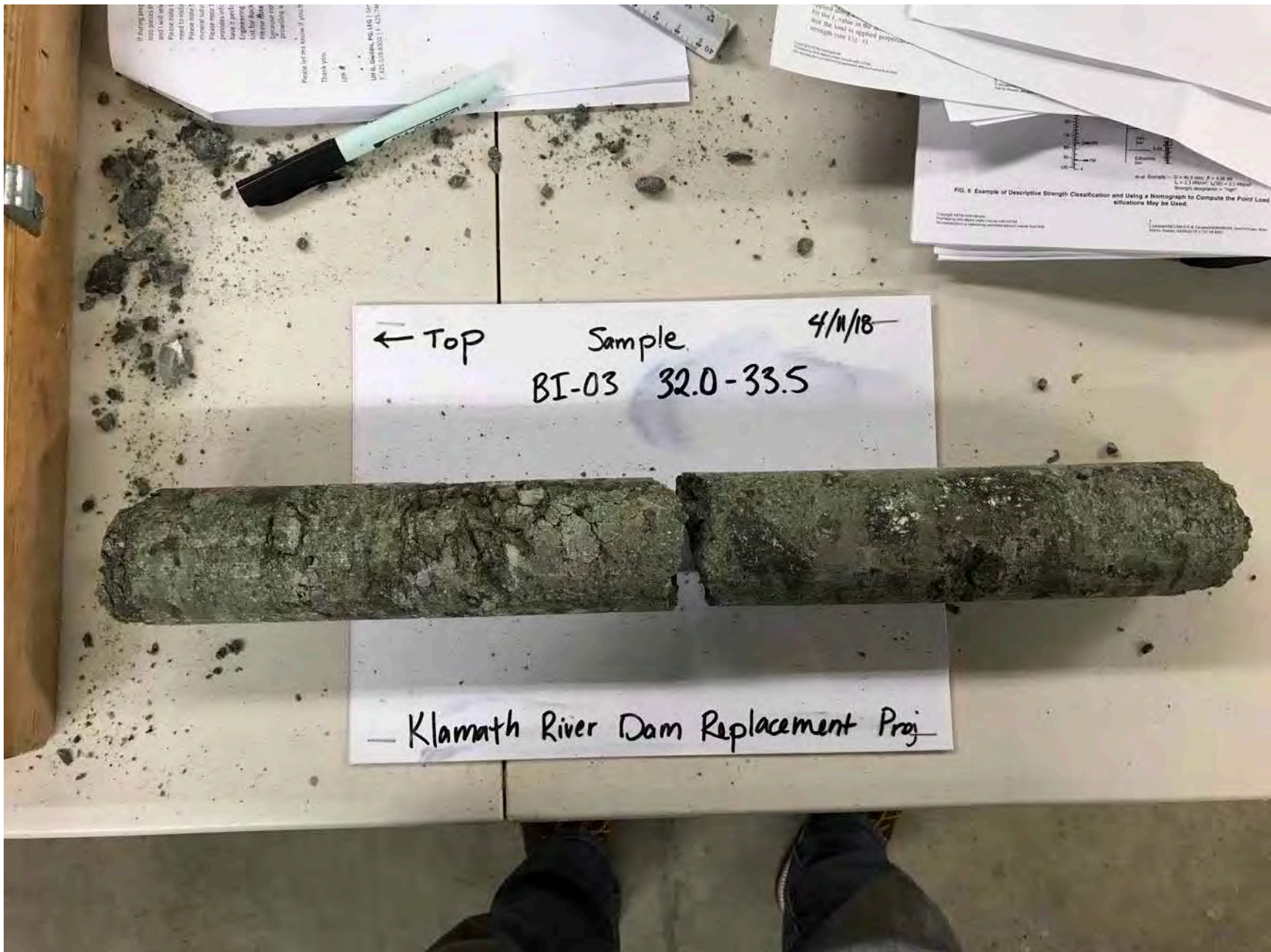
BI-03 29.5 - 30.1



— Klamath River Dam Replacement Proj









# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring: B-01  
Sample: R5  
Depth, ft: 15.6  
Visual Description: Brown Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 60  
Diameter at Failure, D', mm: 54

## STRENGTH DATA

Peak Load, P, kN: 0.17  
Peak Load, P, lbs: 38.2  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.052  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 7.6**  
Size Correction Factor, F: 1.06  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 0.06  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 8**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 20.16  
Total wet wt. (g): 142.33  
Total dry wt (g): 131.89  
**Moisture Content, %: 9.3**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring:	B-01	B-01	B-01	B-01		
Sample:	R6	R6	R6	R6		
Depth, ft:	17.2-17.5	17.2-17.5	17.2-17.5	17.2-17.5		
Visual Description:	Brown Rock	Brown Rock	Brown Rock	Brown Rock		

Test Type	Diametral	Axial	Axial	Axial		
Test Type ID	1	2	2	2		

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None		
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A		

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	58	58	58	58		
Length Perpendicular to Loading, L, mm	30					
Diameter Parallel to Loading, D, mm	58	40	35	23		
Diameter at Failure, D', mm	55	40	30	20		

## STRENGTH DATA

Peak Load, P, kN	0.148	0.346	0.272	0.187		
Peak Load, P, lbs	33.3	77.8	61.1	42.0		
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.046	0.117	0.123	0.127		
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>6.7</b>	<b>17.0</b>	<b>17.8</b>	<b>18.4</b>		
Size Correction Factor, F	1.06	1.04	0.97	0.89		
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.05	0.12	0.12	0.11		
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>7</b>	<b>18</b>	<b>17</b>	<b>16</b>		

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received		
Pan No.						
Pan wt. (g)	20.56	20.56	20.56	20.56		
Total wet wt. (g)	152.32	152.32	152.32	152.32		
Total dry wt (g)	145.93	145.93	145.93	145.93		
<b>Moisture Content, %</b>	<b>5.1</b>	<b>5.1</b>	<b>5.1</b>	<b>5.1</b>		

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring: B-04  
Sample: R5  
Depth, ft: 26.2-26.5  
Visual Description: Brown Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 60  
Diameter at Failure, D', mm: 69

## STRENGTH DATA

Peak Load, P, kN: 0.137  
Peak Load, P, lbs: 30.8  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.033  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 4.8**  
Size Correction Factor, F: 1.12  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 0.04  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 5**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 19.85  
Total wet wt. (g): 116.78  
Total dry wt (g): 107.55  
**Moisture Content, %: 10.5**

Comments:

Invalid point. Did not fail through both loading points.

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring:	B-05	B-05	B-05	B-05	B-05	B-05
Sample:	R7	R7	R7	R7	R7	R7
Depth, ft:	26.2-26.9	26.2-26.9	26.2-26.9	26.2-26.9	26.2-26.9	26.2-26.9
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock

Test Type	Diametral	Diametral	Diametral	Diametral	Axial	Axial
Test Type ID	1	1	1	1	2	2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None	None	None
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60	60	60
Length Perpendicular to Loading, L, mm	30	30	30	30		
Diameter Parallel to Loading, D, mm	60	60	60	60	26	43
Diameter at Failure, D', mm	54	54	56	55	30	38

## STRENGTH DATA

Peak Load, P, kN	26.016	27.563	24.68	19.511	19.242	21.155
Peak Load, P, lbs	5848.6	6196.4	5548.3	4386.2	4325.8	4755.8
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	8.030	8.507	7.345	5.912	8.396	7.287
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>1164.6</b>	<b>1233.9</b>	<b>1065.3</b>	<b>857.5</b>	<b>1217.7</b>	<b>1056.9</b>
Size Correction Factor, F	1.06	1.06	1.07	1.06	0.98	1.03
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	8.51	9.02	7.85	6.29	8.23	7.54
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>1235</b>	<b>1308</b>	<b>1139</b>	<b>913</b>	<b>1194</b>	<b>1093</b>

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	As Received
Pan No.						
Pan wt. (g)	22.43	22.43	22.43	22.43	22.43	22.43
Total wet wt. (g)	187.35	187.35	187.35	187.35	187.35	187.35
Total dry wt (g)	186.12	186.12	186.12	186.12	186.12	186.12
<b>Moisture Content, %</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring:	B-05	B-05	B-05	B-05		
Sample:	R11	R11	R11	R11		
Depth, ft:	36.9-37.3	36.9-37.3	36.9-37.3	36.9-37.3		
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock		

Test Type	Diametral	Diametral	Axial	Axial		
Test Type ID	1	1	2	2		

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None		
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A		

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60		
Length Perpendicular to Loading, L, mm	30	30				
Diameter Parallel to Loading, D, mm	60	60	30	40		
Diameter at Failure, D', mm	56	55	26	32		

## STRENGTH DATA

Peak Load, P, kN	33.123	32.033	14.521	18.344		
Peak Load, P, lbs	7446.3	7201.3	3264.5	4123.9		
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	9.858	9.707	7.311	7.504		
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>1429.8</b>	<b>1407.9</b>	<b>1060.3</b>	<b>1088.3</b>		
Size Correction Factor, F	1.07	1.06	0.95	0.99		
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	10.54	10.33	6.94	7.47		
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>1528</b>	<b>1499</b>	<b>1007</b>	<b>1083</b>		

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received		
Pan No.						
Pan wt. (g)	22.95	22.95	22.95	22.95		
Total wet wt. (g)	152.73	152.73	152.73	152.73		
Total dry wt (g)	152.3	152.3	152.3	152.3		
<b>Moisture Content, %</b>	<b>0.3</b>	<b>0.3</b>	<b>0.3</b>	<b>0.3</b>		

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring:	B-05	B-05	B-05	B-05	B-05	B-05
Sample:	R15	R15	R15	R15	R15	R15
Depth, ft:	46.1-46.8	46.1-46.8	46.1-46.8	46.1-46.8	46.1-46.8	46.1-46.8
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock

Test Type	Diametral	Diametral	Diametral	Diametral	Axial	Axial
Test Type ID	1	1	1	1	2	2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None	None	None
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60	60	60
Length Perpendicular to Loading, L, mm	30	30	30	30		
Diameter Parallel to Loading, D, mm	60	60	60	60	36	34
Diameter at Failure, D', mm	56	56	57	56	35	28

## STRENGTH DATA

Peak Load, P, kN	24.093	33.912	27.929	24.365	22.269	21.115
Peak Load, P, lbs	5416.3	7623.7	6278.7	5477.5	5006.3	4746.8
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	7.171	10.093	8.166	7.251	8.329	9.871
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>1040.0</b>	<b>1463.8</b>	<b>1184.4</b>	<b>1051.7</b>	<b>1208.0</b>	<b>1431.7</b>
Size Correction Factor, F	1.07	1.07	1.07	1.07	1.02	0.97
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	7.66	10.79	8.76	7.75	8.46	9.53
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>1112</b>	<b>1565</b>	<b>1271</b>	<b>1124</b>	<b>1226</b>	<b>1382</b>

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	As Received
Pan No.						
Pan wt. (g)	19.79	19.79	19.79	19.79	19.79	19.79
Total wet wt. (g)	138.47	138.47	138.47	138.47	138.47	138.47
Total dry wt (g)	137.97	137.97	137.97	137.97	137.97	137.97
<b>Moisture Content, %</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1





# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring: B-07  
Sample: R6  
Depth, ft: 29.3-29.6  
Visual Description: Red Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 60  
Diameter at Failure, D', mm: 56

## STRENGTH DATA

Peak Load, P, kN: 0.22  
Peak Load, P, lbs: 49.5  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.065  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 9.5**  
Size Correction Factor, F: 1.07  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 0.07  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 10**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 21.71  
Total wet wt. (g): 148.91  
Total dry wt (g): 139.87  
**Moisture Content, %: 7.7**

Comments:

Invalid point. Did not fail through both loading points.

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring:	B-08	B-08	B-08			
Sample:	R1	R1	R1			
Depth, ft:	37.1-37.6	37.1-37.6	37.1-37.6			
Visual Description:	Gray Rock	Gray Rock	Gray Rock			

Test Type	Diametral	Diametral	Axial			
Test Type ID	1	1	2			

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None			
Loading Orientation Rel. to Bedding	N/A	N/A	N/A			

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60			
Length Perpendicular to Loading, L, mm	30	30				
Diameter Parallel to Loading, D, mm	60	60	36			
Diameter at Failure, D', mm	58	59	46			

## STRENGTH DATA

Peak Load, P, kN	0.692	0.484	0.327			
Peak Load, P, lbs	155.6	108.8	73.5			
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.199	0.137	0.093			
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>28.8</b>	<b>19.8</b>	<b>13.5</b>			
Size Correction Factor, F	1.08	1.08	1.08			
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.21	0.15	0.10			
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>31</b>	<b>21</b>	<b>15</b>			

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received			
Pan No.						
Pan wt. (g)	19.25	19.25	19.25			
Total wet wt. (g)	168.79	168.79	168.79			
Total dry wt (g)	156.2	156.2	156.2			
<b>Moisture Content, %</b>	<b>9.2</b>	<b>9.2</b>	<b>9.2</b>			

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/12/2019  
By: PJ

Boring: B-08  
Sample: R2  
Depth, ft: 38.6-38.9  
Visual Description: Gray Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 60  
Diameter at Failure, D', mm: 58

## STRENGTH DATA

Peak Load, P, kN: 1.122  
Peak Load, P, lbs: 252.2  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.322  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 46.8**  
Size Correction Factor, F: 1.08  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 0.35  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 50**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 20.6  
Total wet wt. (g): 298.27  
Total dry wt (g): 282.19  
**Moisture Content, %: 6.1**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1





# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring: B-08  
Sample: R4  
Depth, ft: 50.2-50.6  
Visual Description: Gray Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 60  
Diameter at Failure, D', mm: 59

## STRENGTH DATA

Peak Load, P, kN: 3.384  
Peak Load, P, lbs: 760.8  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.956  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 138.6**  
Size Correction Factor, F: 1.08  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 1.03  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 150**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 22.27  
Total wet wt. (g): 391.5  
Total dry wt (g): 378.35  
**Moisture Content, %: 3.7**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring: B-10  
Sample: R1  
Depth, ft: 30.4-30.7  
Visual Description: Gray Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 60  
Diameter at Failure, D', mm: 56

## STRENGTH DATA

Peak Load, P, kN: 9.55  
Peak Load, P, lbs: 2146.9  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 2.842  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 412.2**  
Size Correction Factor, F: 1.07  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 3.04  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 441**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 22.44  
Total wet wt. (g): 267.19  
Total dry wt (g): 259.78  
**Moisture Content, %: 3.1**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring:	B-10	B-10				
Sample:	R3	R3				
Depth, ft:	33.4-33.7	33.4-33.7				
Visual Description:	Gray Rock	Gray Rock				

Test Type Diametral Axial  
Test Type ID 1 2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis None None  
Loading Orientation Rel. to Bedding N/A N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm 60 60  
Length Perpendicular to Loading, L, mm 30  
Diameter Parallel to Loading, D, mm 60 44  
Diameter at Failure, D', mm 56 42

## STRENGTH DATA

Peak Load, P, kN 0.374 0.101  
Peak Load, P, lbs 84.1 22.7  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa 0.111 0.031  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi 16.1 4.6**  
Size Correction Factor, F 1.07 1.06  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa 0.12 0.03  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi 17 5**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen As Received As Received  
Pan No.  
Pan wt. (g) 22.32 22.32  
Total wet wt. (g) 159.18 159.18  
Total dry wt (g) 144.98 144.98  
**Moisture Content, % 11.6 11.6**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277

Project No.: 60537920

Client: AECOM

Date: 3/13/2019

Project Name: Klamath River Renewal Project

By: 3/13/2019

Boring:	B-10	B-10	B-10	B-10		
Sample:	R4	R4	R4	R4		
Depth, ft:	37.1-37.4	37.1-37.4	37.1-37.4	37.1-37.4		
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock		
Test Type	Diametral	Diametral	Axial	Axial		
Test Type ID	1	1	2	2		
<b>FOR ANISOTROPIC ROCK:</b>						
Bedding Angle Relative to Axis	None	None	None	None		
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A		
<b>SAMPLE DIMENSIONS</b>						
Width Perpendicular to loading, W, mm	60	60	60	60		
Length Perpendicular to Loading, L, mm	30	30				
Diameter Parallel to Loading, D, mm	60	60	37	36		
Diameter at Failure, D', mm	58	56	33	28		
<b>STRENGTH DATA</b>						
Peak Load, P, kN	0.435	0.521	0.225	0.313		
Peak Load, P, lbs	97.8	117.1	50.6	70.4		
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.125	0.155	0.089	0.146		
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>18.1</b>	<b>22.5</b>	<b>12.9</b>	<b>21.2</b>		
Size Correction Factor, F	1.08	1.07	1.00	0.97		
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.13	0.17	0.09	0.14		
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>20</b>	<b>24</b>	<b>13</b>	<b>20</b>		
<b>MOISTURE CONTENT DATA</b>						
Moisture Condition of Specimen	As Received	As Received	As Received	As Received		
Pan No.						
Pan wt. (g)	22.12	22.12	22.12	22.12		
Total wet wt. (g)	154	154	154	154		
Total dry wt (g)	140.19	140.19	140.19	140.19		
<b>Moisture Content, %</b>	<b>11.7</b>	<b>11.7</b>	<b>11.7</b>	<b>11.7</b>		
Comments:						

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump

Diametral - L/D ratio &gt; 1

Axial - L/D ratio 1/3 to 1

Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring:	B-10	B-10				
Sample:	R7	R7				
Depth, ft:	49-49.5	49-49.5				
Visual Description:	Gray Rock	Gray Rock				

Test Type	Diametral	Axial				
Test Type ID	1	2				

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None				
Loading Orientation Rel. to Bedding	N/A	N/A				

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60				
Length Perpendicular to Loading, L, mm	30					
Diameter Parallel to Loading, D, mm	60	30				
Diameter at Failure, D', mm	58	29				

## STRENGTH DATA

Peak Load, P, kN	2.077	1.996				
Peak Load, P, lbs	466.9	448.7				
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.597	0.901				
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>86.6</b>	<b>130.7</b>				
Size Correction Factor, F	1.08	0.97				
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.64	0.88				
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>93</b>	<b>127</b>				

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received				
Pan No.						
Pan wt. (g)	22.33	22.33				
Total wet wt. (g)	379.89	379.89				
Total dry wt (g)	357.27	357.27				
<b>Moisture Content, %</b>	<b>6.8</b>	<b>6.8</b>				

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277

Project No.: 60537920

Client: AECOM

Date: 3/13/2019

Project Name: Klamath River Renewal Project

By: PJ

Boring:	B-13	B-13	B-13	B-13	B-13	
Sample:	R4	R4	R4	R4	R4	
Depth, ft:	11.9-12.4	11.9-12.4	11.9-12.4	11.9-12.4	11.9-12.4	
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	
Test Type	Diametral	Diametral	Diametral	Axial	Axial	
Test Type ID	1	1	1	2	2	
<b>FOR ANISOTROPIC ROCK:</b>						
Bedding Angle Relative to Axis	None	None	None	None	None	
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	
<b>SAMPLE DIMENSIONS</b>						
Width Perpendicular to loading, W, mm	60	60	60	60	60	
Length Perpendicular to Loading, L, mm	30	30	30			
Diameter Parallel to Loading, D, mm	60	60	60	46	40	
Diameter at Failure, D', mm	59	57	59	45	36	
<b>STRENGTH DATA</b>						
Peak Load, P, kN	12.808	20.405	17.108	16.519	15.518	
Peak Load, P, lbs	2879.4	4587.2	3846.0	3713.6	3488.6	
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	3.618	5.966	4.833	4.805	5.643	
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>524.8</b>	<b>865.4</b>	<b>700.9</b>	<b>696.9</b>	<b>818.4</b>	
Size Correction Factor, F	1.08	1.07	1.08	1.07	1.02	
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	3.91	6.40	5.23	5.16	5.76	
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>567</b>	<b>929</b>	<b>758</b>	<b>749</b>	<b>836</b>	
<b>MOISTURE CONTENT DATA</b>						
Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	
Pan No.						
Pan wt. (g)	22.32	22.32	22.32	22.32	22.32	
Total wet wt. (g)	215.87	215.87	215.87	215.87	215.87	
Total dry wt (g)	215.69	215.69	215.69	215.69	215.69	
<b>Moisture Content, %</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	
Comments:						

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump

Diametral - L/D ratio &gt; 1

Axial - L/D ratio 1/3 to 1

Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring:	B-14	B-14	B-14	B-14	B-14	B-14
Sample:	R6	R6	R6	R6	R6	R6
Depth, ft:	14.2-14.9	14.2-14.9	14.2-14.9	14.2-14.9	14.2-14.9	14.2-14.9
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock

Test Type	Diametral	Diametral	Diametral	Axial	Axial	Axial
Test Type ID	1	1	1	2	2	2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None	None	None
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60	60	60
Length Perpendicular to Loading, L, mm	30	30	30			
Diameter Parallel to Loading, D, mm	60	60	60	49	50	41
Diameter at Failure, D', mm	56	57	58	39	48	36

## STRENGTH DATA

Peak Load, P, kN	0.196	0.188	0.169	0.046	0.053	0.054
Peak Load, P, lbs	44.1	42.3	38.0	10.3	11.9	12.1
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.058	0.055	0.049	0.015	0.014	0.020
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>8.5</b>	<b>8.0</b>	<b>7.0</b>	<b>2.2</b>	<b>2.1</b>	<b>2.8</b>
Size Correction Factor, F	1.07	1.07	1.08	1.04	1.09	1.02
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.06	0.06	0.05	0.02	0.02	0.02
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>9</b>	<b>9</b>	<b>8</b>	<b>2</b>	<b>2</b>	<b>3</b>

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	As Received
Pan No.						
Pan wt. (g)	21.71	21.71	21.71	21.71	21.71	21.71
Total wet wt. (g)	209.08	209.08	209.08	209.08	209.08	209.08
Total dry wt (g)	195.76	195.76	195.76	195.76	195.76	195.76
<b>Moisture Content, %</b>	<b>7.7</b>	<b>7.7</b>	<b>7.7</b>	<b>7.7</b>	<b>7.7</b>	<b>7.7</b>

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring: B-14  
Sample: R7  
Depth, ft: 20.8-21.2  
Visual Description: Gray Rock

Test Type: Diametral  
Test Type ID: 1

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 58  
Length Perpendicular to Loading, L, mm: 30  
Diameter Parallel to Loading, D, mm: 58  
Diameter at Failure, D', mm: 56

## STRENGTH DATA

Peak Load, P, kN: 0.284  
Peak Load, P, lbs: 63.8  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.087  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 12.7**  
Size Correction Factor, F: 1.06  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 0.09  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 13**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 21.98  
Total wet wt. (g): 194.83  
Total dry wt (g): 185.6  
**Moisture Content, %: 5.6**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring: B-14  
Sample: R8  
Depth, ft: 23.7-23.9  
Visual Description: Gray Rock

Test Type: Axial  
Test Type ID: 2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis: None  
Loading Orientation Rel. to Bedding: N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm: 60  
Length Perpendicular to Loading, L, mm:  
Diameter Parallel to Loading, D, mm: 51  
Diameter at Failure, D', mm: 49

## STRENGTH DATA

Peak Load, P, kN: 0.037  
Peak Load, P, lbs: 8.3  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa: 0.010  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi: 1.4**  
Size Correction Factor, F: 1.10  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa: 0.01  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi: 2**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen: As Received  
Pan No.:  
Pan wt. (g): 22.23  
Total wet wt. (g): 109.95  
Total dry wt (g): 104.99  
**Moisture Content, %: 6.0**

Comments:

Invalid test. Did not fail through both loading points.

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1





# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring: B-14 B-14  
Sample: R9 R9  
Depth, ft: 26.1-26.4 26.1-26.4  
Visual Description: Grayish Brown Rock Grayish Brown Rock

Test Type Diametral Axial  
Test Type ID 1 2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis None None  
Loading Orientation Rel. to Bedding N/A N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm 60 60  
Length Perpendicular to Loading, L, mm 30  
Diameter Parallel to Loading, D, mm 60 51  
Diameter at Failure, D', mm 57 49

## STRENGTH DATA

Peak Load, P, kN 1.627 2.247  
Peak Load, P, lbs 365.8 505.1  
Uncorr. Pt. Load Strength Index,  $I_s$ , MPa 0.476 0.600  
**Uncorr. Pt. Load Strength Index,  $I_s$ , psi 69.0 87.1**  
Size Correction Factor, F 1.07 1.10  
Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa 0.51 0.66  
**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi 74 95**

## MOISTURE CONTENT DATA

Moisture Condition of Specimen As Received As Received  
Pan No.  
Pan wt. (g) 22.3 22.3  
Total wet wt. (g) 127.05 127.05  
Total dry wt (g) 124.19 124.19  
**Moisture Content, % 2.8 2.8**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring:	B-15	B-15	B-15	B-15	B-15	B-15
Sample:	R4	R4	R4	R4	R4	R4
Depth, ft:	33-33.5	33-33.5	33-33.5	33-33.5	33-33.5	33-33.5
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock

Test Type	Diametral	Diametral	Diametral	Axial	Axial	Axial
Test Type ID	1	1	1	2	2	2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None	None	None
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60	60	60
Length Perpendicular to Loading, L, mm	30	30	30			
Diameter Parallel to Loading, D, mm	60	60	60	44	45	30
Diameter at Failure, D', mm	59	57	57	42	39	26

## STRENGTH DATA

Peak Load, P, kN	0.72	0.84	1.048	1.447	1.044	0.099
Peak Load, P, lbs	161.9	188.8	235.6	325.3	234.7	22.3
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.203	0.246	0.306	0.451	0.350	0.050
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>29.5</b>	<b>35.6</b>	<b>44.4</b>	<b>65.4</b>	<b>50.8</b>	<b>7.2</b>
Size Correction Factor, F	1.08	1.07	1.07	1.06	1.04	0.95
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.22	0.26	0.33	0.48	0.36	0.05
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>32</b>	<b>38</b>	<b>48</b>	<b>69</b>	<b>53</b>	<b>7</b>

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	As Received
Pan No.						
Pan wt. (g)	21.63	21.63	21.63	21.63	21.63	21.63
Total wet wt. (g)	128.99	128.99	128.99	128.99	128.99	128.99
Total dry wt (g)	124.4	124.4	124.4	124.4	124.4	124.4
<b>Moisture Content, %</b>	<b>4.5</b>	<b>4.5</b>	<b>4.5</b>	<b>4.5</b>	<b>4.5</b>	<b>4.5</b>

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1

# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring:	B-15	B-15	B-15	B-15	B-15	B-15
Sample:	R6	R6	R6	R6	R6	R6
Depth, ft:	43.1-43.6	43.1-43.6	43.1-43.6	43.1-43.6	43.1-43.6	43.1-43.6
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock

Test Type	Diametral	Diametral	Diametral	Axial	Axial	Axial
Test Type ID	1	1	1	2	2	2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None	None	None
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60	60	60
Length Perpendicular to Loading, L, mm	30	30	30			
Diameter Parallel to Loading, D, mm	60	60	60	32	35	30
Diameter at Failure, D', mm	57	57	55	30	32	27

## STRENGTH DATA

Peak Load, P, kN	1.129	1.549	1.129	1.336	1.359	0.771
Peak Load, P, lbs	253.8	348.2	253.8	300.3	305.5	173.3
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.330	0.453	0.342	0.583	0.556	0.374
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>47.9</b>	<b>65.7</b>	<b>49.6</b>	<b>84.5</b>	<b>80.6</b>	<b>54.2</b>
Size Correction Factor, F	1.07	1.07	1.06	0.98	0.99	0.96
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.35	0.49	0.36	0.57	0.55	0.36
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>51</b>	<b>70</b>	<b>53</b>	<b>83</b>	<b>80</b>	<b>52</b>

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	As Received
Pan No.						
Pan wt. (g)	20.45	20.45	20.45	20.45	20.45	20.45
Total wet wt. (g)	238.89	238.89	238.89	238.89	238.89	238.89
Total dry wt (g)	228.86	228.86	228.86	228.86	228.86	228.86
<b>Moisture Content, %</b>	<b>4.8</b>	<b>4.8</b>	<b>4.8</b>	<b>4.8</b>	<b>4.8</b>	<b>4.8</b>

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D= 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277  
Client: AECOM  
Project Name: Klamath River Renewal Project

Project No.: 60537920  
Date: 3/13/2019  
By: PJ

Boring:	B-17	B-17	B-17	B-17	B-17	B-17
Sample:	R3	R3	R3	R3	R3	R3
Depth, ft:	25.1-25.7	25.1-25.7	25.1-25.7	25.1-25.7	25.1-25.7	25.1-25.7
Visual Description:	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock	Gray Rock

Test Type	Diametral	Diametral	Diametral	Axial	Axial	Axial
Test Type ID	1	1	1	2	2	2

## FOR ANISOTROPIC ROCK:

Bedding Angle Relative to Axis	None	None	None	None	None	None
Loading Orientation Rel. to Bedding	N/A	N/A	N/A	N/A	N/A	N/A

## SAMPLE DIMENSIONS

Width Perpendicular to loading, W, mm	60	60	60	60	60	60
Length Perpendicular to Loading, L, mm	30	30	30			
Diameter Parallel to Loading, D, mm	60	60	60	33	41	34
Diameter at Failure, D', mm	59	60	59	30	38	29

## STRENGTH DATA

Peak Load, P, kN	0.583	0.78	0.413	1.206	2.038	1.52
Peak Load, P, lbs	131.1	175.4	92.8	271.1	458.2	341.7
Uncorr. Pt. Load Strength Index, $I_s$ , MPa	0.165	0.217	0.117	0.526	0.702	0.686
<b>Uncorr. Pt. Load Strength Index, <math>I_s</math>, psi</b>	<b>23.9</b>	<b>31.4</b>	<b>16.9</b>	<b>76.3</b>	<b>101.8</b>	<b>99.5</b>
Size Correction Factor, F	1.08	1.09	1.08	0.98	1.03	0.97
Corr. Pt. Load Strength Index, $I_{s(50)}$ , Mpa	0.18	0.24	0.13	0.52	0.73	0.67
<b>Corr. Pt. Load Strength Index, <math>I_{s(50)}</math>, psi</b>	<b>26</b>	<b>34</b>	<b>18</b>	<b>75</b>	<b>105</b>	<b>97</b>

## MOISTURE CONTENT DATA

Moisture Condition of Specimen	As Received	As Received	As Received	As Received	As Received	As Received
Pan No.						
Pan wt. (g)	20.98	20.98	20.98	20.98	20.98	20.98
Total wet wt. (g)	165.97	165.97	165.97	165.97	165.97	165.97
Total dry wt (g)	158.36	158.36	158.36	158.36	158.36	158.36
<b>Moisture Content, %</b>	<b>5.5</b>	<b>5.5</b>	<b>5.5</b>	<b>5.5</b>	<b>5.5</b>	<b>5.5</b>

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump  
Diametral - L/D ratio > 1  
Axial - L/D ratio 1/3 to 1  
Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1



# POINT LOAD STRENGTH INDEX OF ROCK - ASTM D 5731

CTL Job No: 020-277

Project No.: 60537920

Client: AECOM

Date: 3/20/2019

Project Name: Klamath River Renewal Project

By: PJ

Boring: B-19  
Sample: R1  
Depth, ft: 31.3-32.2  
Visual Description: Brown Rock

Test Type Diametral

Test Type ID 1

**FOR ANISOTROPIC ROCK:**

Bedding Angle Relative to Axis None

Loading Orientation Rel. to Bedding N/A

**SAMPLE DIMENSIONS**

Width Perpendicular to loading, W, mm 61

Length Perpendicular to Loading, L, mm 30

Diameter Parallel to Loading, D, mm 61

Diameter at Failure, D', mm 59

**STRENGTH DATA**

Peak Load, P, kN 0.582

Peak Load, P, lbs 130.8

Uncorr. Pt. Load Strength Index,  $I_s$ , MPa 0.162**Uncorr. Pt. Load Strength Index,  $I_s$ , psi 23.5**

Size Correction Factor, F 1.09

Corr. Pt. Load Strength Index,  $I_{s(50)}$ , Mpa 0.18**Corr. Pt. Load Strength Index,  $I_{s(50)}$ , psi 25****MOISTURE CONTENT DATA**

Moisture Condition of Specimen As Received

Pan No.

Pan wt. (g) 19.52

Total wet wt. (g) 97.66

Total dry wt (g) 91.38

**Moisture Content, % 8.7**

Comments:

Test types: 1- Diametral, 2- Axial, 3- Block, 4- Irregular Lump

Diametral - L/D ratio &gt; 1

Axial - L/D ratio 1/3 to 1

Block or Irregular Lumps, D = 30-85 mm; D/W between 1/3 and 1

**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/20/2018****Colorado School of Mines****Mining Engineering Department****ASTM D7012**

Sample ID	Average Length	Average Diameter	Length to Diameter Ratio	Density	Failure Load	Uniaxial Compressive Strength			Notes ( <i>Failure type</i> )
	(in)	(in)		(lbs/ft³)	(lbs)	Failure Stress	UCS (2:1)		
						σ <sub>c</sub> (psi)	(psi)	(MPa)	
B-202 @ 82.0-82.8	5.139	2.368	2.2	133	2,656	603	614	4.2	Non - Structural
B-206 @ 47.4-48.7	5.186	2.402	2.2	166	93,017	20,527	20,886	144.0	Non - Structural
B-206 @ 65.2-66.5	5.188	2.401	2.2	169	70,001	15,467	15,739	108.5	Non - Structural

$$UCS_{2:1\text{correction}} = \frac{\sigma_c}{0.88 + 0.222\left(\frac{d}{l}\right)}$$



**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath Rive****Date: 10/3/2018****Colorado School of Mines****Mining Engineering Department****ASTM D7012**

Sample ID	Average Length	Average Diameter	Length to Diameter Ratio	Density	Failure Load	Uniaxial Compressive Strength			Notes <i>(Failure type)</i>
	(in)	(in)		(lbs/ft³)		(lbs)	Failure Stress	UCS (2:1)	
					σ <sub>c</sub> (psi)		(psi)	(MPa)	
B-207 @ 74.5-75.5	4.864	2.406	2.0	151	14,135	3,109	3,141	21.7	Non - Structural

$$UCS_{2:1\text{correction}} = \frac{\sigma_c}{0.88 + 0.222\left(\frac{d}{l}\right)}$$



# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

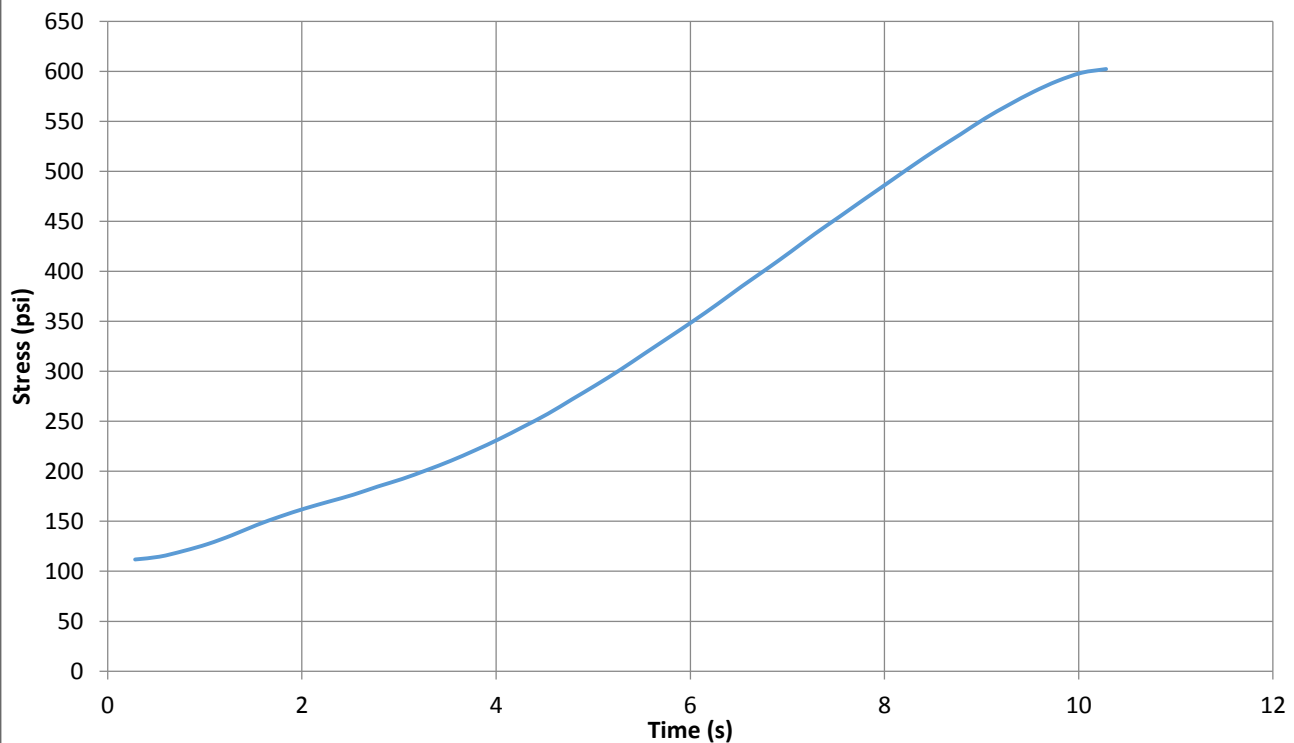
Uniaxial Compressive Strength - ASTM D7012



**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** Igneous  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/20/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/20/2018  
**Core ID:** B-202 @ 82.0-82.8  
**File Name:** B-202 @ 82.0-82.8\_UCS  
**EMI Project No.:** 378



Core Length		Core Diameter		L/D Ratio	Density		
in	cm	in	cm		lb/ft <sup>3</sup>	g/cm <sup>3</sup>	
5.139	13.05	2.368	6.01	2.2	133	2.13	
Failure Load	Failure Stress	UCS 2:1		Static E		Static v	Failure Mode
lbf	psi	psi	MPa	ksi	GPa		
2,656	603	614	4.2	N/A	N/A	N/A	Non - Structural





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

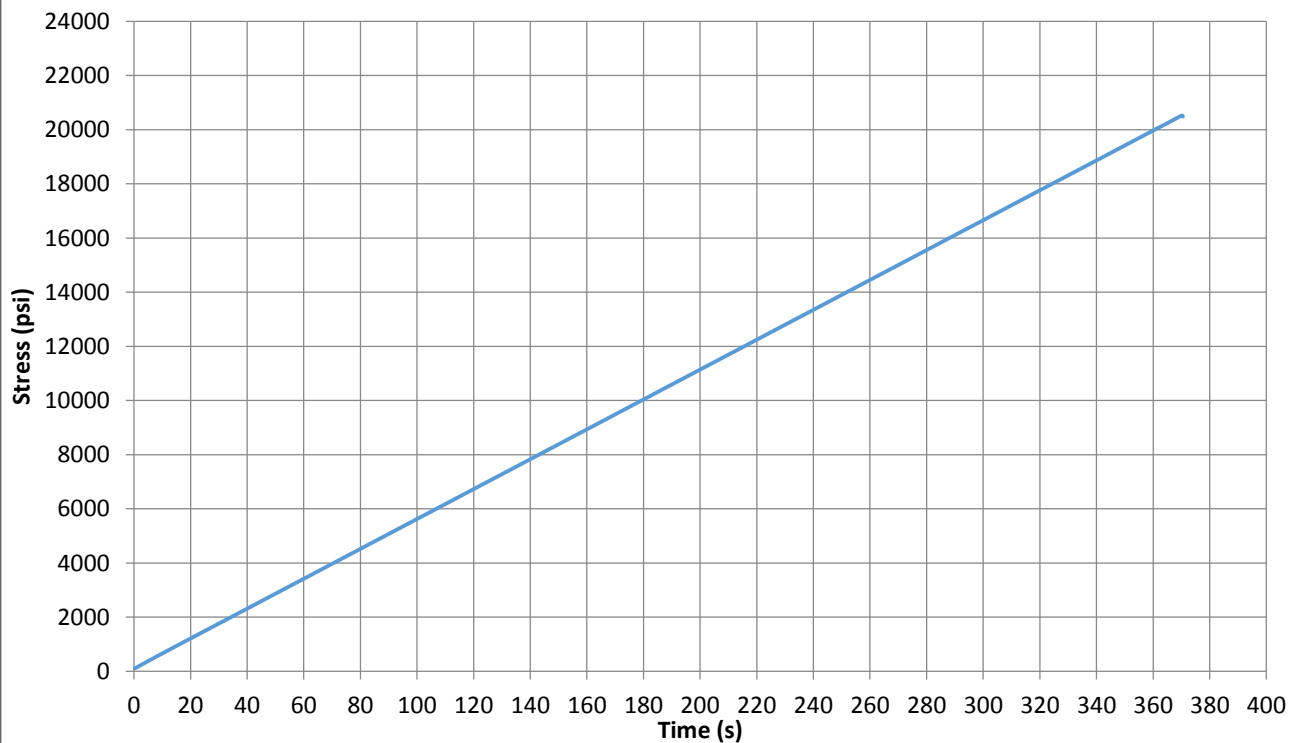
Uniaxial Compressive Strength - ASTM D7012



**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** Igneous  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/20/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/20/2018  
**Core ID:** B-206 @ 47.4-48.7  
**File Name:** B-206 @ 47.4-48.7\_UCS  
**EMI Project No.:** 378



Core Length		Core Diameter		L/D Ratio	Density		
in	cm	in	cm		lb/ft <sup>3</sup>	g/cm <sup>3</sup>	
5.186	13.17	2.402	6.10	2.2	166	2.66	
Failure Load	Failure Stress	UCS 2:1		Static E		Static v	Failure Mode
lbf	psi	psi	MPa	ksi	GPa		
93,017	20,527	20,886	144.0	N/A	N/A	N/A	Non - Structural







# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

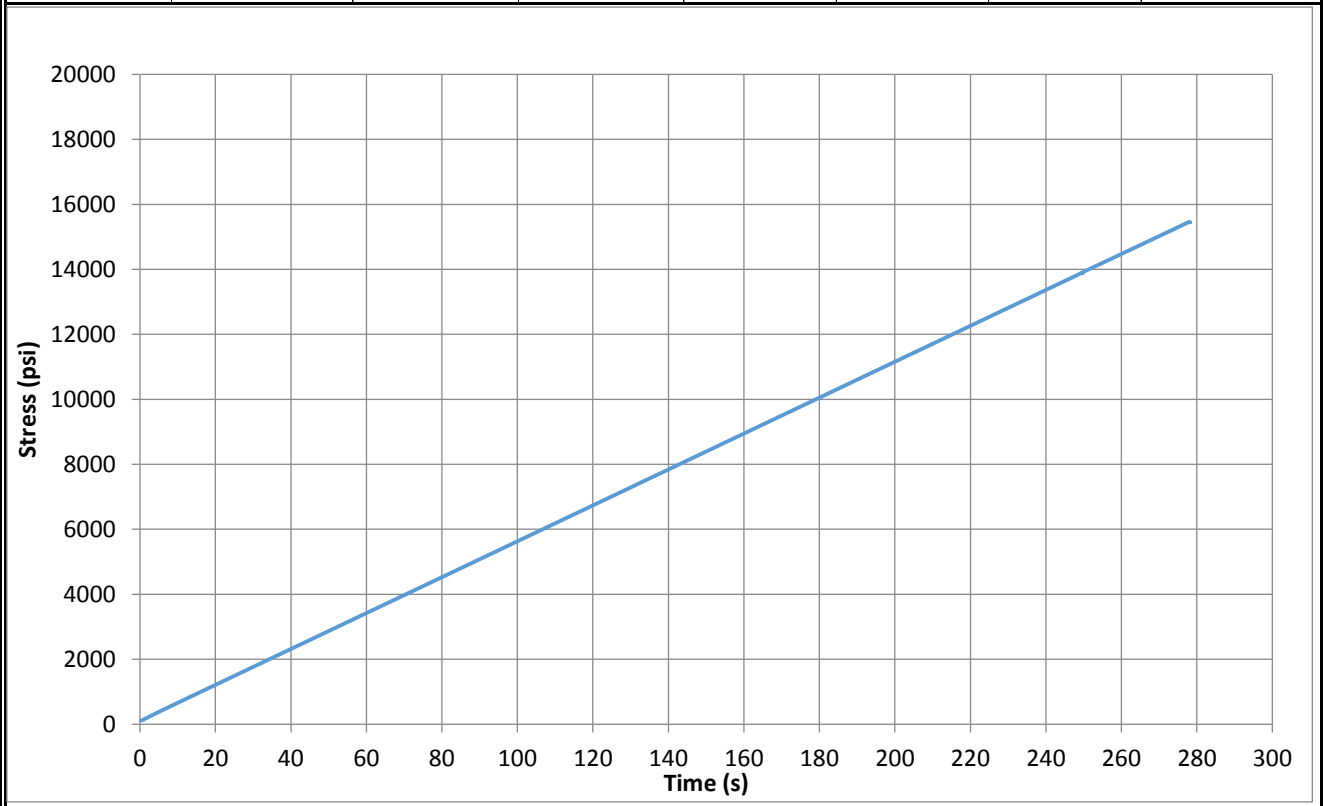
Uniaxial Compressive Strength - ASTM D7012



**Client:** CDM Smith  
**Project:** Klamath River  
**Location:** N/A  
**Rock Type:** Igneous  
**Rock Name:** N/A  
**Characteristics:** N/A  
**Test Performed By:** AK-WL  
**Date Tested:** 9/20/2018  
**Data Reduced By:** AK  
**Date Reduced:** 9/20/2018  
**Core ID:** B-206 @ 65.2-66.5  
**File Name:** B-206 @ 65.2-66.5\_UCS  
**EMI Project No.:** 378



Core Length		Core Diameter		L/D Ratio	Density		
in	cm	in	cm		lb/ft <sup>3</sup>	g/cm <sup>3</sup>	
5.188	13.18	2.401	6.10	2.2	169	2.70	
Failure Load	Failure Stress	UCS 2:1		Static E		Static v	Failure Mode
lbf	psi	psi	MPa	ksi	GPa		
70,001	15,467	15,739	108.5	N/A	N/A	N/A	Non - Structural





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

Uniaxial Compressive Strength - ASTM D7012



**Client:** CDM Smith

**Project:** Klamath River-Yreka Water  
Main Crossing

**Rock Type:** N/A

**Rock Name:** N/A

**Characteristics:** N/A

**Test Performed By:** OF

**Date Tested:** 10/3/2018

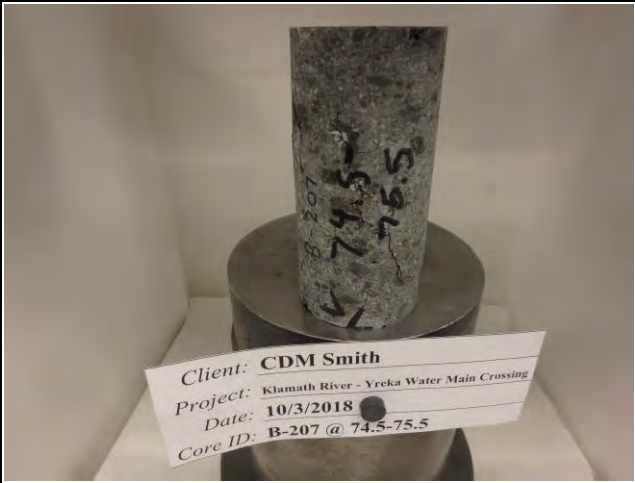
**Data Reduced By:** OF

**Date Reduced:** 10/3/2018

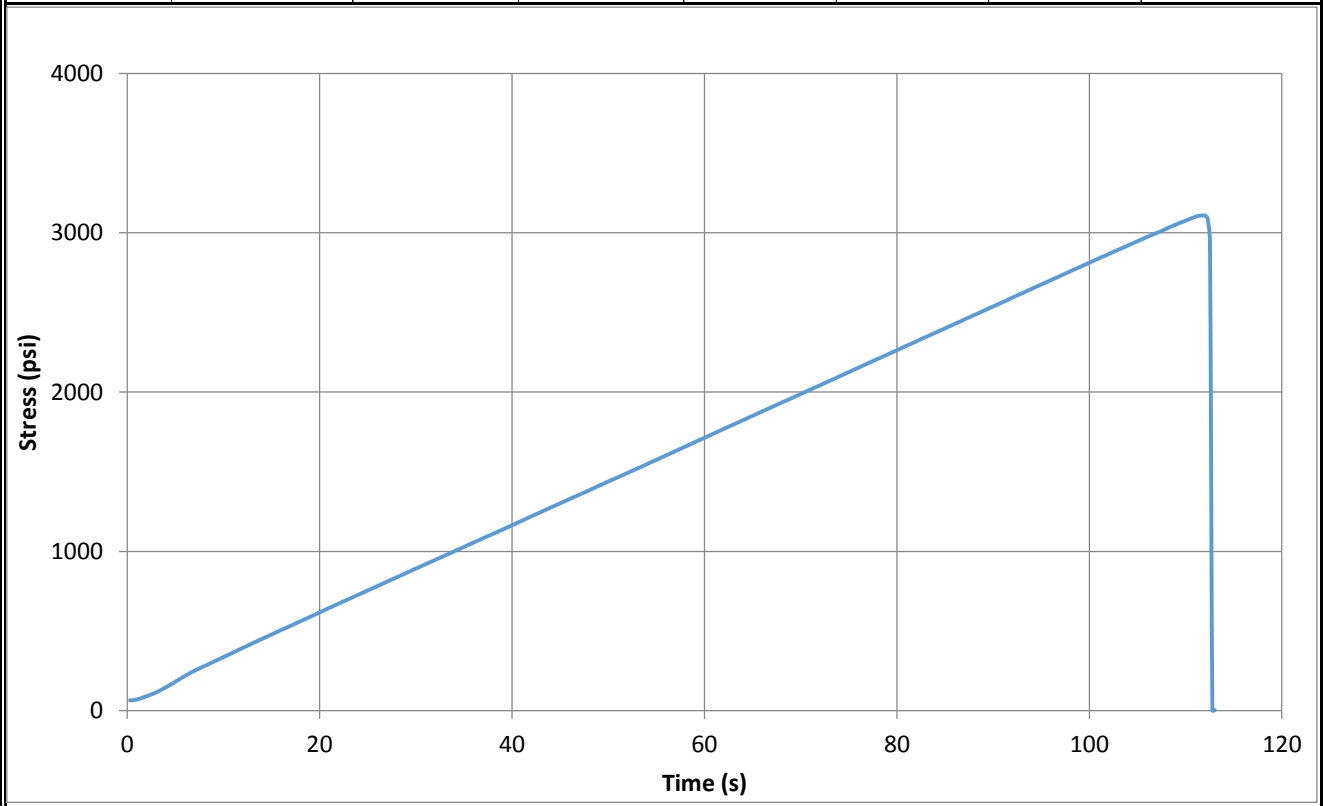
**Core ID:** B-207 @ 74.5-75.5

**File Name:** B-207 @ 74.5-75.5\_UCS

**EMI Project No.:** 382



Core Length		Core Diameter		L/D Ratio	Density		
in	cm	in	cm		lb/ft <sup>3</sup>	g/cm <sup>3</sup>	
4.864	12.35	2.406	6.11	2.0	151	2.42	
Failure Load	Failure Stress	UCS 2:1		Static E		Static v	Failure Mode
lbf	psi	psi	MPa	ksi	GPa		
14,135	3,109	3,141	21.7	N/A	N/A	N/A	Non - Structural
P - Wave		S - Wave		Dynamic E		Dynamic v	
ft/s	m/s	ft/s	m/s	ksi	GPa		
N/A	N/A	N/A	N/A	N/A	N/A	N/A	



**Uniaxial Compression Test without  
Stress-Strain Curves and Moduli  
ASTM D7012 - 14e1**

COMPANY WITH  
QUALITY SYSTEM  
CERTIFIED BY DNV GL  
= ISO 9001 =

**Tonon USA:**  
Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-1-1
Report Date	5/17/2018
Drill hole and Depth	BI-02; 27-27.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Stress Rate	0.5 MPa/s	
Diameter of Specimen	60.54 mm	2.38 in
Height of Specimen	97.72 mm	3.85 in
Load at Peak	16.69 kN	3,752 lbf
Unconfined Compressive Strength	5.80 MPa	841 psi
Type of Failure	Non-Structural	

Note: The provided sample had a height-to-diameter ratio less than 2

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/30/2018
---------------------------	-------------------------	------------------------



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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2028 E Ben White BLVD #240-2660  
Austin, TX 78741

Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
Phone: +1-512-200-3051  
E-mail: fulvio@tononeng.com



Uniaxial Compression Test without  
Stress-Strain Curves and Moduli  
ASTM D7012 - 14e1

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Tonon USA:  
Engineering, Measurements and Testing, LLC

Web: tononeng.com



Picture of the sample upon arrival at Tonon USA Laboratory: no core piece allowed preparation of a specimen with a height-to-diameter ratio between 2 and 2.5.

**Uniaxial Compression Test without  
Stress-Strain Curves and Moduli  
ASTM D7012 - 14e1**

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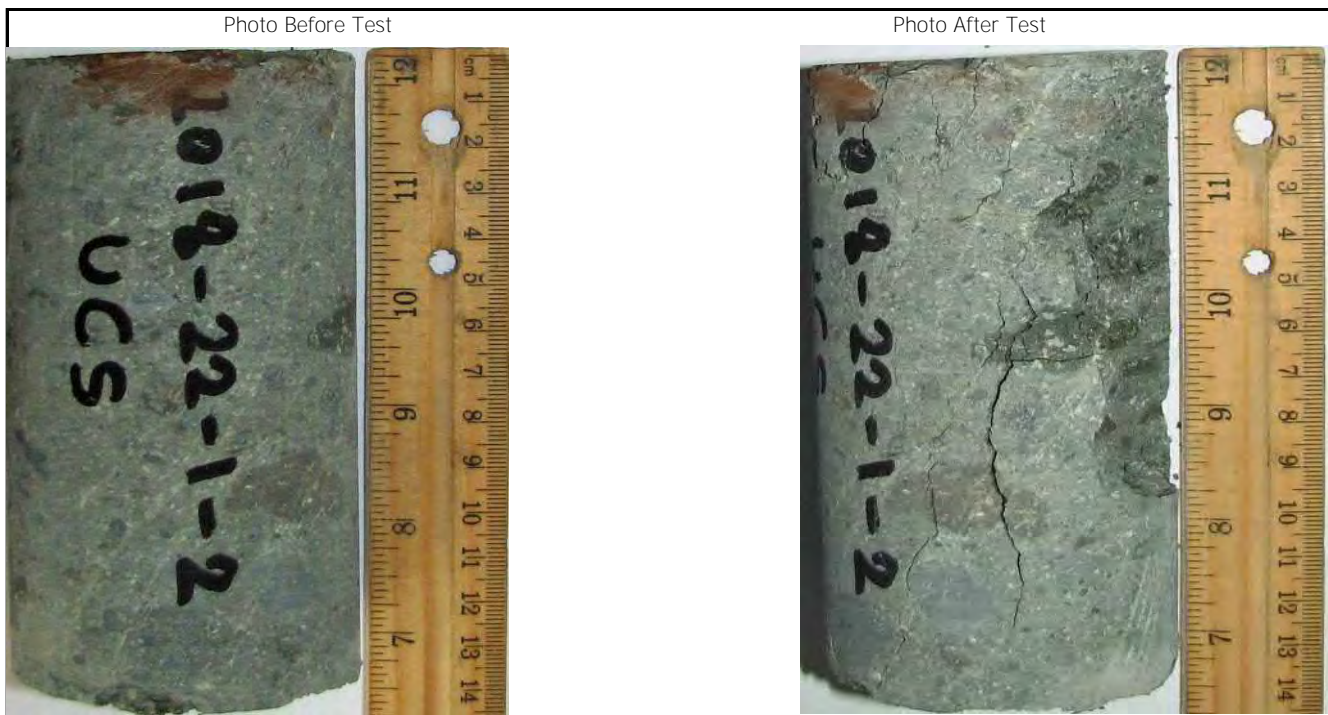
**Tonon USA:**  
Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-1-2
Report Date	5/17/2018
Drill hole and Depth	BI-02; 48.9-50.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Stress Rate	0.5 MPa/s	
Diameter of Specimen	60.85 mm	2.40 in
Height of Specimen	127.87 mm	5.03 in
Load at Peak	34.80 kN	7,823 lbf
Unconfined Compressive Strength	11.97 MPa	1,736 psi
Type of Failure	Non-Structural	

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/30/2018
---------------------------	-------------------------	------------------------



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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2028 E Ben White BLVD #240-2660  
Austin, TX 78741

Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
Phone: +1-512-200-3051  
E-mail: fulvio@tononeng.com

**Uniaxial Compression Test without  
Stress-Strain Curves and Moduli  
ASTM D7012 - 14e1**

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QUALITY SYSTEM  
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= ISO 9001 =

**Tonon USA:**  
Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-1-3
Report Date	5/17/2018
Drill hole and Depth	BI-02; 55.4-56.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Stress Rate	0.5 MPa/s	
Diameter of Specimen	60.68 mm	2.39 in
Height of Specimen	128.33 mm	5.05 in
Load at Peak	45.59 kN	10,248 lbf
Unconfined Compressive Strength	15.77 MPa	2,288 psi
Type of Failure	Non-Structural	

Date Received : 4/24/2018

Date Opened : 4/24/2018

Date Tested: 4/30/2018

Photo Before Test

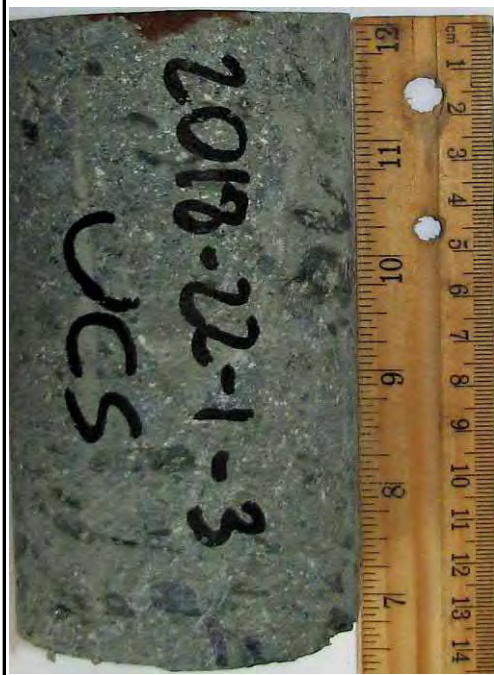


Photo After Test



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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2028 E Ben White BLVD #240-2660  
Austin, TX 78741

Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
Phone: +1-512-200-3051  
E-mail: fulvio@tononeng.com



**Uniaxial Compression Test without  
Stress-Strain Curves and Moduli  
ASTM D7012 - 14e1**

COMPANY WITH  
QUALITY SYSTEM  
CERTIFIED BY DNV GL  
= ISO 9001 =

**Tonon USA:**  
Engineering, Measurements and Testing, LLC

Web: tononeng.com

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-1-4
Report Date	5/17/2018
Drill hole and Depth	BI-03; 17.4-18.4 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Stress Rate	0.5 MPa/s	
Diameter of Specimen	60.59 mm	2.39 in
Height of Specimen	129.81 mm	5.11 in
Load at Peak	4.39 kN	987 lbf
Unconfined Compressive Strength	1.52 MPa	221 psi
Type of Failure	Non-Structural	

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 5/4/2018
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Checked by: Gloria Tonon-Kozma, P.E.

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**Uniaxial Compression Test without  
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ASTM D7012 - 14e1**

COMPANY WITH  
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**Tonon USA:**  
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Web: tononeng.com

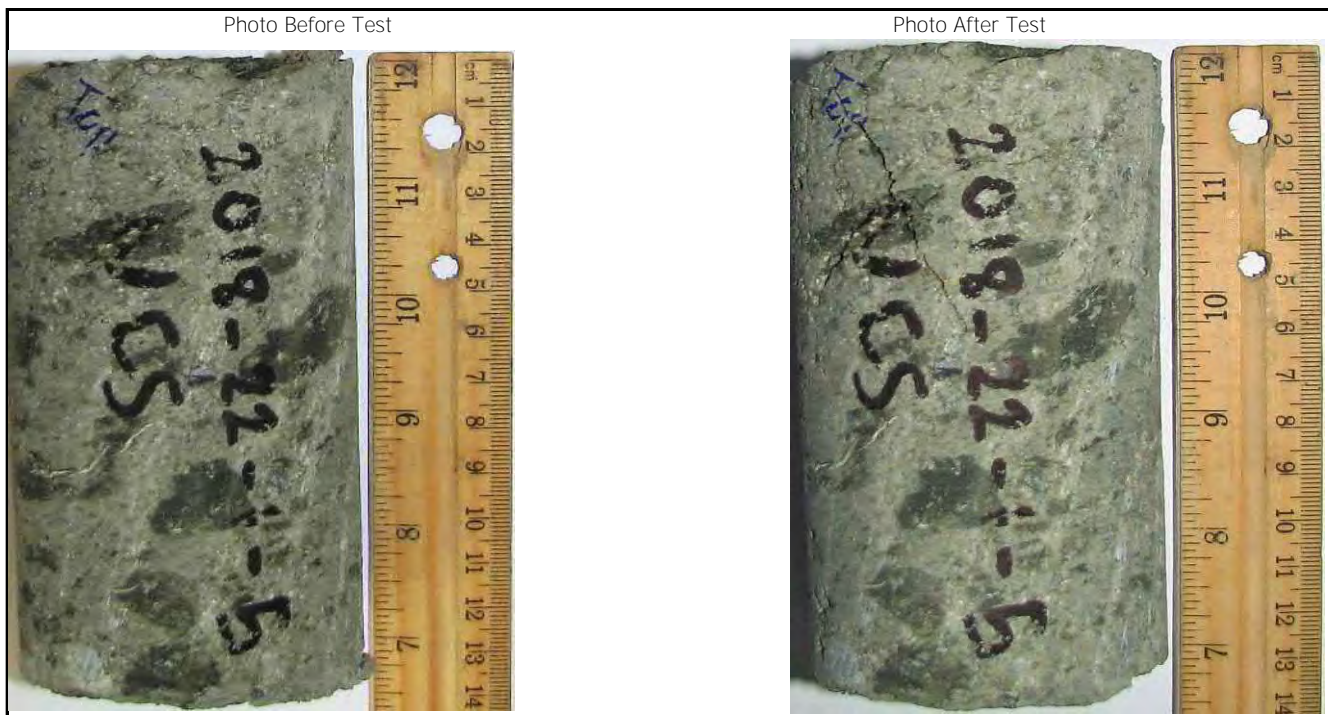
Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-1-5
Report Date	5/17/2018
Drill hole and Depth	BI-03; 21.5-22.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Stress Rate	0.5 MPa/s	
Diameter of Specimen	60.58 mm	2.39 in
Height of Specimen	125.67 mm	4.95 in
Load at Peak	6.99 kN	1,571 lbf
Unconfined Compressive Strength	2.43 MPa	352 psi
Type of Failure	Non-Structural	

Date Received : 4/24/2018

Date Opened : 4/24/2018

Date Tested: 4/30/2018



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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Austin, TX 78741

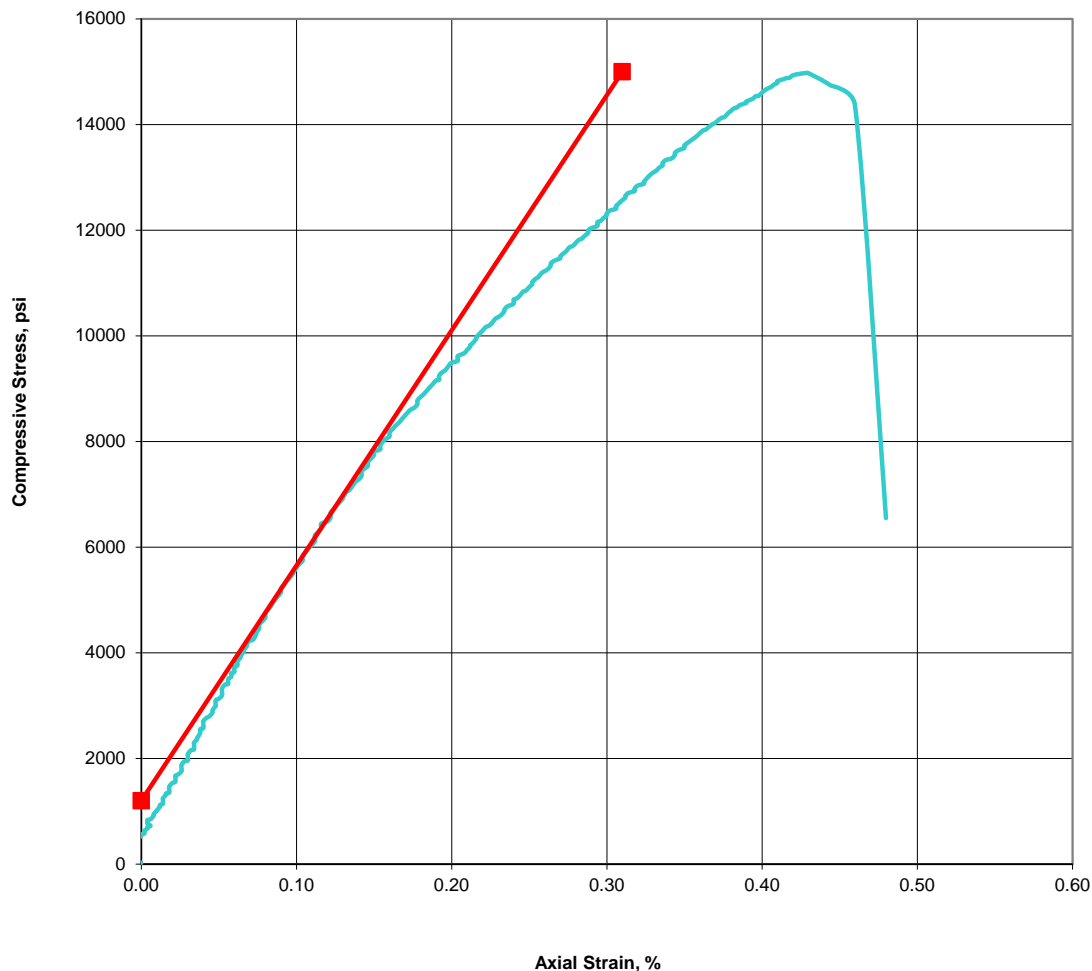
Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
Phone: +1-512-200-3051  
E-mail: fulvio@tononeng.com



# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-277B Boring: B-05 Date: 3/12/2019  
 Client: AECOM Sample: R4 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 19.6-20.2 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks:

Sample Height, in.	5.00	<b>Unconfined Compressive Strength (psi)</b>	<b>14975</b>
Sample Diameter, in.	2.39		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.50		
Wet Density, pcf	160.2	<b>Young's Modulus (E) (psi)</b>	<b>4,450,000</b>
Dry Density, pcf	159.1		
Moisture Content, %	0.7		
Strain Rate, % / min	0.25		



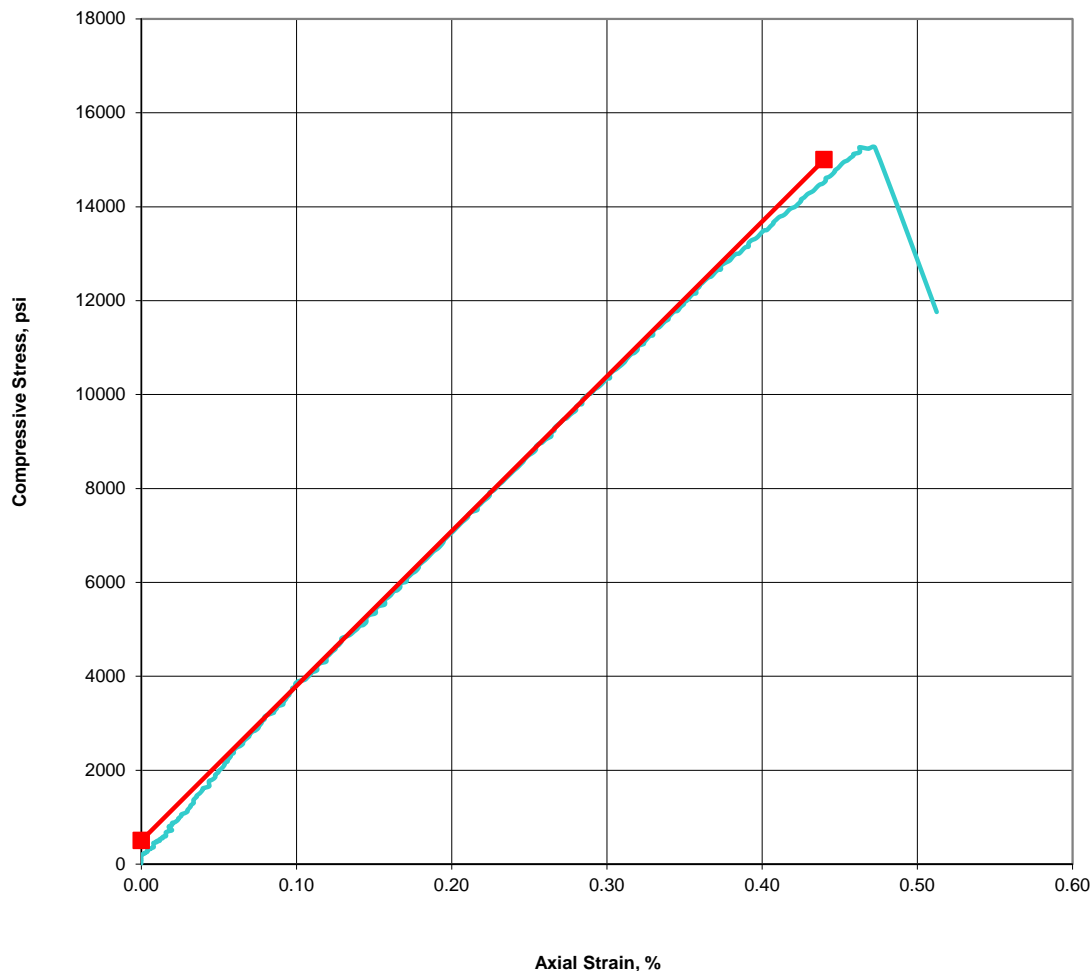




# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-277C Boring: B-08 Date: 3/12/2019  
 Client: AECOM Sample: R3 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 46.1-47 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks:

Sample Height, in.	5.03	<b>Unconfined Compressive Strength (psi)</b>	<b>15268</b>
Sample Diameter, in.	2.40		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.54		
Wet Density, pcf	162.2	<b>Young's Modulus (E) (psi)</b>	<b>3,300,000</b>
Dry Density, pcf	159.3		
Moisture Content, %	1.8		
Strain Rate, % / min	0.25		

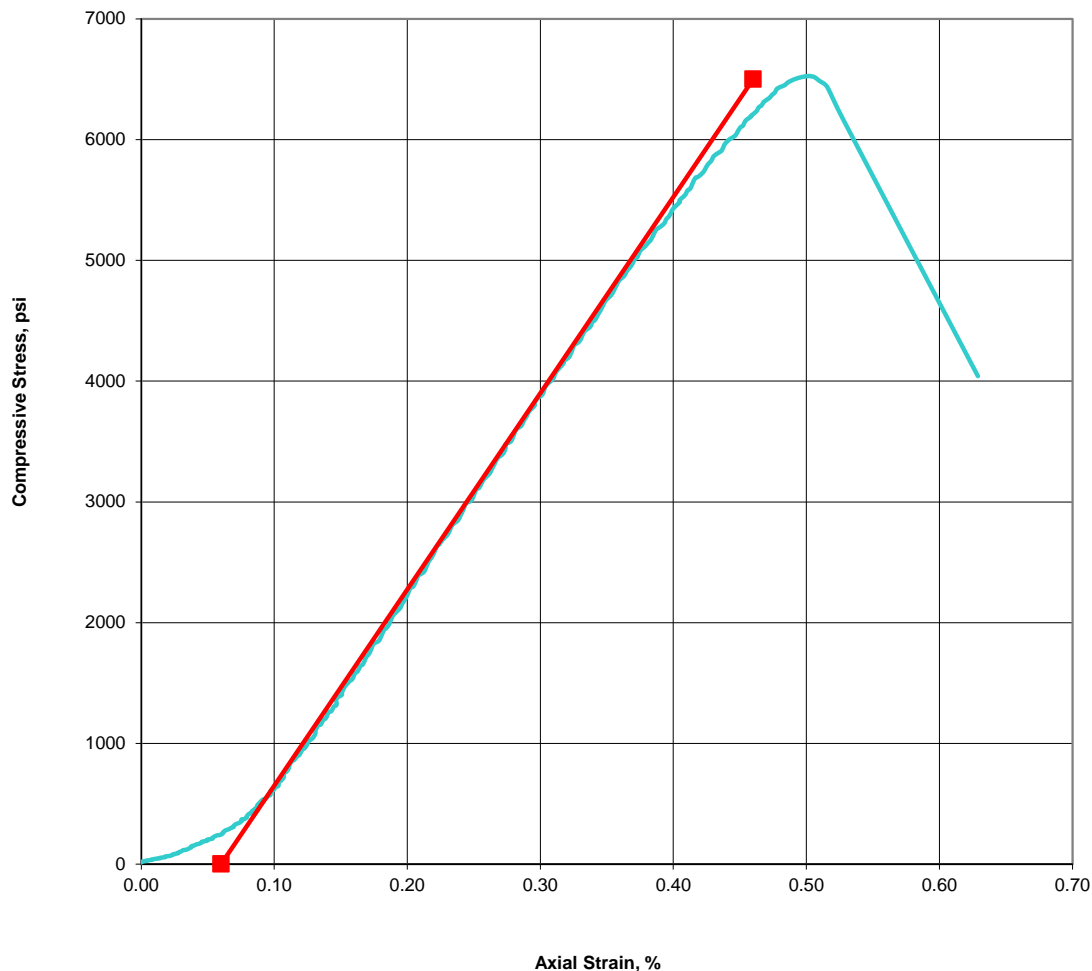




### Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.:	020-277E	Boring: B-13	Date: 3/12/2019
Client:	AECOM	Sample: R5	By: PJ
Project Name:	Klamath River Renewal Project	Depth, ft.: 17.6-18.5	Checked: DC
Project No.:	60537920		
Visual Description: Gray Rock			
Moisture Condition at Test Sample was washed and in a moist state.			
Test Temperature, (°C) Ambient			
Remarks:			

Sample Height, in.	5.04	<b>Unconfined Compressive Strength (psi)</b>	<b>6528</b>
Sample Diameter, in.	2.40		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.52		
Wet Density, pcf	141.3	<b>Young's Modulus (E) (psi)</b>	<b>1,630,000</b>
Dry Density, pcf	140.1		
Moisture Content, %	0.9		
Strain Rate, % / min	0.25		

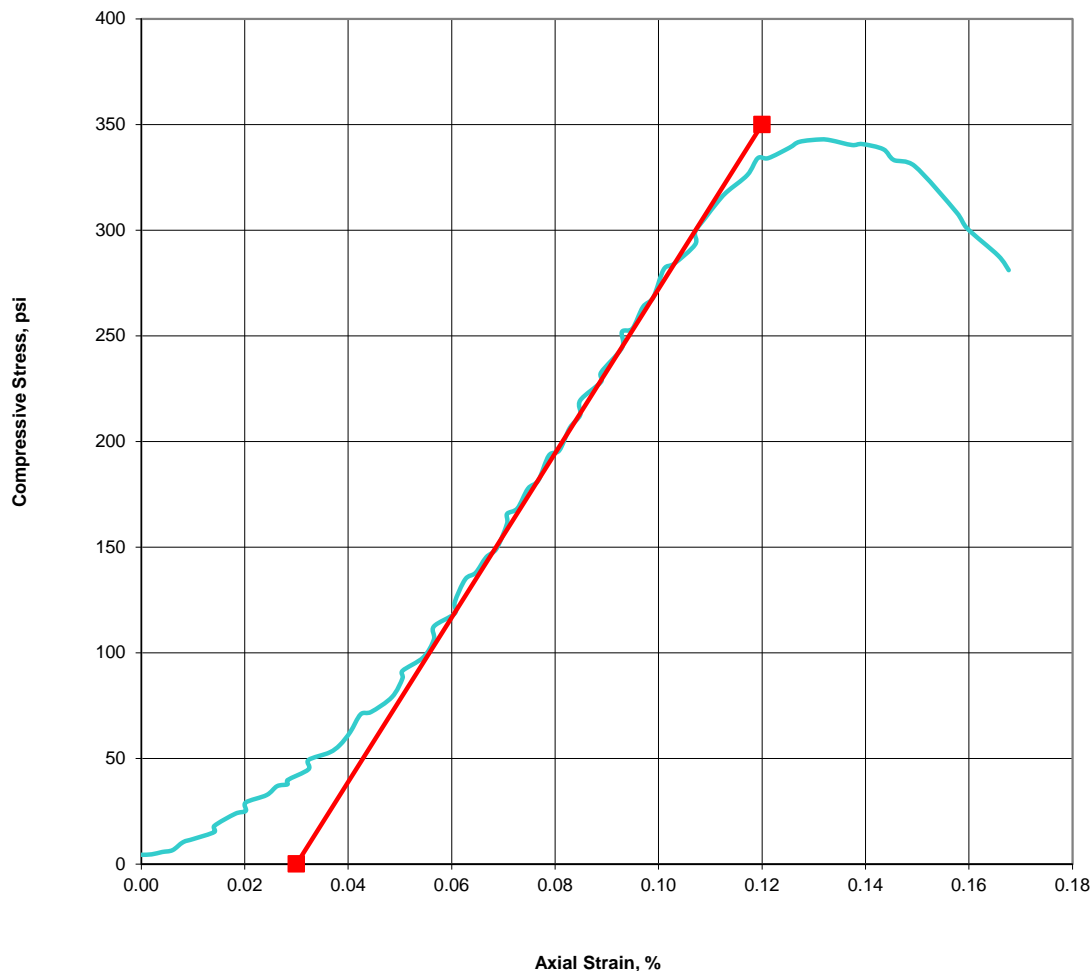




# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-277H Boring: B-20 Date: 3/12/2019  
 Client: AECOM Sample: R1 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 40.1-40.6 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks: Spalling occurred at ends of sample during trimming. Therefore, the measured density is approximate.

Sample Height, in.	4.95	<b>Unconfined Compressive Strength (psi)</b>	<b>343</b>
Sample Diameter, in.	2.40		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.53		
Wet Density, pcf	163.7	<b>Young's Modulus (E) (psi)</b>	<b>388,900</b>
Dry Density, pcf	157.9		
Moisture Content, %	3.7		
Strain Rate, % / min	0.25		



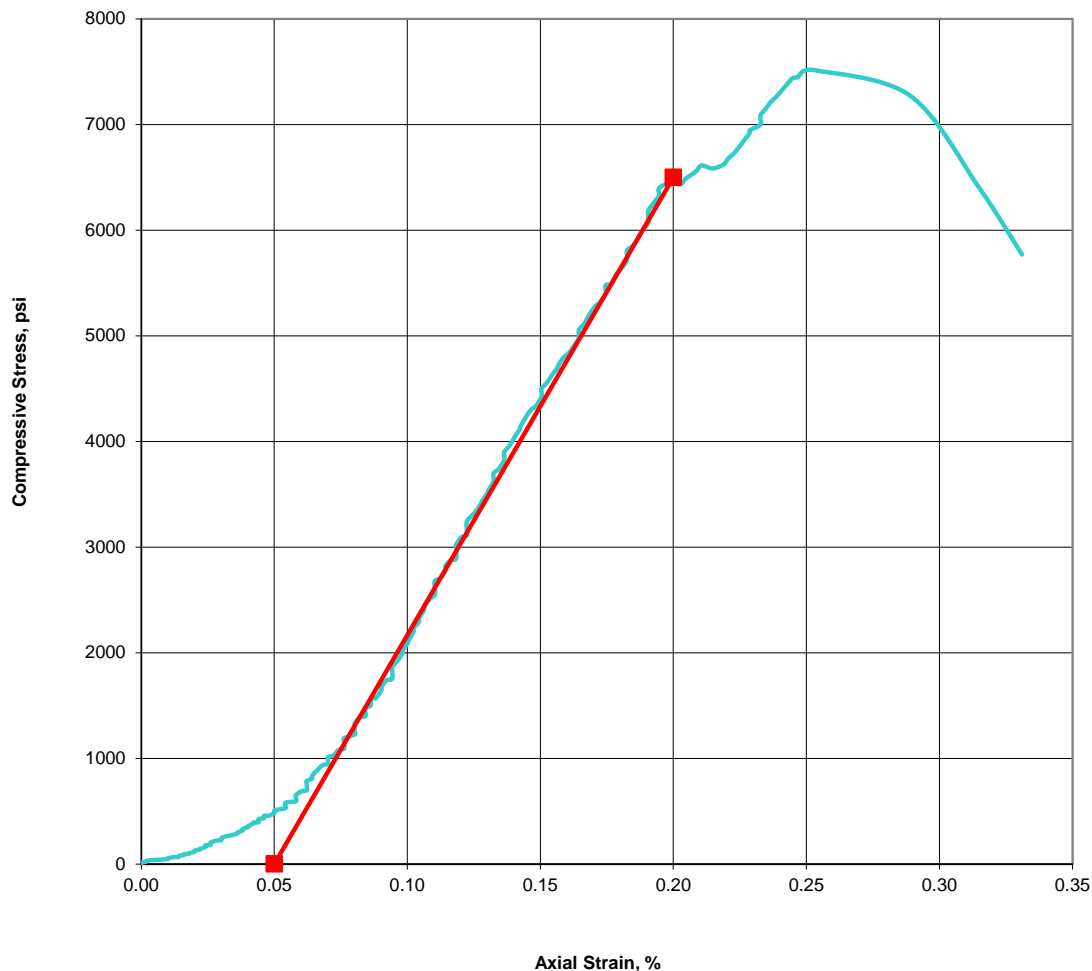




# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-2771 Boring: B-20 Date: 3/12/2019  
 Client: AECOM Sample: R2 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 45.3-46.3 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks: Spalling occurred at ends of sample during trimming. Therefore, the measured density is approximate.

Sample Height, in.	4.98	<b>Unconfined Compressive Strength (psi)</b>	<b>7517</b>
Sample Diameter, in.	2.40		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.54		
Wet Density, pcf	165.7	<b>Young's Modulus (E) (psi)</b>	<b>4,330,000</b>
Dry Density, pcf	160.3		
Moisture Content, %	3.4		
Strain Rate, % / min	0.25		

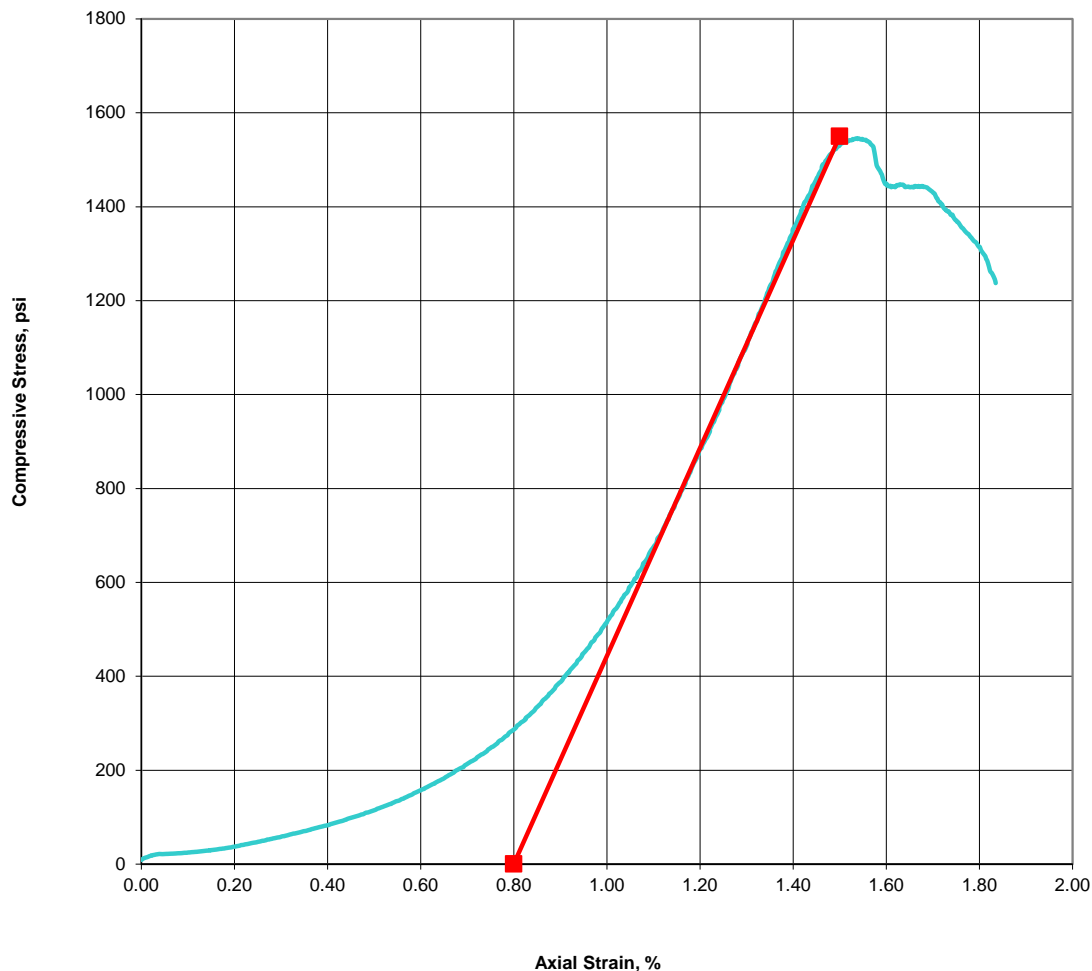




# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-277J Boring: B-15 Date: 3/12/2019  
 Client: AECOM Sample: R6/R7 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 46.5-47.1 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks: Spalling occurred at ends of sample during trimming. Therefore, the measured density is approximate.

Sample Height, in.	4.95	<b>Unconfined Compressive Strength (psi)</b>	<b>1546</b>
Sample Diameter, in.	2.34		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.30		
Wet Density, pcf	144.2	<b>Young's Modulus (E) (psi)</b>	<b>221,400</b>
Dry Density, pcf	136.3		
Moisture Content, %	5.8		
Strain Rate, % / min	0.25		

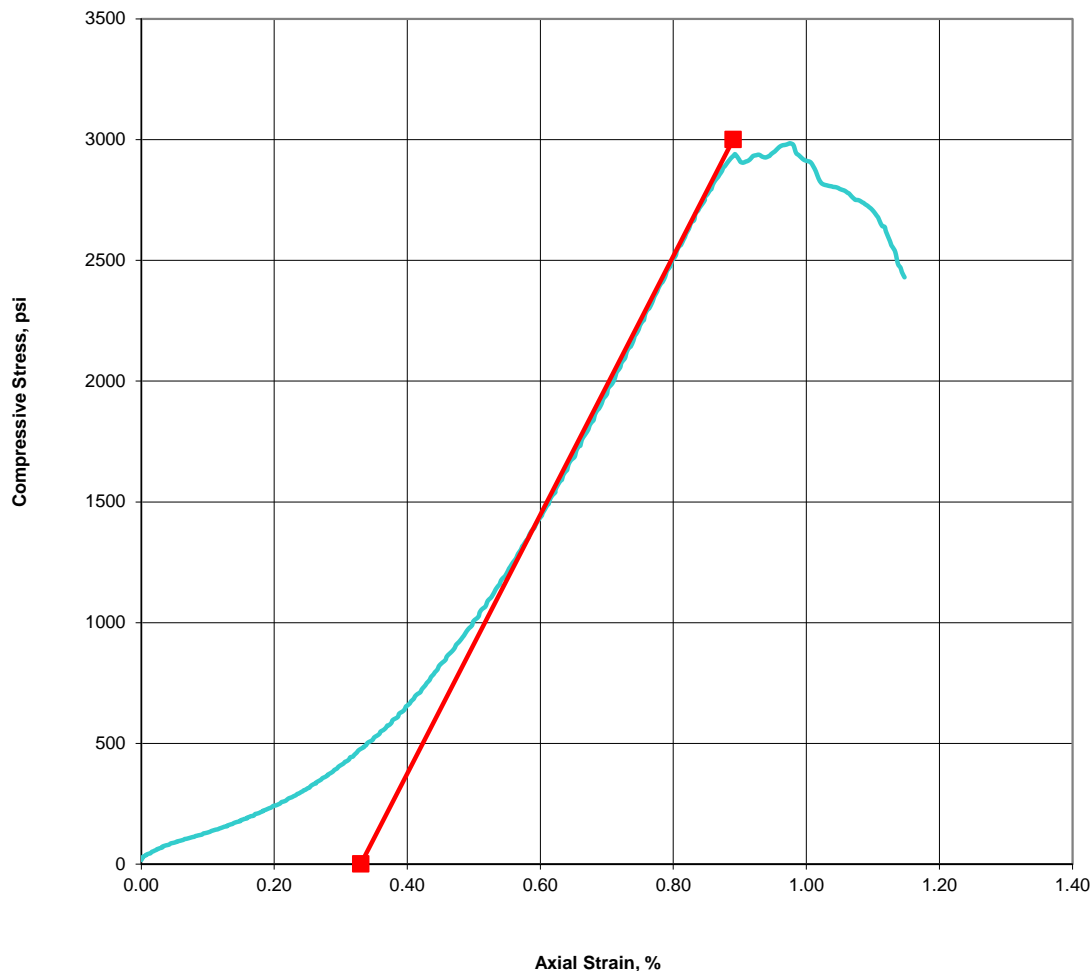




# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-277L Boring: B-17 Date: 3/12/2019  
 Client: AECOM Sample: R2 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 40-41.5 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks: Spalling occurred at ends of sample during trimming. Therefore, the measured density is approximate.

Sample Height, in.	5.03	<b>Unconfined Compressive Strength (psi)</b>	<b>2985</b>
Sample Diameter, in.	2.37		
Height / Diameter	2.1		
Sample Area, in <sup>2</sup>	4.41		
Wet Density, pcf	145.6	<b>Young's Modulus (E) (psi)</b>	<b>535,700</b>
Dry Density, pcf	140.1		
Moisture Content, %	3.9		
Strain Rate, % / min	0.25		



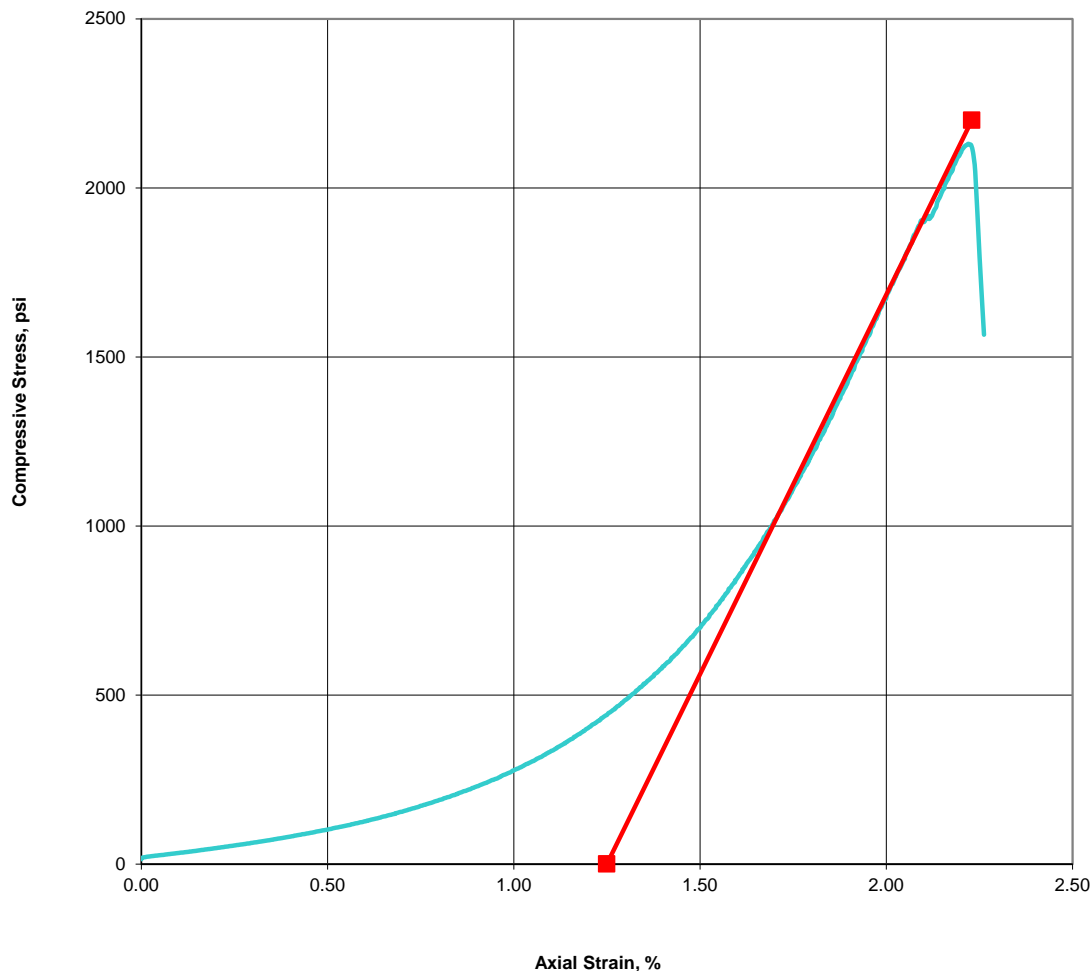




# Unconfined Compressive Strength and Young's Modulus of Rock Core (ASTM D7012D)

CTL Job No.: 020-277M Boring: B-17 Date: 3/12/2019  
 Client: AECOM Sample: R2 By: PJ  
 Project Name: Klamath River Renewal Project Depth, ft.: 17.9-18.6 Checked: DC  
 Project No.: 60537920  
 Visual Description: Gray Rock  
 Moisture Condition at Test Sample was washed and in a moist state.  
 Test Temperature, (°C) Ambient  
 Remarks: Spalling occurred at ends of sample during trimming. Therefore, the measured density is approximate.

Sample Height, in.	5.09	<b>Unconfined Compressive Strength (psi)</b>	<b>2130</b>
Sample Diameter, in.	2.35		
Height / Diameter	2.2		
Sample Area, in <sup>2</sup>	4.33		
Wet Density, pcf	142.9	<b>Young's Modulus (E) (psi)</b>	<b>224,500</b>
Dry Density, pcf	134.9		
Moisture Content, %	5.9		
Strain Rate, % / min	0.25		



**Mohs Hardness**

**Tonon USA**  
Engineering, Measurements and Testing, LLC

Web: [tononeng.com](http://tononeng.com)

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-8-1
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 27-27.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/24/2018
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<b>Mohs Hardness</b>
<b>3</b>

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Mohs Hardness**

**Tonon USA**  
Engineering, Measurements and Testing, LLC

Web: [tononeng.com](http://tononeng.com)

Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-8-2
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 48.9-50.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/24/2018
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<b>Mohs Hardness</b>
<b>3</b>

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

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**Mohs Hardness**

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Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-8-3
Report Date	5/17/2018
Drill Hole and Depth	BI-02; 55.4-56.3 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/24/2018
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<b>Mohs Hardness</b>
<b>3</b>

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**Mohs Hardness**

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Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-8-4
Report Date	5/17/2018
Drill Hole and Depth	BI-03; 17.4-18.4 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/24/2018
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<b>Mohs Hardness</b>
<b>3</b>

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**Mohs Hardness**

**Tonon USA**  
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Project Name	Klamath River Dam Removal
Location	Klamath River
Client	Klamath River Renewal Corporation
Client Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-8-5
Report Date	5/17/2018
Drill Hole and Depth	BI-03; 21.5-22.9 ft
Rock Type	Volcanic Breccia
Geologic Unit	N/A
Moisture Condition	As-received

Date received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/24/2018
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<b>Mohs Hardness</b>
<b>3</b>

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**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/20/2018****Colorado School of Mines****Mining Engineering Department**

Sample ID	Surface	Mohs Hardness
B-206 @ 47.4-48.7	Saw Cut	3-4
B-206 @ 65.2-66.5	Saw Cut	3-4

**Punch Penetration Index Test**

Colorado School of Mines - 13

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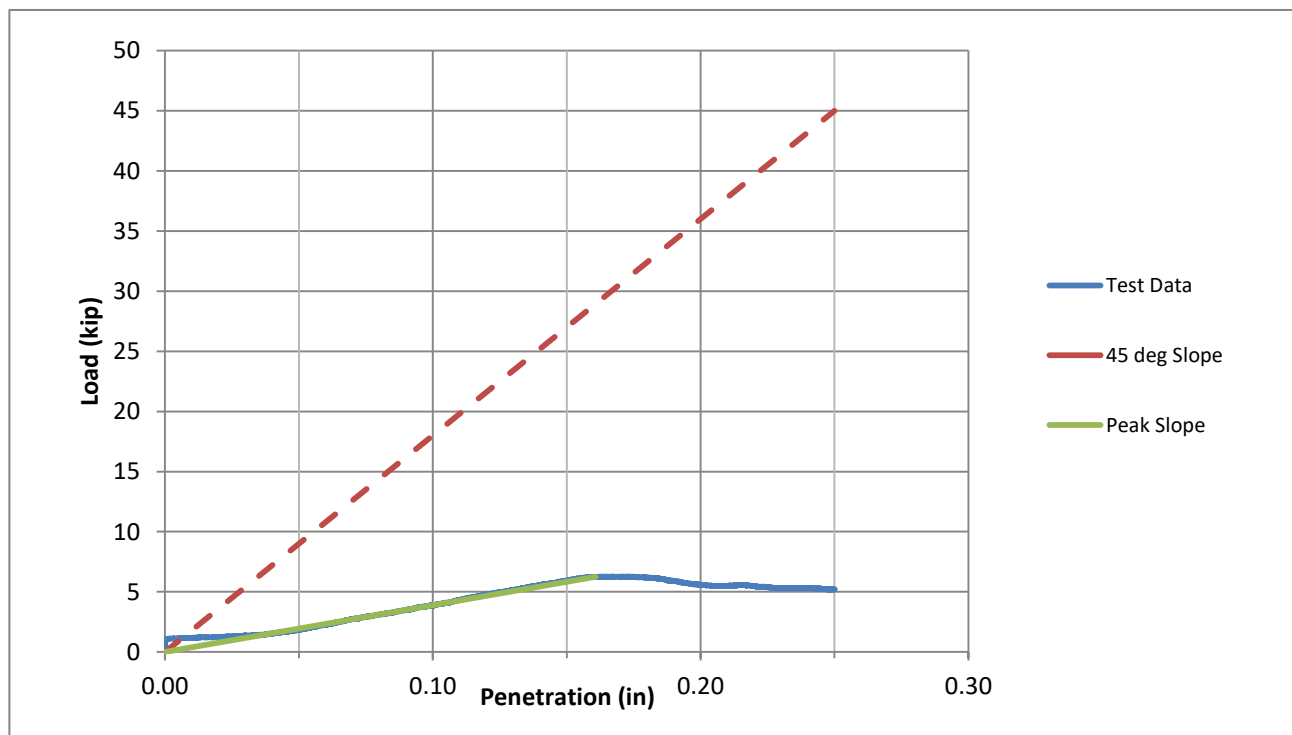
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Project Name	Klamath River Dam Removal	Penetration rate	0.001 in/sec			
Location	Klamath River	Diameter of specimen	60.65	mm	2.39	in
Client	Klamath River Renewal Corporation	Height of specimen	64.62	mm	2.54	in
Client Project No.	60537920	Load at peak	27.81	kN	6,251	lbf
Registry No.	2018-22	45 Degree (Standard) Index	175			
Report No.	2018-22-8-1	Peak Slope Index	39			
Report Date	5/17/2018					
Drill Hole and Depth	BI-02; 50.3-51.3 ft					
Rock Type	Volcanic Breccia					
Geologic Unit	N/A					
Moisture Condition	As-received					

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 5/4/2018
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2028 E Ben White BLVD #240-2660  
Austin, TX 78741

Laboratory Director: Dr. Fulvio Tonon, P.E., Ph.D.  
Phone: +1-512-200-3051  
E-mail: fulvio@tononeng.com





Photo After Test

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

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**Punch Penetration Index Test**

Colorado School of Mines - 13

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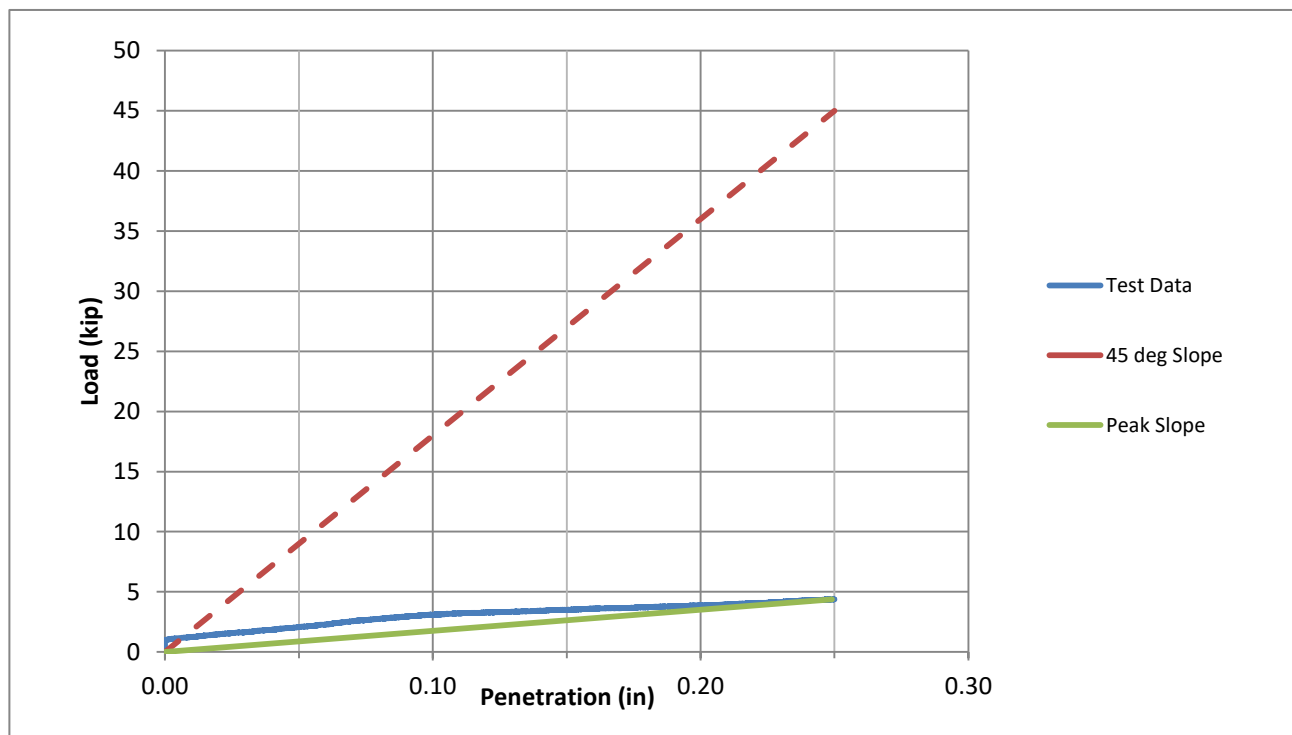
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Project Name	Klamath River Dam Removal	Penetration rate	0.001 in/sec			
Location	Klamath River	Diameter of specimen	60.4	mm	2.38	in
Client	Klamath River Renewal Corporation	Height of specimen	67.53	mm	2.66	in
Client Project No.	60537920	Load at peak	19.46	kN	4,373	lbf
Registry No.	2018-22	45 Degree (Standard) Index	175			
Report No.	2018-22-8-2	Peak Slope Index	18			
Report Date	5/17/2018					
Drill Hole and Depth	BI-03; 24.2-25.1 ft					
Rock Type	Volcanic Breccia					
Geologic Unit	N/A					
Moisture Condition	As-received					

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 5/4/2018
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Austin, TX 78741

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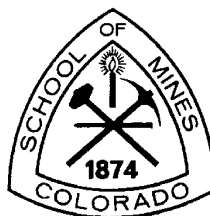


Photo After Test

Performed by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/24/2018****Colorado School of Mines****Mining Engineering Department****ASTM D7625**

Sample ID	Punch Penetration Test Peak Slope (kips/in)
B-202 @ 70.5-71.7	9
B-206 @ 65.2-66.5	195





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

## Punch Penetration Test



**Client:** CDM Smith

**Project:** Klamath River

**Location:** N/A

**EMI Project No.:** 378

**Core ID:** B-202 @ 70.5-71.7

**File Name:** B-202 @ 70.5-71.7\_PP

**Rock Type:** N/A

**Rock Name:** N/A

**Characteristics:** N/A

**Test Performed By:** AK-OF

**Date Tested:** 9/24/2018

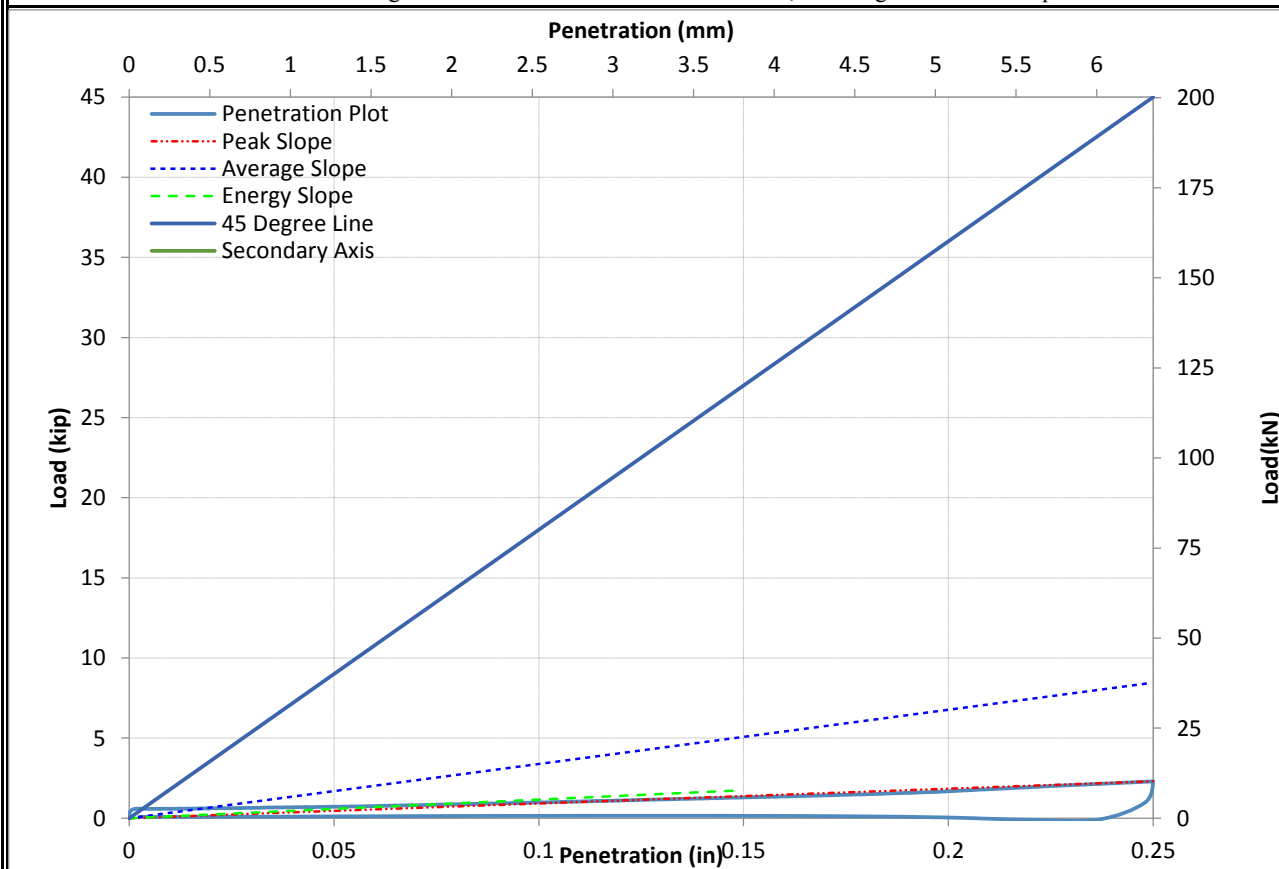
**Data Reduced By:** OF

**Date Reduced:** 9/24/2018



Penetration Rate		Maximum Load		45° (Standard) Index:	
in/s	mm/s	kip	kN	kip/in	kN/mm
0.001	0.025	2.306	10.256	180	31.5
Peak Slope Index		Average Slope Index		Energy Slope Index	
kip/in	kN/mm	kip/in	kN/mm	kip/in	kN/mm
9	1.6	34	5.9	12	2.0

**Note:** Indentor is made of Tungsten Carbide with base diameter of 7.5in, cone angle of 120° and tip radius of 2mm





# EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

## Punch Penetration Test



**Client:** CDM Smith

**Project:** Klamath River

**Location:** N/A

**EMI Project No.:** 378

**Core ID:** B-206 @ 65.2-66.5

**File Name:** B-206 @ 65.2-66.5\_PP

**Rock Type:** N/A

**Rock Name:** N/A

**Characteristics:** N/A

**Test Performed By:** AK-OF

**Date Tested:** 9/24/2018

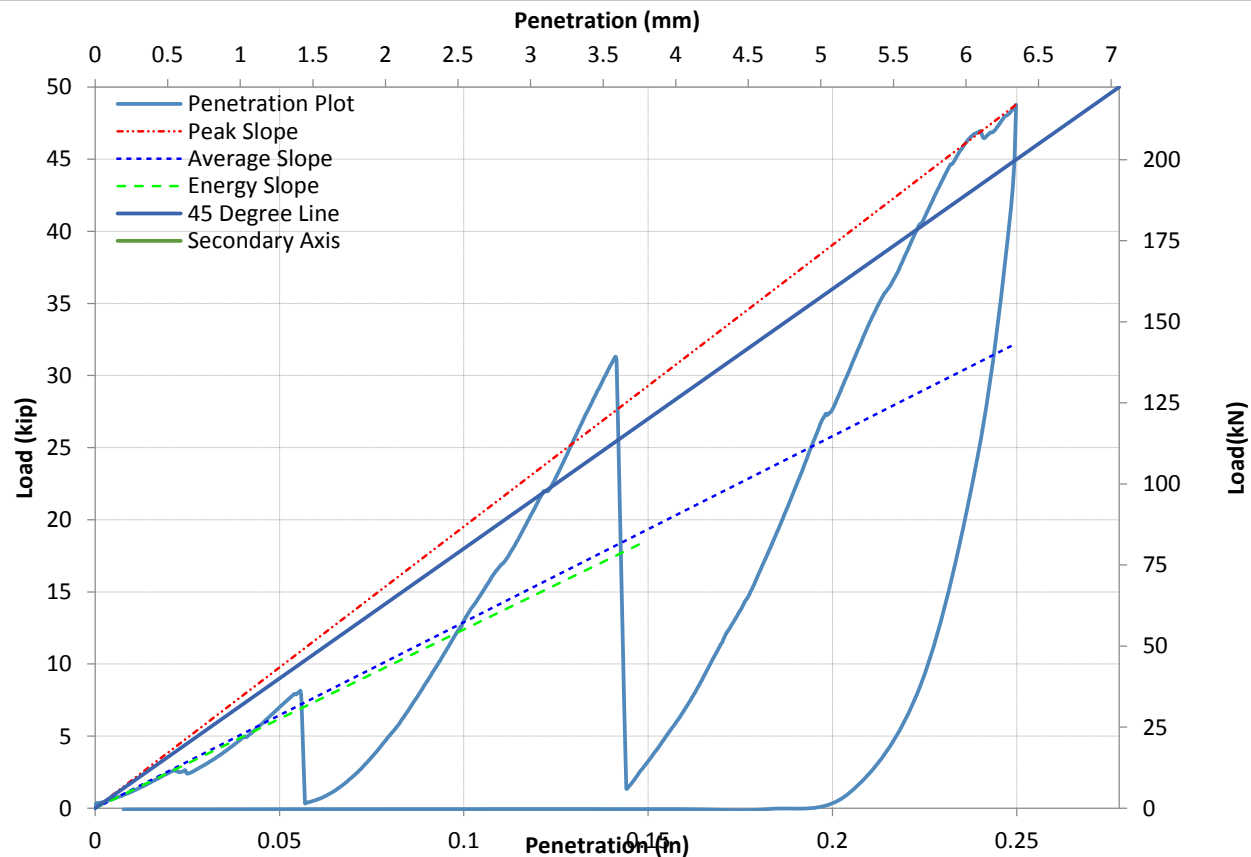
**Data Reduced By:** OF

**Date Reduced:** 9/24/2018



Penetration Rate		Maximum Load		45° (Standard) Index:	
in/s	mm/s	kip	kN	kip/in	kN/mm
0.001	0.025	48.777	216.972	180	31.5
Peak Slope Index		Average Slope Index		Energy Slope Index	
kip/in	kN/mm	kip/in	kN/mm	kip/in	kN/mm
195	34.2	129	22.6	124	21.7

**Note:** Indentor is made of Tungsten Carbide with base diameter of 7.5in, cone angle of 120° and tip radius of 2mm



**Cerchar Abrasiveness Test**  
 ASTM D7625 - 10

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 Tonon USA:  
 Engineering, Measurements and Testing, LLC

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Project Name	Klamath River Dam Removal	Apparatus, Pin R.-H.	West Cerchar, 55/56	
Location	Klamath River	Direction of Scratch	Perpendicular to Core Axis	
Client	Klamath River Renewal Corporation	Pin Wear (mm)	0.156	0.145
Client Project No.	60537920		0.142	0.124
Registry No.	2018-22		0.144	0.133
Report No.	2018-22-5-1		0.162	0.129
Report Date	5/17/2018		0.150	0.140
Drill Hole and Depth	BI-02; 51.3-51.7 ft	Average (mm)	0.143	
Rock Type	Volcanic Breccia	CAIs	1.43	
Formation	N/A	CAI	1.89	
Surface Condition	Cut by Slab Saw	Classification	Medium Abrasiveness	

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/30/2018
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Photo After Test



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

Checked by: Gloria Tonon-Kozma, P.E.

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 2028 E Ben White BLVD #240-2660  
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 E-mail: fulvio@tononeng.com

**Cerchar Abrasiveness Test**  
 ASTM D7625 - 10

 COMPANY WITH  
 QUALITY SYSTEM  
 CERTIFIED BY DNV GL  
 = ISO 9001 =

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Project Name	Klamath River Dam Removal	Apparatus, Pin R.-H.	West Cerchar, 55/56	
Location	Klamath River	Direction of Scratch	Perpendicular to Core Axis	
Client	Klamath River Renewal Corporation	Pin Wear (mm)	0.046	0.037
Client Project No.	60537920		0.083	0.069
Registry No.	2018-22		0.104	0.090
Report No.	2018-22-5-2		0.087	0.098
Report Date	5/17/2018		0.100	0.093
Drill Hole and Depth	BI-03; 25.1-26.1 ft	Average (mm)	0.081	
Rock Type	Volcanic Breccia	CAIs	0.81	
Formation	N/A	CAI	1.28	
Surface Condition	Cut by Slab Saw	Classification	Medium Abrasiveness	

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 4/30/2018
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Photo After Test



Tested by: Dr. Fulvio Tonon, P.E., Ph.D.

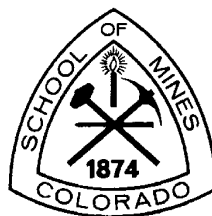
Checked by: Gloria Tonon-Kozma, P.E.

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**Earth Mechanics Institute****Client: CDM Smith****Project: Klamath River****Date: 9/20/2018****Colorado School of Mines****Mining Engineering Department****ASTM D7625**

Sample ID	Cerchar Abrasivity Index (CAIs)*
B-202 @ 69.8-70.5	0.6
B-206 @ 60.0-61.7	3.0

\* CERCHAR tests have been run on saw cut surface. No correction factor has been added to the results.

**Pictures of Sample Before and After**  
**Cerchar Abrasivity Index**

**Client Name:** CDM Smith  
**Project Name:** Klamath River  
**Date:** 9/20/2018  
**Sample ID:** B-206 @ 60.0-61.7



**Before**



**After**

Pictures of Sample Before and After  
Cerchar Abrasivity Index

*Client Name:* CDM Smith  
*Project Name:* Klamath River  
*Date:* 9/20/2018  
*Sample ID:* B-202 @ 69.8-70.5



Before



After

**Thin Section Petrographic Analysis****Tonon USA**  
**Engineering, Measurements, and Testing, LLC**

Web: tononeng.com

Project Name	Klamath River Dam Removal
Project location	Klamath River
Client	Klamath River Renewal Corporation
Client's Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-7-1
Report Date	5/17/2018
Borehole and Depth	BI-02; 51.7-52 ft
Studied by	Lidia Scavo and Fulvio Tonon
Reviewed by	Gloria Tonon-Kozma

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 5/17/2018
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A sample from borehole BI-02; 51.7-52 ft was analyzed under the polarized microscope to determine its mineralogical composition from a 25 X 40 mm (0.9 X 1.58 in) thin section.

Visual inspection of the sample suggests an igneous origin.

**ROCK NAME: BRECCIATED-ALTERED BASALT** (according to EN 12670).



**Fig. 1** - Aspect of the studied sample (hand specimen).

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**Thin Section Petrographic Analysis****Tonon USA**  
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**Hand specimen – Visual inspection:** It is a mafic, greenish and dusty material with a very weak behavior. It is composed of a dark and very fine groundmass with phenocrysts that are millimetric in size, and light to dark colored.

According to the Rock-Color Chart of the Geological Society of America, the groundmass color is Grayish Green (5G 5/2), and the phenocrysts are Grayish Green (10G 4/2) to Light Bluish Gray (5B 7/1).

The rock fizzes under hydrochloric acid, and it can be scratched by a metal tip.

**Probable Origin:** It is an altered Plagioclase-rich basaltic rock.

**Mineralogy:** Plagioclase, Clay Minerals, Olivine, Opaque Minerals, Volcanic Glass, Carbonates

**Textures:** The rock has a porphyric texture with a very fine and dark groundmass, in which there are Plagioclase crystals, rare Olivine crystals, Opaque Minerals, and many alteration Clay Minerals (predominantly Phyllosilicates such as Chlorite).

Plagioclase is the most common mineral phase: crystals are quite large and well zoned. Because of their golden color, clay minerals can be hardly distinguished from the groundmass, except for Chlorite that can be locally seen in amorphous greenish individuals.

Opaque Minerals are mainly made up of Oxides of the Hematite group.

Spotted Carbonates may be also identified.

**Alteration and Mineral Suture Condition:** The rock is highly altered: even the largest phenocrysts show traces of intense alteration acted upon by clayey minerals; Plagioclase crystals are intensively fractured. These fractures are commonly filled with secondary clayey material in a “quasi-stylolitic” pattern.

**Discontinuities:** The rock shows a very pervasive fracture system: many of these fractures have not been filled with secondary mineralization, and they predominantly cross the groundmass. Fractures crossing phenocrysts are instead filled with clay minerals.

**Thin Section Petrographic Analysis**

**Tonon USA**  
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**Description of Individual Minerals:**

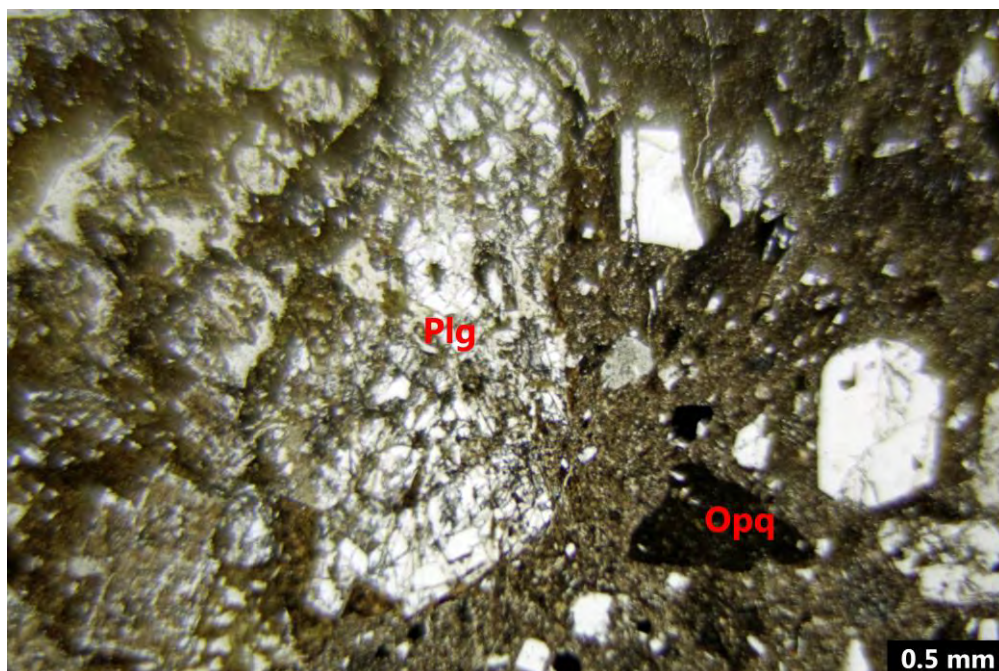
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Plagioclase	33.3	6	1.10	As individual crystals
Chlorite	1.67	2.5	0.05	Very variable in size, alteration single crystals
Oxides	6.67	5.5	0.02-0.8	Spotted Hematite individuals
Glass	50	5	Sub-micrometric	Makes up the groundmass
Clay	8.33	4	Sub-micrometric	Phyllosilicates, unresolvable at a microscopic scale
Weighted Average:		4.2	-	

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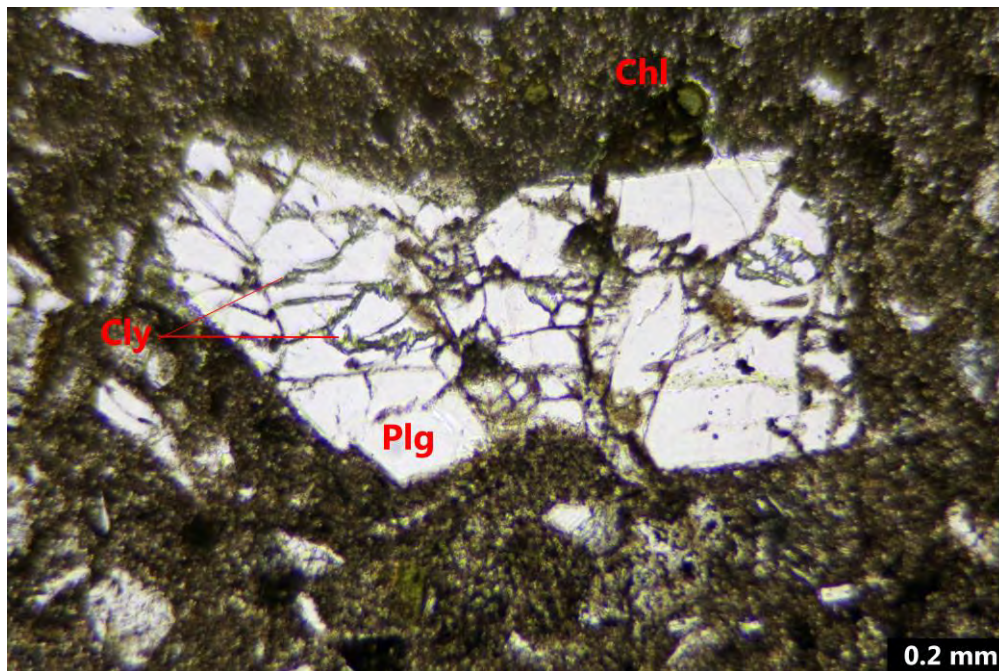


**Fig. 2** - Plane polarized light. Field of view = 4 mm wide (magnification 4X). A view of the studied sample, showing an altered Plagioclase (Plg) crystal near to a big Hematite crystal (Opq).

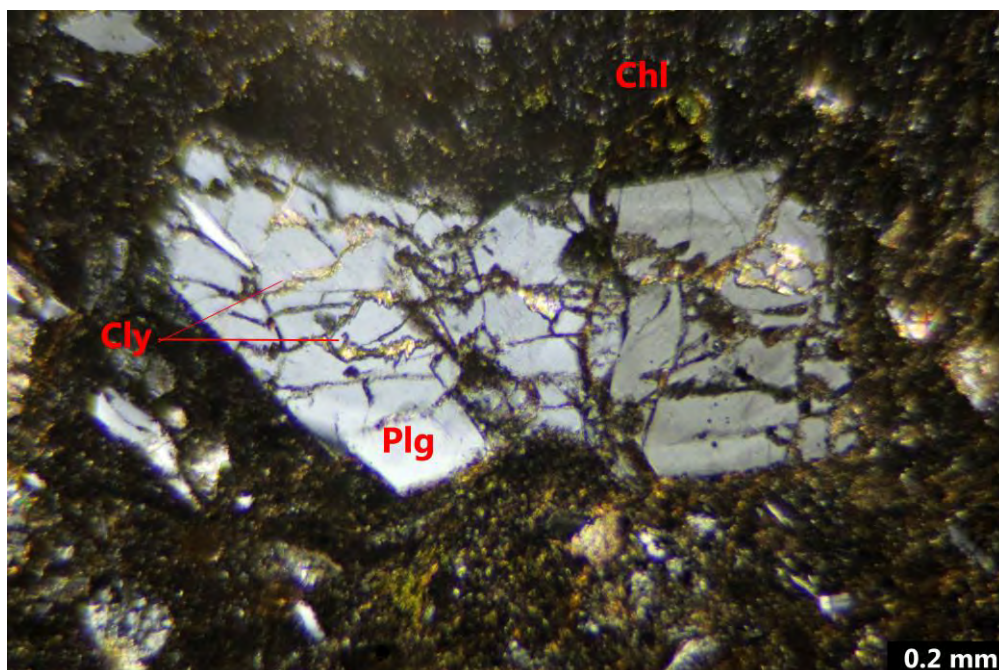


**Fig. 3** - Cross polarized light. Field of view = 4 mm wide (magnification 4X). Same as Figure 2, but under crossed polars.



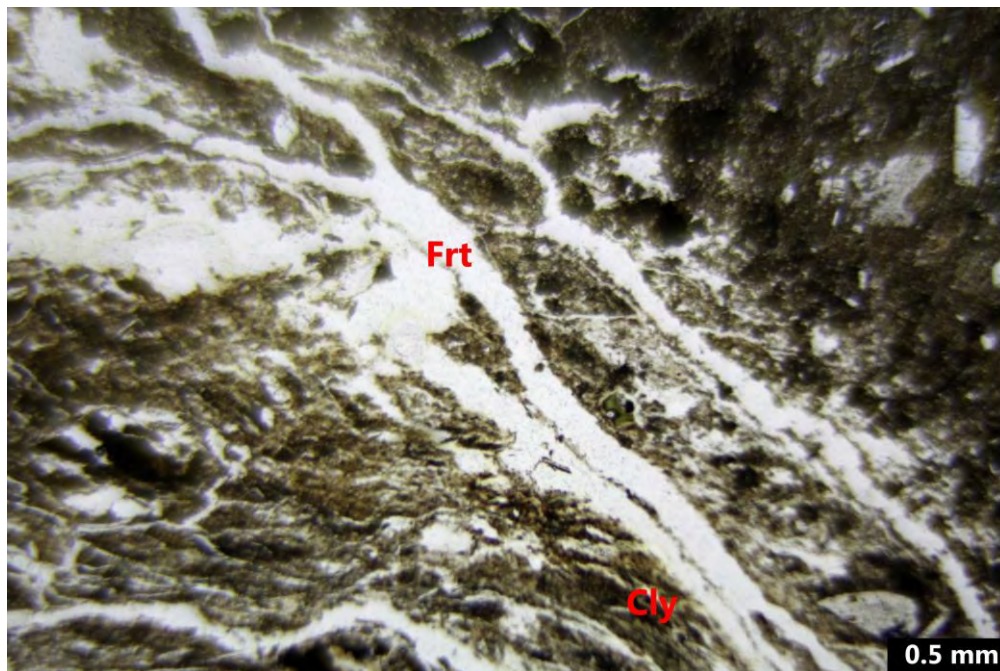


**Fig. 4** - Plane polarized light. Field of view = 1.7 mm wide (magnification 10X). A detail of a Plagioclase grain, crossed by many fractures, all filled with Clay Minerals (Cly). Some Chlorite individuals (Chl) may be identified in the upper part of the picture.

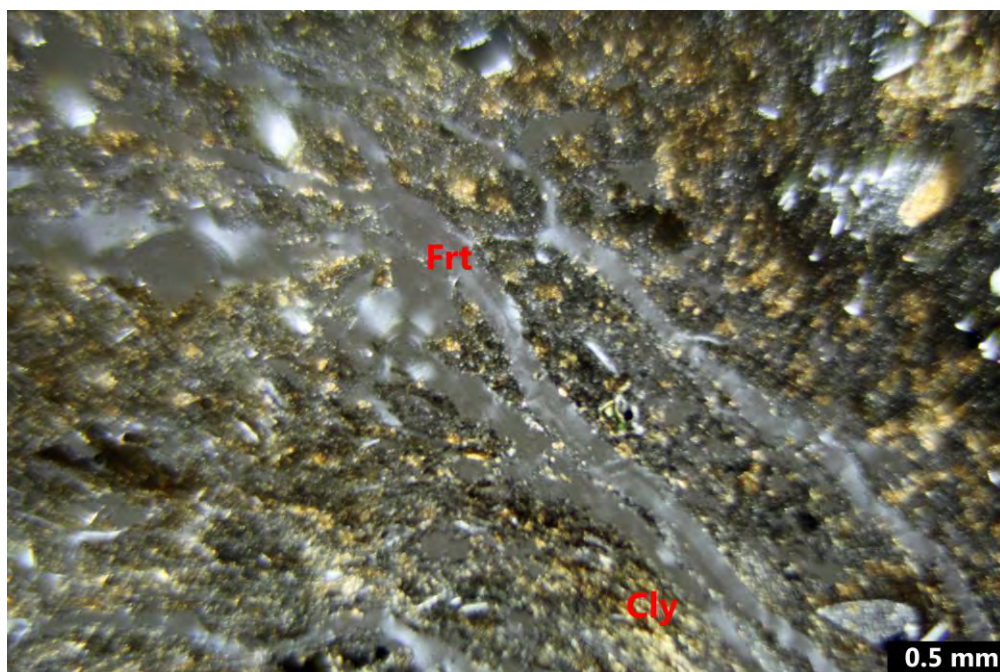


**Fig. 5** - Cross polarized light. Field of view = 1.7 mm wide (magnification 10X). Same as Figure 4, but under crossed polars.





**Fig. 6** - Plane polarized light. Field of view = 4 mm wide (magnification 4X). A selected area of the section with a well-developed fracture system (Frt).



**Fig. 7** - Cross polarized light. Field of view = 4 mm wide (magnification 4X). Same as Figure 6, but under crossed polars.

**Thin Section Petrographic Analysis****Tonon USA**  
**Engineering, Measurements, and Testing, LLC**

Web: tononeng.com

Project Name	Klamath River Dam Removal
Project location	Klamath River
Client	Klamath River Renewal Corporation
Client's Project No.	60537920
Registry No.	2018-22
Report No.	2018-22-7-2
Report Date	5/17/2018
Borehole and Depth	BI-03; 20.8-21 ft
Studied by	Lidia Scavo and Fulvio Tonon
Reviewed by	Gloria Tonon-Kozma

Date Received : 4/24/2018	Date Opened : 4/24/2018	Date Tested: 5/17/2018
---------------------------	-------------------------	------------------------

A sample from borehole BI-03; 20.8-21 ft was analyzed under the polarized microscope to determine its mineralogical composition from a 25 X 40 mm (0.9 X 1.58 in) thin section.

Visual inspection of the sample suggests an igneous origin.

**ROCK NAME: ALTERED VOLCANIC BRECCIA** (according to EN 12670).



**Fig. 1** - Aspect of the studied sample (hand specimen).

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**Thin Section Petrographic Analysis****Tonon USA**  
**Engineering, Measurements, and Testing, LLC**Web: [tononeng.com](http://tononeng.com)

**Hand specimen – Visual inspection:** It is a greenish mafic rock. It appears to be very weak, and it shows a dusty appearance. It is composed of a dark green groundmass with spotted whitish to bluish phenocrysts.

According to the Rock-Color Chart of the Geological Society of America, the groundmass color is Grayish Green (5G 5/2); clasts have colors ranging from Dark Greenish Gray (4G 4/1) to Light Bluish Gray (5B 7/1). The matter also shows alterations that are Dark Greenish Yellow (10Y 6/6).

The rock fizzes under hydrochloric acid, and it can be scratched by a metal tip.

**Probable Origin:** It is an altered volcanic breccia.

**Mineralogy:** Plagioclase, Volcanic Glass, Pyroxene, Chlorite, Clay Minerals, Opaque Minerals, Carbonates.

**Textures:** It is a mafic porphyritic rock with a chaotic structure: no preferred orientation may be identified.

Plagioclase is the most common constituent mineral: its crystals range from sub-millimetric in size to glassy and are usually well shaped. Zonation is irregular.

Some of the clasts are made up of extraneous volcanic clasts; they can be easily identified because of their color variation when compared to the rest of the thin section: these clasts display a different mafic content.

Secondary mineral phases are made up of rare Augite-Pyroxene, Chlorite, Carbonates and Opaque Minerals.

Very common, but not resolvable at a microscopic observation scale, are Volcanic Glass and Clay Minerals. Clay Minerals also represent the main alteration substance of the rock, which affects both the groundmass and the clasts.

**Alteration and Mineral Suture Condition:** The sample shows a substantial clayey alteration, with clear Chlorite individuals associated with very fine-grained Clay Minerals. Spotted secondary Carbonates can be found as fracture filling material.

Crystals in this thin section have well defined rims, but they are also affected by pervasive fractures both within the crystals and all around their boundaries.

**Discontinuities:** The rock is heavily fractured, with two classes of discontinuities: a first one made up of empty cracks crossing the groundmass and the crystals, and a second one made up of Carbonate-filled fractures, sometimes surrounding single crystals or clasts.

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**Description of Individual Minerals:**

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Plagioclase	28.33	6	0.6	As single individuals or as the main part of many external clast groundmass
Chlorite	1.67	2	0.3	As individuals of secondary crystallization
Opaque Minerals	5	5.5	0.1	Spotted individuals of Hematite
Glass	41.67	5	Sub-micrometric	Makes up the groundmass
Pyroxene	1.67	5.5	0.2	Rare sub-euhedral crystals
Carbonates	5	4	0.06	As fracture filling material
Clay Minerals	16.67	2	Sub-micrometric	Phyllosilicates of secondary alteration
Weighted Average:		4.3	-	

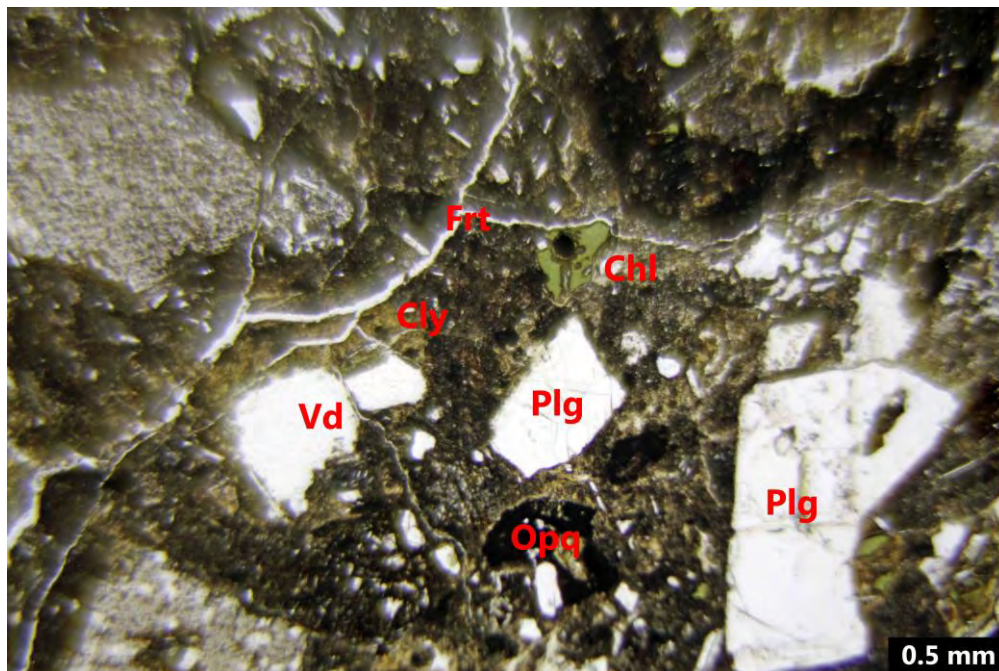
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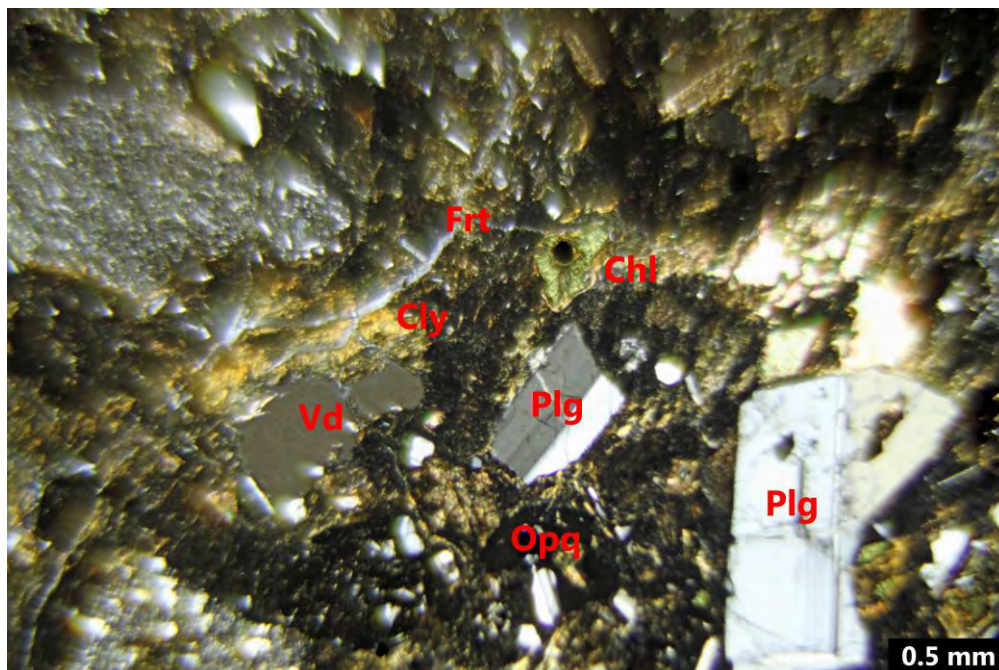
Phone: +1-512-200-3051

E-mail: fulvio@tononeng.com



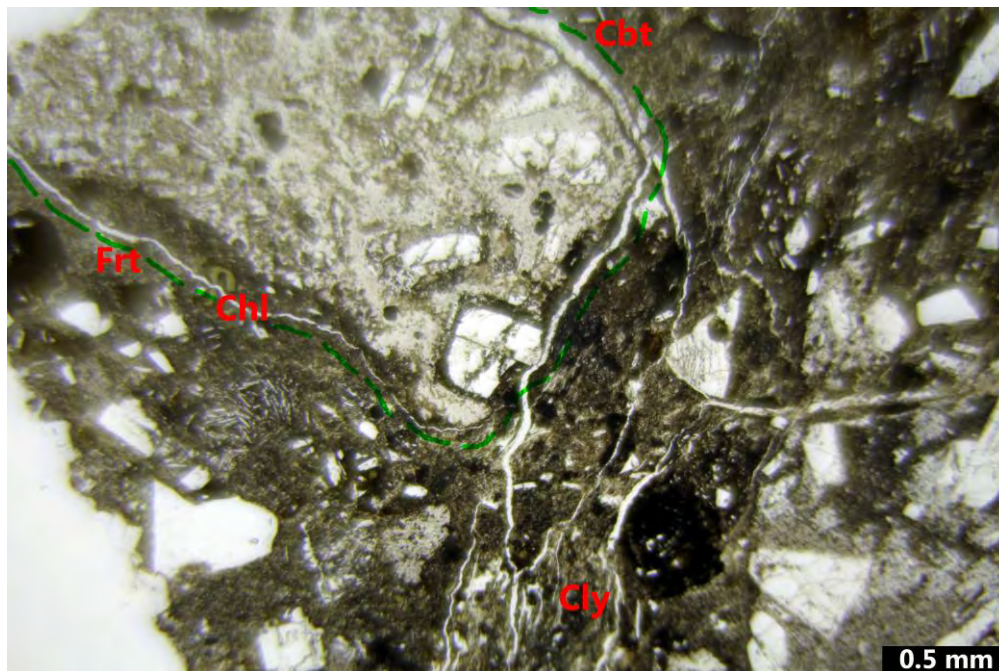


**Fig. 2** - Plane polarized light. Field of view = 4 mm wide (magnification 4X). A view of the studied sample. The most common minerals are: Plagioclase (Plg), Clay Minerals (Cly), Opaque Minerals (Opq), and Chlorite (Chl). Also highlighted here are some structural features, such as fractures (Frt) and voids (Vd).

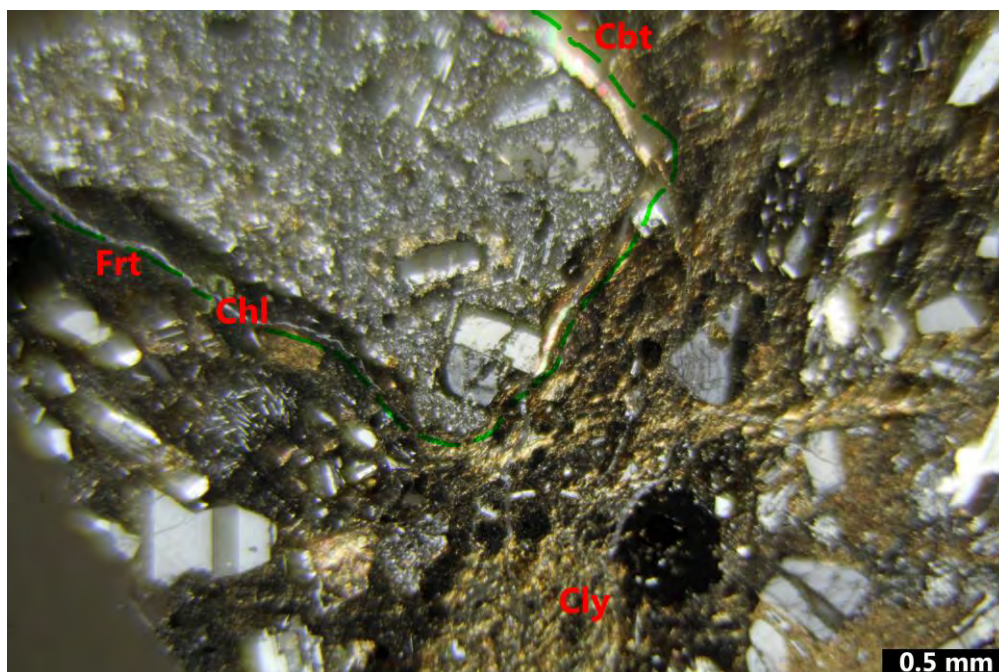


**Fig. 3** - Cross polarized light. Field of view = 4 mm wide (magnification 4X). Same as Figure 2, but under crossed polars.



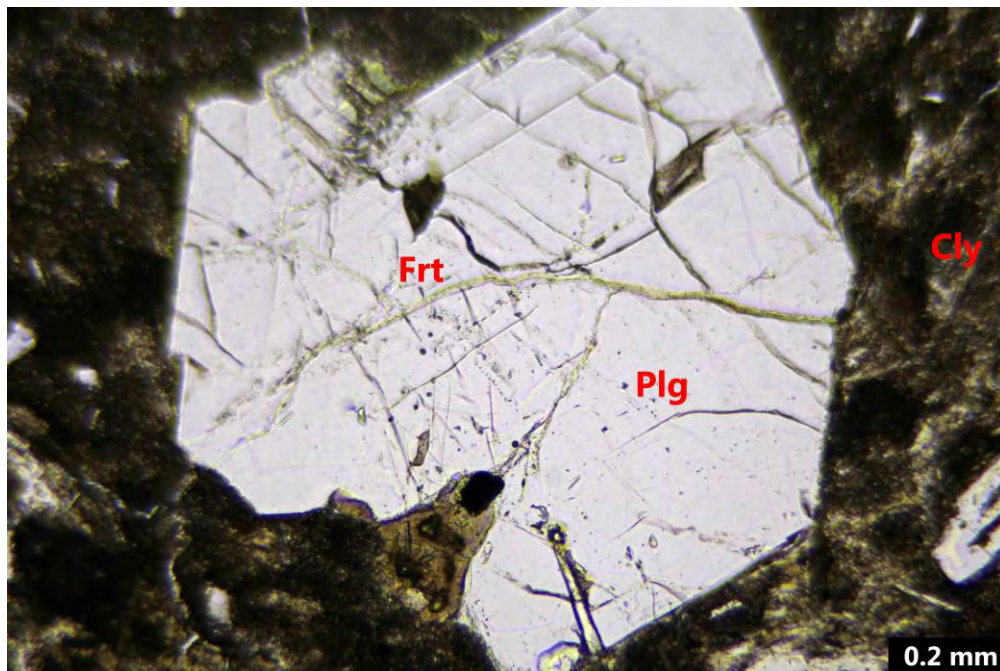


**Fig. 4** - Plane polarized light. Field of view = 4 mm wide (magnification 4X). A view of a volcanic clast. A common feature of all the clasts in this thin section is the presence of fractures surrounding clast boundaries (follow the green dashed line). In this case the fracture is filled with secondary Carbonates (Cbt).

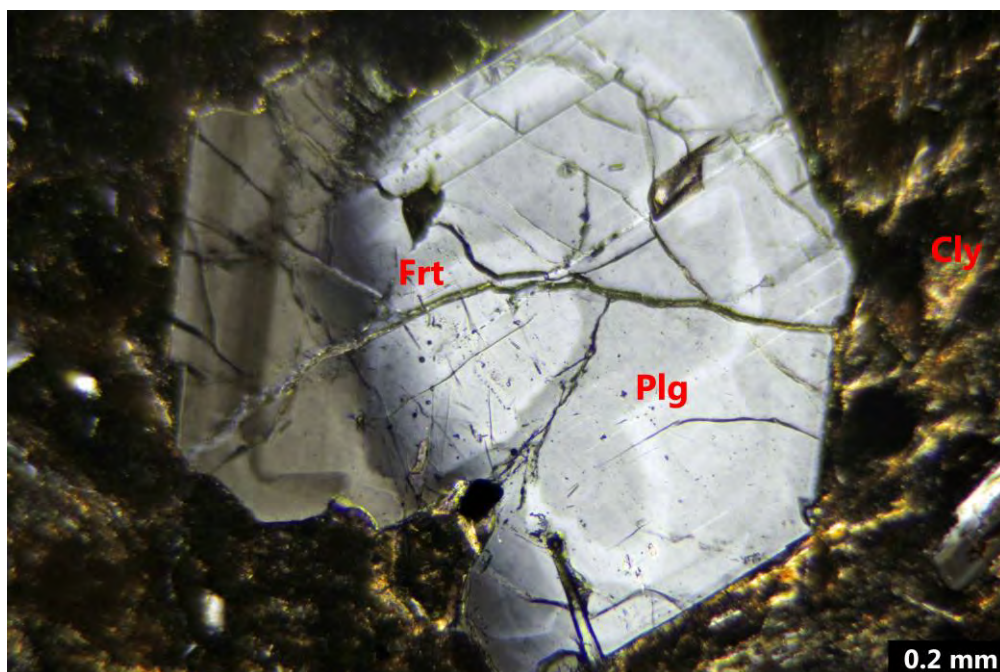


**Fig. 5** - Cross polarized light. Field of view = 4 mm wide (magnification 4X). Same as Figure 4, but under crossed polars.



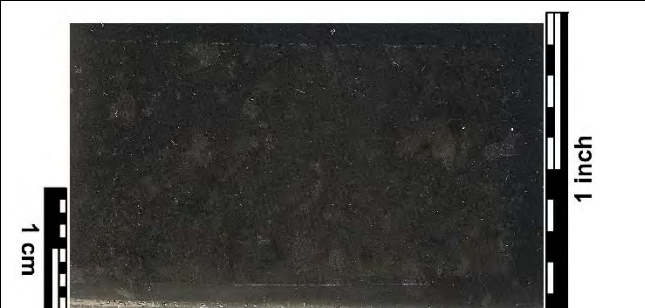
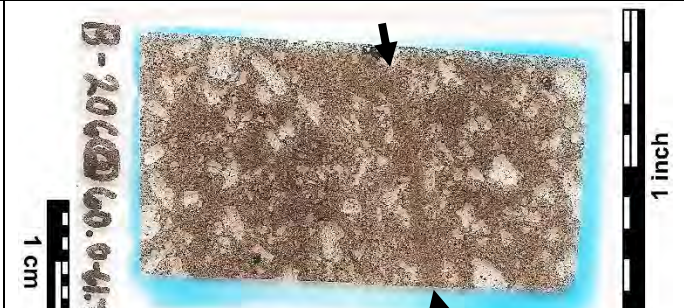



**Fig. 6** - Plane polarized light. Field of view = 1.7 mm wide (magnification 10X). A detail of a Plagioclase crystal, showing grain alteration and suturing features: fractures cross the crystal and are also filled with Clay Minerals.



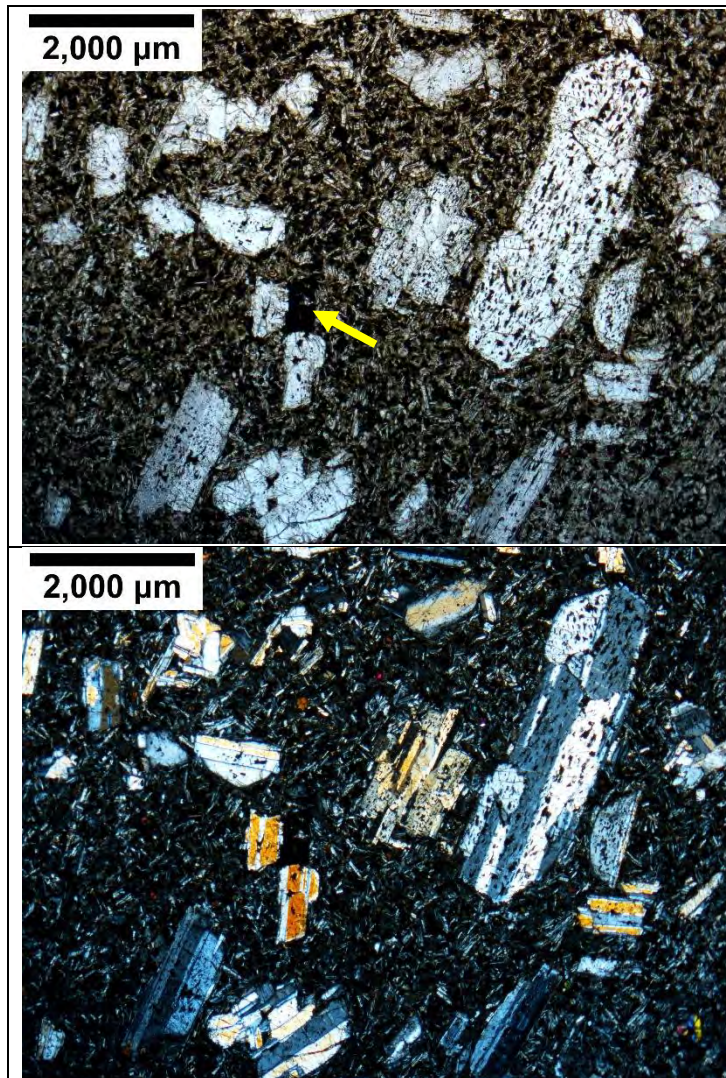
**Fig. 7** - Cross polarized light. Field of view = 1.7 mm wide (magnification 10X). Same as Figure 6, but under crossed polars.

Macroscopic sample description	<b>Porphyritic augite basalt</b> Strongly porphyritic basalt with blocky mm-scale plagioclase phenocrysts randomly oriented and uniformly distributed in black aphanitic groundmass. Plagioclase euhedral to subhedral. Magnetic due to presence of accessory magnetite. Scratches with difficulty with steel scribe. No detectable reaction with hydrochloric acid.		
Brief petrographic description	Large growth-zoned, partially-resorbed, polysynthetically-twinned euhedral labradorite-plagioclase phenocrysts and sparse smaller augite phenocrysts with simple contact twins randomly set in fine-grained groundmass of randomly oriented euhedral plagioclase microlites and anhedral groundmass augite and intercumulus plagioclase. Minor magnetite.		
Constituent minerals	plagioclase	85%	20% 3,000 $\mu\text{m}$ euhedral phenocrysts $40^\circ$ angle between extinction of polysynthetic twins indicates labradorite composition $(\text{NaAlSi}_3\text{O}_8)_{30-50}(\text{CaAl}_2\text{Si}_2\text{O}_8)_{70-50}$ – most grains display sieve-like texture likely reflecting resorption event, but outermost grain margins lack development of resorption embayments, so resorption predates final crystallization. Many grains strongly compositionally growth-zoned. 20% 100 $\mu\text{m}$ euhedral to subhedral microlites with polysynthetic twins in groundmass, randomly oriented 45% anhedral intercumulus grains < 100 $\mu\text{m}$
	augite	7%	2% 500 $\mu\text{m}$ phenocrysts with second-order interference colors and distinct $90^\circ$ cleavage, commonly simple contact twinned 5% 100 $\mu\text{m}$ anhedral microlites in groundmass
	glass	5%	black/very dark green-brown amorphous, nearly opaque, isotropic groundmass supporting both microlites and phenocrysts
	magnetite	3%	<300 $\mu\text{m}$ euhedral opaque black grains, dull silver in reflected light
Porosity	0% intergranular porosity and 0% fracture porosity		
Heterogeneity	none		

																																									
<table><thead><tr><th></th><th>wt%</th><th>norm. wt%</th></tr></thead><tbody><tr><td>Na<sub>2</sub>O</td><td>0.6</td><td>0.7</td></tr><tr><td>MgO</td><td>1.6</td><td>1.9</td></tr><tr><td>Al<sub>2</sub>O<sub>3</sub></td><td>15.9</td><td>19.6</td></tr><tr><td>SiO<sub>2</sub></td><td>47.8</td><td>58.8</td></tr><tr><td>P<sub>2</sub>O<sub>5</sub></td><td>0.2</td><td>0.2</td></tr><tr><td>SO<sub>2</sub></td><td>0.1</td><td>0.1</td></tr><tr><td>K<sub>2</sub>O</td><td>0.8</td><td>1.0</td></tr><tr><td>CaO</td><td>7.1</td><td>8.8</td></tr><tr><td>TiO<sub>2</sub></td><td>0.9</td><td>1.2</td></tr><tr><td>FeO</td><td>6.3</td><td>7.7</td></tr><tr><td>Total</td><td>81.3</td><td>100.0</td></tr></tbody></table>				wt%	norm. wt%	Na <sub>2</sub> O	0.6	0.7	MgO	1.6	1.9	Al <sub>2</sub> O <sub>3</sub>	15.9	19.6	SiO <sub>2</sub>	47.8	58.8	P <sub>2</sub> O <sub>5</sub>	0.2	0.2	SO <sub>2</sub>	0.1	0.1	K <sub>2</sub> O	0.8	1.0	CaO	7.1	8.8	TiO <sub>2</sub>	0.9	1.2	FeO	6.3	7.7	Total	81.3	100.0	<p><b>Billet of porphyritic augite basalt</b> Dark gray blocky plagioclase phenocrysts in black aphanitic groundmass.</p> <p><b>Thin section slide of porphyritic augite basalt</b> Blocky white crystals of plagioclase in dark glassy groundmass. 2-mm wide late-stage aphanitic “dike” cuts sample (between arrows). Blue epoxy impregnation indicates 0% porosity.</p>		
	wt%	norm. wt%																																							
Na <sub>2</sub> O	0.6	0.7																																							
MgO	1.6	1.9																																							
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TiO <sub>2</sub>	0.9	1.2																																							
FeO	6.3	7.7																																							
Total	81.3	100.0																																							
<p>Photograph of cut drill core of porphyritic augite basalt. Sample lacks late-stage veins or other hydrothermal features – very fresh volcanic rock.</p>																																									

Kurt Friehauf, Ph.D., P.G. – friehauf@kutztown.edu





Plane-polarized photomicrograph of main body of sample at very low magnification documenting large sub- to euhedral plagioclase phenocrysts (large blocky crystals) with slight local alignment set in aphanitic groundmass (very dark gray) of glass and plagioclase microlites (tiny white spines). Black grain indicated by arrow is opaque (possibly magnetite).

Cross-polarized photomicrograph of same spot on slide showing polysynthetic twinning (stripes) in plagioclase, and broken nature of some plagioclase phenocrysts. Tiny red, orange, and blue grains in groundmass are augite pyroxene.

## Analytical methods

Billets and cut core samples were sanded smooth with 400-grit carborundum abrasive, examined with hand lens, swivel magnet, and steel scribe.

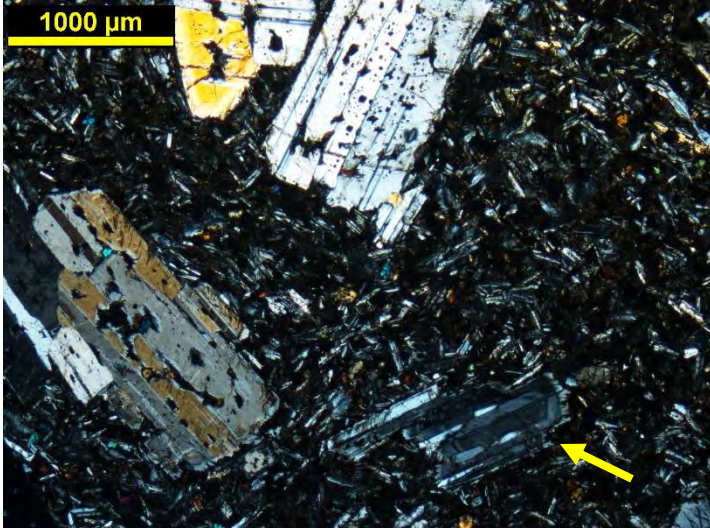
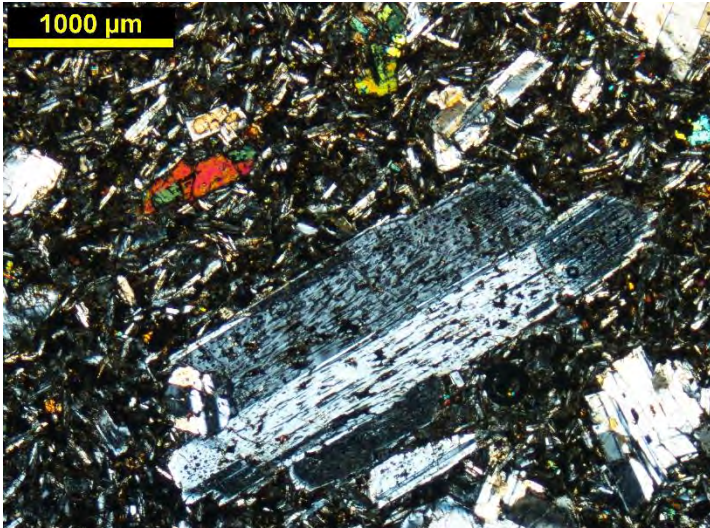
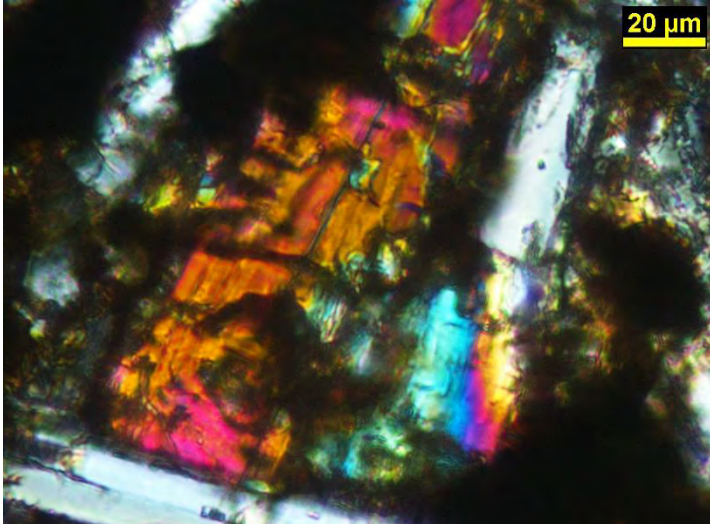
Thin section analysis used a Nikon Pol600 polarized light petrographic microscope (both plane- and cross-polarized light). Relative proportions of high contrast minerals (e.g., plagioclase) were determined by visual comparison with standardized estimation charts.

Chemical analyses were done using a silicon drift detector Bruker Tracer IV-SD portable XRF with vacuum attachment for improved analysis of light elements (Na and Mg) using a mudstone standard. Three 30-seconds spot analyses with 2x4 mm analytical window were averaged to estimate the bulk rock composition using earth materials standards. Oxide weight percent values were calculated from raw elemental weight percent values on a molar basis, allocating oxygen to balance charges. Portable XRF analyses are an objective, quantitative evaluation of the bulk chemical composition and are accurate, but generally with only  $\pm 2\text{-}4\%$  precision – typical of

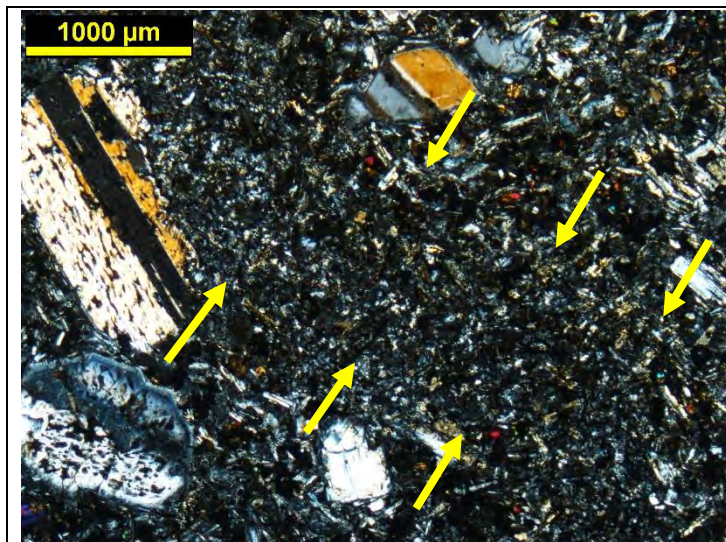
normal rock variability. This analytical method may slightly underestimate the concentrations of  $\text{Na}_2\text{O}$  and  $\text{MgO}$  and slightly overestimate the concentration of  $\text{SiO}_2$  by a few percent in mafic igneous rocks like this sample due to X-ray absorption by abundant iron atoms.

*Kurt Frieauf, Ph.D., P.G. – frieuf@kutztown.edu*

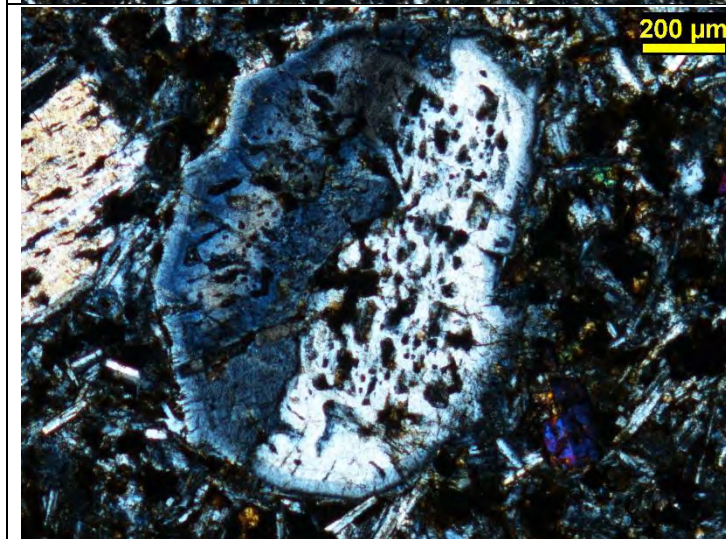


	<p>Cross-polarized photomicrograph of compositionally-zoned plagioclase crystal (yellow arrow) and sieve texture in most plagioclase phenocrysts in sample display (other large, blocky grains with dark holes). Sieve texture suggests partial resorption (dissolution) of plagioclase phenocrysts prior to precipitation of outermost growth zone (because phenocryst outlines lack well-developed resorption embayments). Sharp compositional zonation results from pressure fluctuations in magma shifting crystallization conditions – very common in volcanic or subvolcanic igneous rocks.</p>
	<p>Cross-polarized photomicrograph documenting unusual sieve texture in large plagioclase phenocrysts, and bimodal grain size of augite (i.e., &gt;500 μm phenocrysts and 80-100 μm groundmass crystals).</p>
	<p>Cross-polarized photomicrograph at very high magnification of augite crystal with high second-order interference colors and good 90° cleavage. White grains are plagioclase microlites. This augite crystal is the width of average human hair.</p>

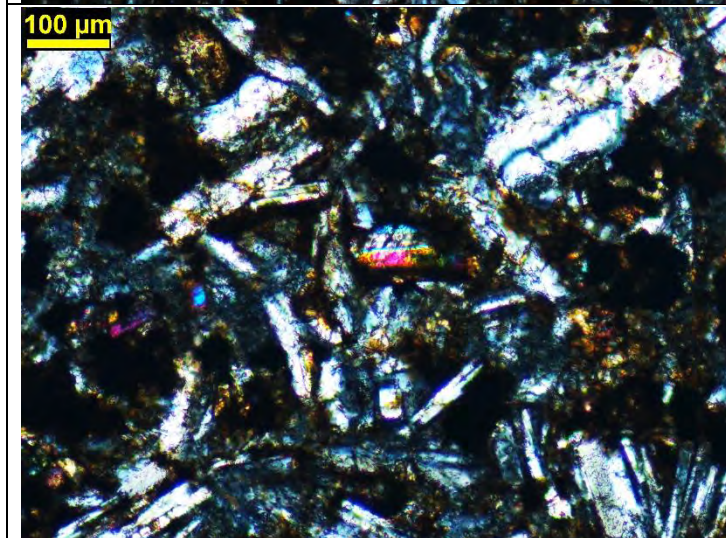




Cross-polarized photomicrograph of late-stage “dike” of very fine-grained basalt (between arrows) cross-cutting microlite- and phenocryst-bearing main body of sample. Dike of fine-grained material lacks phenocrysts, lacks distinct augite grains, and lacks plagioclase microlites. Dike likely represents very late-stage filter-pressing of last liquid from crystal mush.



Cross-polarized photomicrograph detailing sieve texture plagioclase crystal with continuous, unresorbed outermost growth zone. Brightly-colored grains are augite pyroxene.



Cross-polarized photomicrograph at moderately high magnification detailing groundmass augite (colorful grains), euhedral plagioclase microlites (white rectangles), and anhedral intercumulus plagioclase (darker gray material filling in between well-formed crystals).