ADDENDUM NO. 1
November 12, 2014

Contract A - Reversible Water Supply and Runoff Collection Pipeline
Spirit Mountain Recreation Authority

SEH No. FOSJJ 129137

From: Short Elliott Hendrickson Inc.
416 South 6th Street, Suite 200
Brainerd, MN 56401-3540
218.855.1700

To: Document Holders

DOCUMENT HOLDERS on the above-named project are hereby notified that this document shall be appended to, take precedence over and become part of the original bidding documents dated October 2014 for this work. Bids submitted for the construction of this work shall conform to this document.

This Addendum No. 1 consists of 2 pages and attached Bid Form, Alternate Specs, and Attachments listed below.

Changes to Bidding Requirements:

1. Revised Bid Form with various corrections plus Alternates (replace Bid Form with new one attached).
    a. Alternate piping materials. Specs attached. Added Bid Items 29-A, 39-A, 40-A and 44-A.
    b. Alternate Bid Item for HDD Installation of River Pipe. Bid Item 44-B is for installation of 36" HDPE. Installation following Section 33 05 20.

Changes to Specifications:

2. Section 33 11 02, Water Supply Piping, Part 3 Execution, 3.03 Field Quality Control, A,1.,b. Test Pressure DELETE 150psi and INSERT 125psi.

3. Section 33 11 03, Water Transfer Piping, Part 3 Execution, 3.03 Field Quality Control, A,1.,b. Test Pressure DELETE 150psi and INSERT 100psi.

4. Section 33 11 04, Marine Constructed Water Supply Piping, Part 3 Execution, 3.03 Field Quality Control, A,1.,b. Test Pressure DELETE 150psi and INSERT 125psi.

5. Section 33 11 02-Water Supply Piping Between Pump Stations, AND Section 33 11 03-Water Transfer Piping (Grit Chamber to Sta 104) add the following as alternate fitting material.

    Part 2 PRODUCTS, 2.02 Fittings

    C. Ductile Iron Fittings
    1. In lieu of polyethylene, fittings may be ductile iron in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, latest revisions.

Changes to Drawings:

6. Sheet C3, Runoff Collection Structure Schedule, Line 9, Structure 301 change from 84" to 96".

7. Sheet C3, Transfer Pipe Structure Schedule. Add Line 2B, Structure 113, TC= 687.65, Inv.=679.28, MH Dia.=48", Cover type=Solid Lid (this structure is shown on Sheet C11. Connects to Structure 112 apron).

Attachments:

Additional Geotech Borings with Map
Bridge Shops
Bridge Shops 2 Plans
BNSF Agreement

Note: Receipt of this Addendum No. 1 (dated November 12, 2014) shall be acknowledged on Page 6 of the submitted Bid Form. Failure to do so may subject Bidder to disqualification.

END OF ADDENDUM

OFFICIAL SEALED BID

REQUEST FOR BID	RETURN BY OPENING TIME TO:
Issue Date:10/21/2014	Purchasing Division
Bid # SM4501A	RM 100 City Hall
	411 West 1st Street
	Duluth, MN 55802

Buyer: Dennis Sears
Phone: 218-730-5003
Fax: 218-730-5922

Contract A – Reversible Water Supply and Runoff Collection Pipeline

BID OPENING, AT 2:00 PM ON Thursday, November 20, 2014

Note: All bids must be written, signed, and transmitted in a sealed envelope, plainly marked with the bid number, subject matter, and opening date. The City of Duluth reserves the right to split award where there is substantial savings to the city, waive informalities and to reject any and all bids. Bidder should state in proposal if bid is based on acceptance of total order. Sales tax is not to be included in the unit price. Bidder to state freight charges if, proposal is F.O.B. shipping point, freight not allowed. Low bid will not be the only consideration for award of bid. All pages must be signed or initialed by authorized bidder's representative as indicated at the bottom of the page(s) of the request for bid.

BID DEPOSIT REQUIREMENTS: 5% OF BID AMOUNT
Deposit shall mean cash, cashier's check or corporate surety bond payable to or in favor of the City of Duluth.

A PERFORMANCE BOND AND A PAYMENT BOND shall be required of the successful bidder, BOTH in the full amount of the bid.

INSUREANCE CERTIFICATE required per attached requirements.

**********SCHEDULE OF PRICES**********

UNIT PRICE SCHEDULE

Item No.	Description	Unit	Est. Quantity	Bid Unit Price	Bid Price
1	Mobilization	LS	1	$__________	$______________
2	Clear	AC	1.02	$__________	$______________
3	Grub	AC	1.02	$__________	$______________
4	Remove Existing Storm Sewer	LF	504	$__________	$______________
5	Rock Excavation	CY	300	$__________	$______________
6	Relocate Utilities	LS	1	$__________	$______________
7	Traffic Control	LS	1	$__________	$______________

Item No.	Description	Unit	Est. Quantity	Bid Unit Price	Bid Price
8	Materials Testing (Section 01 45 29)	LS	1	$___________	$_______________
9	Dewatering	LS	1	$___________	$_______________
10	Common Borrow	CY	200	$___________	$_______________
11	Common Excavation	CY	1190	$___________	$_______________
	Run-off Collection System				
12	Trench Dam	EA	2	$___________	$_______________
13	12" HDPE STORM PIPE	LF	78	$___________	$_______________
14	12" HDPE FES	EA	2	$___________	$_______________
15	15" HDPE STORM PIPE	LF	146	$___________	$_______________
16	15" HDPE FES	EA	4	$___________	$_______________
17	24" HDPE STORM PIPE	LF	322	$___________	$_______________
18	24" HDPE FES	EA	5	$___________	$_______________
19	36" HDPE STORM PIPE	LF	373	$___________	$_______________
20	36" HDPE FES	EA	1	$___________	$_______________
21	42" HDPE STORM PIPE	LF	344	$___________	$_______________
22	Storm Manhole Type B (48")	EA	2	$___________	$_______________
23	Storm Manhole Type D (72")	EA	3	$___________	$_______________
24	Storm Manhole Type E (84")	EA	2	$___________	$_______________
25	Storm Manhole Type F (96")	EA	1	$___________	$_______________
26	Storm Drainage Casting R1733	EA	10	$___________	$_______________
27	Connect Existing Storm Sewer to Manhole	EA	1	$___________	$_______________
28	Grit Chamber (Inc. Box sections, end sections and 48" MH)	LS	1	$___________	$_______________
TRANSFER PIPE AREA					
29	24" HDPE DR 21 (Transfer Pipe) (Includes fittings)	LF	1476	$___________	$_______________
30	Storm Manhole Type special (48") Tee vert	EA	2	$___________	$_______________

OFFICIAL SEALED BID

Item No.	Description	Unit	Est. Quantity	Bid Unit Price	Bid Price
Pressure Pipe (At pump stations)					
31	24" DUCTILE IRON PIPE	LF	82	$___________	$_______________
32	36" DUCTILE IRON PIPE	LF	77	$___________	$_______________
33	24" DI WYE	EA	3	$___________	$_______________
34	24" DI 45D BEND	EA	10	$___________	$_______________
35	24" DI 22D BEND	EA	5	$___________	$_______________
36	24" x 36" DI REDUCER	EA	1	$___________	$_______________
37	36" DI WYE	EA	1	$___________	$_______________
38	24" BUTTERFLY VALVE	EA	5	$___________	$_______________
Pressure Pipe (Between Pump Stations)					
39	24" HDPE DR 17 (Main to River, except HDD) (Includes fittings)	LF	1559	$___________	$_______________
40	HDD Installed 24" HDPE DR 17	LF	150	$___________	$_______________
41	Jack and Bore 30" Steel Casing	LF	60	$___________	$_______________
42	30" Steel Casing (open cut)	LF	70	$___________	$_______________
43	HDD Installed 30" HDPE CASING PIPE	LF	100	$___________	$_______________
River Pipe					
44	36" HDPE DR 17 (Includes fittings)	LF	1175	$___________	$_______________
45	Pump Station Wetwell (Inc. slide gate)	EA	1	$___________	$_______________
46	4" DIPS HDPE Air Line (DR 11) Laid in trench w/Supply Line	LF	1200	$___________	$_______________
Intake/Oulet Structure Area					
47	Intake Screen	EA	1	$___________	$_______________
48	Tideflex check valve	EA	1	$___________	$_______________
49	48" check valve	EA	1	$___________	$_______________
50	Intake/Outlet Structure Pipes and Fittings	LS	1	$___________	$_______________

Item No.	Description	Unit	Est. Quantity	Bid Unit Price	Bid Price
51	Intake/Outlet Structural Platform	LS	1	$___________	$_______________
52	Support Piling	LS	1	$___________	$_______________
Restoration					
53	Topsoil Borrow	CY	1115	$___________	$_______________
54	Seeding (inc. seed, fertilizer and mulch)	AC	3.7	$___________	$_______________
55	Silt Fence Heavy Duty	LF	7950	$___________	$_______________
56	Silt Fence Floating curtain	LF	1660	$___________	$_______________
57	Erosion Control Blanket Category 4	SY	780	$___________	$_______________
58	Rock Construction Entrance	EA	3	$___________	$_______________
59	Inlet Protection	EA	12	$___________	$_______________
Creek Restoration (Drawing Sheets C24-C25)					
60	Remove Existing Silt Fence	LF	300	$___________	$_______________
61	Remove Existing RC Culvert	LF	160	$___________	$_______________
62	Clear and Grub Tree	EA	4	$___________	$_______________
63	Common Excavation	CY	875	$___________	$_______________
64	Random Riprap Cl. III	CY	35	$___________	$_______________
65	1 1/2" washed rock	CY	45	$___________	$_______________
66	Topsoil Borrow	CY	394	$___________	$_______________
67	Erosion Control Blanket Category 4	SY	2362	$___________	$_______________
68	Hydro Seeding (include seed, fertilizer and mulch)	AC	0.49	$___________	$_______________
69	Silt Fence Heavy Duty	LF	400	$___________	$_______________
Bridge					
70	Install New Bridge (Drawing B1-B2)	LS	1	$___________	$_______________
TOTAL BID PRICE				**$**________________________________	

SCHEDULE OF ALTERNATE BID ITEMS

Item No.	Description	Unit	Est. Quantity	Bid Unit Price	Bid Price
29-A	24" DIP PC-200 (Transfer Pipe) (Includes fittings)	LF	1476	$____________	$________________
39-A	24" DIP PC-200 (Main to River, except HDD) (Includes fittings)	LF	1559	$____________	$________________
40-A	HDD Installed 24" DIP PC-200	LF	150	$____________	$____________
44-A	36" DIP PC-150 DIP (River Pipe)	LF	1175	$____________	$____________
44-B	HDD Installed 36" HDPE DR 17 (River Pipe)	LF	1175	$_____________	$____________

Bidder acknowledges that estimated quantities are not guaranteed, and are solely for the purpose of comparison of Bids, and final payment for all Unit Price Bid items will be based on actual quantities, determined as provided in the Contract Documents.

OFFICIAL SEALED BID

ADDENDUM RECEIPT ACKNOWLEDGEMENTS:

ADDENDUM NO. ______, DATED ______________________

ADDENDUM NO. ______, DATED ______________________

ADDENDUM NO. ______, DATED ______________________

TOTAL BID IN WORDS:

____

CONTRACTOR NAME:

____

THE CONTRACTOR AGREES TO ALL OF THE PROVISIONS CONTAINED IN THE CONTRACT DOCUMENTS. ENCLOSED HEREWITH FIND A CERTIFIED CHECK OR BID BOND IN THE AMOUNT OF AT LEAST 5% OF THE AMOUNT OF PROPOSAL MADE PAYABLE TO THE CITY OF DULUTH AS A PROPOSAL GUARANTEE WHICH IT IS AGREED BY THE UNDERSIGNED WILL BE FORFEITED IN THE EVENT THE FORM OF CONTRACT AND BOND IS NOT EXECUTED, IF AWARDED TO THE UNDERSIGNED.

SIGNED: ______________________________ FOR

____

A PARTNERSHIP (OR)

____

A CORPORATION INCORPORATED UNDER THE LAWS OF THE STATE OF:

____

PRESIDENT ______________________________

VICE-PRES. ______________________________

SECRETARY ______________________________

TREASURER ______________________________

ADDRESS(ES) ______________________________

____

OFFICIAL SEALED BID

BEING DULY SWORN, DEPOSES AND SAYS THAT THERE ARE NO OTHER PERSONS COMPRISING ABOVE COMPANY OR FIRM THAN THE ABOVE NAMES, AND THAT THERE ARE NO PERSONS OR CORPORATIONS INTERESTED IN THE FORGOING PROPOSALS, EITHER AS PRINCIPAL OR SUBCONTRACTOR, OTHER THAN THE ABOVE NAMES; ALSO THAT THE PROPOSALS ARE MADE WITHOUT ANY CONNECTION WITH ANY PERSON OR PERSONS MAKING ANY PROPOSAL FOR THE ABOVE WORK; THAT THEY ARE IN ALL RESPECTS FAIR AND WITHOUT COLLUSION OR FRAUD; AND THAT NO PERSON ACTING IN ANY OFFICIAL CAPACITY FOR THE CITY OF DULUTH IS DIRECTLY OR INDIRECTLY INTERESTED THEREIN, OR IN ANY PORTION OF THE PROFIT THEREOF.

____

SUBSCRIBED AND SWORN TO BEFORE ME THIS

_____________ DAY OF ______________________ A.D., ________

____

NOTARY
PUBLIC

IMPORTANT NOTE BIDDERS:
PLEASE DISREGARD THE NOTE ON PAGE 1 REGARDING SALES TAX FOR THIS BID. ALL APPLICABLE SALES AND/OR USE TAXES ARE TO BE INCLUDED IN BID PRICING. ALSO, ALL BIDS ARE TO BE F.O.B. JOBSITE. THE BLANK ON PAGE ONE FOR FREIGHT IS TO TO BE LEFT BLANK.

****Note: Please self-identify as an MBE _____ or WBE ____ by checking if applicable.**

WATER TRANSFER PIPING & WATER SUPPLY PIPING SYSTEM BETWEEN PUMP STATIONS

PART 2 PRODUCTS

Ductile iron pipe shall be designed and manufactured in accordance with ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51, latest revisions. All pipe shall be manufactured in the U.S.A.

1. PIPE: Ductile Iron pipe shall be 24” Pressure Class 200.

2. FITTINGS: Fittings shall be ductile iron in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, latest revisions.

   All fittings shall be cement mortar and asphaltic coated. Cement mortar lining shall be in accordance with ANSI/AWWA C104/A21.4.

3. JOINTS: Ductile iron pipe and fittings to have rubber gasket joints in accordance with the latest revision of ANSI/AWWA C111/A21.11. Buried piping and fittings shall be either AMERICAN Fastite push-on joint or engineer approved equal.

   All pipe joints shall utilize FM approved and UL listed conductive gaskets with approved copper inserts equal to American Fastite or external copper straps/cables in accordance with manufacturers recommendations. Conductors shall be rated at 600 amps sustained current.

   Where restrained joints are required to resist thrust due to internal pressure, AMERICAN Fast-Grip, AMERICAN Flex-Ring, AMERICAN Lok-Ring joints, or engineer approved equal, shall be utilized at the specified locations.

4. COATING AND LINING: Pipe shall be asphaltic coated on the outside per ANSI/AWWA C151/A21.51, latest revision, and cement lined inside in accordance with ANSI/AWWA C104/A21.4, latest revision.

   All Ductile Iron pipe, fittings, and valves shall be encased with 8 mil V-Bio Enhanced Polyethylene Encasement in accordance with the latest revision of ANSI/AWWA C105/A21.5.

5. TEST AND INSPECTION:

   A. Each pipe shall be subjected to a hydrostatic pressure test of at least 500 psi at the point of manufacture.

B. All pipe 18 inch nominal diameter and greater shall be hydrostatically proof tested to a minimum of 75% yield strength after manufacture.

C. Manufacturer will furnish owner-sworn certificates that pipe has been manufactured, tested and inspected in accordance with applicable specifications.

D. At the owner’s option, the engineer may direct the pipe manufacturer to furnish test certificates from an independent testing laboratory certifying that pipe conforms to all applicable specifications. This independent laboratory shall be approved by the engineer/ owner.

RIVER STATION TO INTAKE-OUTLET

PART 2 PRODUCTS

Ductile iron pipe shall be designed and manufactured in accordance with ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51, latest revisions. All pipe shall be manufactured in the U.S.A.

1. PIPE: Ductile Iron pipe shall be 36” Pressure Class 150.

2. FITTINGS: Fittings shall be ductile iron in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, latest revisions.

   All fittings shall be cement mortar and asphaltic coated. Cement mortar lining shall be in accordance with ANSI/AWWA C104/A21.4.

3. JOINTS: Ductile iron pipe and fittings to have rubber gasket joints in accordance with the latest revision of ANSI/AWWA C111/A21.11. Buried piping and fittings shall be either AMERICAN Fastite push-on joint or engineer approved equal.

   All pipe joints shall utilize FM approved and UL listed conductive gaskets with approved copper inserts equal to American Fastite or external copper straps/cables in accordance with manufacturers recommendations. Conductors shall be rated at 600 amps sustained current.

   Where restrained joints are required to resist thrust due to internal pressure, AMERICAN Fast-Grip, AMERICAN Flex-Ring, AMERICAN Lok-Ring joints, or engineer approved equal, shall be utilized at the specified locations.

4. COATING AND LINING: Pipe shall be asphaltic coated on the outside per ANSI/AWWA C151/A21.51, latest revision, and cement lined inside in accordance with ANSI/AWWA C104/A21.4, latest revision.

   All Ductile Iron pipe, fittings, and valves shall be encased with 8 mil V-Bio Enhanced Polyethylene Encasement in accordance with the latest revision of ANSI/AWWA C105/A21.5.

5. TEST AND INSPECTION:

   A. Each pipe shall be subjected to a hydrostatic pressure test of at least 500 psi at the point of manufacture.

B. All pipe shall be hydrostatically proof tested to a minimum of 75% yield strength after manufacture.

C. Manufacturer will furnish owner-sworn certificates that pipe has been manufactured, tested and inspected in accordance with applicable specifications.

D. At the owner's option, the engineer may direct the pipe manufacturer to furnish test certificates from an independent testing laboratory certifying that pipe conforms to all applicable specifications. This independent laboratory shall be approved by the engineer/ owner.

AMERICAN
ENGINEERING
TESTING, INC.

CONSULTANTS
• ENVIRONMENTAL
• GEOTECHNICAL
• MATERIALS
• FORENSICS

November 9, 2012

SEH, Inc.
3535 Vadnais Center Drive
St. Paul, MN 55110

Attn: Wayne Wambold, PE

RE: Geotechnical Exploration and Testing
Knowlton Creek Run-off and Sediment Control
Spirit Mountain Area
Duluth, Minnesota
AET No. 01-05604

Dear Mr. Wambold:

This letter report presents the results of the geotechnical exploration and testing that we performed for the referenced project. This work is being performed per our September 4, 2012 proposal, which was accepted by you on October 2, 2012. The authorized scope consists of nine standard penetration test borings, soil laboratory testing, and preparation of this data report.

The borings were drilled and sampled at the site on October 22 and 23, 2012. The logs of the test borings are attached. The boring locations were selected and surveyed by SEH. The elevations and location coordinates (St. Louis County Mercator system) appear on the boring logs.

The boring logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted for natural soils, which is based on the standard penetration resistance (N-value). We refer you to the standard sheet entitled "Exploration/Classification Methods" for details on the drilling and sampling methods, the classification methods, and the water level measurement methods. Data sheets concerning the Unified Soils Classification System, the descriptive terminology, and the symbols used on the boring logs are also attached.

In addition to water content testing of cohesive soils, the laboratory testing included:

- 13 sieve analysis tests (in general accordance with ASTM:D6913, Method A)
- 16 Atterberg Limits tests (in general accordance with ASTM:D4318)

The results appear on the borings logs and/or on the data sheets following the boring logs.

Within the limitations of scope, budget, and schedule, our services have been conducted according to generally accepted geotechnical engineering practices at this time and location.

Authored By,
American Engineering Testing, Inc.

Jeffery K. Voyen, PE (MN No. 15928)
Vice President/Principal Engineer
(651) 659-1305 direct
(612) 961-9186 cell
jvoyen@amengtest.com

Attachments:
- Subsurface Boring Logs
- Sieve Analysis Test Results
- Exploration/Classification Methods
- Boring Log Notes
- Unified Soil Classification System

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **1 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **779.8** St. Louis Co. Coordinates: N **3318239** E **4817860**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–0.3	4" FILL, mostly sandy lean clay, a little gravel, trace roots, brown	FILL					16				
1	FILL, mostly gravel, a little silty sand, pieces of concrete, trace roots, brown		40	M	SS	18	17				
2–3	FILL, mostly sandy lean clay, a little gravel and silty sand, pieces of concrete, trace roots, brown		17	M	SS	8	15				
4–6	SILTY SAND, fine grained, brown, a little brownish gray, moist, medium dense, laminations of lean clay (SM) (possible fill)	COARSE ALLUVIUM OR FILL	13	M	SS	14	16				39
6.5–9	FAT CLAY, brown, a little grayish brown, stiff, laminations of silt (CH)	TILL OR FINE ALLUVIUM	9	M	SS	14	34		67	18	
9–11.5	SANDY FAT CLAY, a little gravel, brown, a little light tan, stiff, laminations of silt and fine silty sand (CH)		12	M	SS	18	28		52	18	
11.5–11.9	WEATHERED GRANITE, black and pink	LIKELY BOULDER	50/.3	M	SS	2					

END OF BORING
Obstructed to HSA at 11.9'

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-11.9'	**3.25" HSA**							
		10/23/12	**12:30**	**11.8**	**11.5**	**11.7**		**11.3**
		10/23/12	**12:40**	**11.8**	**11.5**	**11.7**		**11.2**
BORING COMPLETED: **10/23/12**		**10/23/12**	**12:55**	**11.9**	**11.9**	**11.9**		**11.3**
DR: **GH** LG: **TK** Rig: **1C**								

WATER LEVEL MEASUREMENTS

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/9/12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **2 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **780.1** St. Louis Co. Coordinates: N **3318167** E **4817723**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
1	FILL, mostly clayey sand, a little gravel and silty sand, trace roots, brown	FILL	20	M	SS	14	7				40
2, 3	SANDY FAT CLAY, trace roots, brown, a little light brown, very stiff, laminations of sand (CH) (possible fill)	TILL OR FILL	24	M	SS	8	25		61	18	
4	GABBRO, gray	DULUTH COMPLEX OR BOULDER	100/3	M	SS	1					
	END OF BORING Obstructed to HSA at 4.3'										

DEPTH:	DRILLING METHOD
0-4.3'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
10/23/12	11:25	4.3	4.0	4.0		None
10/23/12	11:40	4.3	4.3	4.2		None

BORING COMPLETED: **10/23/12**

DR: **GH** LG: **TK** Rig: **1C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/9/12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **2A (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: ______ St. Louis Co. Coordinates: N **3318167** E **4817728**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
1 2 3 4	No Sampling 0-4.5'										
	No recovery		50/.05	M	SS	0					
	END OF BORING Obstructed to HSA at 4.5' Obstructed to SS at 4.6' Second attempt offset 5'E of Boring 2										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-4.5'	**3.25" HSA**							
		10/23/12	**11:55**	**4.6**	**4.5**	**4.5**		**None**
		10/23/12	**12:05**	**4.6**	**4.5**	**4.5**		**None**
BORING COMPLETED: **10/23/12**								
DR: **GH** LG: **TK** Rig: **1C**								

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **3 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **765.2** St. Louis Co. Coordinates: N **3317911** E **4817805**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	FILL, mixture of sandy lean clay and fat clay, a little gravel, pieces of bituminous, trace roots, brown	FILL	13	M	SS	14	14				
1–2	FILL, mostly silty sand with gravel, pieces of bituminous, dark brown						5				18
2–6.5	FILL, mostly sandy lean clay, a little gravel, trace roots, brown, possible cobble around 5'		15	M	SS	6	12		32	14	
			29	M	SS	1					
6.5–11.5	SILTY SAND WITH GRAVEL, grayish brown to brown, moist, medium dense to dense (SM)	TILL	12	M	SS	12	12				25
			47	M	SS	14					
11.5–15.4	SANDY SILT WITH GRAVEL, brown, apparent cobbles around 11.5', wet, dense (ML/SM)	TILL OR FINE ALLUVIUM	36	W	SS	6	27		NP	NP	
15	*30/0.5 + 50/0.4 (no recovery)		*	-	SS	0					

END OF BORING

Obstructed to SS at 15.4'

DEPTH:	DRILLING METHOD
0-14.5'	3.25" HSA

BORING COMPLETED: **10/23/12**

DR: **GH** LG: **TK** Rig: **1C**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
10/23/12	10:15	13.5	11.5	12.1		11.5
10/23/12	10:25	13.5	11.5	12.1		10.2
10/23/12	10:30	15.4	14.5	14.5		13.4
10/23/12	10:40	15.4	14.5	14.4		12.6

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 01-05604 LOG OF BORING NO. 4 (p. 1 of 1)

PROJECT: Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN

SURFACE ELEVATION: 772.1 St. Louis Co. Coordinates: N 3317888 E 4817683

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	FILL, mostly clayey sand with organic fines, a little gravel and sandy lean clay, trace roots, brown	FILL	18	M	SS	16	20				
1–4	FILL, mostly gravelly silty sand, trace roots, brown						6				22
			51	M	SS	2					
4–6.5	FILL, mostly silty sand, a little lean clay with gravel, pieces of bituminous, brown, a little dark brown		25	M	SS	14					
6.5–11.5	SANDY SILT, a little gravel, brown, moist, dense to very dense (ML)	FINE ALLUVIUM	24	M	SS	14	14		NP	NP	
				▼							
			77	M	SS	16	9				
11.5–13.1	GRAVEL WITH CLAY AND SAND, gray and brown, moist, very dense (GP-GC)	TILL OR RESIDUAL SOIL	*	M/W	SS	8					
			50/.1	M	SS	1					

END OF BORING
Obstructed to HSA at 13.9'
Obstructed to SS at 13.1'
*37/0.5 + 50/0.4

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-13'	3.25" HSA	10/23/12	8:50	12.9	12.0	12.5		11.3
		10/23/12	9:00	12.9	12.0	12.5		9.2
BORING COMPLETED:	10/23/12	10/23/12	9:10	13.1	13.0	13.0		11.5
DR: GH LG: TK Rig: 1C		10/23/12	9:20	13.1	13.0	12.9		10.7

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/7/12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **5 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **751.1** St. Louis Co. Coordinates: N **3317819** E **4817927**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	FILL, mostly silty sand with gravel, brown	FILL					5				16
1			33	M	SS	16					
	FILL, mostly clayey sand with gravel, trace roots, dark brown and brown						10				
2	LEAN CLAY, a little gravel, brown, a little grayish brown, stiff, laminations of silt (CL)	TILL									
3			13	M	SS	6	27		49	19	
4	LEAN CLAY WITH GRAVEL, brown, stiff (CL)										
5			14	M	SS	8	39		44	15	
6	GABBRO, gray	*	50/.05	M	SS	0					
	END OF BORING Obstructed to HSA at 6.3' Obstructed to SS at 6.35' Boring located 16'W and 8'N of staked location	*DULUTH COMPLEX OR BOULDER									

DEPTH:	DRILLING METHOD
0-6.3'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
10/23/12	1:40	6.4	6.3	6.2		None
10/23/12	1:50	6.4	6.3	6.2		None

BORING COMPLETED: **10/23/12**

DR: **GH** LG: **TK** Rig: **1C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **6 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **769.9** St. Louis Co. Coordinates: N **3317680** E **4817788**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS: WC	DEN	LL	PL	%-#200
0–2	FILL, mostly sandy lean clay with gravel, pieces of concrete, brown	FILL	36	M	SS	10	18				
2–6.5	FILL, mostly gravelly silty sand, pieces of concrete and brick, brown and grayish brown		56	M	SS	6					
			40	M	SS	6	10				13
6.5–10	FILL, mostly gravelly sand with silt, pieces of concrete and brick, brown and grayish brown		28	M	SS	8	9				7
10–11.5	FILL, mostly lean clay, a little gravel, pieces of concrete and brick, trace roots, brown, a little dark brown		11	M	SS	12	21				
11.5–14.5	CLAYEY SAND, with organic fines, trace roots, dark brown, stiff (SC)	TOPSOIL	12	M	SS	14	24				
14.5	GABBRO, gray	DULUTH COMPLEX OR BOULDER	50/.1	M	SS	1					
	END OF BORING Obstructed to SS at 14.6'										

DEPTH:	DRILLING METHOD
0-14.5'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
10/22/12	**3:50**	**14.5**	**14.5**	**14.5**		**None**
10/23/12	**4:00**	**14.5**	**14.5**	**14.5**		**None**

BORING COMPLETED: **10/22/12**

DR: **GH** LG: **TK** Rig: **1C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/9/12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **7 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **766.1** St. Louis Co. Coordinates: N **3317625** E **4817804**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–0.5	FILL, mostly silty sand, a little gravel, trace roots, brown	FILL	*	M	SS	8					
0.5–2	FILL, mostly pieces of concrete and brick, a little silty sand										
2–4	FILL, mostly silty sand with gravel, brown		11	M	SS	4	6				27
4–6.5	FILL, mostly silty sand, a little gravel and lean clay, brown, a little black		9	M	SS	2					
6.5–9	LEAN CLAY, trace roots, brown, a little grayish brown, stiff, laminations of silt (CL)	FINE ALLUVIUM	14	M	SS	14	23		35	19	
9–13.5	SILTY CLAY, a little gravel, possible boulder at 13.3', brown, hard (CL-ML)	FINE ALLUVIUM OR TILL	46	M	SS	14	14		22	17	
			**	M	SS	16	12				
			~~50/0~~	~~M~~	~~SS~~	~~0~~					

END OF BORING
Obstructed to HSA at 13.5'
Obstructed to SS at 13.5'
*4/0.5 + 50/0.4
**19/0.5 + 31/0.5 + 50/0.4

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-13.5'	3.25" HSA	10/22/12	2:25	13.5	13.5	13.5		None
		10/23/12	2:35	13.5	13.5	13.5		None

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **10/22/12**

DR: **GH** LG: **TK** Rig: **1C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/7/12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **8 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: **764.8** St. Louis Co. Coordinates: N **3317528** E **4817906**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4	FILL, mostly gravelly silty sand, a little clayey sand, brown and dark brown	FILL	27	M	SS	10	6				15
			40	M	SS	12					
4–6.5	FILL, mostly lean clay, a little gravel and silt, pieces of wood, brown, a little light tan		23	M	SS	6	26				
6.5–11.5	LEAN CLAY WITH SAND AND GRAVEL, brown, hard (CL)	TILL	79	M	SS	12	12				
			55	M	SS	16	12		26	13	
11.5–16	LEAN CLAY WITH SAND, a little gravel, trace roots, brown to dark brown, hard, laminations of fine sand (CL)		55	M	SS	16	13		*	16	
	low plasticity - not able to run reliable LL		38	M	SS	14	12				
16	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14.5'	**3.25" HSA**							
		10/22/12	**1:20**	**16.0**	**14.5**	**16.0**		**None**
		10/22/12	**13.0**	**16.0**	**14.5**	**16.0**		**None**

(WATER LEVEL MEASUREMENTS)

BORING COMPLETED: **10/22/12**

DR: **GH** LG: **TK** Rig: **1C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/7/12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05604** LOG OF BORING NO. **9 (p. 1 of 1)**

PROJECT: **Knowlton Creek Run-Off and Sediment Control; Spirit Mountain Area, Duluth, MN**

SURFACE ELEVATION: 763.3 St. Louis Co. Coordinates: N 3317603 E 4817932

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly clayey sand, a little gravel, brown	FILL	33	M	SS	12	9				
2–4	FILL, mostly silty sand, a little lean clay, brown		15	M	SS	14	10				37
4–6.5	FILL, mostly sand with silt and gravel, brown		18	M	SS	14	5				11
6.5–9	FILL, mostly lean clay, a little sand with silt and silt, brown, a little dark brown		7	M	SS	12	25		34	11	
9–11.5	FILL, mixture of sandy lean clay and clayey sand, a little sand with silt, brown, a little dark brown		10	M	SS	14	20				45
11.5–17	FILL, mostly lean clay, a little gravel, pieces of wood, dark brown and brown		10	M	SS	16	21		34	18	
			10	M	SS	12	16		31	17	
17–19	SANDY LEAN CLAY, a little gravel, a piece of wood, brown, stiff (CL)	TILL	14	M	SS	8	17		24	15	
19–21	SANDY LEAN CLAY WITH GRAVEL, brown, hard (CL)		41	M	SS	16	15				
21	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-19.5'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
10/22/12	11:45	21.0	19.5	19.5		None
10/22/12	11:55	21.0	19.5	19.5		None

BORING COMPLETED: **10/22/12**

DR: **GH** LG: **TK** Rig: **1C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05604.GPJ AET+CPT+WELL.GDT 11/7/12

SIEVE ANALYSIS TEST RESULTS

PROJECT:
Knowlton Creek Run-off and Sediment Control
Spirit Mountain Area
Duluth, Minnesota

AET NO.: 01-05604

DATE: November 6, 2012

TEST METHOD: General conformance with ASTM:D6913, Method A

RESULTS:

Boring Number	1	2	3	3	4	5	6
Sample Depth	4½'-6'	0-2'	1'-2'	7'-8½'	½'-2'	0-1'	4½'-6'
Dry Sample Weight (gms)	214.95	182.23	139.78	250.75	248.76	259.60	216.36
Sieve Size or Number	Percent Passing By Weight						
1½"	100	100	100	100	100	100	100
1"	100	100	100	88	86	100	100
3/4"	100	100	91	88	86	100	83
5/8"	100	100	86	88	81	100	78
1/2"	100	97	86	85	76	90	77
3/8"	100	95	85	83	75	84	72
#4	99	86	79	78	69	71	64
#10	97	80	68	69	63	58	56
#20	94	73	56	63	56	47	47
#40	90	67	42	57	50	38	38
#100	56	50	24	35	31	22	19
#200	39	40	18	25	22	16	13

Note: The small sample size limits the accuracy of the test, and the sample may not necessarily be representative of the entire layer shown on the boring log.

SIEVE ANALYSIS TEST RESULTS

PROJECT:
Knowlton Creek Run-off and Sediment Control
Spirit Mountain Area
Duluth, Minnesota

AET NO.: 01-05604

DATE: November 6, 2012

TEST METHOD: General conformance with ASTM:D6913, Method A

RESULTS:

Boring Number	6	7	8	9	9	9
Sample Depth	7'-8½'	2'-3½'	0-2'	2'-3½'	4½'-6'	9½'-11'
Dry Sample Weight (gms)	273.96	115.22	275.00	215.55	316.18	214.88
Sieve Size or Number	Percent Passing By Weight					
1½"	100	100	100	100	100	100
1"	100	100	100	100	100	89
3/4"	87	100	92	100	100	84
5/8"	77	100	90	100	98	78
1/2"	70	94	86	100	91	78
3/8"	62	82	78	100	89	74
#4	52	71	69	100	84	73
#10	38	64	59	99	74	71
#20	27	60	50	98	61	68
#40	19	56	38	96	44	64
#100	10	34	21	47	17	53
#200	7.3	27	15	37	11	45

Note: The small sample size limits the accuracy of the test, and the sample may not necessarily be representative of the entire layer shown on the boring log.

SAMPLING METHODS

Split-Spoon Samples (SS) - Calibrated to N_{60} Values

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2" O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30". The sampler is driven a total of 18" into the soil. After an initial set of 6", the number of hammer blows to drive the sampler the final 12" is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N_{60} blow count.

Most of today's drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N_{60} values. By using the PDA energy measurement equipment, we are able to determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30". The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviations of the N-values using this method are significantly better than the standard ASTM Method.

Disturbed Samples (DS)/Spin-up Samples (SU)

Sample types described as "DS" or "SU" on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

CLASSIFICATION METHODS

Soil classifications shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil classifications shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

WATER LEVEL MEASUREMENTS

The ground water level measurements are shown at the bottom of the boring logs. The following information appears under "Water Level Measurements" on the logs:

- Date and Time of measurement
- Sampled Depth: lowest depth of soil sampling at the time of measurement
- Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- Cave-in Depth: depth at which measuring tape stops in the borehole
- Water Level: depth in the borehole where free water is encountered
- Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES

(Calibrated Hammer Weight)

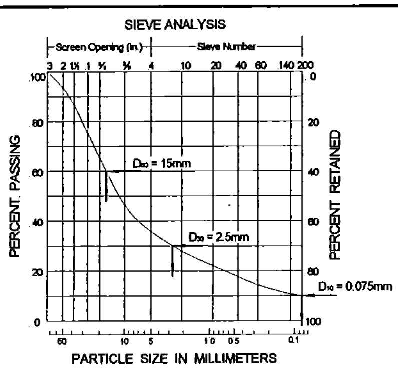
The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

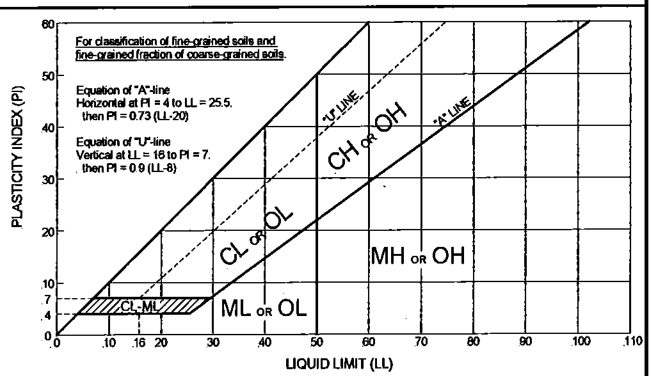
UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines more than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly-graded sand[I]
		Sands with Fines more than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – not dried <0.75	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – not dried <0.75	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
Highly organic soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $\quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{2.5^2}{0.075 \times 15} = 5.6$



Plasticity Chart

Notes

[A]Based on the material passing the 3-in (75-mm) sieve.

[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C]Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D]Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E]$Cu = D_{60}/D_{10}$, $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F]If soil contains ≥15% sand, add "with sand" to group name.

[G]If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H]If fines are organic, add "with organic fines" to group name.

[I]If soil contains ≥15% gravel, add "with gravel" to group name.

[J]If Atterberg limits plot is hatched area, soils is a CL-ML silty clay.

[K]If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.

[L]If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

[M]If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N]PI≥4 and plots on or above "A" line.

[O]PI<4 or plots below "A" line.

[P]PI plots on or above "A" line.

[Q]PI plots below "A" line.

[R]Fiber Content description shown below.

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition (MC Column)

D (Dry):	Absence of moisture, dusty, dry to touch.
M (Moist):	Damp, although free water not visible. Soil may still have a high water content (over "optimum").
W (Wet/ Waterbearing):	Free water visible intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
F (Frozen):	Soil frozen

Layering Notes

Laminations:	Layers less than ½" thick of differing material or color.
Lenses:	Pockets or layers greater than ½" thick of differing material or color.

Peat Description

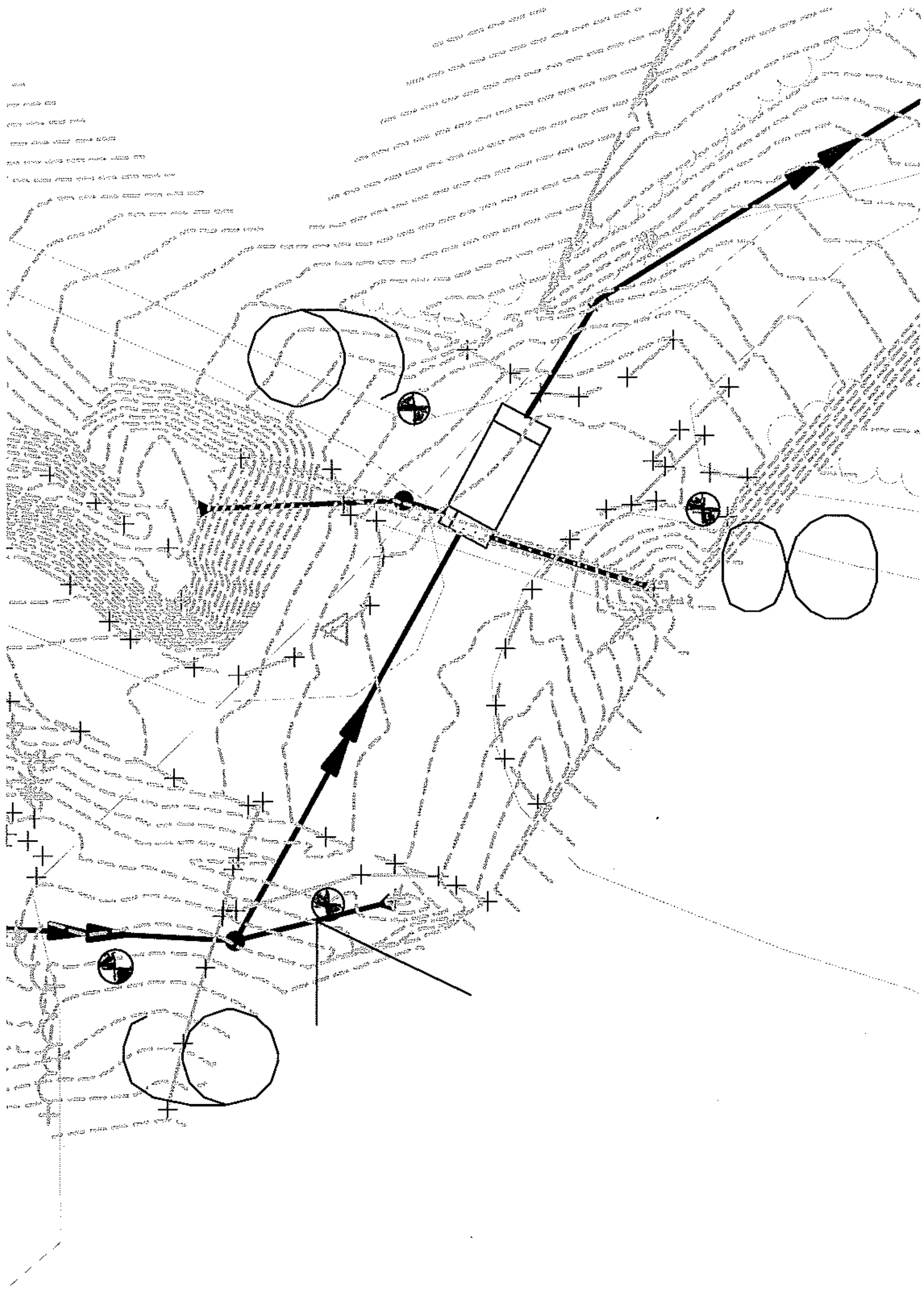
Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

Root Inclusions

With roots:	Judged to have sufficient quantity of roots to influence the soil properties.
Trace roots:	Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.



Modular Bridge Design Calculations

Project Name:	Knowlton Creek Duluth, MN
Serial Number:	61MB21HS20-JMI344
Owner:	Spirit Mountain Recreation Area Duluth, MN
Fabricator:	TrueNorth Steel 5405 Momont Road Missoula, MT 59808 (406) 532-7122
Design Engineer:	Beaudette Consulting Engineers, Inc. 131 West Main St. Missoula, MT 59802 (406) 721-7315
Bridge Design Code:	AASHTO LRFD Bridge Design Specifications 6th Ed 2012
Date:	September 3, 2014

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.
Thomas R. Beaudette
Date 09/05/14 Reg. No. 21133

TABLE OF CONTENTS

Note: NA Is Not Applicable

BEAUDETTE CONSULTING ENGINEERS, INC. bce STRUCTURAL	Project: 21x61 HS20	Page:	1
	Client: TrueNorth Steel	Design By:	CW
	Job #: 14-692	Review By:	MS
	Description: S/N 61MB21HS20-JMI344	Date:	09/03/14

Steel Girder Load Factor Design Simple Span AASHTO 17th Edition 2002 — SB 1/2

Girder Design

Note: NA Is Not Applicable

Girder Miscellaneous Input

Design Live Loading	HS 20-44	
Steel Beam Or Plate Girder Grade	A709 Grade 50W	
Steel Beam Section	W33X118	
Type Of Deck Superstructure	Steel Bridge Corr Plank (2" Min)	
Span Of Beam L (ft)	60.00 ft	
Spacing Of Beams S (ft)	3.75 ft	
Beam Comp Flange Bracing Dist L_b (ft)	1.00 ft	
Number Of Beams N_b	6	
Number Of Design Lanes	2	
D CL Bm Ext Web To Int Edge Curb de (f	1.50 ft	de Positive If Ext Web Is Inboard Of Int Face Of Traffic Railing

Service Level Deflection Summary

Girder Service LL Deflection Span Ratio	L / 594
Girder Dead Load Camber Req (in)	11/8 in
Girder Deflection Dead Load δ_{DMax} (in)	1.317 in
Girder Deflection Live Load δ_{LMax} (in)	1.213 in
Girder Weight (lb/ft)	118.0 lb/ft

Girder Design Loading Input

w_{Deck} (psf)	9.6 psf	Deck 12"x4-1/4" 9 ga = 9.6 psf, Deck 12"x4-1/4" 7 ga = 11.5 psf
w_{Plank} (psf)	0.0 psf	3x Timber Deck = 7.3 psf, 4x Timber Deck = 10.3 psf
$w_{Ballast}$ (psf)	165.0 psf	8" Side Dam, Deck 12x4-1/4", Ballast = 80 psf (140 pcf)
$w_{Wearing}$ (psf)	0.0 psf	2" Wearing Surface = 23.3 psf, Municipality 3" Asphalt = 35.0 psf

Custom Plate Girder Miscellaneous Input

Custom Girder Depth d (in)	29.70 in	NA	$L/18 \le d \le L/12$ (Highway Bridges)	Custom Girder I Section
Custom Girder Web Thickness t_w (in)	0.520 in	NA	$t_w = d/125$	Custom Girder I Section
Custom Girder Flange Width b_f (in)	10.50 in	NA	$d/4 \le b_f \le d/3$	Custom Girder I Section
Custom Girder Flange Thickness t_f (in)	0.670 in	NA	$b_f/24 \le t_f \le b_f/10$	Custom Girder I Section

Custom Plate Girder Proportioning

Applies To Fabricated I-Shaped Girders

Girder Comp Flange b_f	11.50 in	Assume $A_{tf} = A_{cf}$	AASHTO 10.48
Girder Comp Flange b_f>=0.15D	4.71 in		AASHTO 10.48
Girder Comp Flange t_f	0.74 in		AASHTO 10.48
Girder Comp Flange t_f>=1.5t_w	0.83 in		AASHTO 10.48
Girder Tension Flange b_f/t_f	15.54		AASHTO 10.48
Girder Tension Flange b_f/t_f Limit	24.00		AASHTO 10.48

Girder Miscellaneous Calculations

Live Load Distribution Factor	0.833		AASHTO 3.23.1
Reduction In Load Intensity Factor	1.000		AASHTO 3.12.1
Live Load Impact I	0.270		AASHTO 3.8
Load Factor Case	LFD Group I	Loading Equal Or Greater H20 Group 1	AASHTO 3.22.1A
γ	1.30	Loading Less Than H20 Group 1A	AASHTO 3.22.1A
β_D	1.00	Overload Group 1B	AASHTO 3.22.1A
β_L	1.67	See 3.5 & 3.22.5 For 1A & 1B Use	AASHTO 3.22.1A
W_D (k/ft)	0.773 k/ft		

Girder Demand Calculations

M_D (ft*k)	347.74 ft*k	
M_L (ft*k)	806.50 ft*k	App A HS 20-44, FS U80
M_{L+I} (ft*k)	426.86 ft*k	
M_f (ft*k)	1378.78 ft*k	
V_D (k)	23.18 k	
V_L (k)	60.80 k	App A HS 20-44, FS U80
V_{L+I} (k)	32.18 k	
V_f (k)	100.00 k	

Girder Capacity Summary

Girder Design Moment M_f (ft*k)	1378.78 ft*k		
Girder Moment Capacity M_u (ft*k)	1729.17 ft*k	OK	AASHTO 10.48.4.1
Girder Design Shear V_f (k)	100.00 k		
Girder Shear Capacity V_u (k)	501.15 k	OK	AASHTO 10.48.8.1

Girder Service Level Deflection Summary

Girder Service LL Deflection Span Ratio	L / 594	Optional L / 800 Criteria Limit	AASHTO 10.6.2
Girder Trans Axis LL Rotation θ_{LL} (rad)	0.0067 rad	Assume DL Rotation Zero From Camber	AASHTO Brg Manual Pg 39

BEAUDETTE CONSULTING ENGINEERS, INC. bce STRUCTURAL	Project:	21x61 HS20	Page:	2
	Client:	TrueNorth Steel	Design By:	CW
	Job #:	14-692	Review By:	MS
	Description:	S/N 61MB21HS20-JMI344	Date:	09/03/14

Steel Girder Load Factor Design Simple Span AASHTO 17th Edition 2002 SB 2/2

Girder Compact Section Calculations				
Smaller Moment At End L_b M_1 (ft*k)	1378.78 ft*k		Conservatively Mf For Compact Section	AASHTO 10.48.1.1c
F_y (ksi)	50.00 ksi			
Girder Flange Ratio λ=b/t	15.54			
Girder Flange Compact Ratio Limit λ_{cf}	18.38	**OK, Compact Flange**		AASHTO 10.48.1.1a
Girder Web D (in)	31.42 in			AASHTO 10.48.8.1
Girder Web Ratio λ=D/t_w	57.13			
Girder Web Compact Web Ratio Limit λ_{cv}	86.00	**OK, Compact Web**		AASHTO 10.48.1.1b
Girder Web Flange Combined Ratio	129.86			AASHTO 10.48.1.1b
Girder Web Flange Combined Ratio Limit	150.49	**NA**		AASHTO 10.48.1.1b
Girder Lateral Bracing Criteria Ratio L_b/r_y	5.17			
Girder Lateral Bracing Compact Limit	36.92	**OK, Lateral Bracing Compact**		AASHTO 10.48.1.1c
Girder Z_x (in^3)	415.00 in^3			
Girder Compact Moment M_u (ft*k)	1729.17 ft*k			AASHTO 10.48.4.1
Girder NonCompact Section Calculations				
F_y (ksi)	50.00 ksi			
Girder Flange NonCompact Ratio Limit λ_f	24.00	**OK, Compact Flange**		AASHTO 10.48.2.1a
Girder Web D (in)	31.42 in			AASHTO 10.48.8.1
Girder Web t_w (in)	0.550 in			
Girder Web NonCompact $t_w \geq D/150$	0.209 in	**OK, Compact Web**	Assume Unstiffened W	AASHTO 10.48.2.1b
Girder Flange Area A_f (in^2)	8.51 in^2			
Girder Bracing NonCompact Limit (ft)	8.62 ft	**OK, Lateral Bracing Compact**		
Girder Flange f_b (ksi)	46.09 ksi	**OK, Lateral Bracing Compact**		
Girder λ	15400		Assume D_c <= D/2 NonComposite	AASHTO 10.48.4.1
Grider Depth Web In Comp D_c (in)	15.71 in			AASHTO 10.48.4.1
Girder A_{fc} (in^2)	8.51 in^2			
R_b	1.00			AASHTO 10.48.4.1
F_{cr} (ksi)	50 ksi			
Girder S_{xc} (in^3)	359.00 in^3		NonComposite Homogenous, $S_{xc} = S_{xt}$	
Girder NonCompact Moment M_u (ft*k)	1495.83 ft*k			AASHTO 10.48.4.1
Girder Partially Braced Section Calculations				
F_y (ksi)	50.00 ksi			
Girder Factor C_b	1.00		Conservatively 1.0	AASHTO 10.48.4.1
Grider Depth Web In Comp D_c (in)	15.71 in			AASHTO 10.48.4.1
Girder λ	15400		Assume D_c <= D/2 NonComposite	AASHTO 10.48.4.1
Girder I_{yc} (in^4)	93.79 in4		Assume $I_{yc} = I_{yt}$, 10.48.4.1	
Girder A_{fc} (in^2)	8.51 in^2			AASHTO 10.48.4.1
Girder Comp Flange r' (in)	3.32 in			
Girder S_{xc} (in^3)	359.00 in^3		NonComposite Homogenous, $S_{xc} = S_{xt}$	
Girder L_p (ft)	11.75 ft			AASHTO 10.48.4.1
Girder L_r (ft)	26.13 ft			AASHTO 10.48.4.1
Grider Ratio D_c/t_w	28.56			AASHTO 10.48.4.1
Girder Ratio $\lambda/\sqrt{F_y}$	68.87			AASHTO 10.48.4.1
Girder Moment M_r (ft*k)	1495.83 ft*k			AASHTO 10.48.4.1
R_b	1.00			AASHTO 10.48.4.1
Girder LTB Moment M_u (ft*k)	1495.83 ft*k			AASHTO 10.48.4.1
Girder Moment Capacity Calculations			Assume Axial P_u Less Than 15% P_n Else Beam-Column	
Girder Design Moment M_f (ft*k)	1378.78 ft*k			
Girder Moment Capacity M_u (ft*k)	1729.17 ft*k	**OK**		AASHTO 10.48.4.1
Girder Shear Capacity Calculations				
F_y (ksi)	50.00 ksi			
Girder Web D (in)	31.42 in			AASHTO 10.48.8.1
Girder Plastic Shear Force V_p (k)	501.15 k			AASHTO 10.48.8.1
Girder Shear Buckling Coefficient k	5.00		Unstiffened Beams	AASHTO 10.48.8.1
Girder Shear Factor C	1.00			AASHTO 10.48.8.1
Girder Design Shear V_f (k)	100.00 k			
Girder Shear Capacity V_u (k)	501.15 k	**OK**		AASHTO 10.48.8.1
Girder Service Level Deflection Calculations				
Service Deflection Distribution Factor	0.333		All Design Lanes Loaded, Deflect Equal	AASHTO 10.6.4
E_s (ksi)	29000 ksi			
Girder Deflection Dead Load δ_{DMax} (in)	1.317 in		Midspan Location, Dead Load Camber Estimate	
Girder Deflection Live Load δ_{LMax} (in)	1.213 in		Midspan Location, Not Using Reduction In Load Intensity Factor	
Girder Service LL Deflection Span Ratio	L / 594		Optional Service L / 800 Criteria Limit	AASHTO 10.6.2
Girder Trans Axis LL Rotation θ_{LL} (rad)	0.0067 rad		Assume DL Rotation Zero From Camber	AASHTO Brg Manual Pg 39

Girder Design

Note: NA Is Not Applicable

Service Level Deflection Summary

Girder Service LL Deflection Span Ratio	L / 1188	
Girder Dead Load Camber Req (in)	11/8 in	
Girder Deflection Dead Load δ_{DMax} (in)	1.317 in	
Girder Deflection Live Load δ_{LMax} (in)	0.606 in	
Girder Weight (lb/ft)	118.0 lb/ft	

Girder Miscellaneous Input

Design Live Loading	HS 20-44		
Steel Beam Or Plate Girder Grade	A709 Grade 50W		
Steel Beam Section	W33X118		
Type Of Deck Superstructure	Steel Bridge Corr Plank (2" Min)		
Span Of Beam L (ft)	60.00 ft		
Spacing Of Beams S (ft)	3.75 ft		
Beam Comp Flange Bracing Dist L_b (ft)	1.00 ft		
Number Of Beams N_b	6		
Number Of Design Lanes	2		
D CL Bm Ext Web To Int Edge Curb de (f	1.50 ft	de Positive If Ext Web Is Inboard Of Int Face Of Traffic Railing	

Girder Design Loading Input

w_{Deck} (psf)	9.6 psf	Deck 12"x4-1/4" 9 ga = 9.6 psf, Deck 12"x4-1/4" 7 ga = 11.5 psf	
w_{Plank} (psf)	0.0 psf	3x Timber Deck = 7.3 psf, 4x Timber Deck = 10.3 psf	
$w_{Ballast}$ (psf)	165.0 psf	8" Side Dam, Deck 12x4-1/4", Ballast = 80 psf (140 pcf)	
$w_{Wearing}$ (psf)	0.0 psf	2" Wearing Surface = 23.3 psf, Municipality 3" Asphalt = 35.0 psf	

Custom Plate Girder Miscellaneous Input

Custom Girder Depth d (in)	29.70 in NA	$L/18 \le d \le L/12$ (Highway Bridges)	Custom Girder I Section
Custom Girder Web Thickness t_w (in)	0.520 in NA	$t_w = d/125$	Custom Girder I Section
Custom Girder Flange Width b_f (in)	10.50 in NA	$d/4 \le b_f \le d/3$	Custom Girder I Section
Custom Girder Flange Thickness t_f (in)	0.670 in NA	$b_f/24 \le t_f \le b_f/10$	Custom Girder I Section

Custom Plate Girder Proportioning

		Applies To Fabricated I-Shaped Girders	
Girder Comp Flange b_f	11.50 in	Assume $A_{tf} = A_{cf}$	AASHTO 10.48
Girder Comp Flange b_f>=0.15D	4.71 in		AASHTO 10.48
Girder Comp Flange t_f	0.74 in		AASHTO 10.48
Girder Comp Flange t_f>=1.5t_w	0.83 in		AASHTO 10.48
Girder Tension Flange b_f/t_f	15.54		AASHTO 10.48
Girder Tension Flange b_f/t_f Limit	24.00		AASHTO 10.48

Girder Miscellaneous Calculations

Live Load Distribution Factor	0.833		AASHTO 3.23.1
Reduction In Load Intensity Factor	1.000		AASHTO 3.12.1
Live Load Impact I	0.270		AASHTO 3.8
Load Factor Case	LFD Group I	Loading Equal Or Greater H20 Group 1	AASHTO 3.22.1A
γ	1.30	Loading Less Than H20 Group 1A	AASHTO 3.22.1A
β_D	1.00	Overload Group 1B	AASHTO 3.22.1A
β_L	1.67	See 3.5 & 3.22.5 For 1A & 1B Use	AASHTO 3.22.1A
W_D (k/ft)	0.773 k/ft		

Girder Demand Calculations

M_D (ft*k)	347.74 ft*k	
M_L (ft*k)	806.50 ft*k	App A HS 20-44, FS U80
M_{L+I} (ft*k)	426.86 ft*k	
M_f (ft*k)	1378.78 ft*k	
V_D (k)	23.18 k	
V_L (k)	60.80 k	App A HS 20-44, FS U80
V_{L+I} (k)	32.18 k	
V_f (k)	100.00 k	

Girder Capacity Summary

Girder Design Moment M_f (ft*k)	1378.78 ft*k	
Girder Moment Capacity M_u (ft*k)	1729.17 ft*k **OK**	AASHTO 10.48.4.1
Girder Design Shear V_f (k)	100.00 k	
Girder Shear Capacity V_u (k)	501.15 k **OK**	AASHTO 10.48.8.1

Girder Service Level Deflection Summary

Girder Service LL Deflection Span Ratio	L / 1188	Optional L / 800 Criteria Limit	AASHTO 10.6.2
Girder Trans Axis LL Rotation θ_{LL} (rad)	0.0034 rad	Assume DL Rotation Zero From Camber	AASHTO Brg Manual Pg 39

Girder Compact Section Calculations			
Smaller Moment At End L_b M_1 (ft*k)	1378.78 ft*k	Conservatively Mf For Compact Section	AASHTO 10.48.1.1c
F_y (ksi)	50.00 ksi		
Girder Flange Ratio λ=b/t	15.54		
Girder Flange Compact Ratio Limit λ_{cf}	18.38	**OK, Compact Flange**	AASHTO 10.48.1.1a
Girder Web D (in)	31.42 in		AASHTO 10.48.8.1
Girder Web Ratio λ=D/t_w	57.13		
Girder Web Compact Web Ratio Limit λ_{cw}	86.00	**OK, Compact Web**	AASHTO 10.48.1.1b
Girder Web Flange Combined Ratio	129.86		AASHTO 10.48.1.1b
Girder Web Flange Combined Ratio Limit	150.49	**NA**	AASHTO 10.48.1.1b
Girder Lateral Bracing Criteria Ratio L_b/r_y	5.17		
Girder Lateral Bracing Compact Limit	36.92	**OK, Lateral Bracing Compact**	AASHTO 10.48.1.1c
Girder Z_x (in^3)	415.00 in^3		
Girder Compact Moment M_u (ft*k)	1729.17 ft*k		AASHTO 10.48.4.1
Girder NonCompact Section Calculations			
F_y (ksi)	50.00 ksi		
Girder Flange NonCompact Ratio Limit λ_r	24.00	**OK, Compact Flange**	AASHTO 10.48.2.1a
Girder Web D (in)	31.42 in		AASHTO 10.48.8.1
Girder Web t_w (in)	0.550 in		
Girder Web NonCompact t_w≥D/150	0.209 in	**OK, Compact Web** Assume Unstiffened W	AASHTO 10.48.2.1b
Girder Flange Area A_f (in^2)	8.51 in^2		
Girder Bracing NonCompact Limit (ft)	8.62 ft	**OK, Lateral Bracing Compact**	
Girder Flange f_b (ksi)	46.09 ksi	**OK, Lateral Bracing Compact**	
Girder λ	15400	Assume D_c <= D/2 NonComposite	AASHTO 10.48.4.1
Grider Depth Web In Comp D_c (in)	15.71 in		AASHTO 10.48.4.1
Girder A_{fc} (in^2)	8.51 in^2		
R_b	1.00		AASHTO 10.48.4.1
F_{cr} (ksi)	50 ksi		
Girder S_{xc} (in^3)	359.00 in^3	NonComposite Homogenous, $S_{xc} = S_{xt}$	
Girder NonCompact Moment M_u (ft*k)	1495.83 ft*k		AASHTO 10.48.4.1
Girder Partially Braced Section Calculations			
F_y (ksi)	50.00 ksi		
Girder Factor C_b	1.00	Conservatively 1.0	AASHTO 10.48.4.1
Grider Depth Web In Comp D_c (in)	15.71 in		AASHTO 10.48.4.1
Girder λ	15400	Assume D_c <= D/2 NonComposite	AASHTO 10.48.4.1
Girder I_{yc} (in^4)	93.79 in4	Assume $I_{yc} = I_{yt}$, 10.48.4.1	
Girder A_{fc} (in^2)	8.51 in^2		AASHTO 10.48.4.1
Girder Comp Flange r' (in)	3.32 in		
Girder S_{xc} (in^3)	359.00 in^3	NonComposite Homogenous, $S_{xc} = S_{xt}$	
Girder L_p (ft)	11.75 ft		AASHTO 10.48.4.1
Girder L_r (ft)	26.13 ft		AASHTO 10.48.4.1
Grider Ratio D_c/t_w	28.56		AASHTO 10.48.4.1
Girder Ratio $\lambda/\sqrt{F_y}$	68.87		AASHTO 10.48.4.1
Girder Moment M_r (ft*k)	1495.83 ft*k		AASHTO 10.48.4.1
R_b	1.00		AASHTO 10.48.4.1
Girder LTB Moment M_u (ft*k)	1495.83 ft*k		AASHTO 10.48.4.1
Girder Moment Capacity Calculations		Assume Axial P_u Less Than 15% P_n Else Beam-Column	
Girder Design Moment M_f (ft*k)	1378.78 ft*k		
Girder Moment Capacity M_u (ft*k)	1729.17 ft*k	**OK**	AASHTO 10.48.4.1
Girder Shear Capacity Calculations			
F_y (ksi)	50.00 ksi		
Girder Web D (in)	31.42 in		AASHTO 10.48.8.1
Girder Plastic Shear Force V_p (k)	501.15 k		AASHTO 10.48.8.1
Girder Shear Buckling Coefficient k	5.00	Unstiffened Beams	AASHTO 10.48.8.1
Girder Shear Factor C	1.00		AASHTO 10.48.8.1
Girder Design Shear V_f (k)	100.00 k		
Girder Shear Capacity V_u (k)	501.15 k	**OK**	AASHTO 10.48.8.1
Girder Service Level Deflection Calculations			
Service Deflection Distribution Factor	0.167	All Design Lanes Loaded, Deflect Equal	AASHTO 10.6.4
E_s (ksi)	29000 ksi		
Girder Deflection Dead Load δ_{DMax} (in)	1.317 in	Midspan Location, Dead Load Camber Estimate	
Girder Deflection Live Load δ_{LMax} (in)	0.606 in	Midspan Location, Not Using Reduction In Load Intensity Factor	
Girder Service LL Deflection Span Ratio	L / 1188	Optional Service L / 800 Criteria Limit	AASHTO 10.6.2
Girder Trans Axis LL Rotation θ_{LL} (rad)	0.0034 rad	Assume DL Rotation Zero From Camber	AASHTO Brg Manual Pg 39

Table 16-8. - Maximum vehicle moment, reaction, and deflection coefficient. Simple span, one wheel line, impact factor not included *(continued).*

Vehicle type HS 20-44

Span (ft)	Moment (ft-kips)	Reaction[a] (kips)	Deflection[b] coefficient	Span (ft)	Moment (ft-kips)	Reaction[a] (kips)	Deflection[b] coefficient	Span (ft)	Moment (ft-kips)	Reaction[a] (kips)	Deflection[b] coefficient
10	40.00	16.00	5.76×10^{8}	47	287.17	28.85	1.09×10^{11}	84	618.33	32.00	7.17×10^{11}
11	44.00	16.00	7.67×10^{8}	48	296.08	29.00	1.17×10^{11}	85	627.31	32.05	7.44×10^{11}
12	48.00	16.00	9.95×10^{8}	49	305.00	29.14	1.25×10^{11}	86	636.28	32.09	7.72×10^{11}
13	52.00	16.00	1.27×10^{9}	50	313.92	29.28	1.34×10^{11}	87	645.25	32.14	8.00×10^{11}
14	56.00	16.00	1.58×10^{9}	51	322.84	29.41	1.43×10^{11}	88	654.23	32.18	8.29×10^{11}
15	60.00	17.07	1.94×10^{9}	52	331.77	29.54	1.53×10^{11}	89	663.20	32.22	8.59×10^{11}
16	64.00	18.00	2.36×10^{9}	53	340.70	29.66	1.63×10^{11}	90	672.18	32.27	8.90×10^{11}
17	68.00	18.82	2.83×10^{9}	54	349.63	29.78	1.73×10^{11}	91	681.15	32.31	9.21×10^{11}
18	72.00	19.56	3.36×10^{9}	55	358.56	29.89	1.84×10^{11}	92	690.13	32.35	9.53×10^{11}
19	76.00	20.21	3.95×10^{9}	56	367.50	30.00	1.96×10^{11}	93	699.11	32.39	9.85×10^{11}
20	80.00	20.80	4.61×10^{9}	57	376.44	30.11	2.07×10^{11}	94	708.09	32.43	1.02×10^{12}
21	84.00	21.33	5.33×10^{9}	58	385.38	30.21	2.19×10^{11}	95	717.06	32.46	1.05×10^{12}
22	88.00	21.82	6.40×10^{9}	59	394.32	30.31	2.32×10^{11}	96	726.04	32.50	1.09×10^{12}
23	92.00	22.26	7.81×10^{9}	60	403.27	30.40	2.45×10^{11}	97	735.02	32.54	1.12×10^{12}
24	96.33	22.67	9.38×10^{9}	61	412.21	30.49	2.59×10^{11}	98	744.00	32.57	1.16×10^{12}
25	103.68	23.04	1.11×10^{10}	62	421.16	30.58	2.73×10^{11}	99	752.98	32.61	1.20×10^{12}
26	111.08	23.38	1.30×10^{10}	63	430.11	30.67	2.87×10^{11}	100	761.96	32.64	1.23×10^{12}
27	118.52	23.70	1.51×10^{10}	64	439.06	30.75	3.02×10^{11}	101	770.94	32.67	1.27×10^{12}
28	126.00	24.00	1.74×10^{10}	65	448.02	30.83	3.18×10^{11}	102	779.92	32.71	1.31×10^{12}
29	133.52	24.41	1.99×10^{10}	66	456.97	30.91	3.34×10^{11}	103	788.90	32.74	1.35×10^{12}
30	141.07	24.80	2.25×10^{10}	67	465.93	30.99	3.50×10^{11}	104	797.88	32.77	1.39×10^{12}
31	148.65	25.16	2.54×10^{10}	68	474.88	31.06	3.67×10^{11}	105	806.87	32.80	1.44×10^{12}
32	156.25	25.50	2.85×10^{10}	69	483.84	31.13	3.85×10^{11}	106	815.85	32.83	1.48×10^{12}
33	163.88	25.82	3.18×10^{10}	70	492.80	31.20	4.03×10^{11}	107	824.83	32.86	1.52×10^{12}
34	171.76	26.12	3.53×10^{10}	71	501.76	31.27	4.22×10^{11}	108	833.81	32.89	1.57×10^{12}
35	180.60	26.40	3.91×10^{10}	72	510.72	31.33	4.41×10^{11}	109	842.80	32.92	1.61×10^{12}
36	189.44	26.67	4.31×10^{10}	73	519.68	31.40	4.61×10^{11}	110	851.78	32.95	1.66×10^{12}
37	198.30	26.92	4.74×10^{10}	74	528.65	31.46	4.81×10^{11}	111	860.77	32.97	1.70×10^{12}
38	207.16	27.16	5.19×10^{10}	75	537.61	31.52	5.02×10^{11}	112	869.75	33.00	1.75×10^{12}
39	216.03	27.38	5.67×10^{10}	76	546.58	31.58	5.23×10^{11}	113	878.73	33.03	1.80×10^{12}
40	224.90	27.60	6.18×10^{10}	77	555.55	31.64	5.45×10^{11}	114	887.72	33.05	1.85×10^{12}
41	233.78	27.80	6.74×10^{10}	78	564.51	31.69	5.68×10^{11}	115	896.70	33.08	1.90×10^{12}
42	242.67	28.00	7.34×10^{10}	79	573.48	31.75	5.91×10^{11}	116	905.69	33.10	1.95×10^{12}
43	251.56	28.19	7.98×10^{10}	80	582.45	31.80	6.15×10^{11}	117	914.68	33.13	2.00×10^{12}
44	260.45	28.36	8.65×10^{10}	81	591.42	31.85	6.40×10^{11}	118	923.66	33.15	2.06×10^{12}
45	269.36	28.53	9.35×10^{10}	82	600.39	31.90	6.65×10^{11}	119	932.65	33.18	2.11×10^{12}
46	278.26	28.70	1.01×10^{11}	83	609.36	31.95	6.91×10^{11}	120	941.63	33.20	2.16×10^{12}

[a] Reactions are based on point bearing at span ends.

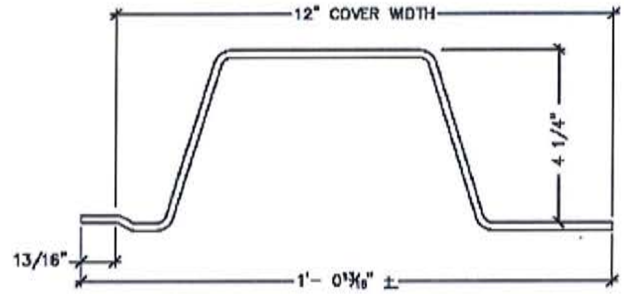
[b] To obtain deflection for one wheel line in inches, divide the deflection coefficient by EI (lb-in²).

[c] Truck loads control for all spans shown.

Deck Splice Connection Design

w_{Deck} (psf)	9.6 psf	Deck 12"x4-1/4" 9 ga = 9.6 psf, Deck 12"x4-1/4" 7 ga = 11.5 psf	
w_{Plank} (psf)	0.0 psf	3x Timber Deck = 7.3 psf, 4x Timber Deck = 10.3 psf	
$w_{Ballast}$ (psf)	165.0 psf	8" Side Dam, Deck 12x4-1/4", Ballast = 80 psf (140 pcf)	
$w_{Wearing}$ (psf)	0.0 psf	2" Wearing Surface = 23.3 psf, Municipality 3" Asphalt = 35 psf	
Deck Splice Connection Miscellaneous Input			
$w_{LLDesignLane}$ (psf)	0.0 psf	640 lb/ft Divided By 10'-0" Lane	
Design Truck Wheel Load P_{LL} (k)	16.00 k		AASHTO 3.6.1.2.2
Factored 1.25*w_{DC} (psf)	218.3 psf	Use 1.25DC	
Factored 1.50*w_{DW} (psf)	0.0 psf	Use 1.50DW	
Factored 1.75*$w_{DesignLane}$*m (psf)	0.0 psf	Use 1.75LL, m Factor Per Input	
Factored 1.30*$w_{DesignLane}$*m (psf)	0.0 psf	Use 1.30LL, m Factor Per Input	
Factored 1.75*P_{LL}*IM*m (k)	37.24 k	Use 1.75LL, IM=33% And m Factor Per Input	
Factored 1.30*P_{LL}*IM*m (k)	27.66 k	Use 1.30LL, IM=33% And m Factor Per Input	
Decking Surface Type	4" Gravel Ballast Over 12"x4-1/4" Corrugated Steel Deck		
Deck Type	12"x4-1/4" 9 Ga Corrugated Steel Deck		
Distributed Factored 1.75*P_{LL}*IM*m (k/ft)	20.08 k/ft	45 Deg Dist From 10" Tire L, Depends Decking D, AASHTO 9.8.5.2	
Distributed Factored 1.30*P_{LL}*IM*m (k/ft)	14.92 k/ft	45 Deg Dist From 10" Tire L, Depends Decking D, AASHTO 9.8.5.2	
Wheel Load Offset From Splice a (in)	10.00 in	Assume Full Tire On One Side, 20 inch W	AASHTO 3.6.1.2.5
Deck Cantilever From Beam Flange l (in)	16.75 in	May Be User Modified	
Wheel Load Offset From Beam Flange b (	6.75 in		
Deck Splice Shear Force $V_{1StrengthI}$ (k/ft)	5.61 k/ft	Strength I Load Case Bolt Shear, Proppe	AISC Table 3-23.12,14
Deck Splice Shear Force $V_{1ServiceII}$ (k/ft)	4.24 k/ft	Service II Load Case Bolt Slip, Propped C	AISC Table 3-23.12,14
Deck Splice Bolts Slip, Shear, Bearing Calculations			
Steel Deck Splice Material Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Deck Splice Bolt Grade	A325-X		
Deck Splice Bolt Diameter (in)	7/8 in		
Hole Size Type	Long-Slotted Holes With Slot Perpendicular Force		AASHTO 6.13.2.8-2
Surface Condition	Class B Surface - Unpainted Blast Cleaned		AASHTO 6.13.2.8-3
Hole Size Type Factor K_h	0.70		AASHTO 6.13.2.8-2
Surface Condition Factor K_s	0.50		AASHTO 6.13.2.8-3
Number Of Slip Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Required Bolt Tension P_t (k)	39 k		AASHTO 6.13.2.8-1
Bolt Slip Resistance Capacity R_n (k)	13.65 k		AASHTO 6.13.2.8
ϕ_s	0.80		AASHTO 6.5.4.2
Number Of Shear Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Bolt Tensile Strength F_{ub} (ksi)	120 ksi		AASHTO 6.4.3.1
Bolt Shear Resistance Capacity $\phi_s R_n$ (k)	27.69 k		AASHTO 6.13.2.7
Bolt Spacing Required $S_{BoltReq}$ (in)	38.61 in		
Bolt Design Spacing S_{bolt} (in)	24.000 in OK		
Splice Bar Thickness t_{Splice} (in)	0.375 in		AASHTO 6.5.4.2
ϕ_{bb}	0.80		AASHTO 6.5.4.2
Bolt Clear Distance Btwn Holes L_{cBtwn} (in)	23.000 in		AASHTO 6.13.2.9
Bolt Clear End Distance L_{cEnd} (in)	2.000 in		AASHTO 6.13.2.9
Bolt Check Distance 2.0d (in)	1.75 in		AASHTO 6.13.2.9
Deck Splice Material F_u (ksi)	70 ksi		AASHTO 6.4.1
Bolt Brg Controlling Thickness (in)	0.375 in	Assumes No Countersunk Holes	AASHTO 6.13.2.9
Deck Splice Force Bearing P_{uBrg} (k)	11.21 k		
Deck Splice Bolt Brg Resistance $\phi_{bb}R_n$ (k)	36.75 k OK		AASHTO 6.13.2.9
Deck To Splice Min Fillet Weld Size (in)	2/16 in		AASHTO 6.13.3.4
Deck To Splice Max Fillet Weld Size (in)	3/16 in		AASHTO 6.13.3.4
Deck To Splice Fillet Weld Size (in)	1/8 in OK		
ϕ_{e2}	0.80		AASHTO 6.5.4.2
Fillet Weld Shear Capacity $\phi_{e2}R_n$ (k/in)	2.97 k/in		AASHTO 6.13.3.2.4b-1
Fillet Weld Length Required $L_{WeldReq}$ (in/ft)	1.89 in/ft		
Fillet Weld Design Length L_{Weld} (in/ft)	4.00 in/ft OK	Minimum Weld Length Shall Be 1.5 in	AASHTO 6.13.3.5
$t_{MinDeckSplice}$ Match Weld Rupture (in)	0.088 in OK		AISC 13th Ed. Page 9-5

Big R Bridge roll-forms 4¼" deep Structural Bridge Deck using Grade 50 steel in either pre-galvanized or bare steel. Our deck is the strongest in the industry. While we use it on our all-steel modular bridges, it can also be installed on bridges that are erected in the field. It is widely used for new construction and to rehabilitate existing bridges.



Bridge Deck Fastening

- Weld each piece to stringer with 3" fillet weld the thickness of the deck.
- Weld between stringers at overlap with 3" fillet weld every 36".
- End splices are to be staggered and located over stringers. Crests of end splices are to be butt welded.
- Can be field bolted to stringers when necessary.

Asphalt Surface Installation

- Clean metal surfaces of all foreign matter.
- Apply tack coat over the deck surface.
- Fill and compact all corrugation troughs with asphalt to the top of the deck.
- Overlay with a leveling course and additional courses as necessary to achieve a final wearing course. Compact to required density.

Engineering Data, 12" x 4¼" Structural Bridge Deck

Thickness		Yield Point (ksi)	Weight (psf)	Moment of Inertia (in.^{4}/ft)	Section Modulus (in.^{3}/ft)	Maximum Net Span*			
Gauge	Inches					HS-20 Span	HS-25 Span	HS-30 Span	HL-93 Span
9	0.149	50	9.6	8.62	3.65	57"	53"	50"	57"
7	0.179	50	11.5	10.34	4.34	65"	60"	56"	65"

* Maximum net span is the clear span between stringer flanges

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bce BEAUDETTE CONSULTING ENGINEERS, INC. STRUCTURAL	Project:	21x61 HS20		Page:	11
	Client:	TrueNorth Steel		Design By:	CW
	Job #:	14-692		Review By:	MS
	Description:	S/N 61MB21HS20-JMI344		Date:	09/03/14

Modular Bridge Design AASHTO LRFD Bridge Design Specification 6th Edition 2012 — SP 1/2

Sole Plate And Bearing Pad Design

Sole Plate And Bearing Pad Miscellaneous Input

Rxn Dead Load Service II $DL_{ServiceII}$ (k)	23.18 k			
Rxn Live Load Service II $LL_{ServiceII}$ (k)	32.18 k			
Design Bearing Pad Length $L_{BearingPad}$ (in)	20.000 in	OK	Transverse To Beam Axis Bearing Pad Width	
Design Bearing Pad Width $W_{BearingPad}$ (in)	10.000 in		Longitudinal To Beam Axis Bearing Pad Length	
Design Bearing Pad Thickness $t_{Bearing}$ (in)	1.000 in		Draw Picture	
Bearing Pad Type	Plain Elastomeric Pad (PEP)			
Elastomeric Pad Hardness	Elastomer Hardness (Shore A) 70			AASHTO Table 14.7.6.2-1
Elastomer Shear Modulus G (ksi)	0.200			AASHTO Table 14.7.6.2-1
Elastomer Creep Deflection Factor a_{cr}	0.45			AASHTO Table 14.7.6.2-1, 14
Compressive Stress Calculations				
Bearing Pad Pressure σ_{DL} (ksi)	0.116 ksi	OK		AASHTO 14.7.6.3.2
Bearing Pad Pressure σ_{LL} (ksi)	0.161 ksi	OK		AASHTO 14.7.6.3.2
Bearing Pad Pressure σ_{DL+LL} (ksi)	0.277 ksi	OK		AASHTO 14.7.6.3.2
Compressive Deflection Calculations				
Elastomer Pad Shape Factor S_i	3.33			AASHTO 14.7.5.1-1
Compressive Strain ε_D	0.009		Break CDP into StrainDL, StrainLL	AASHTO 14.7.5.3.6-1
Compressive Strain ε_L	0.012			AASHTO 14.7.5.3.6-1
Initial DL Comp Deflection δ_D (in)	0.026 in			AASHTO 14.7.5.3.6, C14.7.6.
Maximum Initial Comp Deflection δ_{DMax} (in)	0.070 in	OK	Use PEP Criteria For CDP	AASHTO 14.7.6.3.3
Instant LL Comp Deflection δ_L (in)	0.036 in			AASHTO 14.7.5.3.6
Maximum Initial Comp Deflection δ_{LMax} (in)	0.125 in	OK		AASHTO 14.7.6.3.3
Long Term Comp Deflection δ_{lt} (in)	0.038 in			AASHTO 14.7.5.3.6
Total Compressive Deflection δ_{Total} (in)	0.074 in		No Limit On Total?	AASHTO 14.7.5.3.6
Shear Deformation Calculations			Limited to avoid rollover at edges and delamination due to fatigue	
Steel Girder Set Temperature T_{set} (°F)	55 °F		Assumes One End Fixed, One End Pinne	AASTO 14.7.6.3.4
Procedure A Temperature Ranges	Steel Or Aluminum Cold Climate -30° to 120°F			AASHTO 3.12.2.1
Low Friction Sliding Surface (PTFE)	Utilize Low Friction Sliding Surface (PTFE)			AASHTO 14.7.2
Type Of PTFE	Unfilled or Dimpled Unlubricated -49°F			
Design Coefficient Of Friction (PTFE)	NA		Use Only DL Stress, Conservative	AASTO 14.7.2.5-1
Max PTFE Contact Stress σ_{DL} (ksi)	NA	NA		AASTO 14.7.2.4-1
Max PTFE Contact Stress σ_{DL+LL} (ksi)	NA	NA		AASTO 14.7.2.4-1
Expansion L (ft)	60.00 ft		Input Under Girder Design Span Of Beam L	
Design Contraction Movement Δ_{Contr} (in)	0.398 in		See FHWA Example Step 6.8 Page 6-7	AASTO 14.7.6.3.4
Total Shear Deformation First Slip Δ_u (in)	NA			AASTO 14.7.6.3.1-1, 14.7.6.3
Maximum Total Shear Deformation Δ_S (in)	0.477 in			AASTO 14.7.6.3.4
Bearing Thick $\geq 2\Delta_S$ PEP, $\geq 10\Delta_S$ CDP (in)	0.955 in	OK	Influenced By Temperature Ranges	AASTO 14.7.6.3.4
Rotation Of Bearing Pad Calculations			Limited to ensure no point in the bearing undergoes net uplift	
Trans Axis Rotation $\theta_{TransDL+LLServiceI}$ (rad)	0.0067 rad		Note: Transverse Axis Is Perpendicular To Girder Axis	
Long Axis Rotation $\theta_{LongDL+LLServiceI}$ (rad)	0.0000 rad		Note: Allowance For Uncertainties = 0.005 Rad AASHTO Steel Bridge B	
Trans Axis Rotation $\theta_{TransLLServiceI}$ (rad)	0.0067 rad			
Long Axis Rotation $\theta_{LongLLServiceI}$ (rad)	0.0000 rad			
Trans Axis Rotation Stress σ_S, θ_{Trans} (ksi)	0.223 ksi	OK		AASHTO 14.7.6.3.5b-1
Long Axis Rotation Stress σ_S, θ_{Long} (ksi)	0.000 ksi	OK		AASHTO 14.7.6.3.5b-2
CDP Strain ε_c	NA		E_c = 30 ksi AASHTO Without Testing	AASHTO 14.7.6.3.5c-2
CDP Max Compressive Strain $\varepsilon_{tTransAxis}$	NA	NA	E_c = 16 ksi Alert 15175 CDP	AASHTO 14.7.6.3.5c-1
CDP Max Compressive Strain $\varepsilon_{tLongAxis}$	NA	NA		AASHTO 14.7.6.3.5c-1
Trans Axis Maximum Rotation θ_{sTrans} (rad)	NA	NA		AASHTO 14.7.6.3.5c-3
Long Axis Maximum Rotation θ_{sLong} (rad)	NA	NA		AASHTO 14.7.6.3.5c-4
Trans Axis Maximum Rotation θ_{LTrans} (rad)	NA	NA		AASHTO 14.7.6.3.5c-3
Long Axis Maximum Rotation θ_{Long} (rad)	NA	NA		AASHTO 14.7.6.3.5c-4
Stability Calculations				
Design Bearing Pad Thickness $t_{Bearing}$ (in)	1.000 in			
Maximum Bearing Pad Thickness t_{Max} (in)	3.333 in	OK		AASHTO 14.7.6.3.6
Sole Plate Bending Calculations				
Sole Plate Steel Grade	A709 Grade 50W			AASHTO Table 6.4.1-1
Beam Flange Width b_f (in)	11.50 in			
Design Sole Plate Length $L_{SolePlate}$ (in)	20.000 in	OK	Minimum 3" Each Side Of Beam	
Design Sole Plate Width $W_{SolePlate}$ (in)	12.000 in			
F_b (ksi)	27.50 ksi			AASHTO 17th Table 10.32.1A
Sole Plate Transverse $M_{SPTrans}$ (in*k/in)	0.174 in*k/in			
Sole Plate Thickness Req t_{SPReq} (in)	0.195 in			
Design Sole Plate Thickness $t_{SolePlate}$ (in)	1.000 in	OK		AASHTO 17th 10.29.4.1

Sole Plate Anchor Rod Design - Single Span Bridges

Rxn Dead Load Extreme I $DL_{ExtremeI}$ (k)	28.97 k		
Rxn Live Load Extreme I $LL_{ExtremeI}$ (k)	16.09 k	Engineering Judgement γ=0.50	
Peak Ground Acceleration PGA (%g)	0.02	Site Class B, Enter As Decimal (%g)	AASHTO Figure 3.10.2.1-1
Site Class	D	From Geotechnical Report (A-F)	AASHTO 3.10.3.1-1
Site Factor At Zero-Period F_{pga}	1.60	Based Upon Site Class	AASHTO 3.10.3.2-1
Acceleration Coefficient A_s	0.03		AASHTO 3.10.4.2-2
Horiz Response Acceleration S_1 (%g)	0.01	Site Class B, Enter As Decimal (%g)	AASHTO 3.10.2.1-3
Site Factor For Long-Period F_v	2.40	Based Upon Site Class	AASHTO 3.10.3.2-3
Acceleration Coefficient S_{D1}	0.02		AASHTO 3.10.4.2-6
Seismic Zone	1		AASHTO 3.10.6-1
Min Seismic Connection Force F_{BrgMin} (k)	0.93 k	Seismic Analysis Not Req Single 4.7.4.2	AASHTO 3.10.9.1
Seismic Connection Force F_{Brg} (k)	6.76 k	Seismic Analysis Not Req Single 4.7.4.2	AASHTO 3.10.9.2,3,4
Design Truck Axle Weight W_{Truck} (k)	72.00 k		
Design Tandem Axle Weight W_{Tandem} (k)	50.00 k		
Gamma Factor Extreme I $\gamma_{ExtremeI}$	0.50	Engineering Judgement	AASHTO 3.4.1-1
Total Braking Force F_{Brake} (k)	18.00 k		AASHTO 3.6.4
Total Anchor Connection Force F_{Total} (k)	9.76 k	Force At Each Girder Bearing Location	
Sole Plate Anchor Bolt Grade	ASTM F1554 Grade 36		AASHTO 6.4.3.1
Sole Plate Anchor Bolt Diameter (in)	1 1/4 in		
Number Of Sole Plate Anchor Bolts N_b	2		
ϕ_s	0.75		AASHTO 6.5.4.2
Number Of Shear Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Bolt Tensile Strength F_{ub} (ksi)	58 ksi	Extra Calc: ϕ_t 0.80	AASHTO 6.4.3.1
Sole Plate Anchor Bolt Shear $\phi_s R_n$ (k)	51.24 k OK	Anchor Bolt Tension $\phi_t R_n$ (k) 86.5	AASHTO 6.13.2.12
Anchor Rod To Sole Plate Min Fillet Weld	5/16 in		AASHTO 6.13.3.4
Anchor Rod To Sole Plate Max Fillet Weld	15/16 in		AASHTO 6.13.3.4
Anchor Rod To Sole Plate Fillet Weld Size	5/16 in OK		
ϕ_{e2}	0.80		AASHTO 6.5.4.2
Anchor Rod Fillet Weld Shear Cap $\phi_{e2} R_n$ (l	7.42 k/in		AASHTO 6.13.3.2.4b-1
Anchor Rod Fillet Weld Length $L_{WeldReqAnch}$	0.66 in		AASHTO 6.13.3.5
Anchor Rod Fillet Weld Design $L_{WeldAnchorPl}$	4.42 in OK	Assume Anchor Rod Welded All Around	
$t_{MinAnchorPlate}$ Match Weld Rupture (in)	0.221 in OK		AISC 13th Ed. Page 9-5

Anchor Plate To Supersill Support Beam Design - Single Span Bridges

Supersill Steel Beam Support Section	W6X12		
Anchor Plate Steel Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Design Anchor Plate Thickness $t_{AnchorPlate}$ (	1.000 in OK		AASHTO 17th 10.29.4.1
Anchor Plate To Beam Min Fillet Weld Siz	4/16 in		AASHTO 6.13.3.4
Anchor Plate To Beam Max Fillet Weld Siz	4/16 in		AASHTO 6.13.3.4
Anchor Plate To Beam Fillet Weld Size (in	1/4 in OK		
ϕ_{e2}	0.80		AASHTO 6.5.4.2
Anchor Plate Fillet Weld Shear Cap $\phi_{e2} R_n$	5.94 k/in		AASHTO 6.13.3.2.4b-1
Anchor Plate Fillet Weld Length $L_{WeldReqAnc}$	0.82 in	Weld Required Each Side Anchor Plate	AASHTO 6.13.3.5
Anchor Plate Fillet Weld Design $L_{WeldAnchorl}$	4.00 in OK		
$t_{MinAnchorPlate}$ Match Weld Rupture (in)	0.177 in OK		AISC 13th Ed. Page 9-5

Optional Anchor Rod To Concrete Abutment Design - Single Span Bridges

Concrete Abutment f_c (ksi)	4.0 ksi		
ϕ_b	0.70		AASHTO 5.5.4.2.1
Modification Factor m	0.75	Conservative To Assume m=0.75	AASHTO 5.7.5-3
Anchor Bolt Stress Brg $Stress_{Brg}$ (ksi)	1.79 ksi		AASHTO 5.7.5-2
Anchor Bolt Embed Length Req L_{Req} (in)	3.03 in		
Anchor Bolt Design Embed Length L (in)	12.00 in OK	Check Minimum DOT Req	

For simplicity, assume bearing stress varies linearly from zero at end of

Traffic Railing Design

Traffic Railing Miscellaneous Input

Guardrail Post Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Guardrail Post Section	W6X20		
Strut Beam Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Strut Beam Section	W4X13		
Strut Beam End Plate Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Traffic Railing Test Level	TL-1 Test Level One		AASHTO 13.7.2

Traffic Railing Combined Strong And Weak Axis Bending Dem

Note: TL-1 Requires Force Application Min 18" Above Deck, This Meets

Traffic Rail Post Spacing S_{Post} (ft)	6.25 ft	6'-3" Typical Traffic Rail Post Spacing	
Height Force Above Top Bolt H_{Force} (ft)	1.8125 ft	1'-9-3/4" Typical	
Dist Between Post Bolts $D_{Fastener}$ (ft)	1.4375 ft	1'-5-1/4" Typical	
Transverse Force F_t (k)	13.50 k		AASHTO Table A13.2-1
Longitudinal Force F_L (k)	4.50 k		AASHTO Table A13.2-1
Vertical Force F_v (k)	4.50 k	Use Extreme Event Per AASHTO 3.6.2.1	AASHTO Table A13.2-1
Factored Post Trans Force $F_{tExtremeII}$ (k)	13.50 k	Dist Btwn 1 Post, Extreme Event II CT Fa	AASHTO A13.2, AASHTO 17t
Factored Post Long Force $F_{LExtremeII}$ (k)	1.13 k	Dist Btwn 4 Posts, Extreme Event II CT F	AASHTO A13.2, AASHTO 17t
Factored Post Vert Force $F_{vExtremeII}$ (k)	4.50 k	Dist Btwn 1 Post, Extreme Event II CT Fa	AASHTO A13.2, AASHTO 17t

Traffic Railing Side Dam Calculations

Side Dam Steel Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Deck Type	12"x4-1/4" 9 Ga Corrugated Steel Deck		
Side Dam Plate Bolt Height $h_{BoltSideDam}$ (in)	6.375 in OK	Bottom Deck To Centerline Bolt 6-3/8" Typ.	
Post Extreme II Tension $P_{uSideDamTension}$ (k)	45.78 k	Extreme II Demands	AISC Table 3-23 Case 26, 4 E
Deck Side Dam Min Fillet Weld Size (in)	2/16 in		AASHTO 6.13.3.4
Deck Side Dam Max Fillet Weld Size (in)	3/16 in		AASHTO 6.13.3.4
Deck To Side Dam Fillet Weld Size (in)	1/8 in OK		
ϕ_{e2}	0.80		AASHTO 6.5.4.2
Fillet Weld Shear Capacity $\phi_{e2}R_n$ (k/in)	2.97 k/in		AASHTO 6.13.3.2.4b-1
Fillet Weld Length Required $L_{WeldReq}$ (in)	15.42 in	Weld Length Required Top & Bottom Flutes	
Fillet Weld Design Length L_{Weld} (in)	24.00 in OK	Minimum Weld Length Shall Be 1.5 in	AASHTO 6.13.3.5
$t_{MinSideDam}$ Match Weld Rupture (in)	0.088 in OK		AISC 13th Ed. Page 9-5
ϕ_f	1.00		AASHTO 6.5.4.2
F_y (ksi)	50.00 ksi		AASHTO 17th Table 10.32.1A
Side Dam Design Bending Width W_{SD} (in)	24.00 in	Equals The Width Of Welded Deck To Side Dam At Post	
Side Dam Transverse $M_{uSDTrans}$ (in*k/in)	4.05 in*k/in		
Side Dam Thickness Req t_{SDReq} (in)	0.697 in		
Design Side Dam Thickness t_{SD} (in)	0.375 in No Good		
Side Dam Reinforcement $t_{SDReinfReq}$ (in)	0.588 in		
Side Dam Reinforcement $t_{SDReinf}$ (in)	0.625 in OK	Extend Angle Backing Equal To Side Dam Bending Width	

Traffic Railing Post Strut Force Flange Local Bending Calculations

ϕ	0.90		AISC 13th Ed. J10.1
Post Flange Thickness t_f (in)	0.37 in		AISC Table 1-1
Post Flange Yield F_{yf} (ksi)	50.00 ksi		AASHTO 17th Table 10.32.1A
Post Extreme II Tension $P_{uSideDamTension}$ (k)	45.78 k	Extreme II Demands	AISC Table 3-23 Case 26, 4 E
Post Flange Local Bending ϕR_n (k)	37.47 k No Good		AISC 13th Ed. J10.1

Traffic Railing Post Strut Force Web Local Yielding Calculations

Assume Applied Less Than d

ϕ_b	1.00		AASHTO 6.5.4.2
Post Distance k (in)	0.62 in		AISC Table 1-1
Post Web Thickness t_w (in)	0.26 in		AISC Table 1-1
Post Length Of Bearing N (in)	4.16 in	Depth Of Strut	
Post Web Yield F_{yw} (ksi)	50.00 ksi		AASHTO 17th Table 10.32.1A
Post Extreme II Tension $P_{uSideDamTension}$ (k)	45.78 k	Extreme II Demands	AISC Table 3-23 Case 26, 4 E
Post Web Local Yielding $\phi_b R_n$ (k)	74.07 k OK		AASHTO D6.5.2

Traffic Railing Post Strut Force Web Crippling Calculations

Assume Applied Greater Than d/2

ϕ_w	0.80		AASHTO 6.5.4.2
Post Web Thickness t_w (in)	0.26 in		AISC Table 1-1
Post Flange Thickness t_f (in)	0.37 in		AISC Table 1-1
Post Depth d (in)	6.20 in		AISC Table 1-1
Post Web Yield F_{yw} (ksi)	50.00 ksi		AASHTO 17th Table 10.32.1A
Post Web E (ksi)	29000 ksi		AASHTO 6.4.1
Post Length Of Bearing N (in)	4.16 in	Depth Of Strut	
Post Extreme II Tension $P_{uSideDamTension}$ (k)	45.78 k	Extreme II Demands	AISC Table 3-23 Case 26, 4 E
Post Web Crippling $\phi_w R_n$ (k)	136.43 k OK		AASHTO D6.5.3

Traffic Railing Post Bolts Slip, Shear, Bearing, Tension Calculations

Guardrail Post Bolt Grade	A325-X		
Guardrail Post Bolt Diameter (in)	7/8 in		
Hole Size Type	Long-Slotted Holes With Slot Perpendicular Force		AASHTO 6.13.2.8-2
Surface Condition	Class B Surface - Unpainted Blast Cleaned		AASHTO 6.13.2.8-3
Hole Size Type Factor K_h	0.70		AASHTO 6.13.2.8-2
Surface Condition Factor K_s	0.50		AASHTO 6.13.2.8-3
Number Of Bolts At Side Dam $N_{BoltSide}$	2		
Number Of Bolts At Strut End $N_{BoltStrut}$	2		
Number Of Slip Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Required Bolt Tension P_t (k)	39 k		AASHTO 6.13.2.8-1
Post Design Bolt Force Slip $P_{uBoltSlip}$ (k)	1.46 k	Service II Demands	
Bolt Slip Resistance Capacity R_n (k)	13.65 k OK		AASHTO 6.13.2.8
ϕ_s	0.80		AASHTO 6.5.4.2
Number Of Shear Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Bolt Tensile Strength F_{ub} (ksi)	120 ksi		AASHTO 6.4.3.1
Post Design Bolt Force Shear $P_{uBoltShear}$ (k)	1.13 k	Extreme II Demands	
Post Bolt Shear Capacity $\phi_s R_n$ (k)	27.69 k OK		AASHTO 6.13.2.7
Strut End Plate Thickness $t_{StrutEnd}$ (in)	0.375 in		AASHTO 6.5.4.2
Side Dam Plate Thickness $t_{SideDam}$ (in)	0.375 in		AASHTO 6.5.4.2
ϕ_{bb}	0.80		AASHTO 6.5.4.2
Bolt Clear Distance Btwn Holes L_{cBtwn} (in)	16.250 in		AASHTO 6.13.2.9
Post Bolt Clear End Distance L_{cEnd} (in)	2.000 in		AASHTO 6.13.2.9
Post Bolt Check Distance 2.0d (in)	1.75 in		AASHTO 6.13.2.9
Strut End Plate F_u (ksi)	70 ksi		AASHTO 6.4.1
Post Bolt Brg Controlling Thickness (in)	0.345 in	Assumes No Countersunk Holes	AASHTO 6.13.2.9
Post Force Bearing P_{uBrg} (k)	1.13 k		
Post Bolt Brg Resistance $\phi_{bb} R_n$ (k)	33.81 k OK		AASHTO 6.13.2.9
ϕ_t	0.80		AASHTO 6.5.4.2
Post Service II Bolt Tension $P_{uBoltTension}$ (k)	19.84 k	Service II Demands	AISC Table 3-23 Case 26
Post Extreme II Bolt Tension $P_{uBoltTension}$ (k	15.26 k	Extreme II Demands	AISC Table 3-23 Case 26
Post Bolt Tension Capacity $\phi_t T_n$ (k)	43.85 k OK		AASHTO 6.13.2.10.2-1
Post Bolt Combined Slip Tension R_n (k)	6.71 k OK	Service II Demands	AASHTO 6.13.2.11-3
Post Bolt Combined Shear Tension $\phi_t T_n$ (k	43.85 k OK		AASHTO 6.13.2.11

Traffic Railing Guardrail Bolts Slip, Shear, Bearing, Tension Calculations

Guardrail Bolt Grade	A325-X		
Guardrail Bolt Diameter (in)	5/8 in		
Hole Size Type	Long-Slotted Holes With Slot Perpendicular Force		AASHTO 6.13.2.8-2
Surface Condition	Class B Surface - Unpainted Blast Cleaned		AASHTO 6.13.2.8-3
Hole Size Type Factor K_h	0.70		AASHTO 6.13.2.8-2
Surface Condition Factor K_s	0.50		AASHTO 6.13.2.8-3
Number Of Bolts At Guardrail $N_{BoltRail}$	1		
Number Of Slip Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Required Bolt Tension P_t (k)	19 k		AASHTO 6.13.2.8-1
Guardrail Design Bolt Slip $P_{uBoltSlip}$ (k)	2.93 k	Service II Demands	
Bolt Slip Resistance Capacity R_n (k)	6.65 k OK		AASHTO 6.13.2.8
ϕ_s	0.80		AASHTO 6.5.4.2
Number Of Shear Planes Per Bolt N_s	1		AASHTO 6.13.2.8
Minimum Bolt Tensile Strength F_{ub} (ksi)	120 ksi		AASHTO 6.4.3.1
Guardrail Design Bolt Shear $P_{uBoltShear}$ (k)	1.13 k	Extreme II Demands	
Guardrail Bolt Shear Capacity $\phi_s R_n$ (k)	14.15 k OK		AASHTO 6.13.2.7
Guardrail Thickness $t_{Guardrail}$ (in)	0.105 in		AASHTO 6.5.4.2
Guardrail Post Thickness $t_{GuardrailPost}$ (in)	0.365 in		AASHTO 6.5.4.2
ϕ_{bb}	0.80		AASHTO 6.5.4.2
Bolt Clear Distance Btwn Holes L_{cBtwn} (in)	2.000 in		AASHTO 6.13.2.9
Guardrail Bolt Clear End Dist L_{cEnd} (in)	2.000 in		AASHTO 6.13.2.9
Guardrail Bolt Check Distance 2.0d (in)	1.25 in		AASHTO 6.13.2.9
Guardrail / Post Controlling F_u (ksi)	70 ksi		AASHTO 6.4.1
Guardrail Bolt Brg Control Thickness (in)	0.105 in	Assumes No Countersunk Holes	AASHTO 6.13.2.9
Guardrail Force Bearing P_{uBrg} (k)	1.13 k		
Guardrail Bolt Brg Resistance $\phi_{bb} R_n$ (k)	7.35 k OK		AASHTO 6.13.2.9

HSS Traffic Railing Guardrail Flexural Calculations			C6.12.2.2.2, Ignore Lateral Torsional Resistance For Boxes, Although C	
Traffic Railing Grade	A847			AASHTO 6.4.1
Traffic Railing Section	HSS3X3X1/4			
Strong Axis / Weak Axis Bending	Strong Axis Bending			
Traffic Rail Unbraced Length l (ft)	4			
Number Of HSS Traffic Railings	2			
Traffic Rail Flange Yield Stress F_y (ksi)	50 ksi			AASHTO 6.4.1
Traffic Rail E (ksi)	29000 ksi			AASHTO 6.4.1
Traffic Rail b (in)	2.53 in			AASHTO 6.12.2.2.2
Traffic Rail Thickness t (in)	0.233 in			AASHTO 6.12.2.2.2
Traffic Rail A_g (in^2)	2.44 in^2			AASHTO 6.12.2.2.2
Traffic Rail $S_{xStrong}$, S_{yWeak} (in^3)	2.01 in^3			AASHTO 6.12.2.2.2
Traffic Rail $I_{yStrong}$, I_{xWeak} (in^4)	3.02 in4			AASHTO 6.12.2.2.2
Traffic Rail Flexural M_u (ft*k)	5.49 ft*k		Assume Traffic Rail Continuity Over 2 Spans, Start With 1 Span AISC T	
ϕ_f	1.00			AASHTO 6.5.4.2
Traffic Rail Flexural $\phi_f M_n$ (ft*k)	8.31 ft*k	OK		AASHTO 6.12.2.2.2-1
HSS Traffic Railing Guardrail Shear Calculations				
Traffic Rail Web Yield Stress F_{yw} (ksi)	50 ksi			AASHTO 6.4.1
Traffic Rail Web Depth D (in)	2.53 in			
Traffic Rail Thickness t (in)	0.233 in			AASHTO 6.12.2.2.2
Traffic Rail Plastic Shear Force V_p (k)	34.24 k			AASHTO 6.10.9.2-2
Traffic Rail Web Slenderness λ_w=D/t_w	10.88			AASHTO 6.10.9.3.2
Traffic Rail Shear Buckling Coefficient k	5.00		Unstiffened Webs	AASHTO 6.10.9.2
Traffic Rail Shear Factor C	1.00			AASHTO 6.10.9.3.2
Traffic Rail Shear Buckling V_{cr} (k)	34.24 k			AASHTO 6.10.9.2
Traffic Rail Shear V_u (k)	3.38 k		Conservatively Use Simple Span wl/2	AISC Table 3-23 Case 1
ϕ_v	1.00			AASHTO 6.5.4.2
Traffic Rail Shear $\phi_v V_n$ (k)	34.24 k	OK		AASHTO 6.10.9.1-1
HSS Traffic Railing Guardrail Deflection Calculations				
Traffic Rail Deflection δ_x (in)	0.423 in		Conservatively Use Simple Span 5wl4/38	AISC Table 3-23 Case 1
Traffic Rail Allowable Deflection δ_{xAll} (in)	0.417 in	No Good		

Traffic Railing Strut Compression Calculations

Strut Flange Local Buckling $\lambda_f = b_f/2t_f$	5.880			AISC Tables
Strut Flange Local Buckling Limit λ_r	13.487	OK		AASHTO 6.9.4.2-1
Strut Web Local Buckling $\lambda_w = h/t_w$	10.600			AISC Tables
Strut Web Local Buckling Limit λ_w	35.884	OK		AASHTO 6.9.4.2-1
Strut Length (ft)	1.750 ft		1'-9" Typical	
Strut Effective Length Factor Strong K_x	0.750		Welded End Connections K = 0.75	AASHTO 4.6.2.5
Strut Effective Length Factor Weak K_y	0.750		Welded End Connections K = 0.75	AASHTO 4.6.2.5
Strut Strong Axis Slenderness $K_x l/r_x$	9.16			AASHTO 6.9.3
Strut Weak Axis Slenderness $K_y l/r_y$	15.75			AASHTO 6.9.3
Strut Slenderness Limit Kl/r	120.00	OK	Primary Members Limit	AASHTO 6.9.3
Strut Slenderness λ_c	0.043			AASHTO 6.9.4.1-3
Strut Extreme II Comp $P_{uStrutComp}$ (k)	17.02 k		Extreme II Demands	AISC Table 3-23 Case 26
ϕ_c	1.00			AASHTO 6.5.5
Strut Compression $\phi_c P_n$ (k)	188.08 k	OK		AASHTO 6.9.4.1

Traffic Railing Post Appendix A Limit Calculations

Post Flange Yield Stress $F_{yc} = F_{yt}$ (ksi)	50 ksi	OK	App A Provisions Straight Bridges Only	AASHTO 6.4.1
Post Web D_c (in)	2.74 in			AASHTO 6.10.6.2.3-1
Post Web Slenderness $\lambda_w = 2D_{cp}/t_w$	21.04			AASHTO 6.10.6.2.3-1
Post Web Noncompact Slenderness Limit	137.27	OK, Web Is Non-Slender		AASHTO 6.10.6.2.3-1
Post Flange I_{yc} (in^4)	6.64 in4		Assume Doubly Symmetric	AASHTO 6.10.6.2.3
Post Flange I_{yt} (in^4)	6.64 in4		Assume Doubly Symmetric	AASHTO 6.10.6.2.3
Post Flange Slenderness	1.00			AASHTO 6.10.6.2.3-2
Post Flange NonCompact Slenderness Lir	0.30	OK		AASHTO 6.10.6.2.3-2

Traffic Railing Post Strong Axis Web Plastification Factor Calculations

Post Plastic Moment Capacity M_p (ft*k)	62.50 ft*k			AASHTO D6.1
Post Yield Moment Capacity M_{yc} (ft*k)	55.83 ft*k			AASHTO D6.2.1
Post Yield Moment Capacity M_{yt} (ft*k)	55.83 ft*k			AASHTO D6.2.1
Post Web Hybrid Factor R_h	1.00			AASHTO 6.10.1.10.1
Post Web Compact Ratio $\lambda_{pw(Dcp)}$	90.99	OK, Compact Web	Assume $D_c = D_{cp}$	AASHTO A6.2.1-2
Post Web NonCompact Ratio λ_{rw}	137.27	OK, Compact Web		AASHTO A6.2.1-3
Post Web Plastification Factor R_{pc}	1.12		Assume $F_{yc} = F_{yt}$	AASHTO A6.2.1-4
Post Web Plastification Factor R_{pt}	1.12			AASHTO A6.2.1-5

Traffic Railing Post Strong Axis Compression Flexural Local Buckling Calculations

Post Flange Slenderness $\lambda_f = b_{fc}/2t_{fc}$	8.25			AASHTO A6.3.2-3
Post Flange Compact Ratio λ_{pf}	9.15	OK, Compact Flange		AASHTO A6.3.2-4
Post Flange Local Buckling Coeff k_c	0.76			AASHTO A6.3.2-6
Post Flange Stress F_{yr} (ksi)	35 ksi			AASHTO A6.3
Post Flange NonCompact Ratio λ_{rf}	23.84	OK, Compact Flange		AASHTO A6.3.2-5
Post Web Plastification Factor R_{pc}	1.12		Assume $F_{yc} = F_{yt}$	AASHTO A6.2.1-4
ϕ_f	1.00			AASHTO 6.5.4.2
Post Flexural Local Buckling $\phi_f M_{nc}$ (ft*k)	62.50 ft*k		Local Buckling Resistance Comp Flange	AASHTO A6.3.2

Traffic Railing Post Strong Axis Compression Flange Flexural Lateral Torsional Buckling Calculations

Post Unbraced Length L_{bPost} (ft)	1.8125 ft		1'-9-3/4" Typical	
Post Eff Radius Gyration r_{tPost} (in)	1.65 in			AASHTO A6.3.3-10
Post Depth Btwn Center Flange h_{Post} (in)	5.84 in			AASHTO A6.3.3
Post Limiting Unbraced Length L_p (ft)	3.31 ft	Lb≤Lp		AASHTO A6.3.3-4
Post Limiting Unbraced Length L_r (ft)	19.20 ft	Lb≤Lp		AASHTO A6.3.3-5
Post Moment Gradient Modifier C_b	1.00		Unbraced Cantilever C_b = 1.0, Else Eqn.	AASHTO A6.3.3-6
Post Critical LTB Stress F_{cr} (ksi)	1683.22 ksi			AASHTO A6.3.3-8
Post Web Plastification Factor R_{pc}	1.12		Assume $F_{yc} = F_{yt}$	AASHTO A6.2.1-4
ϕ_f	1.00			AASHTO 6.5.4.2
Post Flexural LTB $\phi_f M_{nc}$ (ft*k)	62.50 ft*k		Lateral Torsional Buckling Resistance Coi	AASHTO A6.3.3

Traffic Railing Post Strong Axis Flexural Compression Flange Demand Calculations			
Post Trans Design Moment M_{Ft} (ft*k)	24.47 ft*k		AISC Table 3-23 Case 26
Post Long Design Moment M_{FL} (ft*k)	2.04 ft*k		
Post Flange Moment $M_{FLFlange}$ (ft*k)	1.02 ft*k	Each Flange M_{FL} / 2	
Design Post Stress f_{bu} (ksi)	21.91 ksi	Assume Symmetrical Section, Noncomposite	
ϕ_f	1.00		AASHTO 6.5.4.2
Maximum Post Flange $\phi_f F_{yf}$ (ksi)	50.00 ksi **OK**		AASHTO 6.4.1
Effective Radius Gyration LTB r_t (in)	1.65 in		AASHTO 6.10.8.2.3-9
Steel Post Limiting Unbraced L_p (ft)	3.31 ft		AASHTO 6.10.8.2.3-4
Moment Gradient Modifier C_b	1.00	Conservatively 1.0	AASHTO 6.10.8.2.3
Compact Web Ratio $2D_c/t_w$	21.04		AASHTO 6.10.1.10.2-4
Compact Web Limit Check λ_{rw}	137.27 **OK**		AASHTO 6.10.1.10.2-4
Web Load Shedding Factor a_{wc}	0.65		AASHTO 6.10.1.10.2-4
Web Load Shedding Factor R_b	1.00		AASHTO 6.10.1.10.2
1st Order Analysis Limiting Factor (ft)	6.01 ft **Use 1st Order Analysis**		AASHTO 6.10.1.6-2
1st Order Post Flange Lat f_{buLat1} (ksi)	5.55 ksi	Assume Symmetrical Section, Noncomposite	
2nd Order Post Elastic F_{cr} (ksi)	1649.30 ksi		AASHTO 6.10.8.2.3-8
2nd Order Post Elastic Factor	NA		AASHTO 6.10.1.6-4
2nd Order Post Flange Lat f_{buLat2} (ksi)	NA	Assume Symmetrical Section, Noncomposite	
Maximum Post Flange $0.6F_{yf}$ (ksi)	30.00 ksi **OK**		AASHTO 6.4.1
Post Design Moment M_{Fc} + 1/3 $f_l S_{xc}$ (ft*k)	26.53 ft*k		AASHTO A6.1.1-1
Post Trans Controlling $\phi_f M_{nc}$ (ft*k)	62.50 ft*k **OK**		
Traffic Railing Post Strong Axis Flexural Tension Flange Calculations			
Trans Design Post Moment M_{Ft} (ft*k)	24.47 ft*k		
Post Web Plastification Factor R_{pt}	1.12		AASHTO A6.2.1-5
ϕ_f	1.00		AASHTO 6.5.4.2
Post Design Moment M_{Ft} + 1/3 $f_l S_{xt}$ (ft*k)	26.53 ft*k	For now, utilize f_{buLat} From Comp Flange	AASHTO A6.1.2-1
Post Flexural Tension Flange $\phi_f M_{nt}$ (ft*k)	62.50 ft*k	Tension Flange Yielding Resistance	AASHTO A6.4-1
Traffic Railing Post Shear Calculations			
Post Web Yield Stress F_{yw} (ksi)	50 ksi **OK**		AASHTO 6.4.1
Post Web D (in)	5.47 in		
Post Plastic Shear Force V_p (k)	41.24 k		AASHTO 6.10.9.2-2
Post Web Slenderness $\lambda_w = D/t_w$	21.04		AASHTO 6.10.9.3.2
Post Shear Buckling Coefficient k	5.00	Unstiffened Webs	AASHTO 6.10.9.2
Post Shear Factor C	1.00		AASHTO 6.10.9.3.2
Post Shear Buckling Resistance V_{cr} (k)	41.24 k		AASHTO 6.10.9.2
Post Design Shear V_u (k)	17.02 k		AISC Table 3-23 Case 26
ϕ_v	1.00		AASHTO 6.5.4.2
Post Shear Capacity $\phi_v V_n$ (k)	41.24 k **OK**		AASHTO 6.10.9.1-1
Traffic Railing Post Strong Axis Service Level Deflection Calculations			
Post Deflection $\delta_{LLOverhang}$ (in)	0.069 in		AISC Table 3-23 Case 26
Post Service LL Deflection Span Ratio	L / 315		

Steel Beam Lateral Nodal Bracing Design

Steel Corrugated Deck Bracing Calculations

Deck Type	12"x4-1/4" 9 Ga Corrugate		Matt assumed Lb=1.0 ft Typical	
Required Flexural Strength $M_{rStrengthI}$ (ft*k)	1378.78 ft*k		Strength I Level	AISC 360-05 A6.3
Lateral Bracing C_d	1.0		Assume Single Curvature, Cd=1.0	AISC 360-05 A6.3
Lateral Bracing h_o (in)	32.16 in			AISC 360-05 A6.3
Lateral Bracing Strength Req P_{br} (k)	10.29 k		Relative Bracing Requirements Used	AISC 360-05 A-6-7
Deck To Beam Min Fillet Weld Size (in)	2/16 in		Per HAS Calc, Grout Pocket Strength	AASHTO 6.13.3.4
Deck To Beam Max Fillet Weld Size (in)	3/16 in		Equal To 24.22 kips, Adequate For Conc	AASHTO 6.13.3.4
Deck To Beam Fillet Weld Size (in)	1/8 in	OK		
ϕ_{e2}	0.80			AASHTO 6.5.4.2
Lateral Fillet Weld Shear Cap $\phi_{e2}R_n$ (k/in)	2.97 k/in			AASHTO 6.13.3.2.4b-1
Lateral Fillet Weld Length $L_{WeldReq}$ (in/ft)	3.47 in/ft		Per Deck Width, Each Foot	AASHTO 6.13.3.5
Lateral Fillet Weld Design L_{Weld} (in/ft)	6.00 in/ft	OK	Minimum Weld Length Shall Be 1.5 in	AASHTO 6.13.3.5
$t_{MinLateralBrace}$ Match Weld Rupture (in)	0.088 in	OK		AISC 13th Ed. Page 9-5
Lateral Bracing Unbraced Length L_b (ft)	1.00 ft		Assume 1 ft Deck Bracing, Midas Model	
ϕ	0.75			AISC 360-05 A6.3
Lateral Bracing Stiffness Req β_{br} (k/in)	571.63 k/in			AISC 360-05 A-6-7
Lateral Bracing Angle Theta θ (°)	90.00 °		90 Degrees Horizontal	
Lateral Bracing Deck A_g (in^2)	3.10 in^2			
Lateral Bracing Deck E (ksi)	29000 ksi			AASHTO 6.4.1
Lateral Bracing Deck Length L (ft)	3.75 ft		Equals Sb Above	
Lateral Bracing Deck Stiffness k (k/in)	1997.25 k/in	OK		
Lateral Bracing Deck Length L_e (ft)	2.79 ft			
Lateral Bracing Deck K	0.750		Welded End Connections K = 0.75	AASHTO 4.6.2.5
Lateral Bracing Deck r (in)	1.67 in			
Lateral Bracing Deck Slenderness KL/r	15.07			
Lateral Bracing Deck Slenderness Limit	120.00	OK		AASHTO 6.9.3

Note: Use Big R Lateral Fastening Requirement Between Stringers At O

Steel Beam Bearing Stiffener Design

Steel Beam Bearing Stiffener Miscellaneous Input			
Factored Beam Reaction $V_{uStrengthI}$ (k)	100.00 k		
Rxn Dist From End Of Member d_{End} (in)	6.00 in		
Steel Beam Web Local Yielding Calculations			
ϕ_b	1.00		AASHTO 6.5.4.2
Beam Flange To Web Fillet Weld Size (in)	1/4 in **NA**	Custom Girder Flange To Web Fillet Weld Size	
Steel Beam Distance k (in)	1.44 in		AISC Table 1-1
Steel Beam Web Thickness t_w (in)	0.55 in		AISC Table 1-1
Steel Beam Length Of Bearing N (in)	12.00 in	Equals Sole Plate Width Above, See Pg 3	AASHTO D6.5.2
Steel Beam Web Yield F_{yw} (ksi)	50.00 ksi		AASHTO 6.4.1
Steel Beam Web Bearing R_u (k)	100.00 k		
Steel Beam Web Bearing $\phi_b R_n$ (k)	429.00 k **OK, No Stiffener Req**		AASHTO D6.5.2
Steel Beam Web Crippling Calculations			
ϕ_w	0.80		AASHTO 6.5.4.2
Steel Beam Web Thickness t_w (in)	0.55 in		AISC Table 1-1
Steel Beam Flange Thickness t_f (in)	0.74 in		AISC Table 1-1
Steel Beam Depth d (in)	32.90 in		AISC Table 1-1
Steel Beam Web Yield F_{yw} (ksi)	50.00 ksi		AASHTO 6.4.1
Steel Beam Web E (ksi)	29000 ksi		AASHTO 6.4.1
Steel Beam Length Of Bearing N (in)	12.00 in	Equals Sole Plate Width Above, See Pg 3	AASHTO D6.5.2
Steel Beam Web Bearing R_u (k)	100.00 k		
Steel Beam Web Bearing $\phi_w R_n$ (k)	244.28 k **OK, No Stiffener Req**		AASHTO D6.5.3
Steel Beam Web Bearing Stiffener Calculations			
Bearing Stiffener Width b_t (in)	5.00 in	Assume Stiffener Plate Ea Side Web	AASHTO 6.10.11.2.2-1
Bearing Stiffener Thickness t_p (in)	0.500 in		AASHTO 6.10.11.2.2-1
Bearing Stiffener Grade	A709 Grade 50W		AASHTO Table 6.4.1-1
Bearing Stiffener Yield F_{ys} (ksi)	50.00 ksi		AASHTO 6.4.1
Bearing Stiffener Width Limit Factor	5.78 in **OK**		AASHTO 6.10.11.2.2-1
ϕ_b	1.00		AASHTO 6.5.4.2
Bearing Stiffener A_{pn} (in^2)	4.00 in^2	Assume 1x1 Clip For Fillet Weld	AASHTO 6.10.11.2.3
Bearing Stiffener Bearing $(R_{sb})_r$ (k)	100.00 k		AASHTO 6.10.11.2.3-1
Bearing Stiffener Bearing $\phi_b(R_{sb})_n$ (k)	280.00 k **OK**		AASHTO 6.10.11.2.3-2
ϕ_c	0.90		AASHTO 6.5.4.2
Bearing Stiffener Effective Length Kl (in)	23.57 in		AASHTO 6.10.11.2.4a
Bearing Stiffener A_s (in^2)	10.45 in^2		AASHTO 6.10.11.2.4b
Bearing Stiffener I_s (in^4)	49.06 in4		
Bearing Stiffener r_s (in)	2.17 in		
Slenderness Ratio Kl/r_s	10.87 **OK**		AASHTO 6.9.3
Steel Beam Web E (ksi)	29000 ksi		AASHTO 6.4.1
Bearing Stiffener Factor λ	0.021		AASHTO 6.9.4.1-3
Bearing Stiffener Compression P_r (k)	100.00 k		
Bearing Stiffener Compression $\phi_c P_n$ (k)	466.01 k **OK**		AASHTO 6.9.2.1
Steel Beam Web Stiffener To Web Weld Calculations			
Bearing Stiffener Min Fillet Weld Size (in)	4/16 in		AASHTO 6.13.3.4
Bearing Stiffener Max Fillet Weld Size (in)	7/16 in		AASHTO 6.13.3.4
Bearing Stiffener Fillet Weld Size (in)	1/4 in **OK**		
ϕ_{e2}	0.80		AASHTO 6.5.4.2
Fillet Weld Shear Capacity $\phi_{e2} R_n$ (k/in)	5.94 k/in		AASHTO 6.13.3.2.4b-1
Bearing Stiffener Depth $d_{Stiffener}$ (in)	29.42 in	Assume 1x1 Clip For Fillet Weld	AASHTO 6.10.11.2.4a
Bearing Stiffener Web Weld P_r (k)	100.00 k		
Bearing Stiffener Weld Capacity $\phi_{e2} R_n$ (k)	698.88 k **OK**	Assume 2 Stiffeners, 4 Welds	AASHTO 6.13.3.5
$t_{MinStiffener}$ Match Weld Rupture (in)	0.354 in **OK**		AISC 13th Ed. Page 9-5

BEAUDETTE CONSULTING ENGINEERS, INC. bce STRUCTURAL	Project:	21x61 HS20	Page: 31
	Client:	TrueNorth Steel	Design By: CW
	Job #:	14-692	Review By: MS
	Description:	S/N 61MB21HS20-JMI344	Date: 09/03/14

Padeye Design

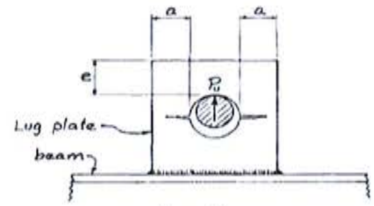

Figure 104.

Padeye Miscellaneous Input				
Padeye Plate Grade	A709 Grade 50W			AASHTO Table 6.4.1-1
Padeye Plate Thickness t_p (in)	0.50 in			
Padeye Plate Length L_p (in)	4.00 in			
Padeye Plate Height H_p (in)	4.00 in			
Padeye Hole Diameter d_{hole} (in)	1.50 in			
Padeye Horizontal Edge Distance a (in)	1.250 in	OK		
Padeye Vertical Edge Distance e (in)	1.250 in	OK		
Padeye Demand P_u (k)	15.75 k			Vertical Service Level Load
Padeye Demand P_u Load Angle θ (°)	90.00 °		From Horizontal, 90° Is Vertical Load, Acts Through Centerline Hole	
Padeye Tension Failure Calculations				
Padeye Ultimate Stress F_u (ksi)	70 ksi			AASHTO 6.4.1
Tension Failure Safety Factor $FS_{Tension}$	5.00			Ricker Page 157
Tension Failure P_n (k)	17.50 k			Ricker Page 157
Padeye Snug Fit Calculations				
Padeye Yield Stress F_y (ksi)	50 ksi			AASHTO 6.4.1
Padeye Allowable Stress F_b (ksi)	33 ksi			
Snug Fit Crushing Failure P_n (k)	33.75 k			Ricker Page 152
Less Than Snug Fit Tearout P_n (k)	28.70 k			Ricker Page 152
Padeye Shear Failure Calculations				
Padeye Yield Stress F_y (ksi)	50 ksi			AASHTO 6.4.1
Shear Failure Safety Factor FS_{Shear}	1.50			AISC 360-05 G2.1.a
Shear Failure V_n (k)	25.00 k			AISC 360-05 G2.1
Padeye Dishing Calculations				
Minimum Padeye Plate Thickness t_{pmin} (in)	0.50 in			Ricker Page 157, AISC 360-0
Padeye Plate Thickness t_p (in)	0.50 in	OK		
Padeye Weld Calculations			Treat Weld Group As Line	
Deck To Beam Min Fillet Weld Size (in)	4/16 in			AASHTO 6.13.3.4
Deck To Beam Max Fillet Weld Size (in)	7/16 in			AASHTO 6.13.3.4
Padeye Fillet Weld Size (in)	1/4 in	OK		
Ω	1.88			AISC 360-05 Table J2.5
Padeye Fillet Weld Shear Cap R_n (k/in)	7.90 k/in		Fillet Weld Each Side Of Padeye	AASHTO 6.13.3.2.4b-1
Padeye Fillet Weld Group S_w (in^2/in)	2.67 in^3/in			
Padeye Fillet Weld Group M_u (in*k)	0.00 in*k			
Padeye Fillet Weld Group P_{uV} (k)	15.75 k			
Padeye Fillet Weld Group P_{uH} (k)	0.00 k			
Padeye Fillet Weld Group f_{1M} (k/in)	0.00 k/in			
Padeye Fillet Weld Group f_{2V} (k/in)	3.94 k/in			
Padeye Fillet Weld Group f_{3H} (k/in)	0.00 k/in			
Padeye Fillet Weld Group f_{peak} (k/in)	3.94 k/in			
Padeye Fillet Weld Group f_{avg} (k/in)	3.94 k/in			
Padeye Fillet Weld Group $R_{nWeldReq}$ (k/in)	2.46 k/in	OK	Minimum Weld Length Shall Be 1.5 in	AASHTO 6.13.3.5
$t_{MinPadeye}$ Match Weld Rupture (in)	0.354 in	OK		AISC 13th Ed. Page 9-5
Padeye Design Summary				
Padeye Demand P_u (k)	15.75 k			
Padeye Controlling Capacity P_n (k)	17.50 k	OK		

Bearing Pressure Design — AASHTO 10.6.2.1

Bearing Pressure Miscellaneous Input

Bridge Dead Load W_{DL} (lb)	69976 lb	Total Bridge Dead Load	Sheet S-BOM1
Bridge Conc Sill Ftg_{DL} (lb)	0 lb	Include Both Sill Weights	
Bridge Ballast W_{DL} (lb)	218913 lb	Total Bridge Ballast Load	
Bridge Dead Load Reaction R_{DL} (lb)	144445 lb		
Bridge Live Load Reaction R_{LL} (lb)	121960 lb		
Supersill Bearing Area A_{Brg} (ft^2)	160.0 ft^2		
Steel Frame Bearing Area A_{Steel} (ft^2)	160.0 ft^2		
Allowable Bearing Pressure q_{All} (psf)	4000 psf		

Bearing Pressure Calculations

Dynamic Load Allowance Factor IM_{Brg}	1.00	Not Req For Foundations Blw Grade	AASHTO 3.6.2.1
Multiple Presence Factor m_{Brg}	1.00		
Load Factor Case	Service I		AASHTO Table 6.4.1-1
γ_{DC}	1.00		AASHTO 3.4.1-1
γ_{LL}	1.00		AASHTO 3.4.1-1
Service I Load Construction P_{uBrgC} (lb)	34988 lb		AASHTO 3.4.1-1
Bearing Pressure Construction q_C (psf)	219 psf	Assume Ballast Placed After Supersill Concrete In Place	
Allowable Bearing Pressure q_{All} (psf)	4000 psf OK		
Service I Load In-Service P_{uBrgS} (lb)	266405 lb		AASHTO 3.4.1-1
Bearing Pressure In-Service q_S (psf)	1665 psf		
Allowable Bearing Pressure q_{All} (psf)	4000 psf OK		

Design Criteria - Total Height East : 4'-3", Total Width : 23'-0", Soil Over Toe 2'-0" Below TOW, 3'-8" Soil Above Abutment

Total Height West : 11'-9"

Bridge DL : 69976 lb

Ballast DL : 218913 lb (165 psf)

Future Wearing Surface DL : 0 lb

Vehicle LL : 121960 lb

Assume 23'-0" Width Abutment w_{DL} : (1/2)(69976 + 218913 + 0) ÷ 23'-0" = 6280 lb/ft

w_{LL} : 121960 ÷ 23'-0" = 5302 lb/ft

Assume 0.1h Eccentricity = (0.10)(18) = 1.80 in

Assume γ_m = 125 pcf (Braun Intertec Soils Letter)

Use Active Pressure γ_{EQ} = 50 psf/ft

Allowable Soil Bearing = 10000 psf, μ = 0.50

USGS Seismic S_s = 0.04g, $k_h = \frac{0.04}{2.5}$ = 0.016, Max $k_h \le (1-k_v)\tan(\phi-i)$, ϕ = 35°, i = 0°, k_v = , k_h = A11.1.1.1

Braking Force LRFD 25% Axle Weights Design Truck or Tandem : (0.25)(32+32+8) = 18.0 k

5% Design Truck Plus Lane Or Design Tandem Plus Lane = (0.05)(32+32+8+(0.64)(61)) = 5.5 k

Eqn : F x N Lanes x m Factor : (18.0)(1)(1.20) = 21.6 k ÷ 23'-0" = 0.93 k/ft At Top

Braking Force 17th 5% Design Lane Plus Concentrated Load For Moment : (0.05)(26 + (0.64)(61)) = 3.25 k

Eqn : F x N Lanes x m Factor : (3.25)(1)(1.20) = 3.90 k ÷ 23'-0" = 0.16 k/ft At Top

(Note : Braking Force Applied 6'-0" Above Roadway, However Bearings Cannot Transmit Moment, Thus Apply At Bearing Elevation. Applied In All Lanes Carrying Traffic In The Same Direction (FHWA Example))

PROJECT : 21X61 HS20 Knowlton Creek

JOB # : 14697 SCALE :

CALCULATED BY : CW DATE : 9/8/14

CHECKED BY : DATE :

SHEET NO. FN 1

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AASHTO S_1 = 2.0% = 0.02 3.10.2.1-3

Site Class D F_v = 2.4 3.10.2.2-3

$S_{D1} = F_v S_1 = (2.4)(0.02) = 0.048 \leq 0.15$ Seismic Zone 1 3.10.6-1

AASHTO 3.11.4 Monobe-Okobe Earthquake Section 11 Appendix

Live Load Surcharge 3.11.6.4

Abutment Height = 4'-3" + 3'-8" = 7'-11" Table 3.11.6.4-1 Interpolate h_{eq} = 3.41 ft

γ_s = 125 pcf

LL Surcharge = $\gamma_s h_{eq}$ = (125)(3.41) = 426 psf

Total Surcharge = LL + Soil = (426) + (3.67)(125) = 885 psf

Wind Load On Abutment, Ignore Conservatively Because This Would Counteract Other Longitudinal Loads

Wind Load On Bridge 0.300 k/ft Sheet CB 1/1 LRFD

$\frac{1}{2}L = (\frac{1}{2})(61) = 30.5$ ft

= (0.300)(30.5)(½) = 4.57 k ; L = 23'-0" = 0.19 k/ft

Total Lateral At Top = Braking + Wind Load = 0.93 + 0.19 = 1.12 k/ft For Soil Bearing Check

(LFactor For Stem Wall Check × 1.75 = 1.96 k/ft)

Note: Because this is a private bridge, earthquake analysis will be ignored, no life-safety issues, low seismic zone

PROJECT: 21X61 HS20 Knowlton Creek
JOB #: 14-692 SCALE:
CALCULATED BY: AW DATE: 9/8/14
CHECKED BY: DATE:

SHEET NO. FN 2

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Abutment Horizontal Stream Flow - Load = 100,000 lb

Bridge DL = 69976 lb

Ballast DL = (21.75)(61.0)(69.0) = 91545 lb (8" Ballast)

Abutment DL = [(3.25)(1.5)(23.0) + (1.0)(4.5)(23.0) + (2)(12.0)(1.0)(3.0) + (2)(12.0)(1.0)(3.0)](150) = 53081 lb

Total Weight = 69976 + 91545 + 53081 = 214602 lb

F = μN = (0.50)(214602) = 107301 lb > F = 100,000 lb OK FS = 1.07 OK

Note: By observation, east abutment controls

PROJECT: 21x61 HS20 Knowlton Creek
JOB #: 14-692 SCALE:
CALCULATED BY: CW DATE: 9/9/14
CHECKED BY: DATE:

SHEET NO. FN 3

14692 ABUTMENT DESIGN H=4.25 FT

Retaining wall analysis in accordance with IBC 2012

Tedds calculation version 2.4.06

Retaining wall details

Stem type	Cantilever
Stem height	h_{stem} = **3.25** ft
Stem thickness	t_{stem} = **18** in
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **150** pcf
Toe length	l_{toe} = **1.5** ft
Heel length	l_{heel} = **1.5** ft
Base thickness	t_{base} = **12** in
Base density	γ_{base} = **150** pcf
Height of retained soil	h_{ret} = **2** ft
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **1.25** ft

Retained soil properties

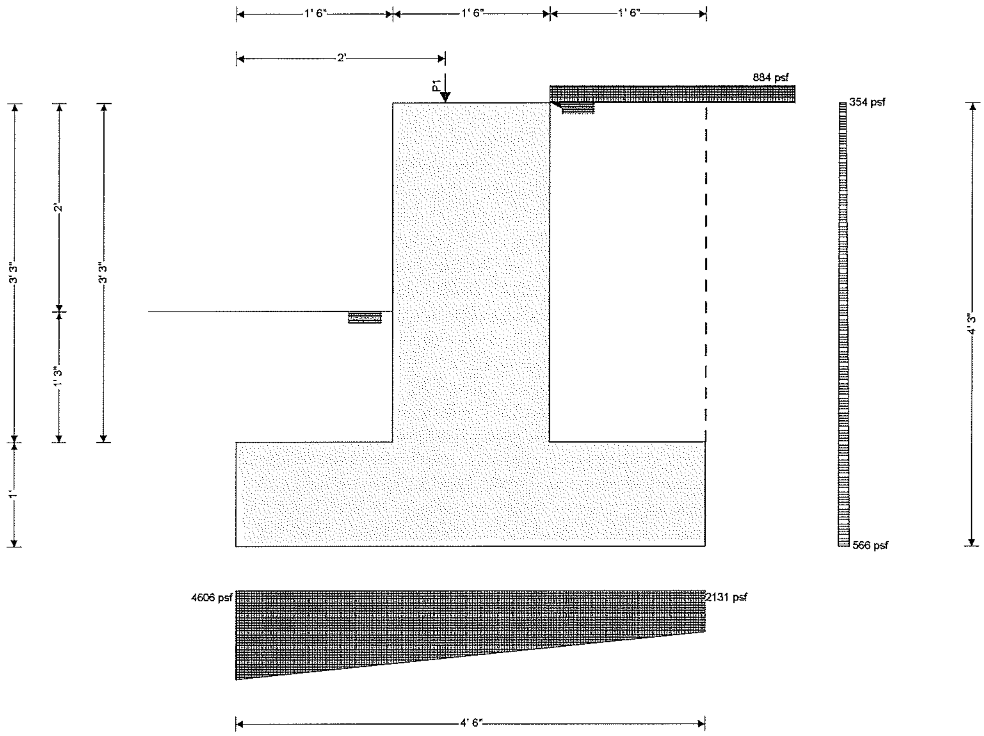
Moist density	γ_{mr} = **125** pcf
Saturated density	γ_{sr} = **125** pcf
Prescribed active lateral soil pressure	p_{Ar} = **50** psf/ft

Base soil properties

Soil type	Medium dense well graded sand
Moist density	γ_{mb} = **125** pcf
Prescribed passive lateral soil pressure	p_{0b} = **250** psf/ft
Allowable bearing pressure	$P_{bearing}$ = **10000** psf

Loading details

Dead surcharge load	$Surcharge_D$ = **458** psf
Live surcharge load	$Surcharge_L$ = **426** psf
Vertical line load at 2 ft	P_{D1} = **6280** plf
	P_{L1} = **5302** plf
Horizontal line load at 3.25 ft	P_{L2} = **1120** plf



Calculate retaining wall geometry

Base length	$l_{base} = l_{toe} + t_{stem} + l_{heel} = \mathbf{4.5}$ ft
Moist soil height	$h_{moist} = h_{soil} = \mathbf{3.25}$ ft
Length of surcharge load	$l_{sur} = l_{heel} = \mathbf{1.5}$ ft
- Distance to vertical component	$x_{sur\_v} = l_{base} - l_{heel} / 2 = \mathbf{3.75}$ ft
Effective height of wall	$h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{4.25}$ ft
- Distance to horizontal component	$x_{sur\_h} = h_{eff} / 2 = \mathbf{2.125}$ ft
Area of wall stem	$A_{stem} = h_{stem} \times t_{stem} = \mathbf{4.875}$ ft^2
- Distance to vertical component	$x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{2.25}$ ft
Area of wall base	$A_{base} = l_{base} \times t_{base} = \mathbf{4.5}$ ft^2
- Distance to vertical component	$x_{base} = l_{base} / 2 = \mathbf{2.25}$ ft
Area of moist soil	$A_{moist} = h_{moist} \times l_{heel} = \mathbf{4.875}$ ft^2
- Distance to vertical component	$x_{moist\_v} = l_{base} - (h_{moist} \times l_{heel}^2 / 2) / A_{moist} = \mathbf{3.75}$ ft
- Distance to horizontal component	$x_{moist\_h} = h_{eff} / 3 = \mathbf{1.417}$ ft
Area of base soil	$A_{pass} = d_{cover} \times l_{toe} = \mathbf{1.875}$ ft^2
- Distance to vertical component	$x_{pass\_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass} = \mathbf{0.75}$ ft
- Distance to horizontal component	$x_{pass\_h} = (d_{cover} + h_{base}) / 3 = \mathbf{0.75}$ ft

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Area of excavated base soil	$A_{exc} = h_{pass} \times l_{toe} =$ **1.875** ft^2
- Distance to vertical component	$x_{exc\_v} = l_{base} - (h_{pass} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{exc} =$ **0.75** ft
- Distance to horizontal component	$x_{exc\_h} = (h_{pass} + h_{base}) / 3 =$ **0.75** ft

Soil coefficients

Coefficient of friction to back of wall	$K_{fr} =$ **0.325**
Coefficient of friction to front of wall	$K_{fb} =$ **0.325**
Coefficient of friction beneath base	$K_{fbb} =$ **0.500**

From IBC 2012 cl.1807.2.3 Safety factor

Load combination 1 — $1.0 \times$ Dead $+ 1.0 \times$ Live $+ 1.0 \times$ Lateral earth

Sliding check

Vertical forces on wall

Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem} =$ **731** plf
Wall base	$F_{base} = A_{base} \times \gamma_{base} =$ **675** plf
Line loads	$F_{P\_v} = P_{D1} + 0 \times P_{L1} =$ **6280** plf
Moist retained soil	$F_{moist\_v} = A_{moist} \times \gamma_{mr} =$ **609** plf
Base soil	$F_{exc\_v} = A_{exc} \times \gamma_{mb} =$ **234** plf
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{moist\_v} + F_{exc\_v} + F_{P\_v} =$ **8530** plf

Horizontal forces on wall

Surcharge load	$F_{sur\_h} = p_{Ar} / \gamma_{mr} \times (Surcharge_D + Surcharge_L) \times h_{eff} =$ **1503** plf
Line loads	$F_{P\_h} = P_{L2} =$ **1120** plf
Moist retained soil	$F_{moist\_h} = p_{Ar} \times h_{eff}^2 / 2 =$ **452** plf
Total	$F_{total\_h} = F_{moist\_h} + F_{sur\_h} + F_{P\_h} =$ **3074** plf

Check stability against sliding

Base soil resistance	$F_{exc\_h} = p_{0b} \times (h_{pass} + h_{base})^2 / 2 =$ **633** plf
Base friction	$F_{friction} = F_{total\_v} \times K_{fbb} =$ **4265** plf
Resistance to sliding	$F_{rest} = F_{exc\_h} + F_{friction} =$ **4898** plf
Factor of safety	$FoS_{sl} = F_{rest} / F_{total\_h} =$ **1.593** > 1.5

PASS - Factor of safety against sliding is adequate

Overturning check

Vertical forces on wall

Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem} =$ **731** plf
Wall base	$F_{base} = A_{base} \times \gamma_{base} =$ **675** plf
Line loads	$F_{P\_v} = P_{D1} + 0 \times P_{L1} =$ **6280** plf
Moist retained soil	$F_{moist\_v} = A_{moist} \times \gamma_{mr} =$ **609** plf

Base soil	$F_{exc\_v} = A_{exc} \times \gamma_{mb} =$ **234** plf
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{moist\_v} + F_{exc\_v} + F_{P\_v} =$ **8530** plf

Horizontal forces on wall

Surcharge load	$F_{sur\_h} = p_{Ar} / \gamma_{mr} \times (Surcharge_D + Surcharge_L) \times h_{eff} =$ **1503** plf
Line loads	$F_{P\_h} = P_{L2} =$ **1120** plf
Moist retained soil	$F_{moist\_h} = p_{Ar} \times h_{eff}^2 / 2 =$ **452** plf
Base soil	$F_{exc\_h} = -p_{0b} \times (h_{pass} + h_{base})^2 / 2 =$ **-633** plf
Total	$F_{total\_h} = F_{moist\_h} + F_{exc\_h} + F_{sur\_h} + F_{P\_h} =$ **2442** plf

Overturning moments on wall

Surcharge load	$M_{sur\_OT} = F_{sur\_h} \times x_{sur\_h} =$ **3193** lb_ft/ft
Line loads	$M_{P\_OT} = abs(P_{L2}) \times (p_2 + t_{base}) =$ **4760** lb_ft/ft
Moist retained soil	$M_{moist\_OT} = F_{moist\_h} \times x_{moist\_h} =$ **640** lb_ft/ft
Total	$M_{total\_OT} = M_{moist\_OT} + M_{sur\_OT} + M_{P\_OT} =$ **8593** lb_ft/ft

Restoring moments on wall

Wall stem	$M_{stem\_R} = F_{stem} \times x_{stem} =$ **1645** lb_ft/ft
Wall base	$M_{base\_R} = F_{base} \times x_{base} =$ **1519** lb_ft/ft
Line loads	$M_{P\_R} = (abs(P_{D1} + 0 \times P_{L1})) \times p_1 =$ **12560** lb_ft/ft
Moist retained soil	$M_{moist\_R} = F_{moist\_v} \times x_{moist\_v} =$ **2285** lb_ft/ft
Base soil	$M_{exc\_R} = F_{exc\_v} \times x_{exc\_v} - F_{exc\_h} \times x_{exc\_h} =$ **650** lb_ft/ft
Total	$M_{total\_R} = M_{stem\_R} + M_{base\_R} + M_{moist\_R} + M_{exc\_R} + M_{P\_R} =$ **18660** lb_ft/ft

Check stability against overturning

Factor of safety	$FoS_{ot} = M_{total\_R} / M_{total\_OT} =$ **2.171** > 1.5

PASS - Factor of safety against overturning is adequate

Bearing pressure check

Vertical forces on wall

Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem} =$ **731** plf
Wall base	$F_{base} = A_{base} \times \gamma_{base} =$ **675** plf
Surcharge load	$F_{sur\_v} = (Surcharge_D + Surcharge_L) \times l_{heel} =$ **1326** plf
Line loads	$F_{P\_v} = P_{D1} + P_{L1} =$ **11582** plf
Moist retained soil	$F_{moist\_v} = A_{moist} \times \gamma_{mr} =$ **609** plf
Base soil	$F_{pass\_v} = A_{pass} \times \gamma_{mb} =$ **234** plf
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{moist\_v} + F_{pass\_v} + F_{sur\_v} + F_{P\_v} =$ **15158** plf

Horizontal forces on wall

Surcharge load	$F_{sur\_h} = p_{Ar} / \gamma_{mr} \times (Surcharge_D + Surcharge_L) \times h_{eff} =$ **1503** plf

Line loads	$F_{P\_h} = P_{L2} = \mathbf{1120}$ plf
Moist retained soil	$F_{moist\_h} = p_{Ar} \times h_{eff}^2 / 2 = \mathbf{452}$ plf
Total	$F_{total\_h} = \max(F_{moist\_h} + F_{pass\_h} + F_{sur\_h} + F_{P\_h} - F_{total\_v} \times K_{fbb}, 0\ \text{plf}) = \mathbf{0}$ plf

Moments on wall

Wall stem	$M_{stem} = F_{stem} \times x_{stem} = \mathbf{1645}$ lb_ft/ft
Wall base	$M_{base} = F_{base} \times x_{base} = \mathbf{1519}$ lb_ft/ft
Surcharge load	$M_{sur} = F_{sur\_v} \times x_{sur\_v} - F_{sur\_h} \times x_{sur\_h} = \mathbf{1779}$ lb_ft/ft
Line loads	$M_P = ((P_{D1} + P_{L1})) \times p_1 = \mathbf{23164}$ lb_ft/ft
Moist retained soil	$M_{moist} = F_{moist\_v} \times x_{moist\_v} - F_{moist\_h} \times x_{moist\_h} = \mathbf{1645}$ lb_ft/ft
Base soil	$M_{pass} = F_{pass\_v} \times x_{pass\_v} = \mathbf{176}$ lb_ft/ft
Total	$M_{total} = M_{stem} + M_{base} + M_{moist} + M_{pass} + M_{sur} + M_P = \mathbf{29928}$ lb_ft/ft

Check bearing pressure

Distance to reaction	$\bar{x} = M_{total} / F_{total\_v} = \mathbf{1.974}$ ft
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2 = \mathbf{-0.276}$ ft
Loaded length of base	$l_{load} = l_{base} = \mathbf{4.5}$ ft
Bearing pressure at toe	$q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base}) = \mathbf{4606}$ psf
Bearing pressure at heel	$q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base}) = \mathbf{2131}$ psf
Factor of safety	$FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = \mathbf{2.171}$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

14692 ABUTMENT DESIGN H=4.25 FT

Retaining wall design in accordance with ACI 318-11

Tedds calculation version 2.4.06

Concrete details

Compressive strength of concrete	$f'_c = \mathbf{4500}$ psi
Concrete type	Normal weight

Reinforcement details

Yield strength of reinforcement	$f_y = \mathbf{60000}$ psi
Modulus of elasticity or reinforcement	$E_s = \mathbf{29000000}$ psi

Cover to reinforcement

Front face of stem	$c_{sf} = \mathbf{1.5}$ in
Rear face of stem	$c_{sr} = \mathbf{2}$ in
Top face of base	$c_{bt} = \mathbf{2}$ in
Bottom face of base	$c_{bb} = \mathbf{3}$ in

From IBC 2012 cl.1605.2.1 Basic load combinations

Load combination no.1	1.4 × Dead
Load combination no.2	1.2 × Dead + 1.6 × Live + 1.6 × Lateral earth
Load combination no.3	1.2 × Dead + 1.0 × Earthquake + 1.0 × Live + 1.6 × Lateral earth
Load combination no.4	0.9 × Dead + 1.0 × Earthquake + 1.6 × Lateral earth

Check stem design at base of stem

Depth of section — $h = \mathbf{18}$ in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2 — $M = \mathbf{8883}$ lb_ft/ft

Depth of tension reinforcement — $d = h - c_{sr} - \phi_{sr} / 2 = \mathbf{15.687}$ in

Tension reinforcement provided — No.5 bars @ 18" c/c

Area of tension reinforcement provided — $A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr}) = \mathbf{0.205}$ in²/ft

Maximum reinforcement spacing - cl.14.3.5 — $s_{max} = \min(18\text{ in}, 3 \times h) = \mathbf{18}$ in

PASS - Reinforcement is adequately spaced

Depth of compression block — $a = A_{sr.prov} \times f_y / (0.85 \times f'_c) = \mathbf{0.267}$ in

Neutral axis factor - cl.10.2.7.3 — $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4\text{ ksi}) / 1\text{ ksi}, 0.65), 0.85) = \mathbf{0.825}$

Depth to neutral axis — $c = a / \beta_1 = \mathbf{0.324}$ in

Strain in reinforcement — $\varepsilon_t = 0.003 \times (d - c) / c = \mathbf{0.142222}$

Section is in the tension controlled zone

Strength reduction factor — $\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) = \mathbf{0.9}$

Nominal flexural strength — $M_n = A_{sr.prov} \times f_y \times (d - a / 2) = \mathbf{15906}$ lb_ft/ft

Design flexural strength — $\phi M_n = \phi_f \times M_n = \mathbf{14316}$ lb_ft/ft

$M / \phi M_n = \mathbf{0.620}$

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis — $A_{sr.des} = \mathbf{0.126}$ in²/ft

Minimum area of tension reinforcement - cl.10.5.3 — $A_{sr.min} = 4 \times A_{sr.des} / 3 = \mathbf{0.169}$ in²/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force — $V = \mathbf{3815}$ lb/ft

Concrete modification factor - cl.8.6.1 — $\lambda = \mathbf{1}$

Nominal concrete shear strength - exp.11-3 — $V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\text{ psi})} \times d = \mathbf{25256}$ lb/ft

Strength reduction factor — $\phi_s = \mathbf{0.75}$

Design concrete shear strength - cl.11.4.6.1 — $\phi V_c = \phi_s \times V_c = \mathbf{18942}$ lb/ft

$V / \phi V_c = \mathbf{0.201}$

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PASS - No shear reinforcement is required

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.14.3.3	$A_{sx.req} = 0.002 \times t_{stem} =$ **0.432** in²/ft
Transverse reinforcement provided	No.5 bars @ 18" c/c each face
Area of transverse reinforcement provided	$A_{sx.prov} = 2 \times \pi \times \phi_{sx}^2 / (4 \times s_{sx}) =$ **0.409** in²/ft

FAIL - Area of reinforcement provided is less than area of reinforcement required

Check base design at toe

Depth of section	h = **12** in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2	M = **6292** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{bb} - \phi_{bb} / 2 =$ **8.688** in
Tension reinforcement provided	No.5 bars @ 12" c/c
Area of tension reinforcement provided	$A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb}) =$ **0.307** in²/ft
Maximum reinforcement spacing - cl.15.10.4	$s_{max} =$ **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block	$a = A_{bb.prov} \times f_y / (0.85 \times f'_c) =$ **0.401** in
Neutral axis factor - cl.10.2.7.3	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4 \text{ ksi}) / 1 \text{ ksi}, 0.65), 0.85) =$ **0.825**
Depth to neutral axis	$c = a / \beta_1 =$ **0.486** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c =$ **0.050614**

Section is in the tension controlled zone

Strength reduction factor	$\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**
Nominal flexural strength	$M_n = A_{bb.prov} \times f_y \times (d - a / 2) =$ **13019** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n =$ **11717** lb_ft/ft
	$M / \phi M_n =$ **0.537**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis	$A_{bb.des} =$ **0.163** in²/ft
Minimum area of tension reinforcement - cl.7.12.2.1	$A_{bb.min} = 0.0018 \times h =$ **0.259** in²/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force	V = **8091** lb/ft
Concrete modification factor - cl.8.6.1	$\lambda =$ **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1 \text{ psi})} \times d =$ **13987** lb/ft
Strength reduction factor	$\phi_s =$ **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c =$ **10490** lb/ft
	$V / \phi V_c =$ **0.771**

PASS - No shear reinforcement is required

Rectangular section in flexure - Chapter 10

Factored bending moment combination 0 — M = **148** lb_ft/ft

Depth of tension reinforcement — $d = h - c_{bt} - \phi_{bt} / 2$ = **9.687** in

Tension reinforcement provided — No.5 bars @ 12" c/c

Area of tension reinforcement provided — $A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt})$ = **0.307** in^2/ft

Maximum reinforcement spacing - cl.15.10.4 — s_{max} = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block — $a = A_{bt.prov} \times f_y / (0.85 \times f'_c)$ = **0.401** in

Neutral axis factor - cl.10.2.7.3 — $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4\text{ ksi}) / 1\text{ ksi}, 0.65), 0.85)$ = **0.825**

Depth to neutral axis — $c = a / \beta_1$ = **0.486** in

Strain in reinforcement — $\varepsilon_t = 0.003 \times (d - c) / c$ = **0.056786**

Section is in the tension controlled zone

Strength reduction factor — $\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9)$ = **0.9**

Nominal flexural strength — $M_n = A_{bt.prov} \times f_y \times (d - a / 2)$ = **14553** lb_ft/ft

Design flexural strength — $\phi M_n = \phi_f \times M_n$ = **13098** lb_ft/ft

$M / \phi M_n$ = **0.011**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis — $A_{bt.des}$ = **0.003** in^2/ft

Minimum area of tension reinforcement - cl.7.12.2.1 — $A_{bt.min} = 0.0018 \times h$ = **0.259** in^2/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force — V = **2220** lb/ft

Concrete modification factor - cl.8.6.1 — λ = **1**

Nominal concrete shear strength - exp.11-3 — $V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\text{ psi})} \times d$ = **15597** lb/ft

Strength reduction factor — ϕ_s = **0.75**

Design concrete shear strength - cl.11.4.6.1 — $\phi V_c = \phi_s \times V_c$ = **11697** lb/ft

$V / \phi V_c$ = **0.190**

PASS - No shear reinforcement is required

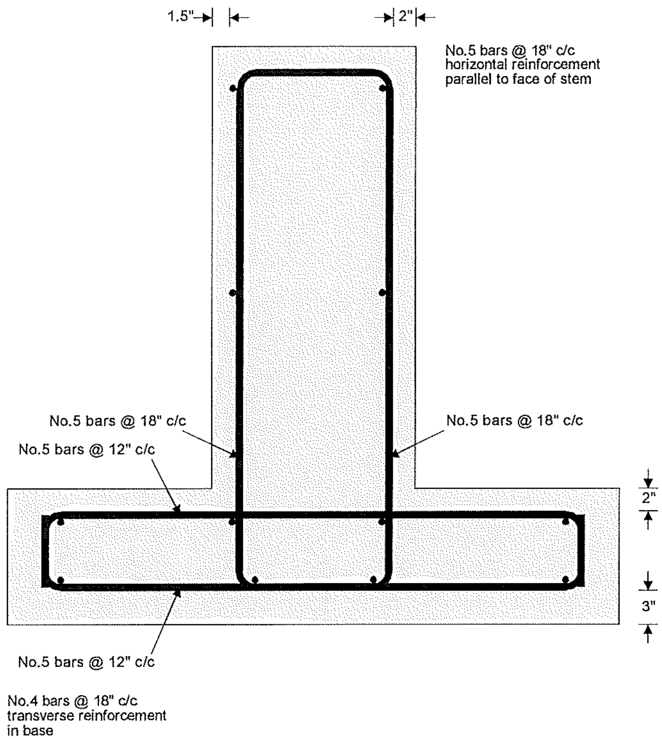
Transverse reinforcement parallel to base

Minimum area of reinforcement - cl.7.12.2.1 — $A_{bx.req} = 0.0018 \times t_{base}$ = **0.259** in^2/ft

Transverse reinforcement provided — No.4 bars @ 18" c/c each face

Area of transverse reinforcement provided — $A_{bx.prov} = 2 \times \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **0.262** in^2/ft

PASS - Area of reinforcement provided is greater than area of reinforcement required



PROJECT: Knowlton Creek Bridge Abutment

JOB #: 14-692	SCALE:	
CALCULATED BY: CW	DATE: 9/9/2014	9
CHECKED BY: CW	DATE:	

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14692 ABUTMENT DESIGN H=11.75 FT

Retaining wall analysis in accordance with IBC 2012

Tedds calculation version 2.4.06

Retaining wall details

Stem type	Cantilever
Stem height	h_{stem} = **10.417** ft
Stem thickness	t_{stem} = **18** in
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **150** pcf
Toe length	l_{toe} = **2.25** ft
Heel length	l_{heel} = **7** ft
Base thickness	t_{base} = **16** in
Base density	γ_{base} = **150** pcf
Height of retained soil	h_{ret} = **2** ft
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **8.417** ft

Retained soil properties

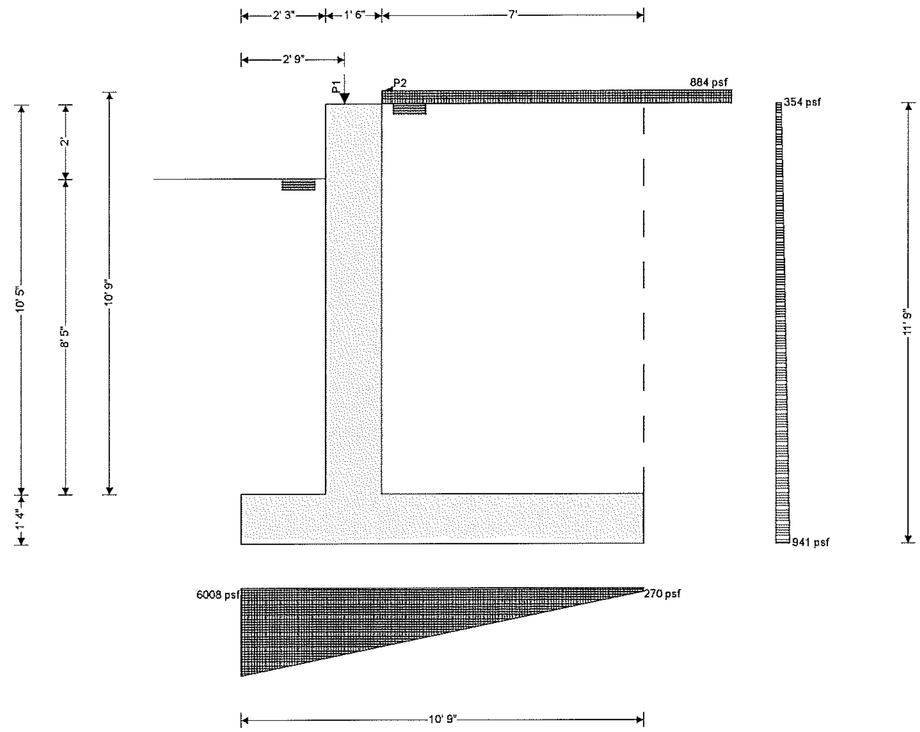
Moist density	γ_{mr} = **125** pcf
Saturated density	γ_{sr} = **125** pcf
Prescribed active lateral soil pressure	p_{Ar} = **50** psf/ft

Base soil properties

Soil type	Medium dense well graded sand
Moist density	γ_{mb} = **125** pcf
Prescribed passive lateral soil pressure	p_{0b} = **250** psf/ft
Allowable bearing pressure	$P_{bearing}$ = **10000** psf

Loading details

Dead surcharge load	$Surcharge_D$ = **458** psf
Live surcharge load	$Surcharge_L$ = **426** psf
Vertical line load at 2.75 ft	P_{D1} = **6280** plf
	P_{L1} = **5302** plf
Horizontal line load at 10.75 ft	P_{L2} = **1120** plf



Calculate retaining wall geometry

Base length	$l_{base} = l_{toe} + t_{stem} + l_{heel} = \mathbf{10.75}$ ft
Moist soil height	$h_{moist} = h_{soil} = \mathbf{10.417}$ ft
Length of surcharge load	$l_{sur} = l_{heel} = \mathbf{7}$ ft
- Distance to vertical component	$x_{sur\_v} = l_{base} - l_{heel} / 2 = \mathbf{7.25}$ ft
Effective height of wall	$h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{11.75}$ ft
- Distance to horizontal component	$x_{sur\_h} = h_{eff} / 2 = \mathbf{5.875}$ ft
Area of wall stem	$A_{stem} = h_{stem} \times t_{stem} = \mathbf{15.625}$ ft^2
- Distance to vertical component	$x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{3}$ ft
Area of wall base	$A_{base} = l_{base} \times t_{base} = \mathbf{14.333}$ ft^2
- Distance to vertical component	$x_{base} = l_{base} / 2 = \mathbf{5.375}$ ft
Area of moist soil	$A_{moist} = h_{moist} \times l_{heel} = \mathbf{72.917}$ ft^2
- Distance to vertical component	$x_{moist\_v} = l_{base} - (h_{moist} \times l_{heel}^2 / 2) / A_{moist} = \mathbf{7.25}$ ft
- Distance to horizontal component	$x_{moist\_h} = h_{eff} / 3 = \mathbf{3.917}$ ft
Area of base soil	$A_{pass} = d_{cover} \times l_{toe} = \mathbf{18.937}$ ft^2
- Distance to vertical component	$x_{pass\_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass} = \mathbf{1.125}$ ft
- Distance to horizontal component	$x_{pass\_h} = (d_{cover} + h_{base}) / 3 = \mathbf{3.25}$ ft

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Area of excavated base soil	$A_{exc} = h_{pass} \times l_{toe} = \mathbf{18.937}\ ft^2$
- Distance to vertical component	$x_{exc\_v} = l_{base} - (h_{pass} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{exc} = \mathbf{1.125}$ ft
- Distance to horizontal component	$x_{exc\_h} = (h_{pass} + h_{base}) / 3 = \mathbf{3.25}$ ft
Soil coefficients	
Coefficient of friction to back of wall	$K_{fr} = \mathbf{0.325}$
Coefficient of friction to front of wall	$K_{fb} = \mathbf{0.325}$
Coefficient of friction beneath base	$K_{fbb} = \mathbf{0.500}$
From IBC 2012 cl.1807.2.3 Safety factor	
Load combination 1	1.0 × Dead + 1.0 × Live + 1.0 × Lateral earth
Sliding check	
Vertical forces on wall	
Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{2344}$ plf
Wall base	$F_{base} = A_{base} \times \gamma_{base} = \mathbf{2150}$ plf
Line loads	$F_{P\_v} = P_{D1} + 0 \times P_{L1} = \mathbf{6280}$ plf
Moist retained soil	$F_{moist\_v} = A_{moist} \times \gamma_{mr} = \mathbf{9115}$ plf
Base soil	$F_{exc\_v} = A_{exc} \times \gamma_{mb} = \mathbf{2367}$ plf
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{moist\_v} + F_{exc\_v} + F_{P\_v} = \mathbf{22256}$ plf
Horizontal forces on wall	
Surcharge load	$F_{sur\_h} = p_{Ar} / \gamma_{mr} \times (Surcharge_D + Surcharge_L) \times h_{eff} = \mathbf{4155}$ plf
Line loads	$F_{P\_h} = P_{L2} = \mathbf{1120}$ plf
Moist retained soil	$F_{moist\_h} = p_{Ar} \times h_{eff}^2 / 2 = \mathbf{3452}$ plf
Total	$F_{total\_h} = F_{moist\_h} + F_{sur\_h} + F_{P\_h} = \mathbf{8726}$ plf
Check stability against sliding	
Base soil resistance	$F_{exc\_h} = p_{0b} \times (h_{pass} + h_{base})^2 / 2 = \mathbf{11883}$ plf
Base friction	$F_{friction} = F_{total\_v} \times K_{fbb} = \mathbf{11128}$ plf
Resistance to sliding	$F_{rest} = F_{exc\_h} + F_{friction} = \mathbf{23011}$ plf
Factor of safety	$FoS_{sl} = F_{rest} / F_{total\_h} = \mathbf{2.637} > 1.5$
	PASS - Factor of safety against sliding is adequate
Overturning check	
Vertical forces on wall	
Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{2344}$ plf
Wall base	$F_{base} = A_{base} \times \gamma_{base} = \mathbf{2150}$ plf
Line loads	$F_{P\_v} = P_{D1} + 0 \times P_{L1} = \mathbf{6280}$ plf
Moist retained soil	$F_{moist\_v} = A_{moist} \times \gamma_{mr} = \mathbf{9115}$ plf

Base soil	$F_{exc\_v} = A_{exc} \times \gamma_{mb}$ = **2367** plf
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{moist\_v} + F_{exc\_v} + F_{P\_v}$ = **22256** plf

Horizontal forces on wall

Surcharge load	$F_{sur\_h} = p_{Ar} / \gamma_{mr} \times (Surcharge_D + Surcharge_L) \times h_{eff}$ = **4155** plf
Line loads	$F_{P\_h} = P_{L2}$ = **1120** plf
Moist retained soil	$F_{moist\_h} = p_{Ar} \times h_{eff}^2 / 2$ = **3452** plf
Base soil	$F_{exc\_h} = \max(-p_{0b} \times (h_{pass} + h_{base})^2 / 2, \min(-F_{moist\_h} - F_{sur\_h} - F_{P\_h}, 0$ plf$))$ = **-8726** plf
Total	$F_{total\_h} = F_{moist\_h} + F_{exc\_h} + F_{sur\_h} + F_{P\_h}$ = **0** plf

Overturning moments on wall

Surcharge load	$M_{sur\_OT} = F_{sur\_h} \times x_{sur\_h}$ = **24409** lb_ft/ft
Line loads	$M_{P\_OT} = abs(P_{L2}) \times (p_2 + t_{base})$ = **13533** lb_ft/ft
Moist retained soil	$M_{moist\_OT} = F_{moist\_h} \times x_{moist\_h}$ = **13519** lb_ft/ft
Total	$M_{total\_OT} = M_{moist\_OT} + M_{sur\_OT} + M_{P\_OT}$ = **51461** lb_ft/ft

Restoring moments on wall

Wall stem	$M_{stem\_R} = F_{stem} \times x_{stem}$ = **7031** lb_ft/ft
Wall base	$M_{base\_R} = F_{base} \times x_{base}$ = **11556** lb_ft/ft
Line loads	$M_{P\_R} = (abs(P_{D1} + 0 \times P_{L1})) \times p_1$ = **17270** lb_ft/ft
Moist retained soil	$M_{moist\_R} = F_{moist\_v} \times x_{moist\_v}$ = **66081** lb_ft/ft
Base soil	$M_{exc\_R} = F_{exc\_v} \times x_{exc\_v} - F_{exc\_h} \times x_{exc\_h}$ = **31024** lb_ft/ft
Total	$M_{total\_R} = M_{stem\_R} + M_{base\_R} + M_{moist\_R} + M_{exc\_R} + M_{P\_R}$ = **132962** lb_ft/ft

Check stability against overturning

Factor of safety	$FoS_{ot} = M_{total\_R} / M_{total\_OT}$ = **2.584** > 1.5

PASS - Factor of safety against overturning is adequate

Bearing pressure check

Vertical forces on wall

Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem}$ = **2344** plf
Wall base	$F_{base} = A_{base} \times \gamma_{base}$ = **2150** plf
Surcharge load	$F_{sur\_v} = (Surcharge_D + Surcharge_L) \times l_{heel}$ = **6188** plf
Line loads	$F_{P\_v} = P_{D1} + P_{L1}$ = **11582** plf
Moist retained soil	$F_{moist\_v} = A_{moist} \times \gamma_{mr}$ = **9115** plf
Base soil	$F_{pass\_v} = A_{pass} \times \gamma_{mb}$ = **2367** plf
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{moist\_v} + F_{pass\_v} + F_{sur\_v} + F_{P\_v}$ = **33746** plf

Horizontal forces on wall

Surcharge load	$F_{sur\_h} = p_{Ar} / \gamma_{mr} \times (Surcharge_D + Surcharge_L) \times h_{eff}$ = **4155** plf
Line loads	$F_{P\_h} = P_{L2}$ = **1120** plf
Moist retained soil	$F_{moist\_h} = p_{Ar} \times h_{eff}^2 / 2$ = **3452** plf
Total	$F_{total\_h} = \max(F_{moist\_h} + F_{pass\_h} + F_{sur\_h} + F_{P\_h} - F_{total\_v} \times K_{fbb}, 0 \text{ plf})$ = **0** plf

Moments on wall

Wall stem	$M_{stem} = F_{stem} \times x_{stem}$ = **7031** lb_ft/ft
Wall base	$M_{base} = F_{base} \times x_{base}$ = **11556** lb_ft/ft
Surcharge load	$M_{sur} = F_{sur\_v} \times x_{sur\_v} - F_{sur\_h} \times x_{sur\_h}$ = **20454** lb_ft/ft
Line loads	$M_P = ((P_{D1} + P_{L1})) \times p_1$ = **31850** lb_ft/ft
Moist retained soil	$M_{moist} = F_{moist\_v} \times x_{moist\_v} - F_{moist\_h} \times x_{moist\_h}$ = **52562** lb_ft/ft
Base soil	$M_{pass} = F_{pass\_v} \times x_{pass\_v}$ = **2663** lb_ft/ft
Total	$M_{total} = M_{stem} + M_{base} + M_{moist} + M_{pass} + M_{sur} + M_P$ = **126117** lb_ft/ft

Check bearing pressure

Distance to reaction	$\bar{x} = M_{total} / F_{total\_v}$ = **3.737** ft
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2$ = **-1.638** ft
Loaded length of base	$l_{load} = l_{base}$ = **10.75** ft
Bearing pressure at toe	$q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base})$ = **6008** psf
Bearing pressure at heel	$q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base})$ = **270** psf
Factor of safety	$FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel})$ = **1.664**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

<u>14692 ABUTMENT DESIGN H=11.75 FT</u>

Retaining wall design in accordance with ACI 318-11

Tedds calculation version 2.4.06

Concrete details

Compressive strength of concrete	f'_c = **4500** psi
Concrete type	Normal weight

Reinforcement details

Yield strength of reinforcement	f_y = **60000** psi
Modulus of elasticity or reinforcement	E_s = **29000000** psi

Cover to reinforcement

Front face of stem	c_{sf} = **1.5** in
Rear face of stem	c_{sr} = **2** in
Top face of base	c_{bt} = **2** in

Bottom face of base c_{bb} = **3** in

From IBC 2012 cl.1605.2.1 Basic load combinations

Load combination no.1 1.4 × Dead

Load combination no.2 1.2 × Dead + 1.6 × Live + 1.6 × Lateral earth

Load combination no.3 1.2 × Dead + 1.0 × Earthquake + 1.0 × Live + 1.6 × Lateral earth

Load combination no.4 0.9 × Dead + 1.0 × Earthquake + 1.6 × Lateral earth

Check stem design at base of stem

Depth of section h = **18** in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2 M = **61053** lb_ft/ft

Depth of tension reinforcement $d = h - c_{sr} - \phi_{sr} / 2$ = **15.625** in

Tension reinforcement provided No.6 bars @ 4" c/c

Area of tension reinforcement provided $A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr})$ = **1.325** in^2/ft

Maximum reinforcement spacing - cl.14.3.5 s_{max} = min(18 in, 3 × h) = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block $a = A_{sr.prov} \times f_y / (0.85 \times f'_c)$ = **1.732** in

Neutral axis factor - cl.10.2.7.3 β_1 = min(max(0.85 - 0.05 × (f'c - 4 ksi) / 1 ksi, 0.65), 0.85) = **0.825**

Depth to neutral axis $c = a / \beta_1$ = **2.1** in

Strain in reinforcement $\varepsilon_t = 0.003 \times (d - c) / c$ = **0.019321**

Section is in the tension controlled zone

Strength reduction factor ϕ_f = min(max(0.65 + (ε_t - 0.002) × (250 / 3), 0.65), 0.9) = **0.9**

Nominal flexural strength $M_n = A_{sr.prov} \times f_y \times (d - a / 2)$ = **97803** lb_ft/ft

Design flexural strength $\phi M_n = \phi_f \times M_n$ = **88023** lb_ft/ft

$M / \phi M_n$ = **0.694**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis $A_{sr.des}$ = **0.902** in^2/ft

Minimum area of tension reinforcement - exp.10-3 $A_{sr.min}$ = max(3 × √(f'c × 1 psi), 200 psi) × d / f_y = **0.629** in^2/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force V = **11262** lb/ft

Concrete modification factor - cl.8.6.1 λ = **1**

Nominal concrete shear strength - exp.11-3 $V_c = 2 \times \lambda \times \sqrt{f'_c \times 1 psi} \times d$ = **25156** lb/ft

Strength reduction factor ϕ_s = **0.75**

Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **18867** lb/ft
	$V / \phi V_c$ = **0.597**

PASS - No shear reinforcement is required

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.14.3.3	$A_{sx.req} = 0.002 \times t_{stem}$ = **0.432** in^2/ft
Transverse reinforcement provided	No.5 bars @ 18" c/c each face
Area of transverse reinforcement provided	$A_{sx.prov} = 2 \times \pi \times \phi_{sx}^2 / (4 \times s_{sx})$ = **0.409** in^2/ft

FAIL - Area of reinforcement provided is less than area of reinforcement required

Check base design at toe

Depth of section	h = **16** in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2	M = **15533** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{bb} - \phi_{bb} / 2$ = **12.688** in
Tension reinforcement provided	No.5 bars @ 12" c/c
Area of tension reinforcement provided	$A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb})$ = **0.307** in^2/ft
Maximum reinforcement spacing - cl.15.10.4	s_{max} = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block	$a = A_{bb.prov} \times f_y / (0.85 \times f'_c)$ = **0.401** in
Neutral axis factor - cl.10.2.7.3	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4 \text{ ksi}) / 1 \text{ ksi}, 0.65), 0.85)$ = **0.825**
Depth to neutral axis	$c = a / \beta_1$ = **0.486** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c$ = **0.0753**

Section is in the tension controlled zone

Strength reduction factor	$\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9)$ = **0.9**
Nominal flexural strength	$M_n = A_{bb.prov} \times f_y \times (d - a / 2)$ = **19155** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n$ = **17239** lb_ft/ft
	$M / \phi M_n$ = **0.901**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis	$A_{bb.des}$ = **0.276** in^2/ft
Minimum area of tension reinforcement - cl.7.12.2.1	$A_{bb.min} = 0.0018 \times h$ = **0.346** in^2/ft

FAIL - Area of reinforcement provided is less than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force	V = **13157** lb/ft
Concrete modification factor - cl.8.6.1	λ = **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1 \text{ psi})} \times d$ = **20426** lb/ft
Strength reduction factor	ϕ_s = **0.75**

Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **15320** lb/ft
	$V / \phi V_c$ = **0.859**

PASS - No shear reinforcement is required

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2	M = **31896** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{bt} - \phi_{bt} / 2$ = **13.687** in
Tension reinforcement provided	No.5 bars @ 12" c/c
Area of tension reinforcement provided	$A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt})$ = **0.307** in²/ft
Maximum reinforcement spacing - cl.15.10.4	s_{max} = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block	$a = A_{bt.prov} \times f_y / (0.85 \times f'_c)$ = **0.401** in
Neutral axis factor - cl.10.2.7.3	β_1 = min(max(0.85 - 0.05 × (f'c - 4 ksi) / 1 ksi, 0.65), 0.85) = **0.825**
Depth to neutral axis	$c = a / \beta_1$ = **0.486** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c$ = **0.081472**

Section is in the tension controlled zone

Strength reduction factor	ϕ_f = min(max(0.65 + (ε_t - 0.002) × (250 / 3), 0.65), 0.9) = **0.9**
Nominal flexural strength	$M_n = A_{bt.prov} \times f_y \times (d - a / 2)$ = **20689** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n$ = **18620** lb_ft/ft
	$M / \phi M_n$ = **1.713**

FAIL - Design flexural strength is less than factored bending moment

By iteration, reinforcement required by analysis	$A_{bt.des}$ = **0.531** in²/ft
Minimum area of tension reinforcement - cl.7.12.2.1	$A_{bt.min} = 0.0018 \times h$ = **0.346** in²/ft

FAIL - Area of reinforcement provided is less than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

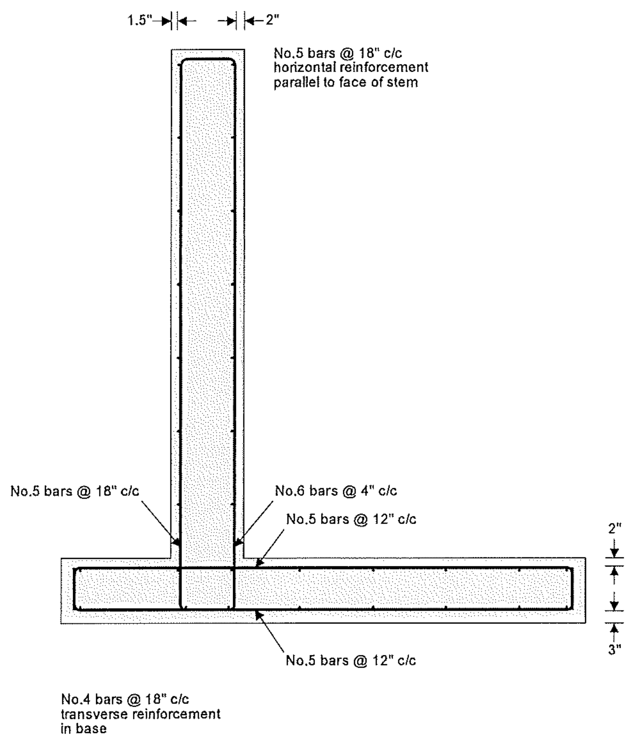
Factored shear force	V = **3507** lb/ft
Concrete modification factor - cl.8.6.1	λ = **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1 \text{ psi})} \times d$ = **22036** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **16527** lb/ft
	$V / \phi V_c$ = **0.212**

PASS - No shear reinforcement is required

Transverse reinforcement parallel to base

Minimum area of reinforcement - cl.7.12.2.1	$A_{bx.req} = 0.0018 \times t_{base}$ = **0.346** in²/ft
Transverse reinforcement provided	No.4 bars @ 18" c/c each face
Area of transverse reinforcement provided	$A_{bx.prov} = 2 \times \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **0.262** in²/ft

FAIL - Area of reinforcement provided is less than area of reinforcement required



bce STRUCTURAL | BEAUDETTE CONSULTING ENGINEERS, INC.

MISSOULA - KALISPELL - BOZEMAN - RAPID CITY
Ph: (406) 721-7315 Fax: (406) 542-8955
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PROJECT: Knowlton Creek Bridge Abutment			
JOB #: 14-692	SCALE:		
CALCULATED BY: CW	DATE: 9/9/2014		10
CHECKED BY: CW	DATE:		

STRUCTURAL GENERAL NOTES

BRIDGE

1. ALL STRUCTURAL STEEL SHAPES AND PLATES SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M 270 GRADE 50W (ASTM A709 / ASTM A588 WEATHERING STEEL), UNLESS NOTED OTHERWISE.
2. TL-1 GUARDRAIL DESIGN IN ACCORDANCE WITH OWNER REQUIREMENTS, DESIGN FROM CONTRACT DOCUMENTS.
3. STEEL DECKING SHALL BE 4.25" DEEP BY 12" LAY LENGTH BY 9 GAUGE "TYPE A" ROLLED FORMED GALVANIZED CORRUGATED STEEL CONFORMING TO ASTM A653 GRADE 50. STEEL DECKING SHALL BE INSTALLED PERPENDICULAR TO THE DIRECTION OF THE SUPPORTING GIRDERS.
4. ALL STRUCTURAL STEEL CONNECTIONS SHALL BE MADE WITH HIGH STRENGTH BOLTS (ASTM A325X TYPE 3), NUTS (ASTM A563 GR DH3), AND WASHERS (ASTM F436 TYPE 3) CONFORMING TO AASHTO M 164, UNLESS NOTED OTHERWISE. TYPICAL CONNECTIONS ARE "SNUG TIGHT" BEARING CONNECTIONS WITH STANDARD WASHERS. USE LOAD INDICATOR WASHERS AT ALL BOLTED DIAPHRAGM SPLICE CONNECTIONS (NOTED AS TCB) OR CONNECTIONS LISTED AS FULLY TENSIONED OR SLIP CRITICAL. LOAD INDICATING DEVICES, DTI'S OR SQUIRTER DTI'S, SHALL CONFORM TO ASTM F959. ANCHOR RODS SHALL CONFORM TO ASTM F1554 GR 36.
5. CERTIFIED MILL TEST REPORTS SHALL BE FURNISHED FOR THE STEEL STRINGERS, STRUCTURAL STEEL PLATES AND SHAPES, STEEL BRIDGE DECKING, HIGH STRENGTH BOLTS, PLAIN ELASTOMERIC PADS (PEP) AND ANCHOR BOLTS, IF REQUIRED BY OWNER.
6. ALL WELDING SHALL BE IN ACCORDANCE WITH AWS D1.5, BRIDGE WELDING CODE. ALL ELECTRODES SHALL BE AS FOLLOWS:
   I. FCAW - E71T AND E81T WEATHERING
   II. SMAW - E70XX L.H. AND E80XX L.H. WEATHERING
7. PLAIN ELASTOMERIC PADS (PEP) SHALL BE HARDNESS (SHORE A) 70 AND SHALL CONFORM TO AASHTO M 251 AND ASTM D4014.
8. EPOXY SHALL BE PER MIL A 81236 (OS), BOND BEARING PAD TO ANCHOR PLATE.
9. EXTERIOR SURFACES SHALL BE CLEANED PER SSPC-SP 6 PRIOR TO SHIPMENT TO ASSURE UNIFORM WEATHERING IN ACCORDANCE WITH OWNER REQUIREMENTS.
10. GUARDRAIL SHALL BE 12 GAUGE W-BEAM WEATHERING CONFORMING TO THE REQUIREMENTS OF AASHTO M 180.
11. THE BOTTOM OF ALL FOOTINGS AND SLABS SHALL BEAR ON SOLID NATIVE, INORGANIC, UNDISTURBED SOIL OR APPROVED COMPACTED FILL. THE FOUNDATION TYPE AND DESIGN CRITERIA ARE BASED ON THE REPORT "GEOTECHNICAL EVALUATION REPORT: PROPOSED MAINTENANCE ROAD BRIDGE, DULUTH, MINNESOTA" BY BRAUN INTERTEC CORPORATION DATED SEPTEMBER 10, 2013. ALLOWABLE SOIL BEARING PRESSURE IS ASSUMED TO BE 4000 PSF.
12. THE OWNER SHALL BE RESPONSIBLE FOR PROVIDING A STATEMENT OF SPECIAL INSPECTIONS PREPARED BY A REGISTERED DESIGN PROFESSIONAL IN CHARGE PER THE LATEST EDITION OF THE IBC SECTIONS 1704 THROUGH 1710. THE OWNER SHALL EMPLOY ONE OR MORE QUALIFIED SPECIAL INSPECTORS TO PROVIDE INSPECTIONS DURING ONSITE INSTALLATION OF THE BRIDGE FOR THE TYPES OF WORK LISTED IN THE STATEMENT OF SPECIAL INSPECTIONS.

FOUNDATION

1. RECOMMENDATIONS FOR FOUNDATION TYPE AND DESIGN CRITERIA WERE PROVIDED BY THE GEOTECHNICAL REPORT "GEOTECHNICAL EVALUATION REPORT: PROPOSED MAINTENANCE ROAD BRIDGE, DULUTH, MINNESOTA", DATED SEPTEMBER 10, 2013 BY BRAUN INTERTEC CORPORATION, A SEPARATE CONSULTANT TO THE OWNER. CONTRACTOR SHALL READ AND BE FAMILIAR WITH ALL ASPECTS AND REQUIREMENTS FOR SITE AND FOUNDATION SUB-GRADE PREPARATION. UNLESS NOTED OTHERWISE, THE GEOTECHNICAL REPORT SHALL BE CONSIDERED PART OF THE CONSTRUCTION DOCUMENTS AND SHALL BE FOLLOWED.
2. THE ABUTMENT IS SUPPORTED ON SPREAD FOOTINGS BEARING ON COMPETENT SUB-GRADE. THE BOTTOM OF ALL EXTERIOR FOOTINGS TO BEAR 72" MINIMUM BELOW FINISHED GRADE.
3. THE BOTTOM OF ALL FOOTINGS AND SLABS TO BEAR ON SOLID NATIVE, INORGANIC, UNDISTURBED SOIL OR APPROVED COMPACTED FILL.
4. THE GEOTECHNICAL ENGINEER SHALL PERFORM AN OPEN EXCAVATION INSPECTION PRIOR TO PLACING FOUNDATIONS TO ENSURE THE BEARING CAPACITY IS SATISFACTORY.
5. THERE SHALL BE A MINIMUM COMPACTION TO 95% OF THE MAXIMUM DRY DENSITY (ASTM D698 STANDARD PROCTOR) OF ALL BACKFILL OF SOILS UNDER PRECAST FOOTINGS.
6. NO CONCRETE SHALL BE PLACED IN EXCAVATION CONTAINING WATER OR ON FROZEN SOIL.
7. IN CASE CONDITIONS FOUND AT THE SITE VARY FROM THOSE INDICATED ON THE DRAWINGS, THE ENGINEER IS TO BE NOTIFIED SO THAT ADJUSTMENTS TO THE FOUNDATION CAN BE MADE TO MEET ACTUAL FIELD CONDITIONS.
8. THE DESIGN AND ERECTION OF ALL SHORING, SHEETING, SOIL STABILITY, AND DEWATERING IS THE SOLE RESPONSIBILITY OF THE CONTRACTOR. THE CONTRACTOR SHALL HIRE A LICENSED ENGINEER TO DESIGN ALL SHORING AND SHEETING.

CAST-IN-PLACE CONCRETE

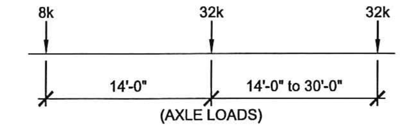
1. CONCRETE PROPERTIES SHALL BE DETERMINED FROM DESIGNATED EXPOSURE CATEGORY F CLASS F2 AS DESCRIBED IN SECTION 4.2.1 OF THE LATEST EDITION OF ACI 318, UNLESS NOTED OTHERWISE.
   a. MINIMUM COMPRESSIVE STRENGTH: F'C = 4500 PSI AT 28 DAYS, NORMAL WEIGHT.
   b. MAXIMUM WATER/CEMENT RATIO LIMIT (W/CM): 0.45
   c. AIR CONTENT W/ 3/4" AGGREGATE SIZE = 6% +/- 1.5%
2. MAXIMUM SLUMP PER SECTION 2.5.1 ACI 117: 3" +/- 1" FOR SLABS AND FOOTINGS, 4" +/- 1" FOR WALLS, COLUMNS AND BEAMS.

QC BLOCK				
LAYOUT	DIM INSP	WELDER	WELD INSP	DATE

3. CONCRETE SHALL BE READY MIXED IN ACCORDANCE W/ ASTM C94. PORTLAND CEMENT SHALL CONFORM TO ASTM C150, TYPE I OR II. NORMALWEIGHT AGGREGATE SHALL CONFORM TO ASTM C33.
4. CURING COMPOUND SHALL CONFORM TO ASTM C309, TYPE 2, CLASS B.
5. CONCRETE SHALL BE AIR-ENTRAINED IN CONFORMANCE TO SECTION 4.2.2.4 OF ACI 301, LATEST EDITION, FOR DURABILITY. INTERIOR CONCRETE SLABS TO RECEIVE A HARD-TROWELED FINISH SHALL NOT UTILIZE AN AIR-ENTRAINED AGENT NOR SHALL THE AIR CONTENT EXCEED 3%.
6. ALL CONCRETE SHALL HAVE A MINIMUM CEMENTITIOUS MATERIAL CONTENT OF 470 POUNDS PER CUBIC YARD, UNLESS NOTED OTHERWISE.
7. CALCIUM CHLORIDE SHALL NOT BE ADDED TO CONCRETE.
8. MATERIAL, MIXING, PLACEMENT AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE LATEST EDITION OF THE "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" (ACI 318) AND SECTION 1905 OF THE IBC. EACH PROPOSED CONCRETE MIX SHALL INCLUDE TEST DATA.
9. CONCRETE PLACEMENT: COLD WEATHER IS DEFINED BY ACI 306 AS "THE AIR TEMPERATURE HAS FALLEN TO, OR IS EXPECTED TO FALL BELOW, 40°F"; WHEN COLD WEATHER CONDITIONS EXIST, PLACE CONCRETE COMPLYING WITH ACI 306. HOT WEATHER IS DEFINED BY ACI 305 AS "ANY COMBINATION OF HIGH AIR TEMPERATURE, LOW RELATIVE HUMIDITY, AND WIND VELOCITY TENDING TO IMPAIR THE QUALITY OF FRESH OR HARDENED CONCRETE OR OTHERWISE RESULTING IN ABNORMAL PROPERTIES"; WHEN HOT WEATHER CONDITIONS EXIST, PLACE CONCRETE COMPLYING WITH ACI 305.
10. TESTING OF COMPOSITE SAMPLES OF FRESH CONCRETE OBTAINED ACCORDING TO ASTM C 172 SHALL BE PERFORMED ON AT LEAST ONE COMPOSITE SAMPLE FOR EACH 100 CUBIC YARD OR FRACTION THEREOF OF EACH CONCRETE MIXTURE PLACED EACH DAY. CAST AND LABORATORY AND/OR FIELD CURE AT LEAST TWO SETS OF TWO STANDARD CYLINDER SPECIMENS FOR EACH COMPOSITE SAMPLE ACCORDING TO ASTM C 31/C 31M. TEST ONE SET OF TWO SPECIMENS AT 7 DAYS AND ONE SET OF TWO SPECIMENS AT 28 DAYS ACCORDING TO ASTM C 39/C 39M. A COMPRESSIVE-STRENGTH TEST SHALL BE THE AVERAGE COMPRESSIVE STRENGTH FROM A SET OF TWO SPECIMENS OBTAINED FROM SAME COMPOSITE SAMPLE AND TESTED AT AGE INDICATED. STRENGTH OF EACH CONCRETE MIXTURE WILL BE SATISFACTORY IF EVERY AVERAGE OF ANY THREE CONSECUTIVE COMPRESSIVE-STRENGTH TESTS EQUALS OR EXCEEDS SPECIFIED COMPRESSIVE STRENGTH AND NO COMPRESSIVE-STRENGTH TEST VALUE FALLS BELOW SPECIFIED COMPRESSIVE STRENGTH BY MORE THAN 500 PSI.
11. ALL DETAILING, FABRICATION, AND ERECTION OF REINFORCING SHALL CONFORM TO LATEST EDITION OF ACI "MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES" (ACI 315) AND THE CURRENT "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" (ACI 318).
12. REINFORCING STEEL:
    ASTM A615 - GRADE 40 FOR #3, GRADE 60 FOR #4 AND LARGER.
    ASTM A706 - WHERE WELDING IS REQUIRED, AT SHEAR WALL BOUNDARY ELEMENTS (TRIM BARS) AND LATERAL FRAME ELEMENTS
    ASTM A185 - WELDED WIRE REINFORCEMENT
13. THE FOLLOWING MINIMUM CONCRETE COVER SHALL BE PROVIDED FOR REINFORCEMENT PER ACI 318.
    CONCRETE CAST AGAINST AND PERMANENTLY EXPOSED TO EARTH: 3"
    CONCRETE CAST AGAINST FORMS AND EXPOSED TO EARTH OR WEATHER
    - #6 THROUGH #18 BARS: 2"
    - #5 BAR AND SMALLER: 1-1/2"

    CONCRETE NOT EXPOSED TO WEATHER OR IN CONTACT WITH GROUND
    - SLABS, WALLS, JOISTS: 3/4"
    - BEAMS, COLUMNS: 1-1/2"
14. UNLESS NOTED OTHERWISE, LAP SPLICES IN CONCRETE SHALL BE CLASS "B" TENSION LAP SPLICES (2'-0" MINIMUM) PER THE LATEST EDITION OF ACI 318. STAGGER ALTERNATE SPLICES A MINIMUM OF ONE LAP LENGTH. LAP WELDED WIRE FABRIC SO THAT THE OVERLAP BETWEEN OUTERMOST CROSS WIRES OF EACH SHEET IS NOT LESS THAN THE CROSS WIRE SPACING PLUS 2 INCHES. ALL SPLICE LOCATIONS ARE SUBJECT TO APPROVAL BY ENGINEER AND SHALL BE MADE ONLY WHERE INDICATED ON THE DRAWINGS. EXTEND ALL HORIZONTAL REINFORCING CONTINUOUS AROUND CORNERS AND INTERSECTIONS OR PROVIDE BENT CORNER BARS TO MATCH AND LAP WITH HORIZONTAL BARS AT CORNERS AND INTERSECTIONS OF FOOTINGS AND WALLS.
15. PROVIDE BAR SUPPORTS AND SPACERS TO SUPPORT ALL REINFORCEMENT IN PROPER LOCATIONS AND WIRE ADEQUATELY AT INTERSECTIONS TO HOLD BARS FIRMLY IN POSITION WHILE CONCRETE IS PLACED. BAR SUPPORTS AND SPACERS WHICH REST ON OR EXPOSED SURFACES SHALL BE HOT DIPPED GALVANIZED OR PLASTIC COATED.
16. VERTICAL DOWELS SHALL MATCH THE SIZE AND SPACING OF THE WALL REINFORCEMENT AND BE SECURED AND SUPPORTED IN PLACE PRIOR TO PLACING CONCRETE, UNLESS NOTED OTHERWISE.
17. WELDING OF REINFORCEMENT IS NOT PERMITTED UNLESS SPECIFICALLY NOTED OR APPROVED IN WRITING BY THE ENGINEER.

DESIGN NOTES



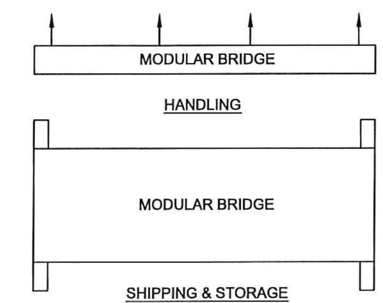
1. DESIGN LIVE LOAD: HS20 (GVW 36 TONS).
2. DESIGN IS BASED ON AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS 6TH EDITION AND ALL INTERIM REVISIONS.
3. LIVE LOAD DEFLECTION AT MIDSPAN IS L/1188 (ONE DESIGN LIVE LOAD TRUCK).
4. TOTAL BRIDGE WEIGHT: APPROX 69,976 LB.
   INTERIOR MODULE WEIGHT: APPROX 21,422 LB PER MODULE.
   OUTER MODULE WEIGHT: APPROX 24,277 LB PER MODULE.
5. (BRIDGE WEIGHT DOES INCLUDE STEEL DECK BUT DOES NOT INCLUDE GRAVEL BALLAST OR FUTURE WEARING SURFACE).

THE OWNER OR OWNER'S REPRESENTATIVE (SITE ENGINEER OF RECORD) IS RESPONSIBLE FOR THE REVIEW OF BRIDGE STRUCTURE DIMENSIONS AND LAYOUT SHOWN HEREIN. ANY DISCREPANCIES BETWEEN REQUIRED FIELD DIMENSIONS AND THOSE SHOWN HEREIN ARE NOT THE RESPONSIBILITY OF TRUENORTH STEEL OR BEAUDETTE CONSULTING ENGINEERS, INC. UNLESS THE DISCREPANCIES HAVE BEEN SPECIFICALLY NOTED WITHIN THIS REVIEW SET OR PREVIOUSLY CONVEYED IN WRITING. YOUR SIGNATURE BELOW ACKNOWLEDGES THIS RESPONSIBILITY AND SERVES AS NOTICE TO PROCEED WITH BRIDGE FABRICATION.

OWNER OR REPRESENTATIVE NAME:

OWNER OR REPRESENTATIVE SIGNATURE:

DATE:



1. LIFTING FORCES MUST BE APPLIED VERTICALLY AND SIMULTANEOUSLY AT PADEYE HANDLING PICK POINTS AS INDICATED.
2. USE SPREADER BAR WHEN HANDLING.
3. LIFTING PIN TO BE WITHIN ⅛" OF PADEYE HOLE SIZE.
4. PADEYE LIFTING CAPACITY: 16.25 KIPS.

SHEET INDEX

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.
Thomas R. Beaudette
Date 09/11/14 Reg. No. 21133

S/N
61MB21HS20-JMI344

TrueNorth Steel

bce
STRUCTURAL
BEAUDETTE CONSULTING ENGINEERS, INC.
MISSOULA KALISPELL
BOZEMAN RAPID CITY
(406) 721-7315
WWW.BCEWEB.COM

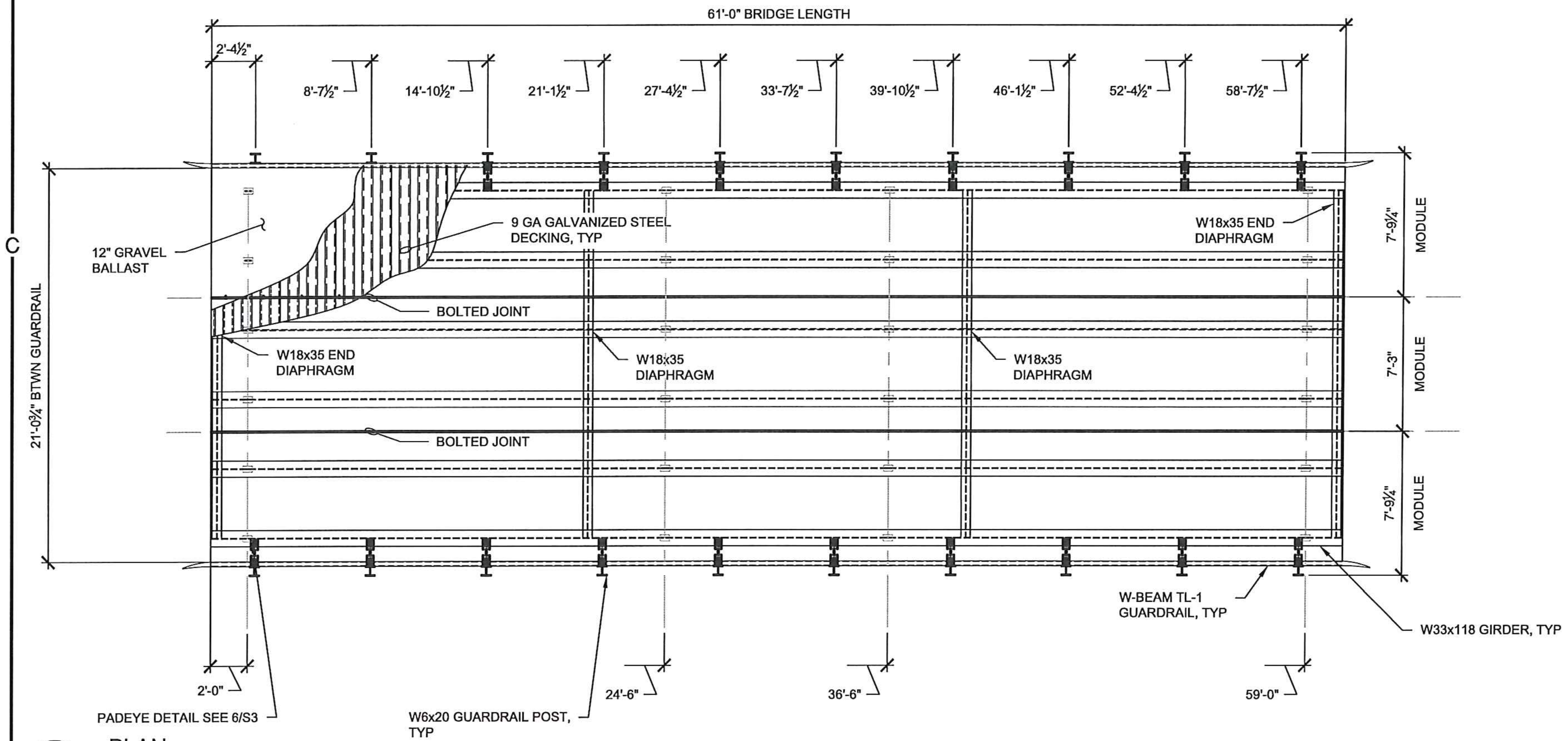
PROJECT IDEN.
61'L x 21'W
HS20
KNOWLTON CREEK BRIDGE
DULUTH, MN

ISSUE BLOCK	
APP	09/11/2014 FOR APPROVAL
CHK	09/09/2014 CHECK PRINT

MANAGEMENT	
JOB NO.:	JMI344
PROJECT NO.:	14692
DRAWN BY:	CAW
CHECKED BY:	MKN

SHEET TITLE
STRUCTURAL GENERAL NOTES

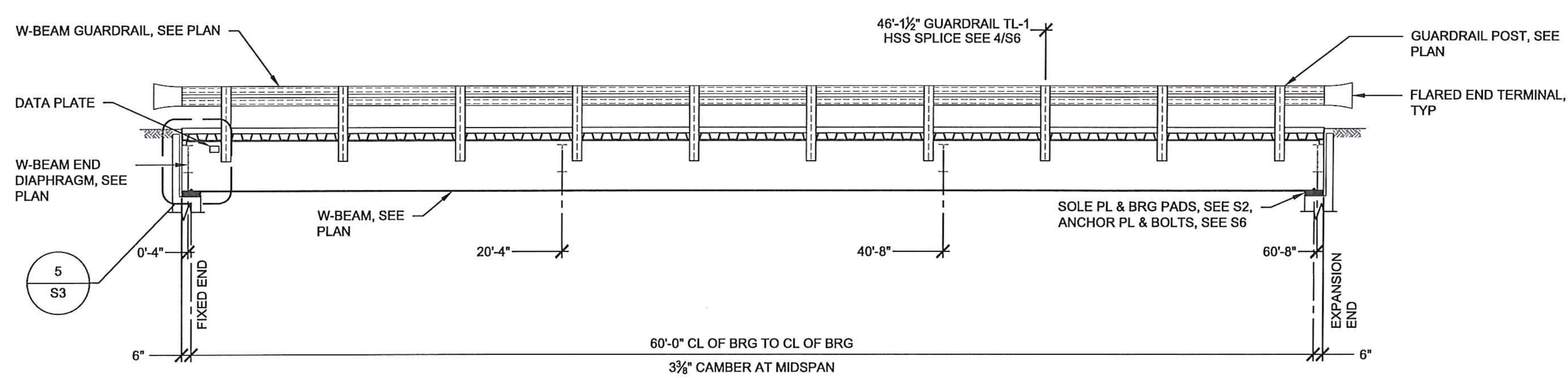
SHEET IDENTIFICATION
S0



1 PLAN

SCALE: 3/16"=1'-0"

0' 2' 10'



2 ELEVATION

SCALE: 3/16"=1'-0"

0' 2' 10'

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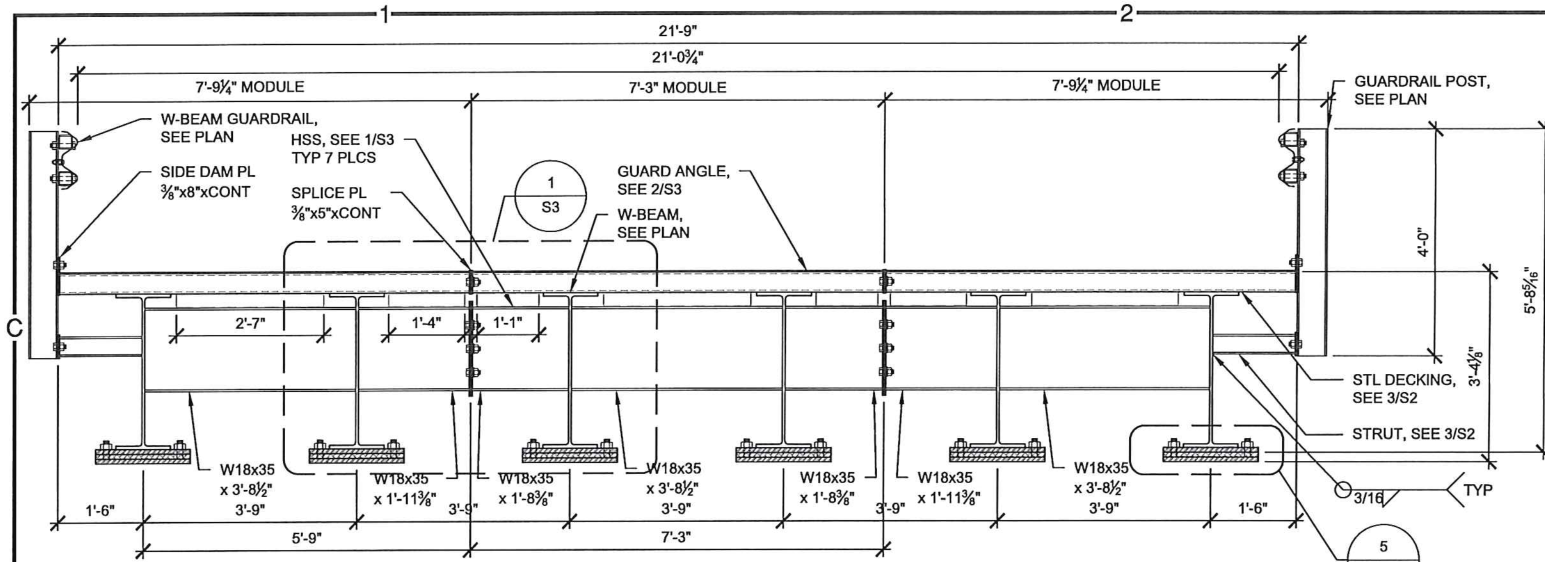
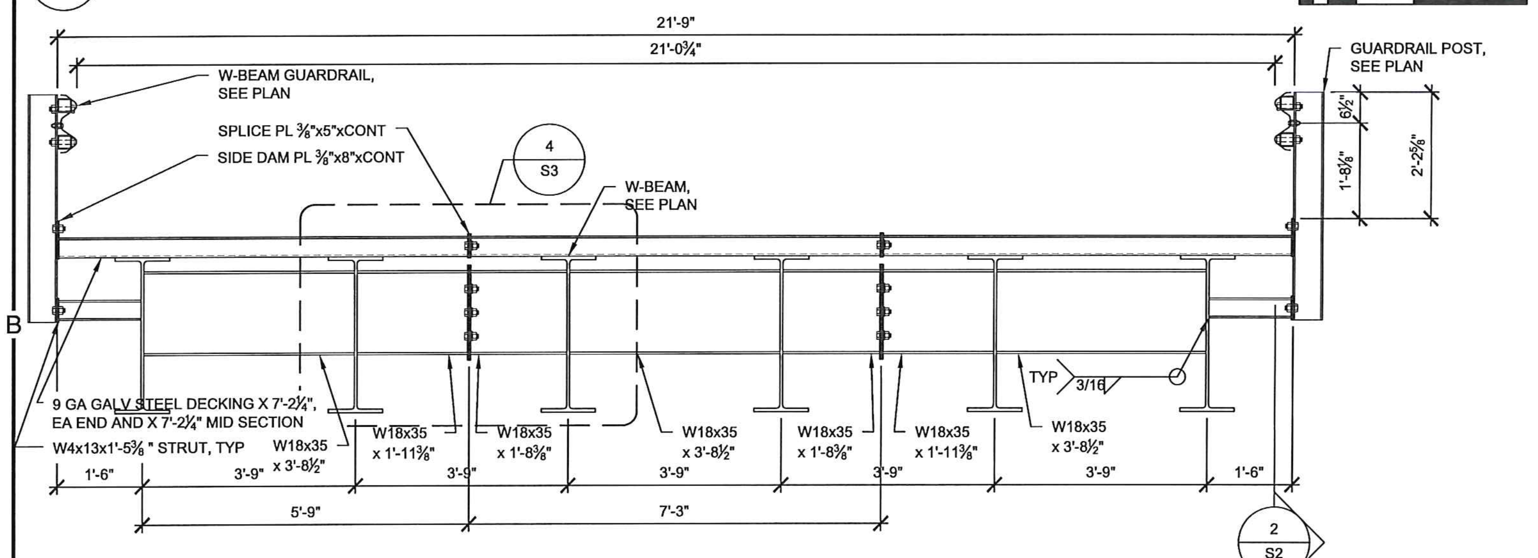
SHEET TITLE
BRIDGE PLAN & ELEVATION

SHEET IDENTIFICATION
S1
2 OF 8



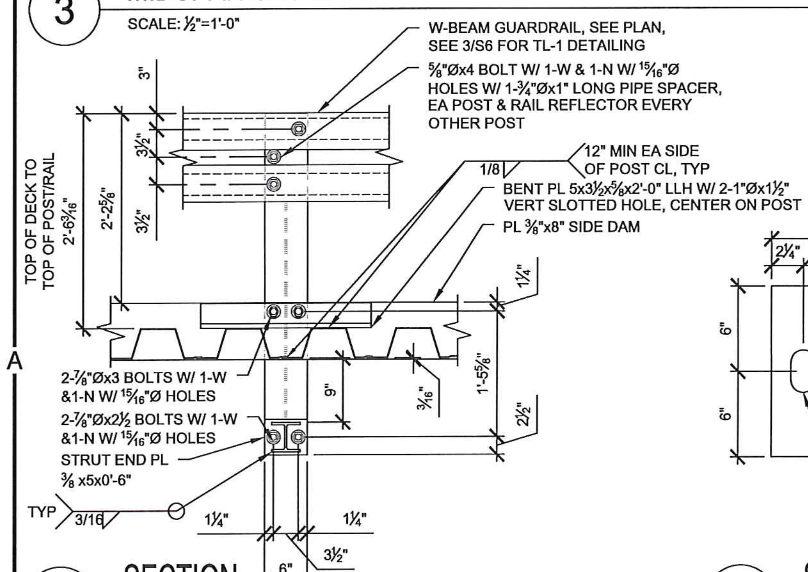
1 END SECTION

SCALE: ½"=1'-0"



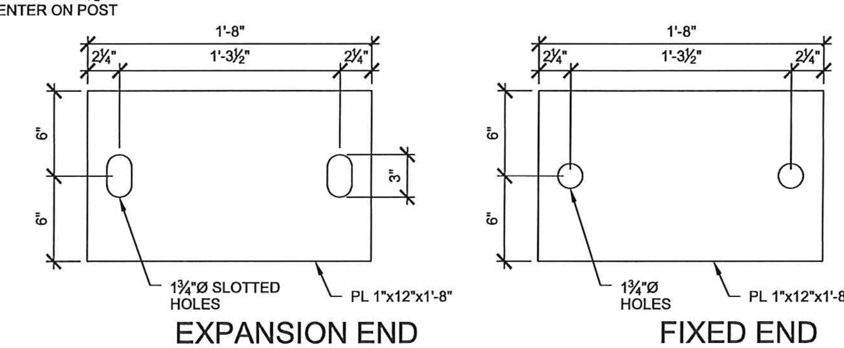
3 MIDSPAN SECTION

SCALE: ½"=1'-0"



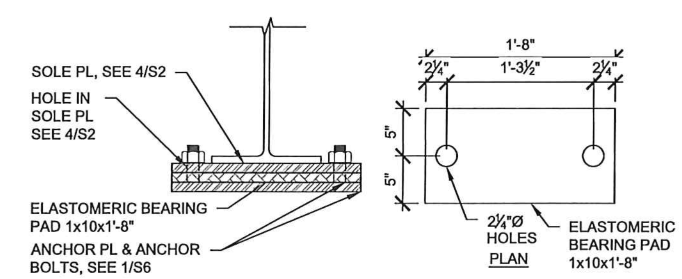
2 SECTION

SCALE: ¾"=1'-0"



4 SOLE PLATE DETAIL

SCALE: 1½"=1'-0"



5 ELASTOMERIC BEARING - EACH END

SCALE: 1"=1'-0"

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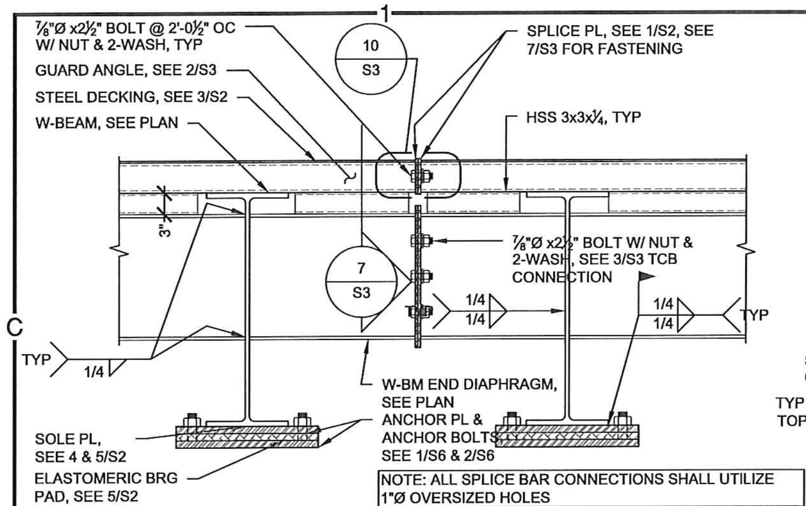
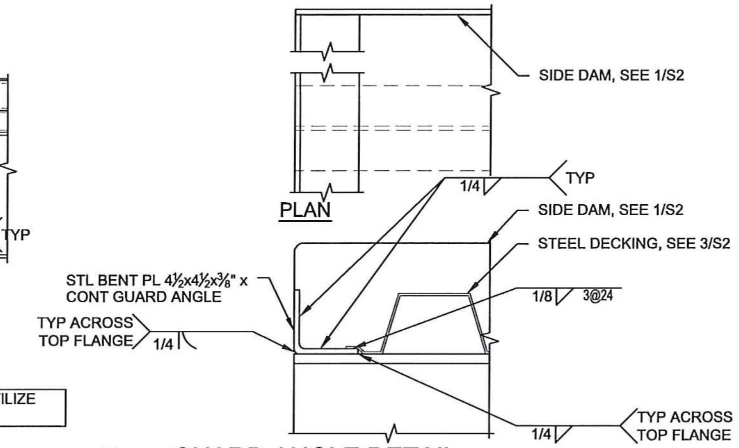
SHEET TITLE
BRIDGE SECTIONS & BEARING DETAILS

SHEET IDENTIFICATION
S2
3 OF 8



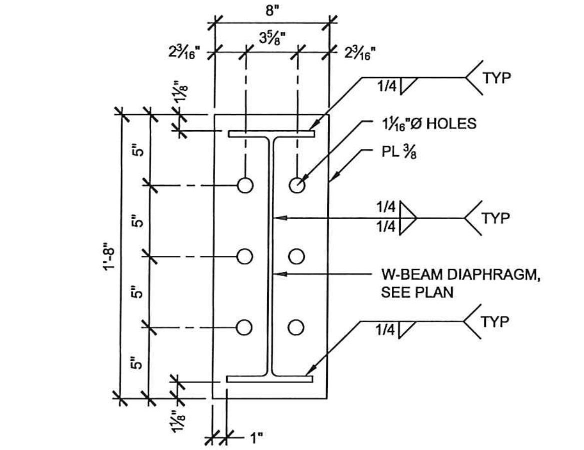
1 DETAIL @ END DIAPHRAGM

SCALE: ¾"=1'-0" — 0" 8" 16" 32"



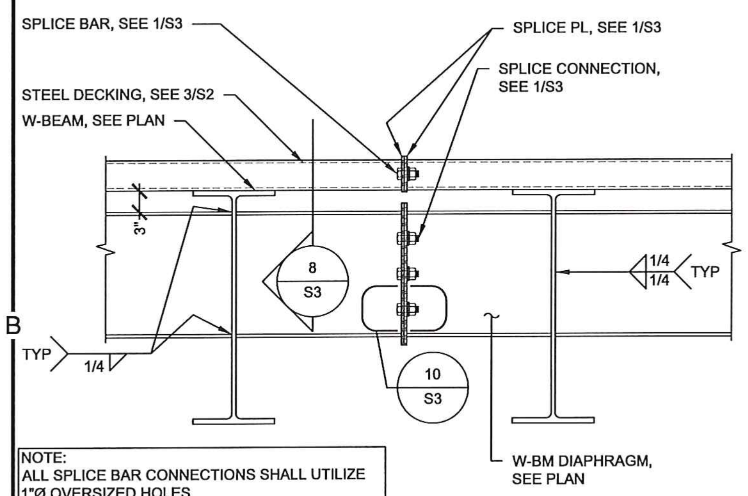
2 GUARD ANGLE DETAIL

SCALE: 1½"=1'-0" — 0" 4" 8" 16"



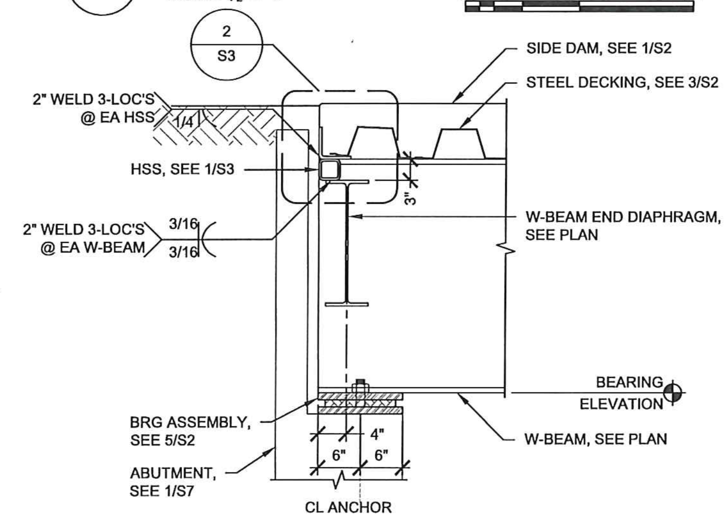
3 SPLICE CONNECTION - TCB

SCALE: 1½"=1'-0" — 0" 4" 8" 16"



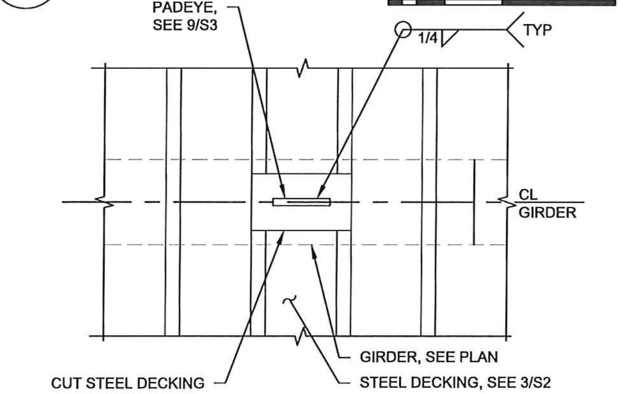
4 DETAIL @ MIDSPAN

SCALE: ¾"=1'-0" — 0" 8" 16" 32"



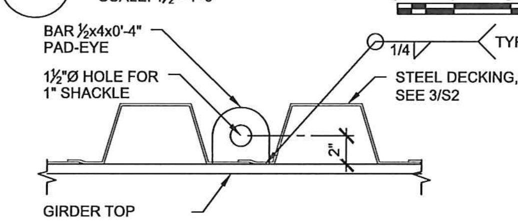
5 END BEARING SECTION

SCALE: ¾"=1'-0" — 0" 8" 16" 32"



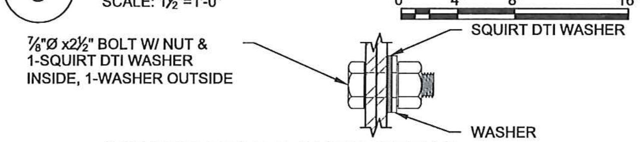
6 PADEYE DETAIL-PLAN

SCALE: 1½"=1'-0" — 0" 4" 8" 16"



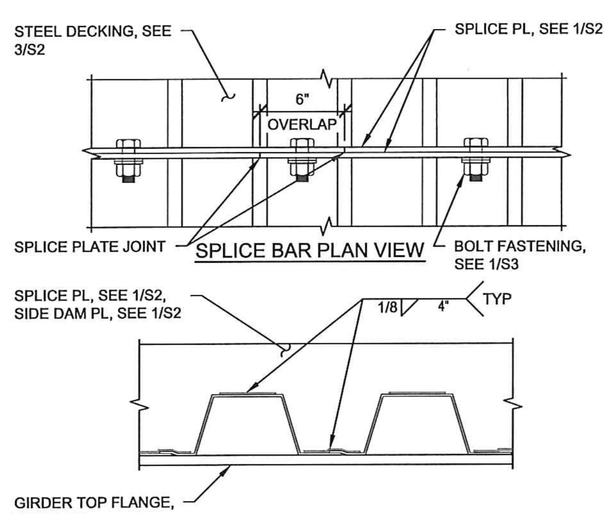
9 PAD-EYE DETAIL

SCALE: 1½"=1'-0" — 0" 4" 8" 16"



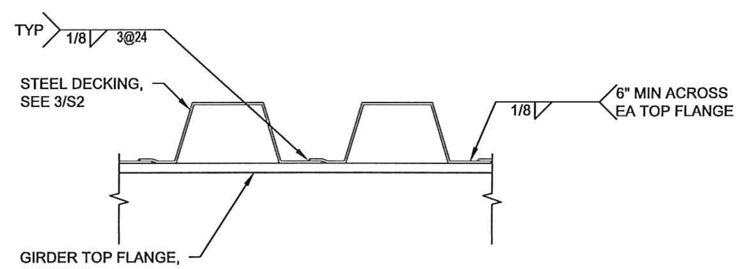
10 SQUIRT DTI WASHER DETAIL

SCALE: 3"=1'-0" — 0" 2" 4" 8"



7 SIDE DAM / SPLICE BAR WELD DETAIL

SCALE: 1½"=1'-0" — 0" 4" 8" 16"



8 TOP SECTION - DECK TO GIRDER CONN

SCALE: 1½"=1'-0" — 0" 4" 8" 16"

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PROJECT IDEN.
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ISSUE BLOCK

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PROJECT NO.:	14692
DRAWN BY:	CAW
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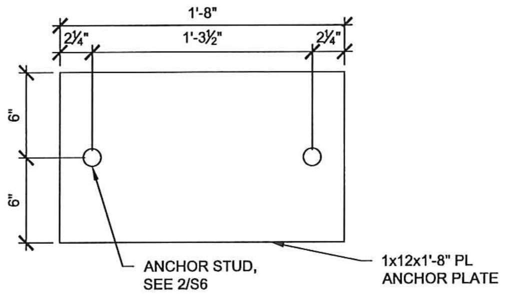
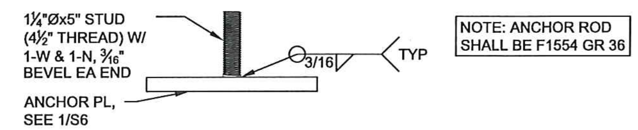
SHEET TITLE
DETAILS

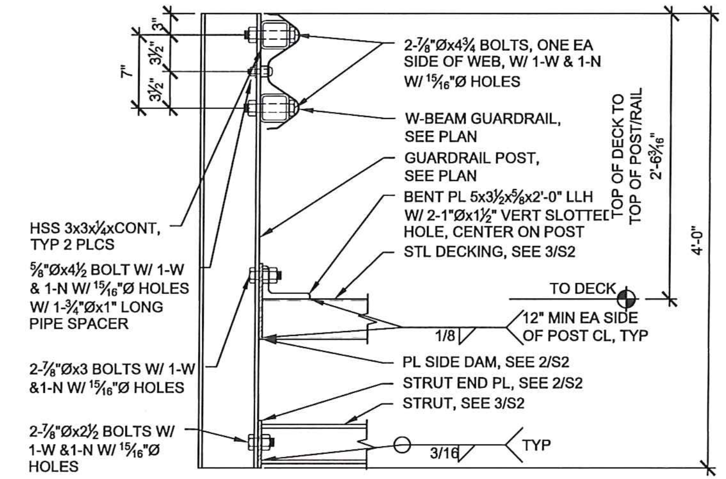
SHEET IDENTIFICATION
S3
4 OF 8



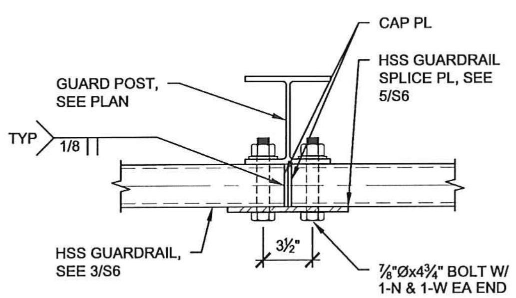
1 ANCHOR PLATE PLAN
SCALE: 1½"=1'-0"



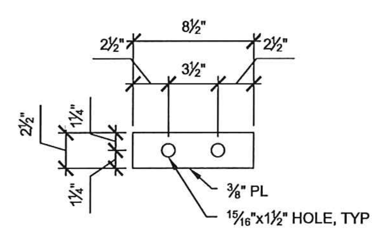
2 ANCHOR PLATE SECTION
SCALE: 1½"=1'-0"



3 GUARDRAIL SYSTEM TL-1 W-BEAM
SCALE: 1"=1'-0"



4 GUARDRAIL TL-1 HSS SPLICE DETAIL
SCALE: 1½"=1'-0"



5 HSS GUARDRAIL SPLICE PLATE
SCALE: 1½"=1'-0"

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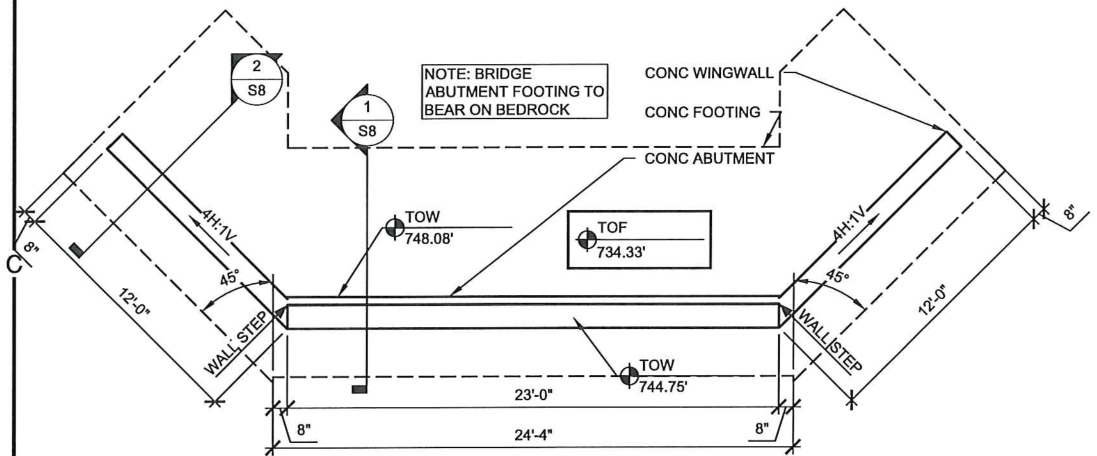
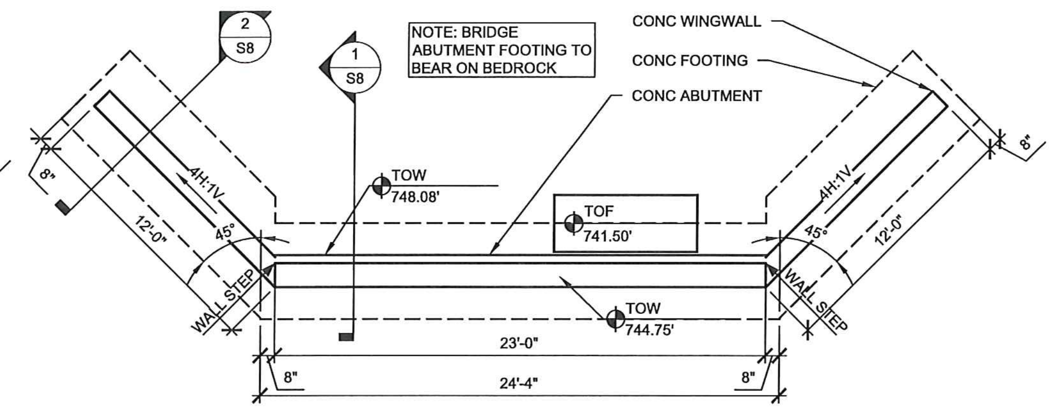
SHEET TITLE
DETAILS

SHEET IDENTIFICATION
S6
5 OF 8



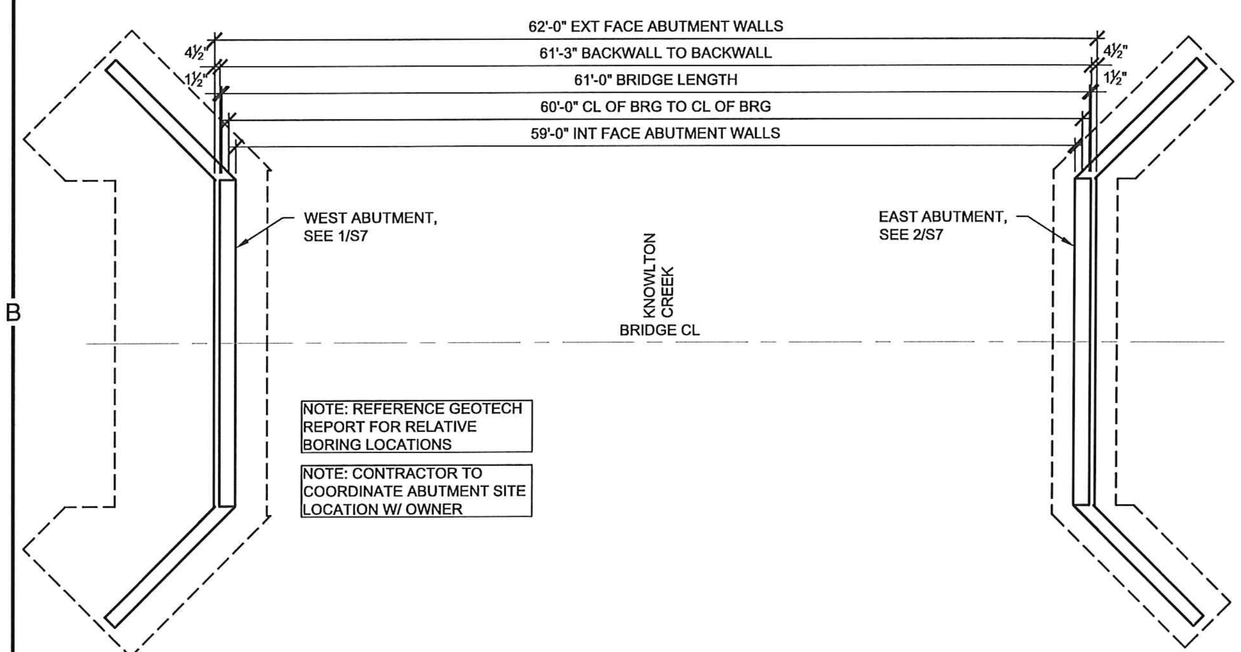
1 SITE ABUTMENT & WING WALL PLAN - WEST ABUTMENT

SCALE: 3/16"=1'-0"



2 SITE ABUTMENT & WING WALL PLAN - EAST ABUTMENT

SCALE: 3/16"=1'-0"



3 BRIDGE ABUTMENT PLAN

SCALE: 1/8"=1'-0"

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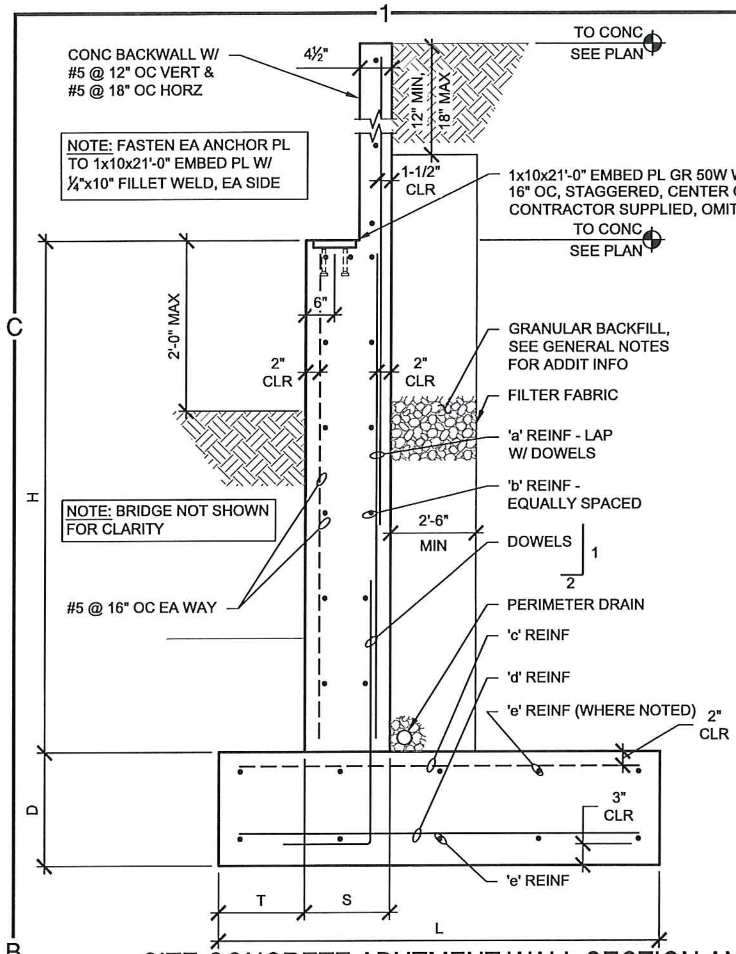
SHEET TITLE
ABUTMENT PLANS

SHEET IDENTIFICATION
S7
6 OF 8



	H = 10'-5"	H = 3'-3"				
L(1)	10'-9"	4'-6"				
T	2'-3"	1'-6"				
S	18"	18"				
D	16"	12"				
'a' REINF	#6 @ 4"	#5 @ 18"				
'b' REINF	#5 @ 16"	#5 @ 16"				
'c' REINF	#6 @ 9"	#5 @ 12"				
'd' REINF	#6 @ 9"	#5 @ 12"				
'e' REINF	8-#5 TOP 8-#5 BOT	4-#5 TOP 4-#5 BOT				
DOWELS	#6 @ 4"	#5 @ 18"				
1	50"	40"				
2	12"	12"				

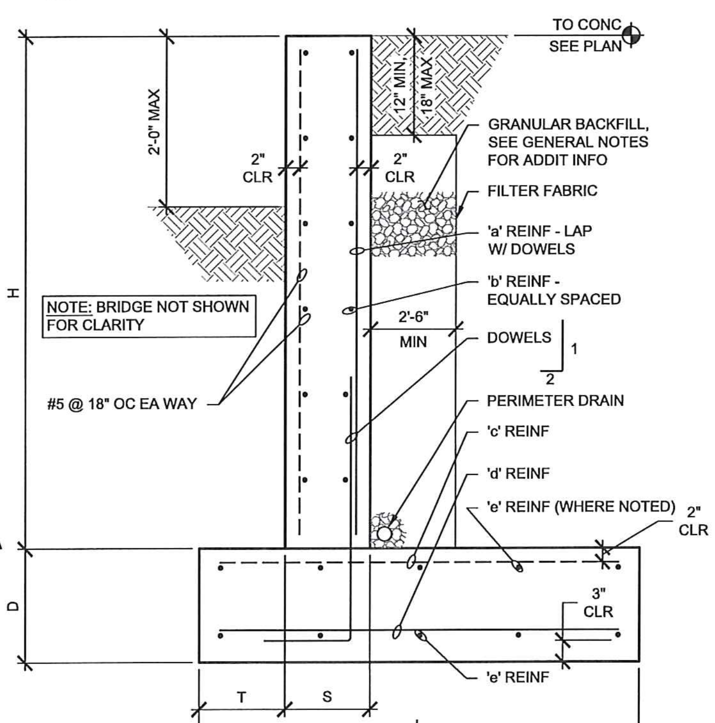
SITE ABUTMENT WALL SCHEDULE

ADDITIONAL REMARKS:

1. FOOTING SIZED BASED ON 10,000 PSF BEARING PRESSURE CAPACITY WITH 0/3 INCREASE FOR LOAD DURATION, SOIL'S ENGINEER TO VERIFY
2. AT CONTRACTOR'S OPTION, EXTEND DOWEL TO TOP OF WALL AND OMIT 'a' REINFORCING

1 SITE CONCRETE ABUTMENT WALL SECTION AND SCHEDULE - (42" FROST DEPTH)

SCALE: NTS



SITE WING WALL SCHEDULE

	H = 13'-9"	H = 6'-7"				
L(1)	10'-9"	4'-6"				
T	2'-3"	1'-6"				
S	12"	12"				
D	16"	12"				
'a' REINF	#6 @ 3"	#5 @ 12"				
'b' REINF	#5 @ 18"	#5 @ 18"				
'c' REINF	#6 @ 9"	#5 @ 12"				
'd' REINF	#6 @ 9"	#5 @ 12"				
'e' REINF	8-#5 TOP 8-#5 BOT	4-#5 TOP 4-#5 BOT				
DOWELS	#6 @ 3"	#5 @ 12"				
1	50"	40"				
2	12"	12"				

ADDITIONAL REMARKS:

1. FOOTING SIZED BASED ON 10,000 PSF BEARING PRESSURE CAPACITY WITH 0/3 INCREASE FOR LOAD DURATION, SOIL'S ENGINEER TO VERIFY
2. AT CONTRACTOR'S OPTION, EXTEND DOWEL TO TOP OF WALL AND OMIT 'a' REINFORCING

2 SITE CONCRETE WING WALL SECTION AND SCHEDULE - (42" FROST DEPTH)

SCALE: NTS

S/N
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09/11/14

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SHEET TITLE
ABUTMENT DETAILS

SHEET IDENTIFICATION
S8

BILL OF MATERIALS

MAJOR MARK	MINOR MARK	QTY	DESCRIPTION	UNIT LENGTH	TOTAL LENGTH	REMARKS	UNIT (LB)	TOTAL (LB)
GR			GUARD RAIL ASSEMBLY TL-1					
	GR1	20	POST	4'-0"	80'-0"	W6x20	80.00	1600.0
	GR2	20	STRUT PL	-	-	PL 3/8"x5x0'-6"	3.20	64.0
	GR3	2	RAIL	61'-0"	122'-0"	12 GA W-BEAM M 180 WEATHERING	396.50	793.0
	GR4	4	RAIL END TREATMENT	-	-	TERMINAL FLARE 12 GA WEATHERING	10.00	40.0
	GR5	20	STRUT	1'-5 3/8"	28'-11 1/2"	W4x13	18.82	376.5
	GR6	4	HSS TUBE	61'-0"	244'-0"	HSS3x3x1/4	535.46	2141.8
	GR7	8	CAP PL	-	-	PL 1/4"x2 7/8x0'-2 7/8"	0.58	4.6
	GR8	20	GUARD BENT PL	-	-	BENT PL 5x3-1/2x5/8x2'-0"	33.60	672.0
	SB	14	REFLECTOR WASHER	-	-	TAB CRYSTAL 2	0.07	1.0
	SB	10	RECTANGULAR WASHER	-	-	CORTEN WEATHERING	0.07	0.7
	SB	20	5/8"ø BOLT	4"	-	A307 GR A A242 GALV	0.44	8.8
	SB	36	5/8"ø BOLT	1 1/4"	-	A307 GR A A242-3	0.19	6.8
	SB	56	5/8"ø NUT HVY HEX	-	-	M 180 TYPE 3	0.30	16.8
	SB	56	5/8"ø WASHER	-	-	F436 TYPE 3	0.03	1.7
	SB	40	7/8"ø BOLT	2 1/2"	-	A325X TYPE 3	0.67	26.8
	SB	40	7/8"ø BOLT	3"	-	A325X TYPE 3	0.80	32.0
	SB	40	7/8"ø BOLT	4 3/4"	-	A325X TYPE 3	1.10	44.0
	SB	120	7/8"ø NUT	-	-	A563 GR DH3	0.30	36.0
	SB	120	7/8"ø WASHER	-	-	F436 TYPE 3	0.07	8.4
	SB	20	3/4"ø x 1" LONG SPACER	-	-	SCH 40 A53	0.09	1.8
								5876.7
DK			METAL DECK					
	DK1	2	SIDE DAM	61'-0"	122'-0"	PL 3/8"x8xCONT	620.98	1242.0
	DK2	4	SPLICE BAR HOLES 24 1/2"	61'-0"	244'-0"	PL 3/8"x5xCONT	387.96	1551.8
	DK4	6	GUARD ANGLE	7'-2 1/4"	43'-1 1/2"	BENT PL 4-1/2x4-1/2x3/8	79.06	474.4
	DK7	183	GALV DECKING	7'-2 1/4"	1315'-3 3/4"	9 GA 4-1/4" x 12" LAY	69.00	12627.0
	FB	64	7/8"ø BOLT	2 1/2"	-	A325X TYPE 3	0.67	42.9
	FB	64	7/8"ø NUT	-	-	A563 GR DH3	0.30	19.2
	FB	64	7/8"ø WASHER	-	-	F436 TYPE 3	0.07	4.5
	FB	64	7/8"ø SQUIRT DTI WASHER	-	-	F959 TYPE A325-3	0.07	4.5
								15966.2
DP			DIAPHRAGM					
	DP1	16	CONNECTION PL	-	-	PL 3/8"x8x1'-8"	17.00	272.0
	DP2	12	EDGE DIAPHRAGM	3'-8 1/2"	44'-6"	W18x35	129.79	1557.5
	DP3	8	CENTER DIAPHRAGM	1'-11 3/8"	15'-7"	W18x35	68.18	545.4
	DP4	6	GUARD ANGLE SUPPORT	2'-7"	15'-6"	HSS3x3x1/4	22.68	136.1
	DP5	4	GUARD ANGLE SUPPORT	1'-4"	5'-4"	HSS3x3x1/4	11.70	46.8
	DP6	8	CENTER DIAPHRAGM	1'-8 3/8"	13'-7"	W18x35	59.43	475.4
	DP7	4	GUARD ANGLE SUPPORT	1'-1"	4'-4"	HSS3x3x1/4	9.51	38.0
	FB	48	7/8"ø BOLT	2 1/2"	-	A325X TYPE 3	0.67	32.2
	FB	48	7/8"ø NUT	-	-	A563 GR DH3	0.30	14.4
	FB	48	7/8"ø WASHER	-	-	F436 TYPE 3	0.07	3.4
	FB	48	7/8"ø SQUIRT DTI WASHER	-	-	F959 TYPE A325-3	0.07	3.4
								3124.5

BM			W-BEAM GIRDER					
	BM1	6	TYP GIRDER	61'-0"	366'-0"	W33x118	7198.00	43188.0
	BM2	6	SOLE PL FIXED	-	-	PL 1"x12x1'-8"	68.05	408.3
	BM3	6	SOLE PL EXPANSION	-	-	PL 1"x12x1'-8"	68.05	408.3
	BM4	12	ELASTOMERIC PAD	-	-	PAD 1"x10x1'-8" DURO 70	12.10	145.2
	BM5	24	PADEYE	-	-	PL 1/2"x4x0'-4"	1.76	42.2
	BM6	12	ANCHOR PL	-	-	PL 1"x12x1'-8"	68.05	816.6
								45008.6
						APPROX BRIDGE WEIGHT (LB)		69976.1
						APPROX INT MODULE WEIGHT (LB)		21422.1
						APPROX OUTER MODULE WEIGHT (LB)		24277.0

bce STRUCTURAL
BEAUDETTE CONSULTING ENGINEERS, INC.
MISSOULA KALISPELL
BOZEMAN RAPID CITY
(406) 721-7315
WWW.BCEWEB.COM

PROJECT IDEN.
61'L x 21'W
HS20
KNOWLTON CREEK BRIDGE
DULUTH, MN

ISSUE BLOCK

APP	09/11/2014	FOR APPROVAL
CHK	09/09/2014	CHECK PRINT

MANAGEMENT

JOB NO.:	JMI344
PROJECT NO.:	14692
DRAWN BY:	CAW
CHECKED BY:	MKN

SHEET TITLE
BILL OF MATERIALS

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.
Thomas R. Beaudette
Date 09/11/14 Reg. No. 21133

NOTE: TRUENORTH STEEL TO VERIFY CONTENTS OF BILL OF MATERIALS LIST PRIOR TO FABRICATION.

S/N
61MB21HS20-JMI344

TrueNorth Steel

SHEET IDENTIFICATION
S-BOM1
8 OF 8

JONES LANG LASALLE

Jones Lang LaSalle Brokerage, Inc.
4300 Amon Carter Blvd., Suite 100
Fort Worth, Texas 76155
tel +1 817-230-2600, fax +1 817 306-8265

October 31, 2014

City of Duluth, Spirit Mountain Recreation Authority
Attention: Ms. Brandy Ream
9500 Spirit Mountain Place
Duluth, Minnesota 55810

14-50943

Dear Mr. Ream:

Enclosed please find one (1) fully executed Agreement for your file. A copy of the executed Agreement must be available upon request at the job sites allowing authorization to do the work. Please contact Roadmaster at telephone (715) 394-1235 or cell (612) 803-2040, at least ten (10) days in advance of entry for each location and **BEFORE YOU DIG, CALL 1-800-533-2891**. If you need additional information please contact me at (817) 230-2630.

Very truly yours,

Katie Robles
Associate Contract Specialist

Enclosure

cc: Charles VonRueden - BNSF Roadmaster – Charles.VonRueden@bnsf.com

PIPELINE LICENSE

THIS PIPELINE LICENSE ("**License**") is made to be effective October 31, 2014 (the "**Effective Date**") by and between **BNSF RAILWAY COMPANY**, a Delaware corporation ("**Licensor**") and **CITY OF DULUTH, SPIRIT MOUNTAIN RECREATION AUTHORITY**, a Minnesota corporation ("**Licensee**").

In consideration of the mutual covenants contained herein, the parties agree to the following:

GENERAL

1. Grant of License. Licensor hereby grants Licensee a non-exclusive license, subject to all rights, interests, and estates of third parties, including, without limitation, any leases, use rights, easements, liens, or other encumbrances, and upon the terms and conditions set forth below, to construct and maintain, in strict accordance with the drawings and specifications approved by Licensor as part of Licensee's application process (the "**Drawings and Specifications**"), one (1) pipeline, 24 inches in diameter inside a 30 inch Steel casing (collectively, the "**Pipeline**"), across or along Licensor's rail corridor at or near the station of Riverside Junction, County of St. Louis, State of Minnesota, Line Segment 0500, Mile Post 8.64 as shown on the attached Drawing No. 61849, dated September 2, 2014, attached hereto as **Exhibit "A"** and incorporated herein by reference (the "**Premises**").

2. Term. This License shall commence on the Effective Date and shall continue for a period of twenty-five (25) years, subject to prior termination as hereinafter described.

3. Existing Improvements. Licensee shall not disturb any improvements of Licensor or Licensor's existing lessees, licensees, easement beneficiaries or lien holders, if any, or interfere with the use, repair, maintenance or replacement of such improvements.

4. Use of the Premises. Licensee shall use the Premises solely for construction, maintenance, and use of the Pipeline in accordance with the Drawings and Specifications. The Pipeline shall carry water, and Licensee shall not use the Pipeline to carry any other material or use the Premises for any other purpose.

5. Alterations. Except as set forth in this License, Licensee may not make any alterations to the Premises or permanently affix anything to the Premises or any buildings or other structures adjacent to the Premises without Licensor's prior written consent.

COMPENSATION

6. License Fee. Licensee shall pay Licensor, prior to the Effective Date, the sum of one thousand five hundred and No/100 Dollars $ 1,500.00 as compensation for the use of the Premises.

7. Costs and Expenses.

   7.1 For the purpose of this License, "cost" or "costs" and "expense" or "expenses" includes, but is not limited to, actual labor and material costs including all assignable additives, and material and supply costs at current value where used.

   7.2 Licensee agrees to reimburse Licensor (pursuant to the terms of **Section 8** below) for all costs and expenses incurred by Licensor in connection with Licensee's use of the Premises or the presence, construction and maintenance of the Pipeline, including but not limited to the furnishing of Licensor's flaggers and any vehicle rental costs incurred. Licensee shall bear the cost of flagger services and other safety measures provided by Licensor, when deemed necessary by Licensor's representative. Flagging **costs** shall include, but not be limited to, the following: pay for at least an eight (8) hour basic day with time and one-half or double time for overtime, rest days and holidays (as applicable); vacation allowance; paid holidays (as applicable); railway and unemployment insurance; public liability and property damage insurance; health and welfare benefits; transportation; meals; lodging and supervision. Negotiations for railway labor or collective bargaining agreements and rate changes authorized by appropriate Federal authorities may increase flagging rates. Flagging rates in effect at the time of performance by the flaggers will be used to calculate the flagging costs pursuant to this **Section 7.**

8. Payment Terms. All invoices are due thirty (30) days after the date of invoice. If Licensee fails to pay any monies due to Licensor within thirty (30) days after the invoice date, then Licensee shall pay interest on such unpaid sum from the due date until paid at an annual rate equal to the lesser of (i) the prime rate last published in *The Wall Street Journal* in the preceding December plus two and one-half percent (2-1/2%), or (ii) the maximum rate permitted by law.

LICENSOR'S RESERVED RIGHTS

9. Reserved Rights of Use. Licensor excepts and reserves the right, to be exercised by Licensor and any other parties who may obtain written permission or authority from Licensor:

9.1 to maintain, use, operate, repair, replace, modify and relocate any utility, power or communication pipe/lines/cables and appurtenances (other than the Pipeline) and other facilities or structures of like character upon, over, under or across the Premises existing as of the Effective Date;

9.2 to construct, maintain, renew, use, operate, change, modify and relocate any tracks or additional facilities, structures and related appurtenances upon, over, under or across the Premises; or

9.3 to use the Premises in any manner as Licensor in its sole discretion deems appropriate, provided Licensor uses all commercially reasonable efforts to avoid material interference with the use of the Premises by Licensee for the purpose specified in **Section 4** above.

10. Right to Require Relocation. If at any time during the term of this License, Licensor desires the use of its rail corridor in such a manner as would, in Licensor's reasonable opinion, be interfered with by the Pipeline, Licensee shall, at its sole expense, within thirty (30) days after receiving written notice from Licensor to such effect, make such changes in the Pipeline as in the sole discretion of Licensor may be necessary to avoid interference with the proposed use of Licensor's rail corridor, including, without limitation, the relocation of the Pipeline, or the construction of a new pipeline to replace the Pipeline. Notwithstanding the foregoing, Licensee agrees to make all emergency changes and minor adjustments, as determined by Licensor in its sole discretion, to the Pipeline promptly upon Licensor's request.

LICENSEE'S OPERATIONS

11. Construction and Maintenance of the Pipeline.

11.1 Licensee shall notify Licensor's Roadmaster, at 2304 N 28th St., Superior, WI 54880, telephone (715) 394-1235, at least ten (10) business days prior to installation of the Pipeline and prior to entering the Premises for any subsequent maintenance thereon. In the event of emergency, Licensee shall notify Licensor of Licensee's entry onto the Premises at the telephone number above as soon as practicable and shall promptly thereafter follow up with written notice of such entry.

11.2 Licensee's on-site supervisors shall retain/maintain a fully executed copy of this License at all times while on the Premises.

11.3 While on the Premises, Licensee shall use only public roadways to cross from one side of Licensor's tracks to the other.

11.4 Any contractors or subcontractors performing work on the Pipeline or entering the Premises on behalf of Licensee shall be deemed servants and agents of Licensee for purposes of this License.

11.5 Under no conditions shall Licensee be permitted to conduct any tests, investigations or any other activity using mechanized equipment and/or machinery, or place or store any mechanized equipment, tools or other materials, within twenty-five (25) feet of the centerline of any railroad track on the Premises unless Licensee has obtained prior written approval from Licensor. Licensee shall, at its sole cost and expense, perform all activities on and about the Premises in such a manner as not at any time to endanger or interfere with (i) the existence or use of present or future tracks, roadbeds, or property of Licensor, (ii) the safe operation and activities of Licensor or existing third parties, or (iii) the rights or interests of third parties. If ordered to cease using the Premises at any time by Licensor's personnel due to any hazardous condition, Licensee shall immediately do so. Notwithstanding the foregoing right of Licensor, the parties agree that Licensor has no duty or obligation to monitor Licensee's use of the Premises to determine the safe nature thereof, it being solely Licensee's responsibility to ensure that Licensee's use of the Premises is safe. Neither the exercise nor the failure by Licensor to exercise any rights granted in this Section will alter the liability allocation provided by this License.

11.6 Licensee shall, at its sole cost and expense, construct and maintain the Pipeline in such a manner and of such material that the Pipeline will not at any time endanger or interfere with (i) the existence or use of present or future tracks, roadbeds, or property of Licensor, (ii) the safe operation and activities of Licensor or existing third parties, or (iii) the rights or interests of third parties. The construction of the Pipeline shall be completed within one (1) year of the Effective Date, and any subsequent maintenance shall be completed within one (1) year of initiation. Within fifteen (15) days after completion of the construction of the Pipeline or the performance of any subsequent maintenance thereon, Licensee shall, at Licensee's own cost and expense, restore the Premises to substantially their state as of the Effective Date, unless otherwise approved in advance by Licensor in writing. On or before expiration or termination of this License for any reason, Licensee shall, at its sole cost and expense, surrender the Premises to Licensor pursuant to the terms and conditions set forth in **Section 24** hereof.

11.7 Licensor may direct one or more of its field engineers to observe or inspect the construction and/or maintenance of the Pipeline at any time for compliance with the Drawings and Specifications and Legal Requirements (defined below). If ordered at any time to halt construction or maintenance of the Pipeline by Licensor's personnel due to non-compliance with the Drawings and Specifications or any other hazardous condition, Licensee shall immediately do so. Notwithstanding the foregoing right of Licensor, the parties agree that Licensor has no duty or obligation to observe or inspect, or to halt work on, the Pipeline, it being solely Licensee's responsibility to ensure that the Pipeline is constructed and maintained in strict accordance with the Drawings and Specifications and in a safe and workmanlike manner in compliance with all terms hereof. Neither the exercise of, nor the failure by Licensor to exercise, any right granted by this Section will alter in any way the liability allocation provided by this License. If at any time Licensee shall, in the sole judgment of Licensor, fail to properly perform its obligations under this **Section 11**, Licensor may, at its option and at Licensee's sole expense, arrange for the performance of such work as it deems necessary for the safety of its operations and activities. Licensee shall promptly reimburse Licensor for all costs and expenses of such work, pursuant to the terms of **Section 8**. Licensor's failure to perform any obligations of Licensee shall not alter the liability allocation hereunder.

12. Boring and Excavation.

12.1 Prior to Licensee conducting any boring, excavation, or similar work on or about any portion of the Premises, Licensee shall explore the proposed location for such work with hand tools to a depth of at least three (3) feet below the surface of the ground to determine whether pipelines or other structures exist below the surface, provided, however, that in lieu of the foregoing, Licensee shall have the right to use suitable detection equipment or other generally accepted industry practice (*e.g.*, consulting with the Underground Services Association) to determine the existence or location of pipelines and other subsurface structures prior to drilling or excavating with mechanized equipment. Licensee may request information from Licensor concerning the existence and approximate location of Licensor's underground lines, utilities, and pipelines at or near the vicinity of the proposed Pipeline by contacting Licensor's Telecommunications Helpdesk at least thirty (30) business days prior to installation of the Pipeline. Upon receiving Licensee's timely request, Licensor will provide Licensee with the information Licensor has in its possession regarding any existing underground lines, utilities, and pipelines at or near the vicinity of the proposed Pipeline and, if applicable, identify the location of such lines on the Premises pursuant to Licensor's standard procedures. Licensor does not warrant the accuracy or completeness of information relating to subsurface conditions of the Premises and Licensee's operations will be subject at all times to the liability provisions herein.

12.2 For all bores greater than 26-inch diameter and at a depth less than 10.0 feet below bottom of rail, a soil investigation must be performed by Licensee and reviewed by Licensor prior to construction. This study is to determine if granular material is present, and to prevent subsidence during the installation process. If the investigation determines in Licensor's reasonable opinion that granular material is present, Licensor may select a new location for Licensee's use, or may require Licensee to furnish for Licensor's review and approval, in Licensor's sole discretion, a remedial plan to deal with the granular material. Once Licensor has approved any such remedial plan in writing, Licensee shall, at Licensee's sole cost and expense, carry out the approved plan in accordance with all terms thereof and hereof.

12.3 Any open hole, boring, or well, constructed on the Premises by Licensee shall be safely covered and secured at all times when Licensee is not working in the actual vicinity thereof. Following completion of that portion of the work, all holes or borings constructed on the Premises by Licensee shall be:

12.3.1 filled in to surrounding ground level with compacted bentonite grout; or

12.3.2 otherwise secured or retired in accordance with any applicable Legal Requirement. No excavated materials may remain on Licensor's property for more than ten (10) days, but must be properly disposed of by Licensee in accordance with applicable Legal Requirements.

LIABILITY AND INSURANCE

13. Liability and Indemnification.

13.1 For purposes of this License: (a) "**Indemnitees**" means Licensor and Licensor's affiliated companies, partners, successors, assigns, legal representatives, officers, directors, shareholders, employees, and agents; (b) "**Liabilities**" means all claims, liabilities, fines, penalties, costs, damages, losses, liens, causes of action, suits, demands, judgments, and expenses (including, without limitation, court costs, reasonable attorneys' fees, costs of investigation, removal and remediation, and governmental oversight costs) environmental or otherwise; and (c) "**Licensee Parties**" means Licensee or Licensee's officers, agents, invitees, licensees, employees, or contractors, or any party directly or indirectly employed by any of them, or any party they control or exercise control over.

13.2 TO THE FULLEST EXTENT PERMITTED BY LAW, LICENSEE SHALL, AND SHALL CAUSE ITS CONTRACTOR TO, RELEASE, INDEMNIFY, DEFEND AND HOLD HARMLESS INDEMNITEES FOR, FROM, AND AGAINST ANY AND ALL LIABILITIES OF ANY NATURE, KIND, OR DESCRIPTION DIRECTLY OR INDIRECTLY ARISING OUT OF, RESULTING FROM, OR RELATED TO (IN WHOLE OR IN PART):

13.2.1 THIS LICENSE, INCLUDING, WITHOUT LIMITATION, ITS ENVIRONMENTAL PROVISIONS,

13.2.2 ANY RIGHTS OR INTERESTS GRANTED PURSUANT TO THIS LICENSE,

13.2.3 LICENSEE'S OCCUPATION AND USE OF THE PREMISES,

13.2.4 THE ENVIRONMENTAL CONDITION AND STATUS OF THE PREMISES CAUSED BY OR CONTRIBUTED TO BY LICENSEE, OR

13.2.5 ANY ACT OR OMISSION OF ANY LICENSEE PARTY.

13.3 TO THE FULLEST EXTENT PERMITTED BY LAW, LICENSEE NOW AND FOREVER WAIVES ANY AND ALL CLAIMS THAT BY VIRTUE OF ENTERING INTO THIS LICENSE, LICENSOR IS A GENERATOR, OWNER, OPERATOR, ARRANGER, OR TRANSPORTER FOR THE PURPOSES OF THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT, AS AMENDED ("CERCLA") OR OTHER ENVIRONMENTAL LAWS (DEFINED BELOW). LICENSEE WILL INDEMNIFY, DEFEND, AND HOLD THE INDEMNITEES HARMLESS FROM ANY AND ALL SUCH CLAIMS. NOTHING IN THIS LICENSE IS MEANT BY EITHER PARTY TO CONSTITUTE A WAIVER OF ANY INDEMNITEE'S COMMON CARRIER DEFENSES AND THIS LICENSE SHOULD NOT BE SO CONSTRUED. IF ANY AGENCY OR COURT CONSTRUES THIS LICENSE TO BE A WAIVER OF ANY INDEMNITEE'S COMMON CARRIER DEFENSES, LICENSEE AGREES TO INDEMNIFY, HOLD HARMLESS, AND DEFEND INDEMNITEES FOR ANY LIABILITIES RELATED TO THAT CONSTRUCTION OF THIS LICENSE. IN NO EVENT AS BETWEEN LICENSOR AND LICENSEE AS TO USE OF THE PREMISES AS CONTEMPLATED BY THIS LICENSE SHALL LICENSOR BE RESPONSIBLE TO LICENSEE FOR THE ENVIRONMENTAL CONDITION OF THE PREMISES.

13.4 IF ANY EMPLOYEE OF ANY LICENSEE PARTY ASSERTS THAT HE OR SHE IS AN EMPLOYEE OF ANY INDEMNITEE, TO THE FULLEST EXTENT PERMITTED BY LAW, LICENSEE SHALL, AND SHALL CAUSE ITS CONTRACTOR TO, RELEASE, INDEMNIFY, DEFEND, AND HOLD THE INDEMNITEES HARMLESS FROM AND AGAINST ANY LIABILITIES ARISING OUT OF OR RELATED TO (IN WHOLE OR IN PART) ANY SUCH ASSERTION INCLUDING, BUT NOT LIMITED TO, ASSERTIONS OF EMPLOYMENT BY AN INDEMNITEE RELATED TO THE FOLLOWING OR ANY PROCEEDINGS THEREUNDER: THE FEDERAL EMPLOYERS' LIABILITY ACT, THE SAFETY APPLIANCE ACT, THE LOCOMOTIVE INSPECTION ACT, THE OCCUPATIONAL SAFETY AND HEALTH ACT, THE RESOURCE CONSERVATION AND RECOVERY ACT, AND ANY SIMILAR STATE OR FEDERAL STATUTE.

13.5 THE FOREGOING OBLIGATIONS OF LICENSEE SHALL NOT APPLY TO THE EXTENT LIABILITIES ARE PROXIMATELY CAUSED BY THE GROSS NEGLIGENCE OR WILLFUL MISCONDUCT OF ANY INDEMNITEE, BUT SHALL APPLY TO ALL OTHER LIABILITIES, INCLUDING THOSE ARISING FROM OR ATTRIBUTED TO ANY OTHER ALLEGED OR ACTUAL NEGLIGENCE, INTENTIONAL ACTS, OR STRICT LIABILITY OF ANY INDEMNITEE.

13.6 Upon written notice from Licensor, Licensee agrees to assume the defense of any lawsuit or other proceeding brought against any Indemnitee by any entity, relating to any matter covered by this License for which Licensee has an obligation to assume liability for and/or save and hold harmless any Indemnitee. Licensee shall pay all costs and expenses incident to such defense, including, but not limited to, reasonable attorneys' fees, investigators' fees, litigation and appeal expenses, settlement payments, and amounts paid in satisfaction of judgments.

14. Personal Property Risk of Loss. **ALL PERSONAL PROPERTY, INCLUDING, BUT NOT LIMITED TO, FIXTURES, EQUIPMENT, OR RELATED MATERIALS UPON THE PREMISES WILL BE AT THE RISK OF LICENSEE ONLY, AND NO INDEMNITEE WILL BE LIABLE FOR ANY DAMAGE THERETO OR THEFT THEREOF, WHETHER OR NOT DUE IN WHOLE OR IN PART TO THE NEGLIGENCE OF ANY INDEMNITEE.**

15. Insurance. Licensee shall, at its sole cost and expense, procure and maintain during the life of this License the following insurance coverage:

15.1 Commercial General Liability Insurance. This insurance shall contain broad form contractual liability with a combined single limit of a minimum of $5,000,000 each occurrence and an aggregate limit of at least $10,000,000 but in no event less than the amount otherwise carried by Licensee. Coverage must be purchased on a post 2004 ISO occurrence or equivalent and include coverage for, but not limited to, the following:

- Bodily Injury and Property Damage
- Personal Injury and Advertising Injury
- Fire legal liability
- Products and completed operations

This policy shall also contain the following endorsements or language, which shall be indicated on the certificate of insurance:

- The definition of insured contract shall be amended to remove any exclusion or other limitation for any work being done within 50 feet of railroad property.
- Waiver of subrogation in favor of and acceptable to Licensor.
- Additional insured endorsement in favor of and acceptable to Licensor and Jones Lang LaSalle Brokerage, Inc.
- Separation of insureds.
- The policy shall be primary and non-contributing with respect to any insurance carried by Licensor.

It is agreed that the workers' compensation and employers' liability related exclusions in the Commercial General Liability Insurance policy(s) required herein are intended to apply to employees of the policy holder and shall not apply to Licensor's employees.

No other endorsements limiting coverage may be included on the policy.

15.2 Business Automobile Insurance. This insurance shall contain a combined single limit of at least $1,000,000 per occurrence, and include coverage for, but not limited to the following:

- Bodily injury and property damage.
- Any and all vehicles owned, used or hired.

This policy shall also contain the following endorsements, which shall be indicated on the certificate of insurance:

- Waiver of subrogation in favor of and acceptable to Licensor.
- Additional insured endorsement in favor of and acceptable to Licensor.
- Separation of insureds.

- The policy shall be primary and non-contributing with respect to any insurance carried by Licensor.

15.3 Workers' Compensation and Employers' Liability Insurance. This insurance shall include coverage for, but not limited to:

- Licensee's statutory liability under the workers' compensation laws of the state(s) in which the services are to be performed. If optional under state laws, the insurance must cover all employees anyway.
- Employers' Liability (Part B) with limits of at least $500,000 each accident, $500,000 by disease policy limit, $500,000 by disease each employee.

This policy shall also contain the following endorsements or language, which shall be indicated on the certificate of insurance:

- Waiver of subrogation in favor of and acceptable to Licensor.

15.4 Railroad Protective Liability Insurance. This insurance shall name only Licensor as the Insured with coverage of at least $5,000,000 per occurrence and $10,000,000 in the aggregate. The coverage obtained under this policy shall only be effective during the initial installation and/or construction of the Pipeline. **THE CONSTRUCTION OF THE PIPELINE SHALL BE COMPLETED WITHIN ONE (1) YEAR OF THE EFFECTIVE DATE.** If further maintenance of the Pipeline is needed at a later date, an additional Railroad Protective Liability Insurance Policy shall be required. The policy shall be issued on a standard ISO form CG 00 35 12 03 and include the following:

- Endorsed to include the Pollution Exclusion Amendment.
- Endorsed to include the Limited Seepage and Pollution Endorsement.
- Endorsed to include Evacuation Expense Coverage Endorsement.
- No other endorsements restricting coverage may be added.
- The original policy must be provided to Licensor prior to performing any work or services under this License.
- Definition of "Physical Damage to Property" shall be endorsed to read: "means direct and accidental loss of or damage to all property owned by any named insured and all property in any named insured's care, custody and control arising out of the acts or omissions of the contractor named on the Declarations."

In lieu of providing a Railroad Protective Liability Policy, for a period of one (1) year from the Effective Date, Licensee may participate in Licensor's Blanket Railroad Protective Liability Insurance Policy available to Licensee or its contractor. The limits of coverage are the same as above. The cost is $1,150.00.

☒ I **elect** to participate in Licensor's Blanket Policy;

☐ I **elect not** to participate in Licensor's Blanket Policy.

15.5 Pollution Legal Liability (PLL) Insurance. Intentionally deleted, not required for this permit

15.6 Other Requirements:

15.6.1 Where allowable by law, all policies (applying to coverage listed above) shall contain no exclusion for punitive damages.

15.6.2 Licensee agrees to waive its right of recovery against Licensor for all claims and suits against Licensor. In addition, Licensee's insurers, through the terms of the policy or a policy endorsement, must waive their right of subrogation against Licensor for all claims and suits, and the certificate of insurance must reflect the waiver of subrogation endorsement. Licensee further waives its right of recovery, and its insurers must also waive their right of subrogation against Licensor for loss of Licensee's owned or leased property, or property under Licensee's care, custody, or control.

15.6.3 Licensee is not allowed to self-insure without the prior written consent of Licensor. If granted by Licensor, any self-insured retention or other financial responsibility for claims shall be covered directly by Licensee in lieu of insurance. Any and all Licensor liabilities that would otherwise, in accordance with the provisions of this License, be covered by Licensee's insurance will be covered as if Licensee elected not to include a self-insured retention or other financial responsibility for claims.

15.6.4 Prior to entering the Premises, Licensee shall furnish to Licensor an acceptable certificate(s) of insurance including an original signature of the authorized representative evidencing the required coverage, endorsements, and amendments. Licensee shall notify Licensor in writing at least 30 days prior to any cancellation, non-renewal, substitution, or material alteration. In the event of a claim or lawsuit involving Licensor arising out of this License, Licensee will make available any required policy covering such claim or lawsuit.

15.6.5 Any insurance policy shall be written by a reputable insurance company acceptable to Licensor or with a current Best's Guide Rating of A- and Class VII or better, and authorized to do business in the state(s) in which the service is to be provided.

15.6.6 If coverage is purchased on a "claims made" basis, Licensee hereby agrees to maintain coverage in force for a minimum of three years after expiration or termination of this License. Annually, Licensee agrees to provide evidence of such coverage as required hereunder.

15.6.7 Licensee represents that this License has been thoroughly reviewed by Licensee's insurance agent(s)/broker(s), who have been instructed by Licensee to procure the insurance coverage required by this License. Allocated Loss Expense shall be in addition to all policy limits for coverages referenced above.

15.6.8 Not more frequently than once every five years, Licensor may reasonably modify the required insurance coverage to reflect then-current risk management practices in the railroad industry and underwriting practices in the insurance industry.

15.6.9 If any portion of the operation is to be subcontracted by Licensee, Licensee shall require that the subcontractor shall provide and maintain insurance coverages as set forth herein, naming Licensor as an additional insured, and shall require that the subcontractor shall release, defend and indemnify Licensor to the same extent and under the same terms and conditions as Licensee is required to release, defend and indemnify Licensor herein.

15.6.10 Failure to provide evidence as required by this Section 15 shall entitle, but not require, Licensor to terminate this License immediately. Acceptance of a certificate that does not comply with this Section shall not operate as a waiver of Licensee's obligations hereunder.

15.6.11 The fact that insurance (including, without limitation, self-insurance) is obtained by Licensee shall not be deemed to release or diminish the liability of Licensee, including, without limitation, liability under the indemnity provisions of this License. Damages recoverable by Licensor shall not be limited by the amount of the required insurance coverage.

15.6.12 These insurance provisions are intended to be a separate and distinct obligation on the part of the Licensee. Therefore, these provisions shall be enforceable and Licensee shall be bound thereby regardless of whether or not indemnity provisions are determined to be enforceable.

15.6.13 For purposes of this Section 15, Licensor shall mean "Burlington Northern Santa Fe, LLC", "BNSF Railway Company" and the subsidiaries, successors, assigns and affiliates of each.

COMPLIANCE WITH LAWS, REGULATIONS, AND ENVIRONMENTAL MATTERS

16. Compliance with Laws, Rules, and Regulations.

16.1 Licensee shall observe and comply with any and all laws, statutes, regulations, ordinances, orders, covenants, restrictions, or decisions of any court of competent jurisdiction (**"Legal Requirements"**) relating to the construction, maintenance, and use of the Pipeline and the use of the Premises.

16.2 Prior to entering the Premises, Licensee shall and shall cause its contractor(s) to comply with all of Licensor's applicable safety rules and regulations. Licensee must ensure that each of its employees, contractors, agents or invitees entering upon the Premises completes the safety orientation program at the Website "www.BNSFcontractor.com" (the **"Safety Orientation"**) within one year prior to entering upon the Premises. Additionally, Licensee must ensure that each and every employee of Licensee, its contractors, agents and invitees possess a card certifying completion of the Safety Orientation prior to entering upon the Premises. Licensee must renew the Safety Orientation annually.

16.3 Licensee shall obtain on or before the date it or its contractor enters the Premises, any and all additional rights-of way, easements, licenses and other agreements relating to the grant of rights and interests in and/or access to the Premises (collectively, the **"Rights"**) and such other rights, licenses, permits, authorizations, and approvals (including without limitation, any necessary local, state, federal or tribal authorizations and environmental permits) that are necessary in order to permit Licensee to construct, maintain, own and operate the Pipeline and otherwise to perform its obligations hereunder in accordance with the terms and conditions hereof.

16.4 Licensee shall either require that the initial stated term of each such Rights be for a period that does not expire, in accordance with its ordinary terms, prior to the last day of the term of this License or, if the initial stated term of any such Right expires in accordance with its ordinary terms on a date earlier than the last day of the term of this License, Licensee shall, at its cost, exercise any renewal rights thereunder, or otherwise acquire such extensions, additions and/or replacements as may be necessary, in order to cause the stated term thereof to be continued until a date that is not earlier than the last day of the term of this License.

16.5 Upon the expiration or termination of any Right that is necessary in order for Licensee to own, operate or use the Pipeline in accordance with the terms and conditions of this License, this License thereby shall automatically expire upon such expiration or termination of the Right.

17. Environmental.

17.1 Licensee shall strictly comply with all federal, state and local environmental Legal Requirements and regulations in its use of the Premises, including, but not limited to, the Resource Conservation and Recovery Act, as amended (RCRA), the Clean Water Act, the Oil Pollution Act, the Hazardous Materials Transportation Act, and CERCLA (collectively referred to as the "**Environmental Laws**"). Licensee shall not maintain a treatment, storage, transfer or disposal facility, or underground storage tank, as defined by Environmental Laws on the Premises. Licensee shall not release or suffer the release of oil or hazardous substances, as defined by Environmental Laws on or about the Premises.

17.2 Licensee covenants that it will not handle or transport "hazardous waste" or "hazardous substances", as "hazardous waste" and "hazardous substances" may now or in the future be defined by any federal, state, or local governmental agency or body through the Pipeline on Licensor's property. Licensee agrees periodically to furnish Licensor with proof, satisfactory to Licensor that Licensee is in compliance with the provisions of this **Section 17.2.**

17.3 Licensee shall give Licensor immediate notice to Licensor's Resource Operations Center at (800) 832-5452 of any known (i) release of hazardous substances on, from, or affecting the Premises, (ii) violation of Environmental Laws, or (iii) inspection or inquiry by governmental authorities charged with enforcing Environmental Laws with respect to Licensee's use of the Premises. Licensee shall use the best efforts to promptly respond to any release on, from, or affecting the Premises. Licensee also shall give Licensor immediate notice of all measures undertaken on behalf of Licensee to investigate, remediate, respond to or otherwise cure such release or violation.

17.4 If Licensor has notice from Licensee or otherwise of a release or violation of Environmental Laws arising in any way with respect to the Pipeline which occurred or may occur during the term of this License, Licensor may require Licensee, at Licensee's sole risk and expense, to take timely measures to investigate, remediate, respond to or otherwise cure such release or violation affecting the Premises or Licensor's right-of-way.

17.5 Licensee shall promptly report to Licensor in writing any conditions or activities upon the Premises known to Licensee which create a risk of harm to persons, property or the environment and shall take whatever action is necessary to prevent injury to persons, property, or the environment arising out of such conditions or activities; provided, however, that Licensee's reporting to Licensor shall not relieve Licensee of any obligation whatsoever imposed on it by this License. Licensee shall promptly respond to Licensor's request for information regarding said conditions or activities.

<u>DISCLAIMER OF WARRANTIES</u>

18. <u>No Warranties</u>.

18.1 **LICENSOR'S DUTIES AND WARRANTIES ARE LIMITED TO THOSE EXPRESSLY STATED IN THIS LICENSE AND SHALL NOT INCLUDE ANY IMPLIED DUTIES OR IMPLIED WARRANTIES, NOW OR IN THE FUTURE. NO REPRESENTATIONS OR WARRANTIES HAVE BEEN MADE BY LICENSOR OTHER THAN THOSE CONTAINED IN THIS LICENSE. LICENSEE HEREBY WAIVES ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THE PREMISES OR WHICH MAY EXIST BY OPERATION OF LAW OR IN EQUITY, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY, HABITABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**

18.2 **LICENSOR MAKES NO WARRANTY, REPRESENTATION OR CONDITION OF ANY KIND, EXPRESS OR IMPLIED, CONCERNING (A) THE SCOPE OF THE LICENSE OR OTHER RIGHTS GRANTED HEREUNDER TO LICENSEE OR (B) WHETHER OR NOT LICENSEE'S CONSTRUCTION, MAINTENANCE, OWNERSHIP, USE OR OPERATION OF THE PIPELINE WILL VIOLATE OR INFRINGE UPON THE RIGHTS, INTERESTS AND ESTATES OF THIRD PARTIES, INCLUDING, WITHOUT LIMITATION, ANY LEASES, USE RIGHTS, EASEMENTS AND LIENS OF ANY THIRD PARTY.**

19. Disclaimer of Warranty for Quiet Enjoyment. **LICENSOR DOES NOT WARRANT ITS TITLE TO THE PREMISES NOR UNDERTAKE TO DEFEND LICENSEE IN THE PEACEABLE POSSESSION OR USE THEREOF. NO COVENANT OF QUIET ENJOYMENT IS MADE.**

20. Eviction at Risk of Licensee. In case of the eviction of Licensee by anyone owning, claiming title to, or claiming any interest in the Premises, or by the abandonment by Licensor of the affected rail corridor, Licensor shall not be liable (i) to refund Licensee any compensation paid hereunder, except for the pro-rata part of any recurring charge paid in advance, or (ii) for any damage Licensee sustains in connection with the eviction.

LIENS AND TAXES

21. Liens and Charges. Licensee shall promptly pay and discharge any and all liens arising out of any construction, alterations or repairs done, suffered or permitted to be done by Licensee on Premises. Licensor is hereby authorized to post any notices or take any other action upon or with respect to Premises that is or may be permitted by law to prevent the attachment of any such liens to Premises; provided, however, that failure of Licensor to take any such action shall not relieve Licensee of any obligation or liability under this **Section 21** or any other Section of this License.

22. Taxes. Licensee shall pay when due any taxes, assessments or other charges (collectively, "**Taxes**") levied or assessed by any governmental or quasi-governmental body upon the Pipeline or any other improvements constructed or installed on the Premises by or for Licensee (collectively, the "**Improvements**") or any Taxes levied or assessed against Licensor or the Premises that are attributable to the Improvements.

DEFAULT, TERMINATION, AND SURRENDER

23. Default and Termination. In addition to and not in limitation of Licensor's right to terminate for failure to provide evidence of insurance as required pursuant to the terms of **Section 15**, the following events are also deemed to be events of default pursuant to which Licensor has the right to terminate as set forth below:

23.1 If default shall be made in any of Licensee's covenants, agreements, or obligations contained in this License and Licensee fails to cure said default within thirty (30) days after written notice is provided to Licensee by Licensor, or in case of any assignment or transfer of this License in violation of **Section 26** below, Licensor may, at its option, terminate this License by serving five (5) days' notice in writing upon Licensee. Notwithstanding the foregoing, Licensor shall have the right to terminate this License immediately if Licensee fails to provide evidence of insurance as required in **Section 15**.

23.2 Should Licensee not comply fully with the obligations of **Section 17** regarding the handling or transporting of hazardous waste or hazardous material, notwithstanding anything contained in any other provision of this License, Licensor may, at its option, terminate this License by serving five (5) days' notice of termination upon Licensee.

23.3 Any waiver by Licensor of any default or defaults shall not constitute a waiver of the right to terminate this License for any subsequent default or defaults, nor shall any such waiver in any way affect Licensor's ability to enforce any Section of this License. The remedy set forth in this **Section 23** shall be in addition to, and not in limitation of, any other remedies that Licensor may have at law or in equity.

23.4 In addition to and not in limitation of Licensor's rights to terminate this License for failure to provide evidence of insurance or occurrence of defaults as described above, this License may be terminated by either party, at any time, by serving thirty (30) days' written notice of termination upon the other party. Such termination shall not release either party hereto from any liability or obligation under the License, whether of indemnity or otherwise, resulting from any acts, omissions or events happening prior to the date of termination or thereafter in case by the terms of the License it is provided that anything shall or may be done after termination hereof.

24. Surrender of the Premises.

24.1 On or before expiration or termination of this License for any reason, Licensee shall, at its sole cost and expense:

24.1.1 if so directed by Licensor in writing, remove the Improvements, the Pipeline and all appurtenances thereto, or, at the sole discretion of Licensor, fill and cap or otherwise appropriately decommission the Pipeline with a method satisfactory to Licensor;

24.1.2 report and restore any damage to the Premises or Licensor's other property arising from, growing out of, or connected with Licensee's use of the Premises;

24.1.3 remedy any unsafe conditions on the Premises created or aggravated by Licensee; and

24.1.4 leave the Premises in substantially the condition which existed as of the Effective Date.

24.2 Upon any expiration or termination of this License, if Licensee fails to surrender the Premises to Licensor or if Licensee fails to complete its obligations under **Section 24.1** above (the "**Restoration Obligations**"), Licensee shall have a limited license to enter upon the Premises solely to the extent necessary for Licensee to complete the Restoration Obligations, and all liabilities and obligations of Licensee hereunder shall continue in effect until the Premises are surrendered and the Restoration Obligations are completed. Neither termination nor expiration shall release Licensee from any liability or obligation under this License, whether of indemnity or otherwise, resulting from any acts, omissions or events happening prior to the date of termination, or, if later, the date when Licensee surrenders the Premises and all of the Restoration Obligations are completed.

24.3 If Licensee fails to complete the Restoration Obligations within thirty (30) days after the date of such termination of its tenancy, then Licensor may, at its election, either: (i) remove the Pipeline and the other Improvements or otherwise restore the Premises, and in such event Licensee shall, within thirty (30) days after receipt of bill therefor, reimburse Licensor for cost incurred, (ii) upon written notice to Licensee, take and hold the Pipeline and the other Improvements and personal property as its sole property, without payment or obligation to Licensee therefor, or (iii) specifically enforce Licensee's obligation to restore and/or pursue any remedy at law or in equity against Licensee for failure to so restore. Further, if Licensor has consented to the Pipeline and the other Improvements remaining on the Premises following termination, Licensee shall, upon request by Licensor, provide a bill of sale in a form acceptable to Licensor conveying the Pipeline and the other Improvements to Licensor.

MISCELLANEOUS

25. Successors and Assigns. All provisions contained in this License shall be binding upon, inure to the benefit of, and be enforceable by the respective successors and assigns of Licensor and Licensee to the same extent as if each such successor and assign was named a party to this License.

26. Assignment.

26.1 Licensee may not sell, assign, transfer, or hypothecate this License or any right, obligation, or interest herein (either voluntarily or by operation of law, merger, or otherwise) without the prior written consent of Licensor, which consent may not be unreasonably withheld or delayed by Licensor. Any attempted assignment by Licensee in violation of this **Section 26** shall be a breach of this License and, in addition, shall be voidable by Licensor in its sole and absolute discretion.

26.2 For purposes of this **Section 26**, the word "assign" shall include without limitation (a) any sale of the equity interests of Licensee following which the equity interest holders of Licensee immediately prior to such sale own, directly or indirectly, less than 50% of the combined voting power of the outstanding voting equity interests of Licensee, (b) any sale of all or substantially all of the assets of (i) Licensee and (ii) to the extent such entities exist, Licensee's parent and subsidiaries, taken as a whole, or (c) any reorganization, recapitalization, merger or consolidation involving Licensee. Notwithstanding the foregoing, any reorganization, recapitalization, merger or consolidation following which the equity interest holders of Licensee immediately prior to such reorganization, recapitalization, merger or consolidation own, directly or indirectly, at least 50% of the combined voting power of the outstanding voting equity interests of Licensee or any successor thereto or the entity resulting from such reorganization, recapitalization, merger or consolidation shall not be deemed an assignment. THIS LICENSE SHALL NOT RUN WITH THE LAND WITHOUT THE EXPRESS WRITTEN CONSENT OF LICENSOR, SUCH CONSENT TO BE IN LICENSOR'S SOLE DISCRETION.

26.3 Notwithstanding the provisions of **Section 26.1** above or anything contained in this License to the contrary, if Licensee sells, assigns, transfers, or hypothecates this License or any interest herein in contravention of the provisions of this License (a "**Purported Assignment**") to another party (a "**Purported Transferee**"), the Purported Transferee's enjoyment of the rights and privileges granted under this License shall be deemed to be the Purported Transferee's agreement to be bound by all of the terms and provisions of this License, including but not limited to the obligation to comply with the provisions of **Section 15** above concerning insurance requirements. In addition to and not in limitation of the foregoing, Licensee, for itself, its successors and assigns, shall indemnify, defend and hold harmless Licensor for all Liabilities of any nature, kind or description of any person or entity directly or indirectly arising out of, resulting from or related to (in whole or in part) a Purported Assignment.

26.4 The provisions of this **Section 26** shall survive the expiration or earlier termination of this License.

27. Notices. Any notice, invoice, or other writing required or permitted to be given hereunder by one party to the other shall be in writing and the same shall be given and shall be deemed to have been served and given if (i) placed in the United States mail, certified, return receipt requested, or (ii) deposited into the custody of a nationally recognized overnight delivery service, addressed to the party to be notified at the address for such party specified below, or to such other address as the party to be notified may designate by giving the other party no less than thirty (30) days' advance written notice of such change in address.

If to Licensor: Jones Lang LaSalle Brokerage, Inc.
4300 Amon Carter Blvd., Suite 100
Fort Worth, TX 76155
Attn: Permits/Licenses

with a copy to: BNSF Railway Company
2500 Lou Menk Dr. – AOB3
Fort Worth, TX 76131
Attn: Senior Manager Real Estate

If to Licensee: City of Duluth, Spirit Mountain Recreation Authority
9500 Spirit Mountain Place
Duluth, Minnesota 55810

28. Survival. Neither termination nor expiration will release either party from any liability or obligation under this License, whether of indemnity or otherwise, resulting from any acts, omissions or events happening prior to the date of termination or expiration, or, if later, the date when the Pipeline and the other Improvements are removed and the Premises are restored to its condition as of the Effective Date.

29. Recordation. It is understood and agreed that this License shall not be placed or allowed to be placed on public record.

30. Applicable Law. All questions concerning the interpretation or application of provisions of this License shall be decided according to the substantive laws of the State of Texas without regard to conflicts of law provisions.

31. Severability. To the maximum extent possible, each provision of this License shall be interpreted in such manner as to be effective and valid under applicable law, but if any provision of this License shall be prohibited by, or held to be invalid under, applicable law, such provision shall be ineffective solely to the extent of such prohibition or invalidity, and this shall not invalidate the remainder of such provision or any other provision of this License.

32. Integration. This License is the full and complete agreement between Licensor and Licensee with respect to all matters relating to Licensee's use of the Premises, and supersedes any and all other agreements between the parties hereto relating to Licensee's use of the Premises as described herein. However, nothing herein is intended to terminate any surviving obligation of Licensee or Licensee's obligation to defend and hold Licensor harmless in any prior written agreement between the parties.

33. Joint and Several Liability. If Licensee consists of two or more parties, all the covenants and agreements of Licensee herein contained shall be the joint and several covenants and agreements of such parties.

34. Waiver. The waiver by Licensor of the breach of any provision herein by Licensee shall in no way impair the right of Licensor to enforce that provision for any subsequent breach thereof.

35. Interpretation.

35.1 This License shall be interpreted in a neutral manner, and not more strongly for or against any party based upon the source of the draftsmanship; both parties hereby agree that this License shall not be subject to the principle that a contract would be construed against the party which drafted the same. Article titles, headings to sections and paragraphs and the table of contents (if any) are inserted for convenience of reference only and are not intended to be a part or to affect the meaning or interpretation hereof. The exhibit or exhibits referred to herein shall be construed with and as an integral part of this License to the same extent as if they were set forth verbatim herein.

35.2 As used herein, "include", "includes" and "including" are deemed to be followed by "without limitation" whether or not they are in fact followed by such words or words of like import; "writing", "written" and comparable terms refer to printing, typing, lithography and other means of reproducing words in a visible form; references to any person are also to that person's successors and permitted assigns; "hereof", "herein", "hereunder" and comparable terms refer to the entirety hereof and not to any particular article, section, or other subdivision hereof or attachment hereto; references to any gender include references to the masculine or feminine as the context requires; references to the plural include the singular and vice versa; and references to this License or other documents are as amended, modified or supplemented from time to time.

36. Counterparts. This License may be executed in multiple counterparts, each of which shall, for all purposes, be deemed an original but which together shall constitute one and the same instrument, and the signature pages from any counterpart may be appended to any other counterpart to assemble fully executed documents, and counterparts of this License may also be exchanged via email or electronic facsimile machines and any email or electronic facsimile of any party's signature shall be deemed to be an original signature for all purposes.

37. Licensor's Representative. Jones Lang LaSalle Brokerage, Inc. is acting as representative for BNSF Railway Company.

END OF PAGE – SIGNATURE PAGE FOLLOWS

This License has been duly executed by the parties hereto as of the date below each party's signature; to be effective, however, as of the Effective Date.

LICENSOR:

BNSF RAILWAY COMPANY a Delaware corporation

By: Jones Lang LaSalle Brokerage, Inc.,
4300 Amon Carter Blvd, Suite 100
Fort Worth, TX 76155

By: ______________________
Ed Darter

Title: Sr. Vice President - National Accounts

Date: ______________________

LICENSEE:

CITY OF DULUTH, SPIRIT MOUNTAIN RECREATION AUTHORITY a Minnesota corporation

By: 9500 Spirit Mountain Place
Duluth, Minnesota 55810

By: Brandy Rean

Title: Executive Director

Date: 10-1-14

COORDINATE SYSTEM: MN_N

TRACKING NO. 14-50943

EXHIBIT "A"

ATTACHED TO CONTRACT BETWEEN

BNSF RAILWAY COMPANY

AND

CITY OF DULUTH, SPIRIT MOUNTAIN RECREATION AUTHORITY

-N-

MAP REF. s60183

SCALE: 1 IN.= 200 FT.
TWIN CITIES DIV.
LAKES SUBDIV.
L.S. 0500 MP 8.64
DATE 09/09/2014

SECTION: 23
TOWNSHIP: 49N
RANGE: 15W
MERIDIAN: 4PM

To: L.S. 0028

To: DULUTH

DESCRIPTION OF PIPELINE
PIPELINE SHOWN BOLD

	CARRIER PIPE	CASING PIPE		CARRIER PIPE	CASING PIPE
SIZE:	24"	30"	LENGTH ON R/W:	350'	120'
CONTENTS:	WATER		WORKING PRESSURE:	100	
PIPE MATERIAL:	HDPE	STEEL	BURY: BASE/RAIL TO TOP OF CASING		8'
SPECIFICATIONS / GRADE	SDR 17 DIPS PE4710	35,000 PSI	BURY: NATURAL GROUND		4'
WALL THICKNESS:	1.518"	0.406"	BURY: ROADWAY DITCHES		4'
COATING:	-	YES	CATHODIC PROTECTION		N/A

VENTS: NUMBER - SIZE - HEIGHT OF VENT ABOVE GROUND -
NOTE: CASING TO BE JACKED OR DRY BORED ONLY

AT RIVERSIDE JCT.
COUNTY OF ST. LOUIS

STATE OF MN

TR

REVISION 1

DRAWING NO. 61849