# MEMORANDUM



Date:	July 21, 2021	Job No.: 4722
То:	Justin Curewitz, PE, PTOE	
Cc:		
From:	Christopher Jones, P.E.	
Subject:	605178; Billerica – Boston Road (Route 3A) Roadw Traffic Signal Mast Arm Foundation Recommenda	

This memorandum details the findings of the soil exploration program relevant to the traffic signal mast arms and the foundation recommendations for those structures. A summary if the recommendations is shown in the table below:

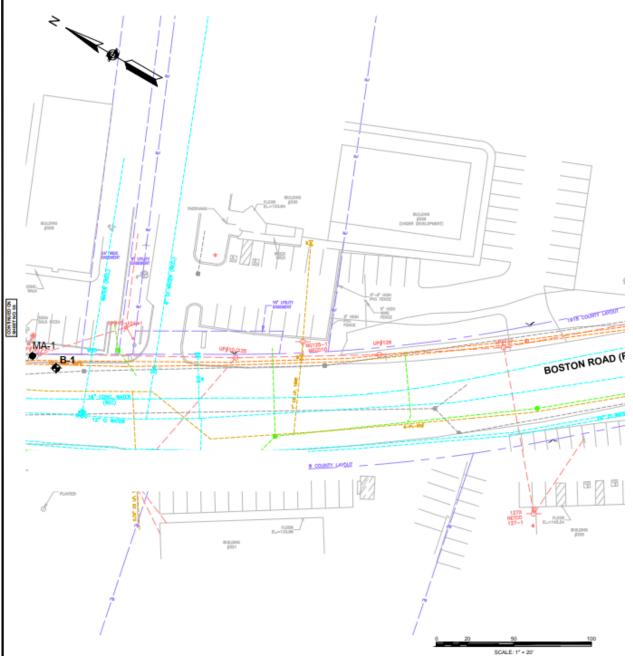
Mast Arm	Arm Length		Foundation Size						
Wast Arm	Ann Length	Diameter	Depth	Vert. Bars	Ties				
MA-1	25′	3'-6"	9'-0"	18–#8	#5 @ 12"				
MA-2	35′	3'-6"	10'-6"	18–#8	#5 @ 9"				
MA-3	40′	3'-6"	10'-6"	18–#8	#5 @ 9"				
MA-4	35′	3'-6"	14'-6″	18–#8	#5 @ 9"				
MA-5	35′	3'-6"	14'-6"	18–#8	#5 @ 9"				
MA-6	45′	4'-0"	11'-6"	18–#9	#5 @ 9"				
MA-7	25′	3'-6"	9'-0″	18–#8	#5 @ 12"				
MA-8	40'	3'-6"	14'-6"	18–#8	#5 @ 9"				

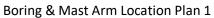
NOTE: BORING B-8 AT MA-8 ENCOUNTERED BEDROCK AT A DEPTH OF 11'-6". THE FOUNDATION FOR MA-8 SHALL BE CORED AND SOCKETED INTO BEDROCK TO THE SPECIFICED FOUNDATION DEPTH.

Supporting information for these recommendations is contained on following pages.

Wind Zone for foundation selection: 110 mph

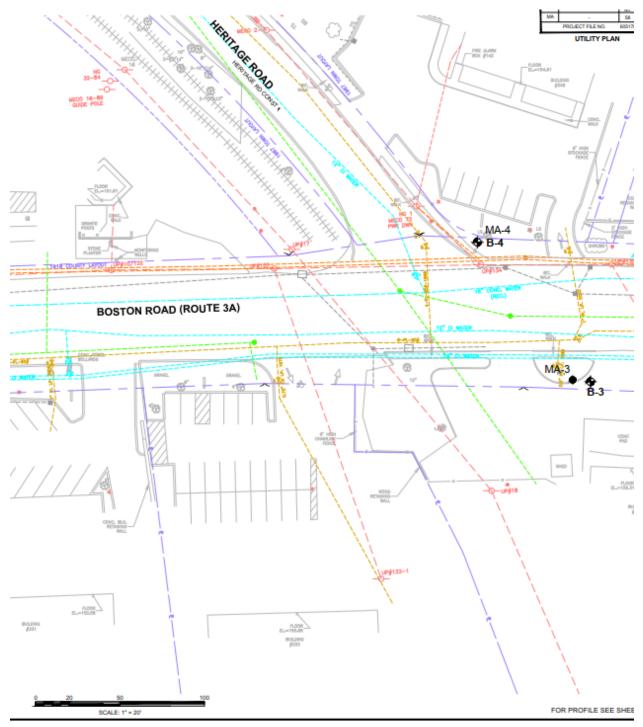
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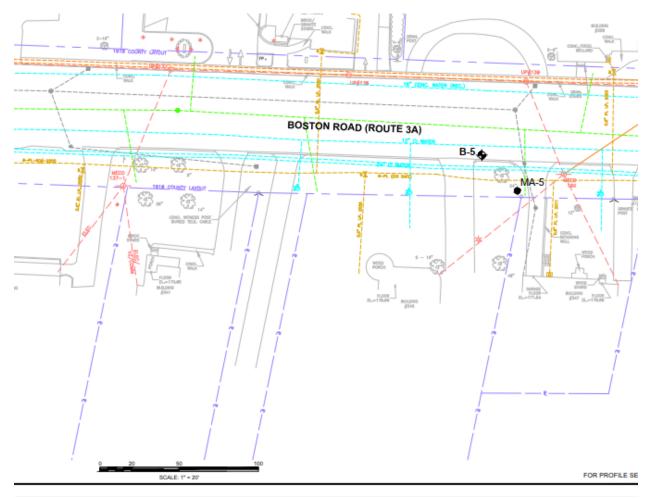
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Boring & Mast Arm Location Plan 2



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Boring & Mast Arm Location Plan 3



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Boring & Mast Arm Location Plan 4



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#### Mast Arm MA1 / Boring B1

Northern	n Drill Se	rvice, Inc.		Client: BETA G	roup, Inc.		Boring #	
130 East N	Aain Street,	Northborou	gh, MA 01532	Project: Bostor	n Rd Mast A	Arms	B-1	
TEI 508.3	93-6900 E4	X 508-393-	6001	Location: Bosto	Page 1 OF 1			
File #:	33-030017	0000000	0001	Looditoin boot	CASING	SAMPLER	CORE BARREL	
Date Start	ed: 6/30/20	)21		TYPE	HW	S/S	NX	
Date Com	pleted: 6/30	/2021		SIZE	4"	2"		
Driller: Ju	stin Raymo	nd		HAMMER		140		
Site Rep.:				FALL		30"		
				Ground Water	level: 5.7'			
	5	SAMPLE			Strata			
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change		PLE DESCRIPTION	
S-1	.5'2.5'	24"	12"	8-7-5-5			dense, dark brown silty fin an coarse sand, trace I.	
S-2	4'6'	24"	12"	7-12-16-14		S-2: Medium dense, tan fine sand, little medium to coarse gravel, trace coarse sand.		
S-3	9'11'	24"	17"	10-11-13-16		S-3: Medium dense, tan fine sand, some medium to coarse gravel, trace coarse sand.		
S-4	14'16'	24"	10"	12-21-36-24		S-4: Very dense, gray fine sand, some medium to coarse gravel, some silt, trace coarse sand.		
S-5	19'21'	15"	6"	38-48-100/3"		S-5:Very dense, gray fine sand, some medium gravel, trace coarse sand. Glacial till		
S-6	24'26'	15"	4"	47-51-100/3			nse, gray fine sand, sand, some medium avel.	
						Bottom of Ex	ploration = 25.5'	
			0.101.0050 1	0.30 Medium Der		Dense 50+		

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Standard Penetration Value: 28

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 25'

Diam	eter	Depth	Vert. Bars	Tie Bars
3'-6"		9'-0"	18–#8	#5 @ 12"



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#### Mast Arm MA2 / Boring B2

Northern	Drill Ser	rvice, Inc.		Client: BETA G	Froup, Inc.			Boring #				
130 East M	lain Street,	Northborou	gh, MA 01532	Project: Bosto	n Rd. Mast /	B-2						
TEL 508-39	EL 508-393-6900 FAX 508-393-6901			EL 508-393-6900 FAX 508-393-6901			Location: Boston Rd, Billerica, MA				Page 1 OF 1	
File #:					CASING	SAMPLER	CORE BA	ARREL				
Date Starte	ed: 6/25/20	)21		TYPE	HW	S/S						
Date Comp	leted: 6/25	/2021		SIZE	4"	2"						
Driller: Jus	tin Raymor	nd		HAMMER		140						
Site Rep.:				FALL		30"						
				Ground Water	level:	4.5						
	5	SAMPLE			Strata							
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change	SAM	LE DESCR	RIPTION				
S-1	0-2'	24"	16"	3-2-2-4		S-1: Loose, b trace, mediur		medium sand, gravel.				
S-2	4'-6'	24"	14"	16-18-17-15		S-2: Dense, t medium to co trace coarse	arse gravel					
S-3	9'-11'	24"	6"	11-14-11-9		S-3: Medium some mediur silt, trace coa	n to large gr					
S-4	14'-16'	24"	12"	71-44-22-19		S-4: Very der medium to co sand, trace s	arse gravel	arse sand and , some fine				
S-5	19'-21'	15"	9*	34-48-100/3"		S-5: Very der sand and me trace fine sar	dium to coa nd.					
S-6	24'-26'	0"	0"	100/0*		20.5'- 1' boul S-6: Split sp		no recovery				
						Bottom of Ex	ploration =	26'				
Cohesionle	ess Density	y Blows/ft:	0-10 Loose 10	0-30 Medium-De	nse 30-50	Dense 50+	Very Dens	e	Average			

Average Standard

Average Standard Penetration Value: 30

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 35'

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	10'-6"	18–#8	#5 @ 9"



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#### Mast Arm MA3 / Boring B3

n Drill Se	rvice, Inc.		Client: BETA G	roup, Inc.			Boring #
Aain Street,	Northborou	gh, MA 01532	Project: Bosto	n Rd. Mast /	Arms		B-3
8-393-6900 FAX 508-393-6901 Location: Boston Rd, Billerica, MA							Page 1 OF
				CASING	SAMPLER	CORE B	ARREL
ed: 6/28/2	021		TYPE .	HW	S/S		
pleted: 6/28	/2021		SIZE	4"	2"		
stin Raymo	nd		HAMMER		140		
			FALL		30"		
			Ground Water	level: 5.5'	1		
5	AMPLE			Strata			
Depth	Pen. In.	Rec. In.	Blows/6"	Change	SAMP	LE DESCI	RIPTION
0'-2'	24"	6"	6-3-6-7		sand, some s	mall to med	
4'-6'	24"	3"	35-19-14-18		S-2: Dense, gray/tan coarse sand and medium to coarse gravel. Trace fine sand. Strong petroleum odor.		
9'-11'	24"	12"	14-11-12-13		S-3: Medium dense, gray fine sand, some tan coarse sand, trace silt.		
14'-16'	23"	10"	26-45-66-100/5"				
					Bottom of Exp	ploration =	15.5'
	fain Street, 93-6900 F.A ed: 6/28/2 oleted: 6/28 stin Raymo 5 0'-2' 4'-6' 9'-11'	Depth  Pen. In.    0'-2'  24"    9'-11'  24"	ed: 6/28/2021 oleted: 6/28/2021 stin Raymond SAMPLE Depth Pen. In. Rec. In. 0'-2' 24" 6" 4'-6' 24" 3" 9'-11' 24" 12"	Main Street, Northborough, MA 01532  Project: Boston    93-6900 FAX 508-393-6901  Location: Boston    ad:  6/28/2021  TYPE    stin Raymond  SIZE    Ground Water    SAMPLE    0'-2'  24"    4'-6'  24"    9'-11'  24"    9'-11'  24"	Main Street, Northborough, MA 01532  Project: Boston Rd. Mast /    93-6900 FAX 508-393-6901  Location: Boston Rd, Biller    CASING  CASING    ad:  6/28/2021  TYPE    bleted:  6/28/2021  SIZE    stin Raymond  HAMMER  FALL    Ground Water level: 5.5'    SAMPLE  Strata    0f-2'  24*  6"  6-3-6-7    4'-6'  24"  3"  35-19-14-18    9'-11'  24"  12"  14-11-12-13	Itain Street, Northborough, MA 01532  Project: Boston Rd. Mast Arms    33-6900 FAX 508-393-6901  Location: Boston Rd, Billerica, MA    ad:  6/28/2021    ad:  6/28/2021    stin Raymond  SIZE    HAMMER  140    FALL  30"    Ground Water level:  5.5"    SAMPLE  Strata    Depth  Pen. In.    Rec. In.  Blows/6"    Change  SAMP    0'-2'  24"    6"  6-3-6-7    S-1:Loose, br  sand, some sr    ad: -6'  24"    3"  35-19-14-18    S-2: Dense, gr  medium to confine sand. Stm    9'-11"  24"    14'-16'  23"    10"  25-45-66-100/5"    S-4: Very den coarse sand coarse sand coarse sand.    coarse sand.	Main Street, Northborough, MA 01532  Project: Boston Rd. Mast Arms    93-6900 FAX 508-393-6901  Location: Boston Rd, Billerica, MA    CASING  SAMPLER  CORE B.    ad:  6/28/2021  TYPE  HW  S/S

Average Standard Penetration Value: 28

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 40'

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	10'-6"	18–#8	#5 @ 9"



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#### Mast Arm MA4 / Boring B4

Northern Drill Service, Inc.				Client: BETA C	Boring #			
		the second s	gh, MA 01532	Project: Bosto	n Rd Mast A	rms		B-4
	i08-393-6900 FAX 508-393-6901 Location: Boston Rd, Billerica, MA							Page 1 OF
TEL 508-393- File #:	6900 FA	Y 208-383-	0901	Location: Bost	CASING	SAMPLER	CORE B	ARREL
Date Started:	6/30/20	21		TYPE	HW	S/S	NX	
Date Complet				SIZE	4"	2"		
Driller: Justin				HAMMER		140		
Site Rep.:	,			FALL		30"		
				Ground Water	level: 6.2			
	s	AMPLE			Strata			
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change	SAME	LE DESCR	RIPTION
S-1	0'-2'	24ª	20"	5-8-9-8	onungo	S-1: Medium medium sand coarse gravel	dense, brov , some med	vn fine to tium to
S-2	4'-6"	24"	12"	3-6-9-13		S-2: Medium dense, grey fine sand, some coarse sand, trace coarse grave trace silt.		
S-3	9'-11'	24"	18"	9-9-10-9		S-3: Medium some silt, trac coarse sand.		
S-4	14'-16'	5"	2*	100/5"	13'-15'	S-4: Very den some fine sar 13'-15': 2" bo	nd, some si	
C-1	17'-22'	60"	59*			C-1: RQD=59	9% Gray Sa	ndstone
C-2	22'-27'	60"	60"			C-2: RQD= 9 white granite.		andstone/
						Bottom of Ex	ploration =	27'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: 17

Assign generalized soil classification: Wet Sand (Loose)

Mast Arm Length: 35'

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	14'-6"	18–#8	#5 @ 9"



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### Mast Arm MA5 / Boring B5

Northern Drill Service, Inc. 130 East Main Street, Northborough, MA 01532 TEL 508-393-6900 FAX 508-393-6901				Client: BETA G	roup, Inc.	Client: BETA Group, Inc.					
				Project: Bosto		B-5					
				Location: Bosto		Page 1 OF 1					
File #:					CASING	SAMPLER	CORE B	ARREL			
Date Started: 6/28/2021				TYPE	HW	S/S					
Date Com	pleted: 6/28	3/2021		SIZE	4"	2"					
Driller: Ju	stin Raymo	nd		HAMMER		140	-				
Site Rep.:				FALL		30"		-			
				Ground Water	level: 5.1'						
		SAMPLE			Strata						
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change		PLE DESC				
S-1	.5'-2.5'	24"	12"	6-8-8-4		gravel.	l, some me	dium to coarse			
S-2 S-3	4'-6' 9'-11'	3" 24"	0 15"	100/3" 11-12-11-16		S-2: No recovery. 1.5' boulder 4'-5.5' S-3: Medium dense, tan fine to mediu sand, some coarse gravel, trace silt.					
S-4	14'-16'	24"	19"	16-25-24-32				ind, some siit, e coarse sand			
S-5	19'-21'	3"	2"	100/3"	19'	S-5:Very dense, gray coarse sand, some fine sand, some coarse gravel, weathered rock at 19', advance boring to 24'					
S-6	24'-26'	8"	2"	32-100/2"		S-6: Very der coarse grave Decomposed	Trace fine	carse sand and sand.			
						Bottom of Ex	ploration =	24.5			

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: A boulder was encountered from 4'-6'. Although blow counts between 9'-11' had N=23, resulting in a dense sand classification, this would be only at the very bottom of the foundation. Therefore conservatively classify as a loose sand over the full shaft length.

Assign generalized soil classification: Wet Sand (loose)

Mast Arm Length: 35'

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	14'-6″	18–#8	#5 @ 9"



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### Mast Arm MA6 / Boring B6

Northern Drill Service, Inc.				Client: BETA G	aroup, Inc.			Boring #	
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms				B-6	
								Page 1 OF	
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd. Billerica, MA CASING SAMPLER CORE B			CORE BA	RREL	
Pile #. Date Started: 7/1/2021				TYPE	HW	S/S NX			
				SIZE	4"	2"			
Date Completed:7/1/2021 Driller: Justin Raymond				HAMMER		140			
Site Rep.:				FALL	30"				
				Ground Water	level: 6.2'				
	5	SAMPLE			Strata				
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change	SAMP	SAMPLE DESCRIPTION		
S-1	0-2"	24"	7"	3-2-3-4		S-1:Loose, brown fine sand, some coarse sand, trace coarse gravel.			
S-2	4'-6'	23"	8"	11-60-100/5"		S-2: Very dense, tan coarse sand and medium to coarse gravel, some fine sand.			
S-3	9'-11'	24"	13"	21-19-90-100/3"		S-3:Very Dense, tan fine sand and medium to coarse gravel, some coarse sand, trace silt.			
C-1:	12'-17'	60"	55"			C-1: RQD= 62% Gray Sandstone			
C-2:	17'-22'	60"	60"			C-2: RQD= 72% Gray Sandstone			
						Bottom of Ex	ploration =	22'	
	Densih		0.101.0000 10	20 Medium Deu		Deneo 50+	Ven/ Dener		

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

#### Average Standard Penetration Value: 84

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 45'

Diameter	Depth	Vert. Bars	Tie Bars
4'-0"	11'-6″	18–#9	#5 @ 9"



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# Mast Arm MA7 / Boring B7

Northern Drill Service, Inc. 130 East Main Street, Northborough, MA 01532 TEL 508-393-6900 FAX 508-393-6901				Client: BETA Group, Inc.				Boring #
				Project: Bosto		B-7 Page 1 OF 1		
				Location: Boste				
File #:					CASING	SAMPLER	CORE B	
Date Started: 7-1-2021				TYPE	HW	S/S		4X
Date Completed:7-1-2021					4*	2"		
	stin Raymo	nd		HAMMER		140		
Site Rep.:				FALL	30"			
				Ground Water		1		
	1	SAMPLE		-	Strata			
No. S-1	Depth 0-2'	Pen. In. 24"	Rec. In. 12"	Blows/6" 1-2-1-2	Change	SAME S-1:Loose, br	PLE DESC	
	0.000					S-2: Medium dense, tan fine to medium sand, some medium to coarse gravel, trace coarse sand. S-3:Medium dense, tan coarse sand an trace fine sand. weathered rock encountered 11'.		
S-2	4'-6'	24"	19"	7-9-11-10				
S-3	9'-11'	24"	9"	11-11-15-47	11'			
C-1	13'-18'	60"	60*			C-1:RQD= 40	1%	
C-2	18'-13'	60*	60"			C-2: RQD=65%		
						Bottom of Ex	ploration =	23'

Average Standard Penetration Value: 20

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 25'

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	9'-0"	18–#8	#5 @ 12"



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### Mast Arm MA8 / Boring B8

Northern Drill Service, Inc.				Client: BETA Group, Inc.				Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms				B-8
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd. Billerica, MA				Page 1 OF
TEL 508-393-6900 FAX 508-393-6901							CORE BA	RREL
Date Start	ed: 6/23/20	21		TYPE	HW	S/S	NX	
Date Completed:6/23/2021				SIZE	4"	2"		
Driller: Ju	stin Raymor	nd		HAMMER		140		
Site Rep.:				FALL		30"		
				Ground Water	level: 7.1'			
	s	AMPLE			Strata			
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change	SAMPLE DESCRIPTION		
S-1	0-2'	24"	12"	13-4-4-3		S-1:Loose, brown fine to medium sand, some some small coarse gravel.		
S-2	4'-6'	24"	18"	4-4-8-30	7	S-2: M-Dense, tan fine to medium sand Some coarse gravel, Trace coarse sand Boulder from 7'-10.5'.		
S-3	10.5'-12.5'	5"	3"	100/5"		S-3:Very dense, tan fine sand, some silt, trace coarse sand, trace small coarse gravel.		
C-1	13'-18'	60"	56"			Top of rock 1 C-1: RQD= 2		ay granite
C-2	18'-23'	60"	60"			C-2: RQD= 48% Light gray granite		
						Bottom of Exp	ploration =	23'
	1		1	-30 Medium-De	L	Dense 50+		

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: 12

Assign generalized soil classification: Wet Sand (Loose)

Mast Arm Length: 40'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	14'-6"	18–#8	#5 @ 9"

Note: Bedrock was encountered at a depth of 11.5'. Core and socket the final 3' of the foundation into the bedrocks

Ref: 0:\4100s\4153 - Easton Depot St\Engineering\Geotechnical\2020-09-25 Mast Arm Foundation Recommendations.docx

