SHEYENE AQUADUCT STRUCTURE

Client Name:	**U.S. ARMY CORPS OF ENGINEERS**	**Design By:**	**MBI**
Project Name:	**FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4**	**Review By:**	
Work Describtion:	**Sheyenne Aquaduct Structure - Retaining Walls**	**Date:**	**2/10/2011**
	Panel B	**Job #:**	**34091004**
File Path:	P:\Mpls\34 ND\09\34091004 Fargo Moorhead Metropolitan Feas. Study\WorkFiles_Phase4\070 Structural\Aqueducts\Sheyene\[34091004 PH4 Sheyene Retaining Walls Panel B.xlsx]Stem		
REF.	**1**		
	2		

ID#	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Name	100 yr. flood	100 yr. flood + ice	500 yr. flood	T.O. Levee	Normal flow + ice	Construction
Load Category	Usual	Unusual	Unusual	Extreme	Usual	Unusual
Tributary - Water El. (ft)	914.56	914.56	914.67	916	903.24	**NA**
Diversion - Head Water El. (ft)	902.12	902.12	903.32	916	**NA**	**NA**
Diversion - Tail Water El. (ft)	901.91	901.91	903.06	916	**NA**	**NA**
Tributary - T.O. Wall El. (ft)	916					
Tributary - T.O. Deck L.P. El.(ft)	898.7					
Tributary - T.O. Deck H.P. El.(ft)	900.7					
Diversion - T.O. Mat El. (ft)	895.68					
Tributary - Deck Slab thickness @ L.P. (ft)	2					
Tributary - Deck Slab thickness @ H.P. (ft)	4					
Diversion - Mat Slab thickness (ft)	4					
Tibutary - Water height (ft)	**15.86**	**15.86**	**15.97**	**17.3**	**4.54**	**NA**
Diversion - Head Water height (ft)	**6.44**	**6.44**	**7.64**	**20.32**	**NA**	**NA**
Ice	**NA**	2ft Ice	**NA**	**NA**	2ft Ice	**NA**
Ice Load	**NA**	10 kips/ft	**NA**	**NA**	10 kips/ft	**NA**
Ice Laod El. (ft)	**NA**	**914.56**	**NA**	**NA**	**903.24**	**NA**
Uplift @ HW (ft)	**10.44**	**10.44**	**11.64**	**24.32**	**NA**	**NA**
Uplift @ TW (ft)	**10.23**	**10.23**	**11.38**	**24.32**	**NA**	**NA**
Pile Condition	**Undrained**	**Undrained**	**Undrained**	**Undrained**	**Drained**	**Undrained**
Load Category	**Usual**	**Unusual**	**Unusual**	**Extreme**	**Usual**	**Unusual**
Safety Factors	2	1.5	1.5	1.15	2	1.5
Allwable Lateral Capacity (tons)	**18**	**20.5**	**20.5**	**24**	**11.5**	**20.5**
Allowable Pile Capacity (tons) - Axial	**61.95**	**82.60**	**82.60**	**107.74**	**36.525**	**82.60**
Allowable Pile Capacity (tons) - Uplift	**38.65**	**51.53**	**51.53**	**67.22**	**5.9**	**51.53**

Pile Capacity	**Ultimate Axial Capacity (kips)**	**Allowable Lateral Capacity (kips)**		
		0.5" (Usual)	**0.67" (Unusual)**	**0.875" (Extreme)**
Undrained - Axial	247.8	36	41	48
Undrained - Uplift	154.6			
Drained - Axial	146.1	23	29	36
Drained - Uplift	23.6			

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COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004		
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Panel B		

Monolith Structure

ITEM		UNIT	QUANITY	UNIT COST	TOTAL Cost
FURNISH HP14x73 WALL PILING		LF	1,800	0	$0
INSTALL HP14x73 WALL PILING		LF	1,800	0	$0
PILE TEST, 60.0 ft	Long	EA	4	0	$0
FOOTING CONCRETE		CY	205	0	$0
	Forming	SF	820		
STEM CONCRETE		CY	242	0	$0
	Forming	SF	3,476		
STEEL REINFORCEMENT		LB	90,180	0	$0
WALL RAILING		LF	81	0	$0
SHEET PILE CUT-OFF WALL		SF	1,610	0	$0
					$0

Structure Length = 80.5 ft

No. piles = 36 Each

Length = 50 ft

Note: HP14x73 pile used for design, use HP14x73 to allow for corrosion

LENGTH

(FRONT & Back FACE) 10 FT

Native Soil has low permeability assume cut-off minimal to prevent scour

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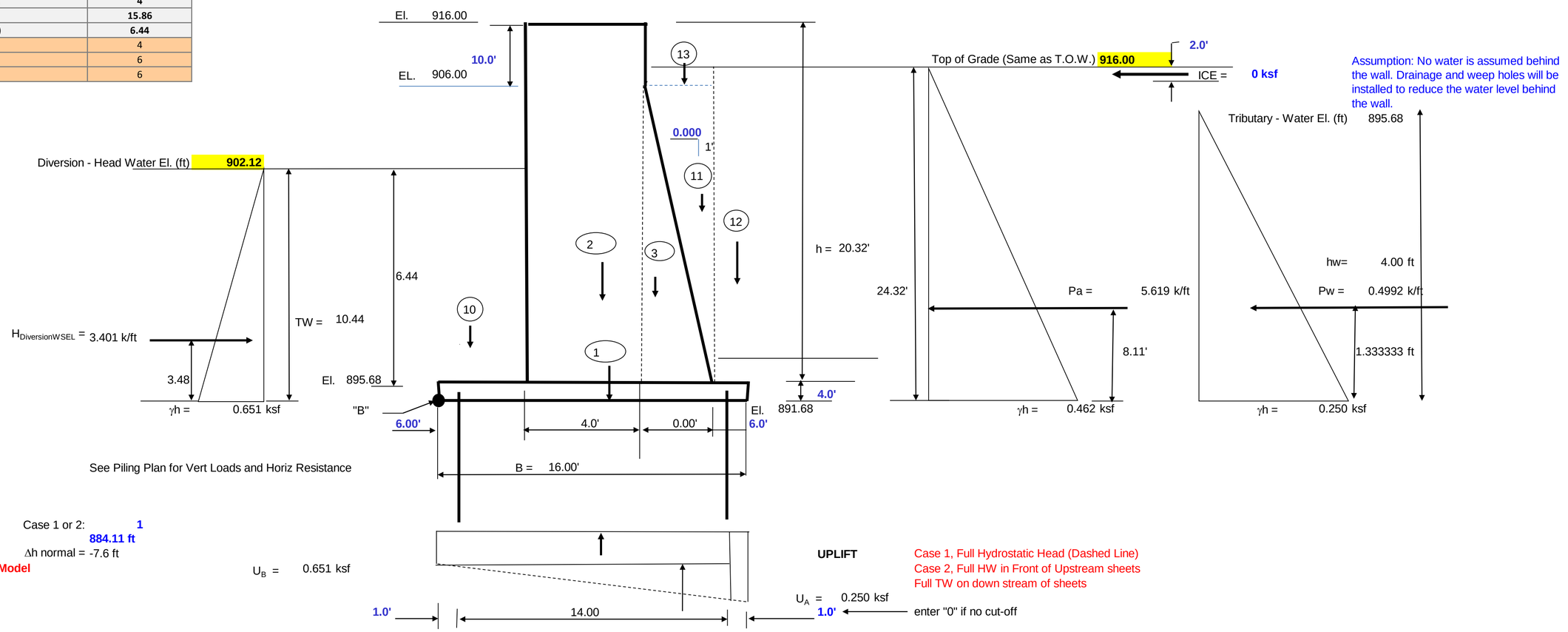
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 1 100 yr. flood Panel B	

ID#	Case 1
Name	100 yr. flood
Load Category	Usual
Tributary - Water El. (ft)	914.56
Diversion - Head Water El. (ft)	902.12
Diversion - Tail Water El. (ft)	901.91
Tributary - T.O. Wall El. (ft)	916
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	895.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	15.86
Diversion - Head Water height (ft)	6.44
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 80.5 ft**
Stepped Ftg Ls = **2.0 ft** overlap distance at stepped ftg



See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: **1**
Normal Water Level, El. **884.11 ft**
Δh normal = -7.6 ft
See Geotechnical seepage Model

U_B = 0.651 ksf

UPLIFT
Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets

U_A = 0.250 ksf
enter "0" if no cut-off

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	80.5	16.00	4.00	0.15	rec	772.8	8.00	6,182.4
Stem	2	80.5	4.00	20.32	0.15	rec	981.5	8.00	7,851.6
Batter	3	80.5	0.00	10.32	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1754.3**	ΣM_V =	**14,034.0**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	80.5	6.00	6.44	0.0624	rec	194.1	3.00	582.3
H.W. on Stem Slope	11	80.5	0.00	10.32	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	80.5	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	80.5	6.00	20.32	0.0626	rec	614.4	13.00	7,987.1
H.W. on Footing	12w	80.5	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**808.5**	ΣM_V =	**8,569.4**

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	80.5	16.00	0.651	rec	-839.1	8.00	-6,713
	U_A	80.5	16.00	-0.402	tri	258.8	10.67	2,760
					ΣU =	**-580.3**	ΣM_U =	**-3,952**

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COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004		
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls		
2/11/11				Load Cases: Case 1 100 yr. flood	Panel B	

Horizontal Loads

	L	H	Pressure		ICE	arm	Mu
	ft	ft	ksf		K	ft	ft-k
ICE	80.5	2.00	0.00	rec	0.0	23.32	0.0

	L	Force		H	arm	Mw
	ft	k/ft		K	ft	ft-k
SOIL	80.5	-5.619		-452.32	8.11	-3666.81
Water Loads						
H_{TW}	80.5	3.401	tri	273.75	3.48	952.64
H_{HW}	80.5	-0.499	tri	-40.19	1.33	-53.58
			ΣWater =	**233.56**	ΣM_W =	**-2767.8**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-6720	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	22603	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**15,884**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**1,982**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-219**	kips

Location of Resultant	Xr = ΣM / P =	8.01	ft from Toe
	e = B/2 - Xr =	(0.01)	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	196	cy (includes stepped)	820	sf
Stem Conc:	242	cy	3476	sf
Total =	438			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
Bot mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
								cy	**LB/cy**
							35,234	196	180.1748864
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	19.82	161	10,849	21,698.94	
	Longitudinal:	9	6	3.40	80	40	10,880	21,760.00	
Top Face	Transverse:	9	6	3.40	3.5	161	1,916		
	Longitudinal:	9	6	3.40	80	8	2,176		
Dowels	Vertical I.F.	9	6	3.40	19.8	161	10,849		
	Vertical O.F.	9	6	3.40	19.8	161	10,849		
								cy	**LB/cy**
							47,520	242	196.0935907
						Σ =	**82,755**		
	Lap Splices (long. Bars)	9		3.40	8	273	7,426		
						Σ Bar Wt=	90,180	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	V	arm	Mv
	ft	kcf		K	ft	ft-k
Diversion WSEL	6.44	0.0624	0.401856	1.294	2.147	2.777736
Tributary SEL =	20.32	0.019	0.38608	3.923	6.773	26.56889
Tributary WSEL =	0.00	0.0624	0	0.000	0.000	0
Sum				3.923		26.56889
Net Forces				2.629		23.79116

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MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 2 100 yr. flood + ice Panel B	

ID#	Case 2
Name	100 yr. flood + ice
Load Category	Unusual
Tributary - Water El. (ft)	914.56
Diversion - Head Water El. (ft)	902.12
Diversion - Tail Water El. (ft)	901.91
Tributary - T.O. Wall El. (ft)	916
Tributary - T.O. Deck L.P. El.(ft)	898.7
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Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

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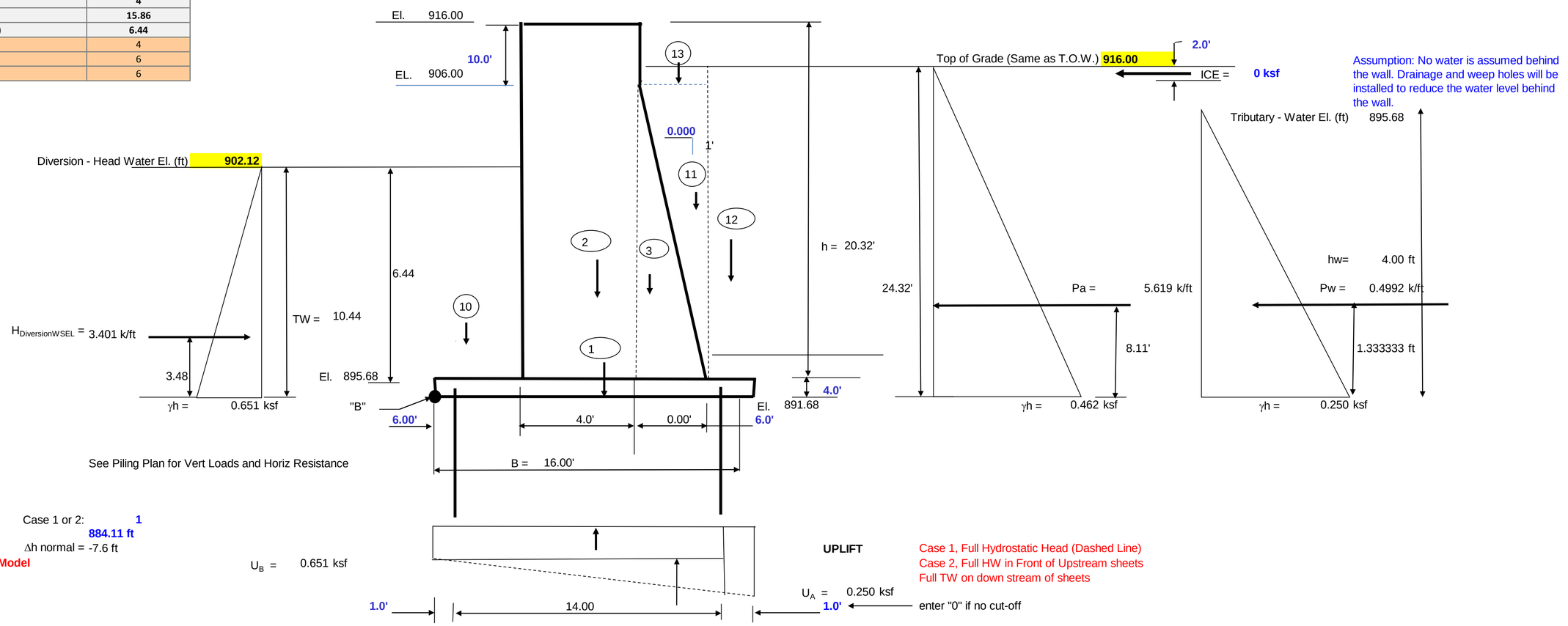
Frost Depth = 5.0 ft provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = 903.24 ft DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 80.5 ft**
Stepped Ftg Ls = 2.0 ft overlap distance at stepped ftg



UPLIFT
Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets
enter "0" if no cut-off

Case 1 or 2: 1
Normal Water Level, El. 884.11 ft
Δh normal = -7.6 ft
See Geotechnical seepage Model

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	80.5	16.00	4.00	0.15	rec	772.8	8.00	6,182.4
Stem	2	80.5	4.00	20.32	0.15	rec	981.5	8.00	7,851.6
Batter	3	80.5	0.00	10.32	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1754.3**	ΣM_V =	**14,034.0**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	80.5	6.00	6.44	0.0624	rec	194.1	3.00	582.3
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H.W. Above Slope	13	80.5	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	80.5	6.00	20.32	0.0626	rec	614.4	13.00	7,987.1
H.W. on Footing	12w	80.5	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**808.5**	ΣM_V =	**8,569.4**

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	80.5	16.00	0.651	rec	-839.1	8.00	-6,713
	U_A	80.5	16.00	-0.402	tri	258.8	10.67	2,760
					ΣU =	**-580.3**	ΣM_U =	**-3,952**

Horizontal Loads	L ft	H ft	Pressure ksf	ICE K	arm ft	Mu ft-k

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2/11/11				Load Cases: Case 2 100 yr. flood + ice	Panel B

ICE	80.5	2.00	0.00	rec	0.0	23.32	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	80.5		-5.619		-452.32	8.11	-3666.81	
Water Loads								
H_{TW}	80.5		3.401	tri	273.75	3.48	952.64	
H_{HW}	80.5		-0.499	tri	-40.19	1.33	-53.58	
				ΣWater =	**233.56**	ΣM_W =	**-2767.8**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-6720	kip-ft
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Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**15,884**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**1,982**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-219**	kips

Location of Resultant	Xr = ΣM / P =	8.01	ft from Toe
	e = B/2 - Xr =	(0.01)	ft
	B/6 =	2.667	ft

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Stem Conc:	242	cy	3476	sf
Total =	438			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
Bot mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
								cy	**LB/cy**
							35,234	196	180.1748864
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	19.82	161	10,849	21698.936	
	Longitudinal:	9	6	3.40	80	40	10,880	21760	
Top Face	Transverse:	9	6	3.40	3.5	161	1,916		
	Longitudinal:	9	6	3.40	80	8	2,176		
Dowels	Vertical I.F.	9	6	3.40	19.8	161	10,849		
	Vertical O.F.	9	6	3.40	19.8	161	10,849		
								cy	**LB/cy**
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	Lap Splices (long. Bars)	9		3.40	8	273	7,426		
						Σ Bar Wt=	90,180	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	6.44	**0.0624**	0.401856	1.294	2.147	2.777736
Tributary SEL =	20.32	**0.019**	0.38608	3.923	6.773	26.56889
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
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ID#	Case 3
Name	500 yr. flood
Load Category	Unusual
Tributary - Water El. (ft)	914.67
Diversion - Head Water El. (ft)	903.32
Diversion - Tail Water El. (ft)	903.06
Tributary - T.O. Wall El. (ft)	916
Tributary - T.O. Deck L.P. El.(ft)	898.7
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Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	15.97
Diversion - Head Water height (ft)	7.64
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

File:

MN State Building Codes
Frost Depth = 5.0 ft provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = 903.24 ft DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 80.5 ft**
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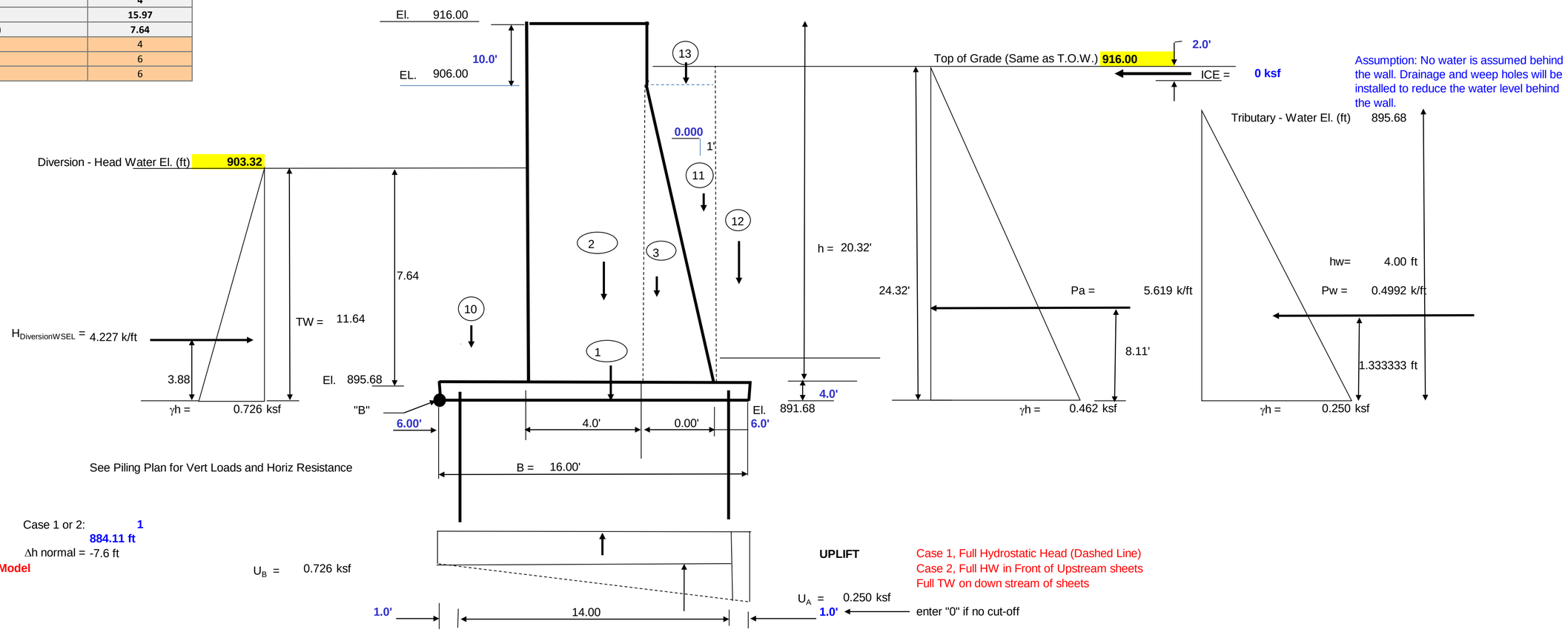

See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: 1
Normal Water Level, El. 884.11 ft
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UPLIFT
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Batter	3	80.5	0.00	10.32	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1754.3**	ΣM_V =	**14,034.0**
T.W on ftg Stem	10	80.5	6.00	7.64	0.0624	rec	230.3	3.00	690.8
H.W. on Stem Slope	11	80.5	0.00	10.32	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	80.5	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	80.5	6.00	20.32	0.0626	rec	614.4	13.00	7,987.1
H.W. on Footing	12w	80.5	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**844.7**	ΣM_V =	**8,677.9**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	80.5	16.00	0.726	rec	-935.5	8.00	-7,484
	U_A	80.5	16.00	-0.477	tri	307.0	10.67	3,275
					ΣU =	**-628.5**	ΣM_U =	**-4,209**

Horizontal Loads		L ft	H ft	Pressure ksf		ICE K	arm ft	Mu ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				Load Cases: Case 3 500 yr. flood — Panel B	

ICE	80.5	2.00	0.00	rec	0.0	23.32	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	80.5		-5.619		-452.32	8.11'	-3666.81	
Water Loads								
H_{TW}	80.5		4.227	tri	340.30	3.88	1320.35	
H_{HW}	80.5		-0.499	tri	-40.19	1.33	-53.58	
				ΣWater =	**300.11**	ΣM_W =	**-2400.0**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-6609	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	22712	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**16,103**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**1,970**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-152**	kips

Location of Resultant	Xr = ΣM / P =	8.17	ft from Toe
	e = B/2 - Xr =	(0.17)	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	196	cy (includes stepped)	820	sf
Stem Conc:	242	cy	3476	sf
Total =	438			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
Bot mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
								cy	**LB/cy**
							35,234	196	180.1748864
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	19.82	161	10,849	21698.936	
	Longitudinal:	9	6	3.40	80	40	10,880	21760	
Top Face	Transverse:	9	6	3.40	3.5	161	1,916		
	Longitudinal:	9	6	3.40	80	8	2,176		
Dowels	Vertical I.F.	9	6	3.40	19.8	161	10,849		
	Vertical O.F.	9	6	3.40	19.8	161	10,849		
								cy	**LB/cy**
							47,520	242	196.0935907
						Σ =	**82,755**		
	Lap Splices (long. Bars)	9		3.40	8	273	7,426		
						Σ Bar Wt=	90,180	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	7.64	**0.0624**	0.476736	1.821	2.547	4.637815
Tributary SEL =	20.32	**0.019**	0.38608	3.923	6.773	26.56889
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				3.923		26.56889
Net Forces				2.101		21.93108

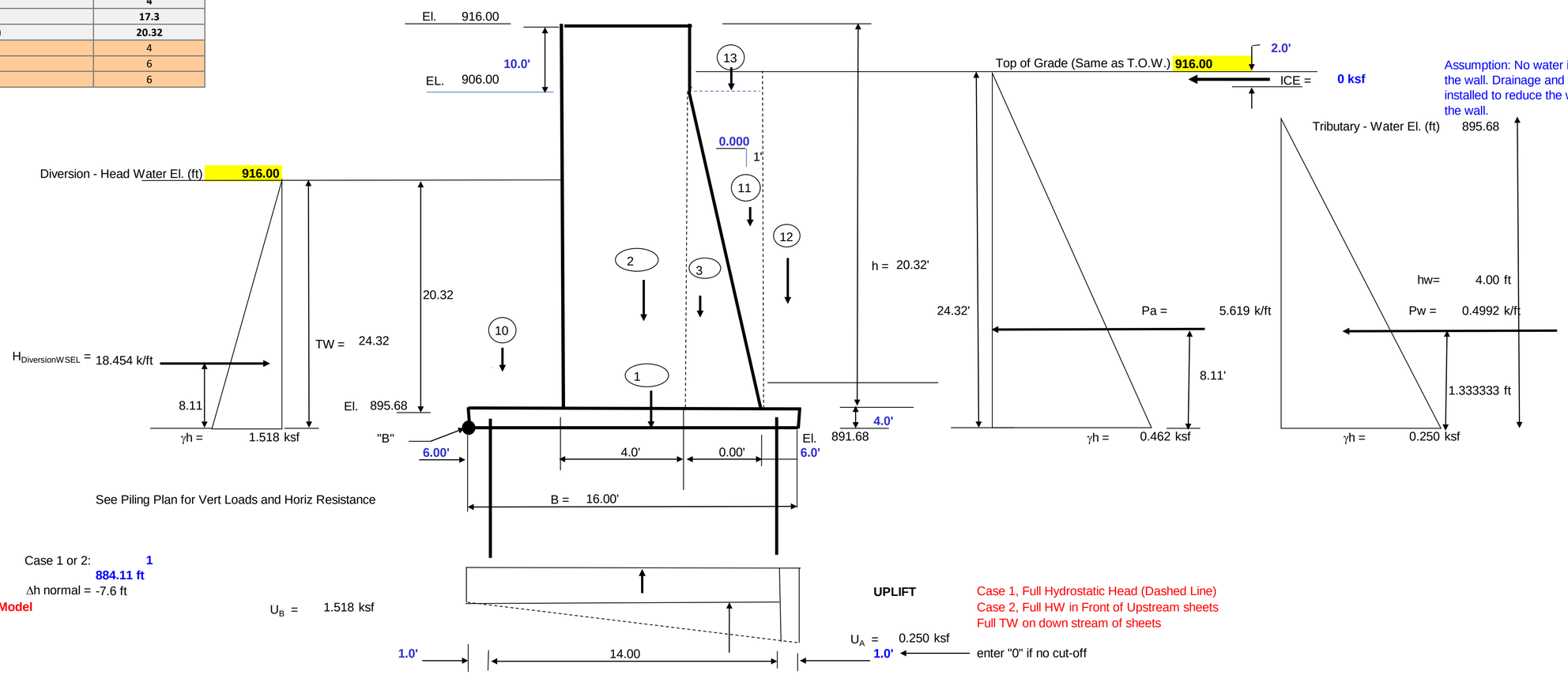
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 4 T.O. Levee Panel B	

ID#	Case 4
Name	T.O. Levee
Load Category	Extreme
Tributary - Water El. (ft)	NA
Diversion - Head Water El. (ft)	916
Diversion - Tail Water El. (ft)	916
Tributary - T.O. Wall El. (ft)	916
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	895.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	17.3
Diversion - Head Water height (ft)	20.32
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 80.5 ft**
Stepped Ftg Ls = **2.0 ft** overlap distance at stepped ftg



See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: **1**
Normal Water Level, El. **884.11 ft**
Δh normal = -7.6 ft
See Geotechnical seepage Model

U_B = 1.518 ksf

U_A = 0.250 ksf

UPLIFT
Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets
enter "0" if no cut-off

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	80.5	16.00	4.00	0.15	rec	772.8	8.00	6,182.4
Stem	2	80.5	4.00	20.32	0.15	rec	981.5	8.00	7,851.6
Batter	3	80.5	0.00	10.32	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1754.3**	ΣM_V =	**14,034.0**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	80.5	6.00	20.32	0.0624	rec	612.4	3.00	1,837.3
H.W. on Stem Slope	11	80.5	0.00	10.32	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	80.5	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	80.5	6.00	20.32	0.0626	rec	614.4	13.00	7,987.1
H.W. on Footing	12w	80.5	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**1226.8**	ΣM_V =	**9,824.4**

Uplift Loads		L ft	W ft	Pressure ksf		**U** K	arm ft	**Mu** ft-k
	U_B	80.5	16.00	1.518	rec	-1954.6	8.00	-15,637
	U_A	80.5	16.00	-1.268	tri	816.6	10.67	8,710
					ΣU =	**-1138.1**	ΣM_U =	**-6,927**

Horizontal Loads	L ft	H ft	Pressure ksf	**ICE** K	arm ft	**Mu** ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				Load Cases: Case 4 T.O. Levee Panel B	

ICE	80.5	2.00	0.00	rec	0.0	23.32	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	80.5		-5.619		-452.32	8.11'	-3666.81	
Water Loads								
H_{TW}	80.5		18.454	tri	1485.52	8.11	12042.59	
H_{HW}	80.5		-0.499	tri	-40.19	1.33	-53.58	
				ΣWater =	**1445.33**	ΣM_W =	**8322.2**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	1395	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	23858	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**25,254**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**1,843**	kips
Sum of Horizontal Forces	H = Σhorizontal	**993**	kips

Location of Resultant	Xr = ΣM / P =	13.70	ft from Toe
	e = B/2 - Xr =	(5.70)	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	196	cy (includes stepped)	820	sf
Stem Conc:	242	cy	3476	sf
Total =	438			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
Bot mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
								cy	**LB/cy**
							35,234	196	180.1748864
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	19.82	161	10,849	21698.936	
	Longitudinal:	9	6	3.40	80	40	10,880	21760	
Top Face	Transverse:	9	6	3.40	3.5	161	1,916		
	Longitudinal:	9	6	3.40	80	8	2,176		
Dowels	Vertical I.F.	9	6	3.40	19.8	161	10,849		
	Vertical O.F.	9	6	3.40	19.8	161	10,849		
								cy	**LB/cy**
							47,520	242	196.0935907
						Σ =	**82,755**		
	Lap Splices (long. Bars)	9		3.40	8	273	7,426		
						Σ Bar Wt=	90,180	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	20.32	**0.0624**	1.267968	12.883	6.773	87.25784
Tributary SEL =	20.32	**0.019**	0.38608	3.923	6.773	26.56889
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				3.923		26.56889
Net Forces				-8.960		-60.6889

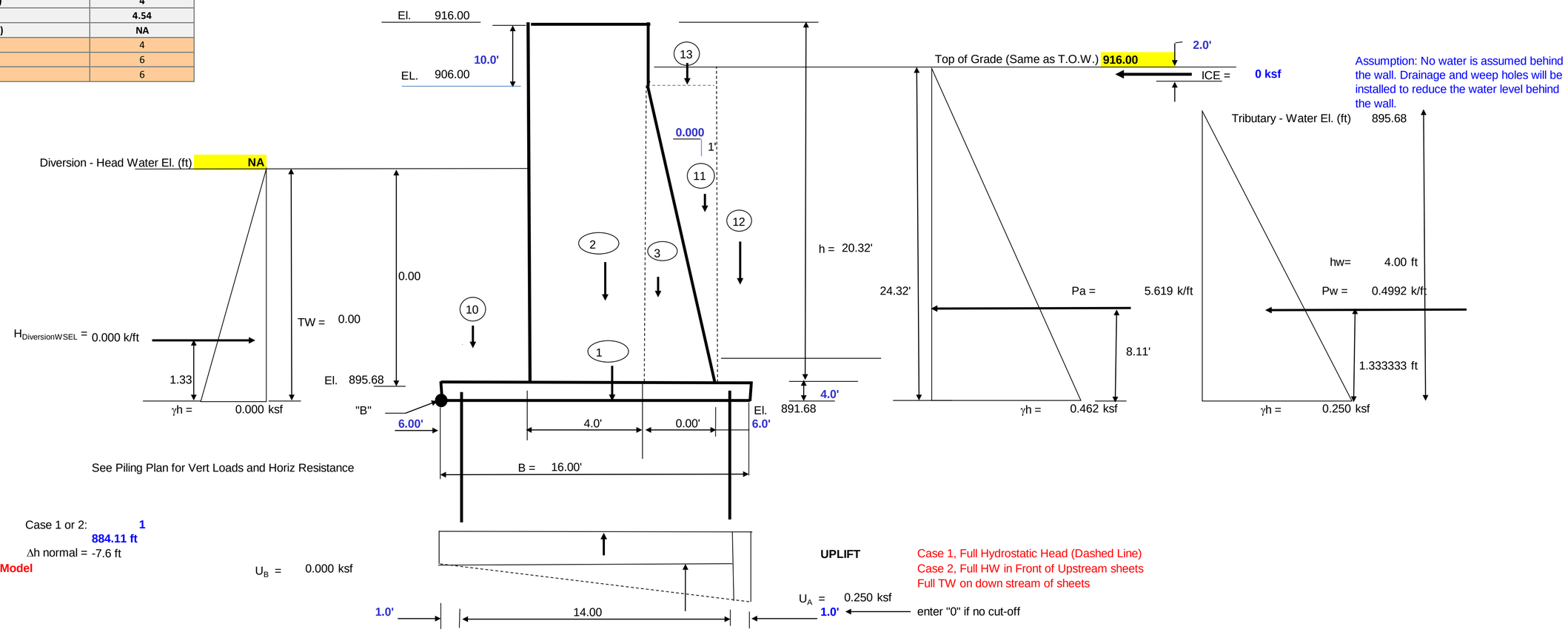
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 5 Normal flow + ice Panel B	

ID#	Case 5
Name	Normal flow + ice
Load Category	Usual
Tributary - Water El. (ft)	903.24
Diversion - Head Water El. (ft)	NA
Diversion - Tail Water El. (ft)	NA
Tributary - T.O. Wall El. (ft)	916
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	895.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	4.54
Diversion - Head Water height (ft)	NA
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

File:

MN State Building Codes
Frost Depth = 5.0 ft provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = 903.24 ft DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 80.5 ft**
Stepped Ftg Ls = 2.0 ft overlap distance at stepped ftg



Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets
enter "0" if no cut-off

Case 1 or 2: 1
Normal Water Level, El. 884.11 ft
Δh normal = -7.6 ft
See Geotechnical seepage Model

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	80.5	16.00	4.00	0.15	rec	772.8	8.00	6,182.4
Stem	2	80.5	4.00	20.32	0.15	rec	981.5	8.00	7,851.6
Batter	3	80.5	0.00	10.32	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1754.3**	ΣM_V =	**14,034.0**
T.W on ftg Stem	10	80.5	6.00	0.00	0.0624	rec	0.0	3.00	0.0
H.W. on Stem Slope	11	80.5	0.00	10.32	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	80.5	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	80.5	6.00	20.32	0.0626	rec	614.4	13.00	7,987.1
H.W. on Footing	12w	80.5	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**614.4**	ΣM_V =	**7,987.1**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	80.5	16.00	0.000	rec	0.0	8.00	0
	U_A	80.5	16.00	0.250	tri	-160.7	10.67	-1,715
					ΣU =	**-160.7**	ΣM_U =	**-1,715**

Horizontal Loads	L ft	H ft	Pressure ksf	ICE K	arm ft	Mu ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				Load Cases: Case 5 Normal flow + ice — Panel B	

ICE	80.5	2.00	0.00	rec	0.0	23.32	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	80.5		-5.619		-452.32	8.11'	-3666.81	
Water Loads								
H_{TW}	80.5		0.000	tri	0.00	1.33	0.00	
H_{HW}	80.5		-0.499	tri	-40.19	0.00	0.00	
				ΣWater =	**-40.19**	ΣM_W =	**-3666.8**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-5381	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	22021	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**16,640**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,208**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-493**	kips

Location of Resultant	Xr = ΣM / P =	7.54	ft from Toe
	e = B/2 - Xr =	0.46	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	196	cy (includes stepped)	820	sf
Stem Conc:	242	cy	3476	sf
Total =	438			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
Bot mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
								cy	**LB/cy**
							35,234	196	180.1748864
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	19.82	161	10,849	21698.936	
	Longitudinal:	9	6	3.40	80	40	10,880	21760	
Top Face	Transverse:	9	6	3.40	3.5	161	1,916		
	Longitudinal:	9	6	3.40	80	8	2,176		
Dowels	Vertical I.F.	9	6	3.40	19.8	161	10,849		
	Vertical O.F.	9	6	3.40	19.8	161	10,849		
								cy	**LB/cy**
							47,520	242	196.0935907
						Σ =	**82,755**		
	Lap Splices (long. Bars)	9		3.40	8	273	7,426		
						Σ Bar Wt=	90,180	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	0.00	**0.0624**	0	0.000	0.000	0
Tributary SEL =	20.32	**0.019**	0.38608	3.923	6.773	26.56889
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				3.923		26.56889
Net Forces				3.923		26.56889

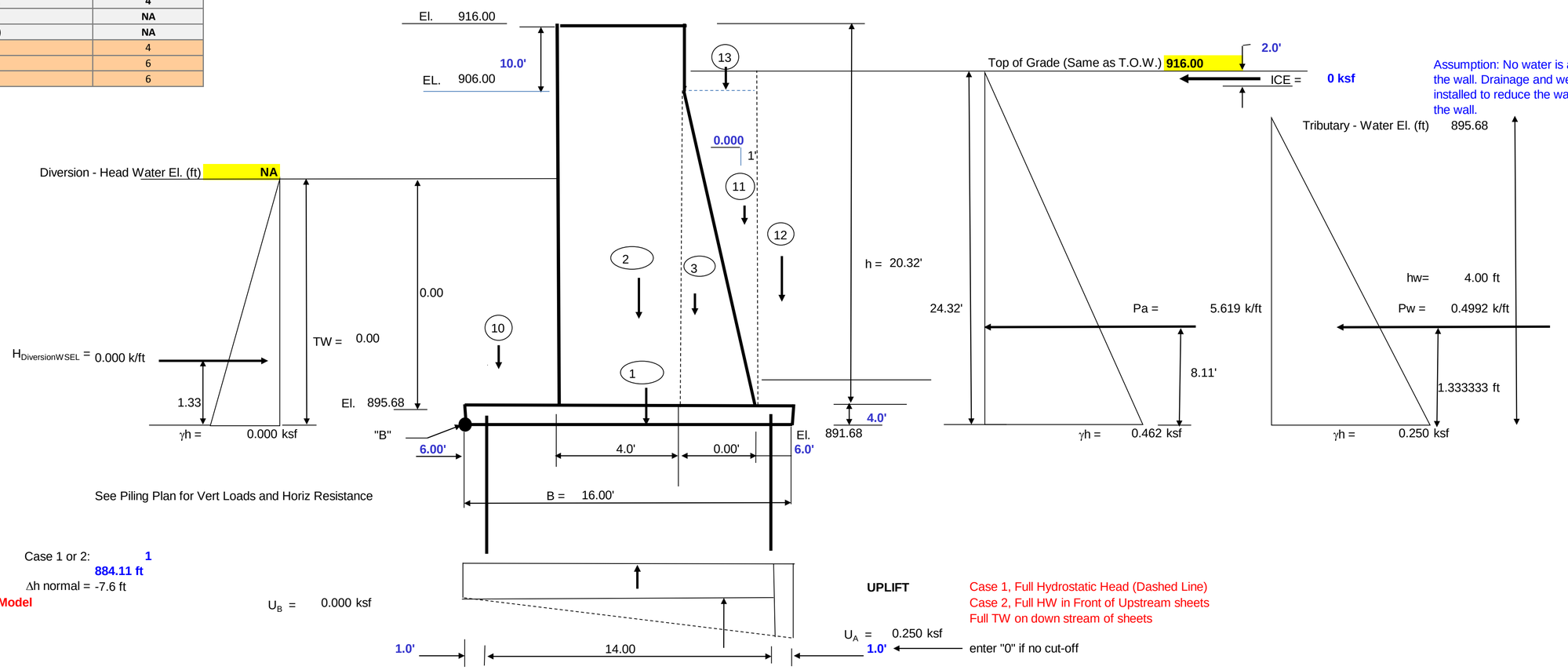
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 6 Construction Panel B	

ID#	Case 6
Name	Construction
Load Category	Unusual
Tributary - Water El. (ft)	NA
Diversion - Head Water El. (ft)	NA
Diversion - Tail Water El. (ft)	NA
Tributary - T.O. Wall El. (ft)	916
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	895.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	NA
Diversion - Head Water height (ft)	NA
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 80.5 ft**
Stepped Ftg Ls = **2.0 ft** overlap distance at stepped ftg



Case 1 or 2: **1**
Normal Water Level, El. **884.11 ft**
Δh normal = -7.6 ft
See Geotechnical seepage Model

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	80.5	16.00	4.00	0.15	rec	772.8	8.00	6,182.4
Stem	2	80.5	4.00	20.32	0.15	rec	981.5	8.00	7,851.6
Batter	3	80.5	0.00	10.32	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1754.3**	ΣM_V =	**14,034.0**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	80.5	6.00	0.00	0.0624	rec	0.0	3.00	0.0
H.W. on Stem Slope	11	80.5	0.00	10.32	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	80.5	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	80.5	6.00	20.32	0.0626	rec	614.4	13.00	7,987.1
H.W. on Footing	12w	80.5	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**614.4**	ΣM_V =	**7,987.1**

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	80.5	16.00	0.000	rec	0.0	8.00	0
	U_A	80.5	16.00	0.250	tri	-160.7	10.67	-1,715
					ΣU =	**-160.7**	ΣM_U =	**-1,715**

Horizontal Loads	L ft	H ft	Pressure ksf	ICE K	arm ft	Mu ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				Load Cases: Case 6 Construction Panel B	

ICE	80.5	2.00	0.00	rec	0.0	23.32	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	80.5		-5.619		-452.32	8.11'	-3666.81	
Water Loads								
H_{TW}	80.5		0.000	tri	0.00	1.33	0.00	
H_{HW}	80.5		-0.499	tri	-40.19	1.33	-53.58	
				ΣWater =	**-40.19**	ΣM_W =	**-3720.4**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-5435	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	22021	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**16,586**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,208**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-493**	kips

Location of Resultant	Xr = ΣM / P =	7.51	ft from Toe
	e = B/2 - Xr =	0.49	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	196	cy (includes stepped)	820	sf
Stem Conc:	242	cy	3476	sf
Total =	438			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
Bot mat	Transverse:	9	6	3.40	15.5	165	8,696		
	Longitudinal:	9	6	3.40	82	32	8,922		
								cy	**LB/cy**
							35,234	196	180.1748864
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	19.82	161	10,849	21698.936	
	Longitudinal:	9	6	3.40	80	40	10,880	21760	
Top Face	Transverse:	9	6	3.40	3.5	161	1,916		
	Longitudinal:	9	6	3.40	80	8	2,176		
Dowels	Vertical I.F.	9	6	3.40	19.8	161	10,849		
	Vertical O.F.	9	6	3.40	19.8	161	10,849		
								cy	**LB/cy**
							47,520	242	196.0935907
						Σ =	**82,755**		
	Lap Splices (long. Bars)	9		3.40	8	273	7,426		
						Σ Bar Wt=	90,180	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	0.00	**0.0624**	0	0.000	0.000	0
Tributary SEL =	20.32	**0.019**	0.38608	3.923	6.773	26.56889
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				3.923		26.56889
Net Forces				3.923		26.56889

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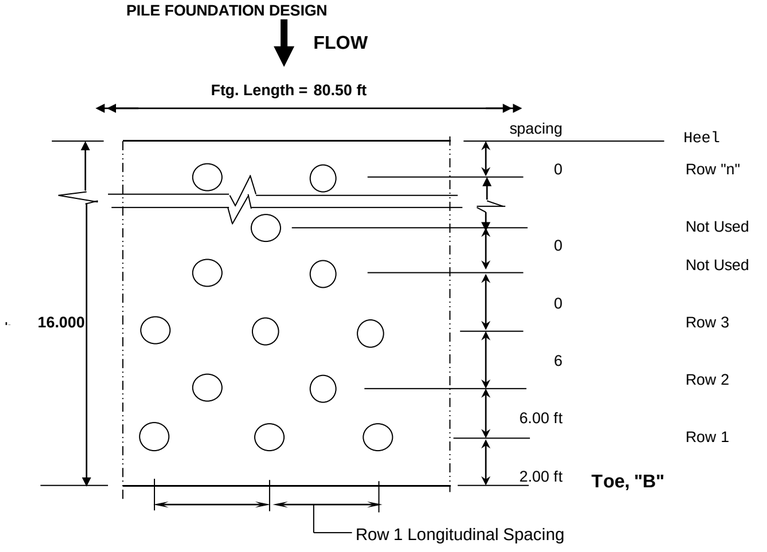
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Panel B	

PILE FOUNDATION DESIGN



L = 80.50 ft

PILE PATTERN GEOMETRY

Transverse Spacing		Distance to Toe, d_{toe}	Longitudinal Spacing	Batter	Piles per Row (**N**)	Edge Dist (ft)		Trial N
Row 1 to Toe	**2.00 ft**	2.0 ft	**2.50 ft**	**0** "/12"	**12**	26.50	1	33
Row 1 to Row 2	**6.00 ft**	8.0 ft	**5.00 ft**	**0** "/12"	**12**	12.75	0	17
Row 2 to Row 3	**6.00 ft**	14.0 ft	**5.00 ft**	**0** "/12"	**12**	12.75	1	17
Row 3 to Row 4	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 4 to Row 5	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 5 to Row 6	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 6 to Row 7	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 7 to Row 8	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 8 to Row 9	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 9 to Row 10	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 10 to Row 11	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 11 to Row 12	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 12 to Row 13	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 13 to Row 14	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Row 14 to Row 15	**0.00 ft**	0.0 ft	**0.00 ft**	**0** "/12"	**0**	40.25	0	0
Last Row to Heel	2.00 ft							
	16.00 ft				**ΣN =**	**36**		67

Note: Enter 0 for Longitudinal Spacing for Rows Not Used)

Pile Properties: Pile Type: **HP** (C.I.P or HP) Pile Length = **50.0 ft**

HP Nominal Depth, h = **14.0 in**

Wt. per ft, plf **73**

Ftg EL. 891.68

Pile Tip El. 842.68

Pile Cap Embed = **1.00 ft**

Total pile Length = 1,800 LF

Pile Group Properties

N.A. of Pile Group to Toe

$X_{NA} = (\Sigma N * d_{toe}) / \Sigma N =$ **8.00 ft**

	Dist. From N.A. to Pile Row	d	N	$I = N * d^2$
1	Dist. To Row 1	6.00 ft	12	432.0
0	Dist. To Row 2	0.00 ft	12	0.0
1	Dist. Row 3	-6.00 ft	12	432.0
0	Row 4 (not used)	0.00 ft	0	0.0
0	Row 5 (not used)	0.00 ft	0	0.0
0	Row 6 (not used)	0.00 ft	0	0.0
0	Row 7 (not used)	0.00 ft	0	0.0
0	Row 8 (not used)	0.00 ft	0	0.0
0	Row 9 (not used)	0.00 ft	0	0.0
0	Row 10 (not used)	0.00 ft	0	0.0
0	Row 11 (not used)	0.00 ft	0	0.0
0	Row 12 (not used)	0.00 ft	0	0.0
0	Row 13 (not used)	0.00 ft	0	0.0
0	Row 14 (not used)	0.00 ft	0	0.0
0	Row 15 (not used)	0.00 ft	0	0.0
			36	$\Sigma I =$ **864.0**

ALLOWABLE LOADS (from Geotechnical)							
	Service	**Allowable Pile Loads**					
	ID#	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	Name	100 yr. flood	100 yr. flood + ice	500 yr. flood	T.O. Levee	Normal flow + ice	Construction
	Load Category	Usual	Unusual	Unusual	Extreme	Usual	Unusual
Allwable Lateral Capacity (tons)		18.0 tons	20.5 tons	20.5 tons	24.0 tons	11.5 tons	20.5 tons
Allowable Pile Capacity (tons) - Axial		62.0 tons	82.6 tons	82.6 tons	107.7 tons	36.5 tons	82.6 tons
Safety Factors		2.00	1.50	1.50	1.15	2.00	1.50

w/o Group effects

Summary Pile Reactions

Load Combinations	Allowable Pile Capacity (tons) - Axial	Pile Loads (tons/pile) 1	2	3	4	5	6	7	8	9	10	11	12	Max. Vertical Load (Tons)	Horiz Pile Group Capacity (k)	Check
Case 1	**62.0 tons**	27.5	27.5	27.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.6	1,296	**OK**
Case 2	**82.6 tons**	27.5	27.5	27.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.6	1,476	**OK**
Case 3	**82.6 tons**	26.2	27.4	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.5	1,476	**OK**
Case 4	**107.7 tons**	-10.9	25.6	62.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.1	1,728	**OK**
Case 5	**36.5 tons**	34.2	30.7	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.2	828	**OK**
Case 6	**82.6 tons**	34.4	30.7	26.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.4	828	**OK**

Max Service : P = **62.1**

Using solid mechanics equations adapted for discrete elements, the forces in the pile rows for different load combinations are determined.
The force in each pile row is found using:

$$\text{Pile Load} = P / N + M_{NA} / I$$

First, the moment about the toe must be translated to get the moment about the neutral axis of the pile group.

$$e_{toe} = M_{toe} / P$$

Then the eccentricity about the neutral axis of the pile group is

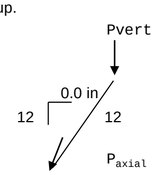
$$e_{NA} = X_{NA} - e_{toe}$$

The moment about the neutral axis of the pile group becomes

$$M_{NA} = P * e_{NA}$$

For battered pile, the Vertical pile load needs to be transformed to the axial load along the pile axis

$$\text{Paxial} = 1.000\ \text{Pvert}$$



FORCE RESULTANT (see Stability Analysis)

CASE	Event		Vertical Load P (kips)	Horizontal	ΣM toe (kip-	$e_{toe} = M_{toe} / P$	$e_{NA} = X_{NA} - e_{toe}$	$M_{NA} = P * e_{NA}$

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
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COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				**Panel B**	

Case 1	**100 yr. flood**	**Usual**	1,982	219	15,884	8.01	-0.01	-24
Case 2	**100 yr. flood + ice**	**Unusual**	1,982	219	15,884	8.01	-0.01	-24
Case 3	**500 yr. flood**	**Unusual**	1,970	152	16,103	8.17	-0.17	-339
Case 4	**T.O. Levee**	**Extreme**	1,843	-993	25,254	13.70	-5.70	-10510
Case 5	**Normal flow + ice**	**Usual**	2,208	493	16,640	7.54	0.46	1024
Case 6	**Construction**	**Unusual**	2,208	493	16,586	7.51	0.49	1077

SERVICE

Case **Case 1**
Flood Event **100 yr. flood**
Usual

Vertical Load, P = 1982 kips
Horizontal Load, H = 219 kips
M_{NA} = -24 kip-ft

36

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	55.1		-0.2	54.9 kips/pile	27.5 tons/pile	27.5 tons/pile
2	Row 2	55.1		0.0	55.1 kips/pile	27.5 tons/pile	27.5 tons/pile
3	Row 3	55.1		0.2	55.2 kips/pile	27.6 tons/pile	27.6 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
					max:	**27.6 tons/pile**	**max: 27.6 tons/pile**

Assumed lateral Capacity: 36.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance
1	Row 1	0	12	0.0	432	1.000	432 kips
2	Row 2	0	12	0.0	432	1.000	432 kips
3	Row 3	0	12	0.0	432	1.000	432 kips
4	Row 4	0	0	0.0	0	1.000	0 kips
5	Row 5	0	0	0.0	0	1.000	0 kips
6	Row 6	0	0	0.0	0	1.000	0 kips
7	Row 7	0	0	0.0	0	1.000	0 kips
8	Row 8	0	0	0.0	0	1.000	0 kips
9	Row 9	0	0	0.0	0	1.000	0 kips
10	Row 10	0	0	0.0	0	1.000	0 kips
11	Row 11	0	0	0.0	0	1.000	0 kips
12	Row 12	0	0	0.0	0	1.000	0 kips
13	Row 13	0	0	0.0	0	1.000	0 kips
14	Row 14	0	0	0.0	0	1.000	0 kips
15	Row 15	0	0	0.0	0	1.000	0 kips
			36		1296		**1296 kips**

OK

Case **Case 2**
Flood Event **100 yr. flood + ice**
Unusual

Vertical Load, P = 1982 kips
Horizontal Load, H = 219 kips
M_{NA} = -24 kip-ft

36

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	55.1		-0.2	54.9 kips/pile	27.5 tons/pile	27.5 tons/pile
2	Row 2	55.1		0.0	55.1 kips/pile	27.5 tons/pile	27.5 tons/pile
3	Row 3	55.1		0.2	55.2 kips/pile	27.6 tons/pile	27.6 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
					max:	**27.6 tons/pile**	**max: 27.6 tons/pile**

Assumed lateral Capacity: 41.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance
1	Row 1	0	12	0.0	492	1.000	492 kips
2	Row 2	0	12	0.0	492	1.000	492 kips
3	Row 3	0	12	0.0	492	1.000	492 kips

4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			36		1476		**1476 kips**	**OK**

Case **Case 3**
Flood Event **500 yr. flood**
Unusual

Vertical Load, P = 1970 kips
Horizontal Load, H = 152 kips
M_{NA} = -339 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	54.7		-2.4	52.4 kips/pile	26.2 tons/pile	26.2 tons/pile
2	Row 2	54.7		0.0	54.7 kips/pile	27.4 tons/pile	27.4 tons/pile
3	Row 3	54.7		2.4	57.1 kips/pile	28.5 tons/pile	28.5 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
						max: **28.5 tons/pile**	**max:** **28.5 tons/pile**

Assumed lateral Capacity: 41.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	12	0.0	492	1.000	492 kips	
2	Row 2	0	12	0.0	492	1.000	492 kips	
3	Row 3	0	12	0.0	492	1.000	492 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			36		1476		**1476 kips**	**OK**

Case **Case 4**
Flood Event **T.O. Levee**
Extreme

Vertical Load, P = 1843 kips
Horizontal Load, H = -993 kips
M_{NA} = -10510 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	51.2		-73.0	-21.8 kips/pile	-10.9 tons/pile	-10.9 tons/pile
2	Row 2	51.2		0.0	51.2 kips/pile	25.6 tons/pile	25.6 tons/pile
3	Row 3	51.2		73.0	124.2 kips/pile	62.1 tons/pile	62.1 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
						max: **62.1 tons/pile**	**max:** **62.1 tons/pile**

Assumed lateral Capacity: 48.0 kips/pile

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls **Panel B**	

	Horizontal Pile Capacity	Batter "/ft	N	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	12	0.0	576	1.000	576 kips	
2	Row 2	0	12	0.0	576	1.000	576 kips	
3	Row 3	0	12	0.0	576	1.000	576 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			36		1728		**1728 kips**	**OK**

Case **Case 5**
Flood Event **Normal flow + ice**
Usual

Vertical Load, P = 2208 kips
Horizontal Load, H = 493 kips
M_{NA} = 1024 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		Axial Pile Load
1	Row 1	61.3		7.1	68.4 kips/pile	34.2 tons/pile	34.2 tons/pile
2	Row 2	61.3		0.0	61.3 kips/pile	30.7 tons/pile	30.7 tons/pile
3	Row 3	61.3		-7.1	54.2 kips/pile	27.1 tons/pile	27.1 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
					max:	**34.2 tons/pile**	**max: 34.2 tons/pile**

Assumed lateral Capacity: 23.0 kips/pile

	Horizontal Pile Capacity	Batter "/ft	N	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	12	0.0	276	1.000	276 kips	
2	Row 2	0	12	0.0	276	1.000	276 kips	
3	Row 3	0	12	0.0	276	1.000	276 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			36		828		**828 kips**	**OK**

Case **Case 6**
Flood Event **Construction**
Unusual

Vertical Load, P = 2208 kips
Horizontal Load, H = 493 kips
M_{NA} = 1077 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		Axial Pile Load
1	Row 1	61.3		7.5	68.8 kips/pile	34.4 tons/pile	34.4 tons/pile
2	Row 2	61.3		0.0	61.3 kips/pile	30.7 tons/pile	30.7 tons/pile
3	Row 3	61.3		-7.5	53.9 kips/pile	26.9 tons/pile	26.9 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile

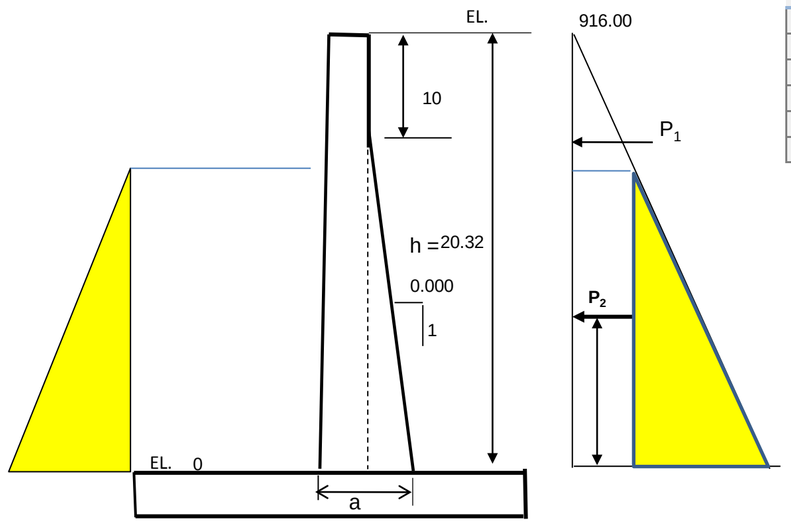
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				Panel B	

11	Row 11	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
12	Row 12	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
13	Row 13	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
14	Row 14	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
15	Row 15	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
					max:	**34.4 tons/pile**	**max:**	**34.4 tons/pile**	

Assumed lateral Capacity: 41.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	12	0.0	276	1.000	276 kips	
2	Row 2	0	12	0.0	276	1.000	276 kips	
3	Row 3	0	12	0.0	276	1.000	276 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			36		828		**828 kips**	**OK**

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Panel B 0	



CASE	Event		HW	TW	Dh	TW -ftg
Case 1	100 yr. flood	Usual	902.12	901.91	0.21	901.91
Case 2	100 yr. flood + ice	Unusual	902.12	901.91	0.21	901.91
Case 3	500 yr. flood	Unusual	914.670	903.06	11.61	903.06
Case 4	T.O. Levee	Extreme	916.000	916.00	0.00	916.00
Case 5	Normal flow + ice	Usual	0.000	0.000	0.00	0.00
Case 6	Construction	Unusual	0.000	0.000	0.00	0.00

LOAD FACTORS

Hf =	1.30	hydraulic Factor
LF =	1.70	
Unsual & Extreme =	0.75	
TOP THICK =	4.0 ft	48.0 in
Batter at Base =	0.00 ft	0.0 in
a =	4.00 ft	48.0 in

Load Factors - Hydraulic Structures	
live load, LL =	1.7
dead load, DL =	1.4
flood level , FL =	1
Fluid, F =	1.7
hydraulic, Hf =	1.3
direct tension hydraulic, Hf =	1.65
ICE =	1.7

WALL DESIGN:

Horizontal Load Components and Moments about Bottom of Stem (Service)

CASE	Event	Condition	Load Factor	H (kips/ft)	Moment (kip-ft/ ft)	Vu (kips/ft)	Mu (kip-ft/ ft)
Case 1	100 yr. flood	Usual	1	2.63	23.791	5.81	52.58
Case 2	100 yr. flood + ice	Unusual	0.75	2.63	23.791	4.36	39.43
Case 3	500 yr. flood	Unusual	0.75	2.10	21.931	3.48	36.35
Case 4	T.O. Levee	Extreme	0.75	-8.96	-60.689	14.85	100.59
Case 5	Normal flow + ice	Usual	1	3.92	26.569	8.67	58.72
Case 6	Construction	Unusual	0.75	3.92	26.569	6.50	44.04

STEM DESIGN VALUES

MU, k-ft/ft	100.59	k-ft/ft
VU, k/ft	14.85	k/ft

ACI 318-05 w/ Modifications per EM 1110-2-2104 ref. EM 110-2-2104

9.3 - Design Strength

ϕ = **0.9** 9.3.2.1 - Tension Controlled sections

0.75 9.3.2.3 - Shear and torsion

FLEXURAL STEEL FOR RECTANGULAR CONCRETE SECTIONS

fy=	60	ksi	
Fc'=	4	ksi	
B1=	0.85		
Muh =	101	k-ft /ft	**Includes: hf = 1.3**
Vuh=	14.85	k / ft	
bw=	12	in.	
h=	48	in	
cover=	4	in (include correct stirrup bar dia.)	
d=	43.50	in	
pb=	0.0285		pb=0.85*B1*Fc'/ fy*(87 / (87+fy))
.75*pb=	0.0214		
m=fy / 0.85*Fc'=	17.647		

TRIAL

Ru=Mn/bd^2 =	59.067		**ACI 10.5.1** **ACI 10.5.3**
REQ'D p=	0.0010	**O.K.**	p(min)= 3*SQRT(Fc')/fy 200* / fy 4/3*p
p=	0.0013		0.00316 0.00333 0.0013
			EM 110-2-2104 2-8 c. (not less than Temp & Shrinkage, half in each face)
As (REQ'D)=	0.81	in^2	p(min)= 0.0028 /2 → As =0.5*$p_{T\&S}$bh = 0.8064 in^2
			As = #9 @ 12 = 1.00 in^2

SELECT STEEL

bar #=	9		
spacing, s=	6	in	
# OF BAR=	1	(ENTER 1 IF PER FT, b=12")	a
As=	1.999	in^2	
d=	43.4375	in	
p = As/bd =	0.0038	**O.K. < 0.375pb**	**EM 110-2-2104**
p =	**0.135**	**pb**	**MAXIMUM TENSILE REINFORCEMENT**
T= As*fy =	119.9	k	a) For singly reinforced flexural members
C= B1*Fc' *b*a =	342.0	**a**	1) p = **0.25** pb Recommended limit
a= T/C =	0.351	in	2) p = **0.375** pb Max. permitted upper limit not requiring special study
Mn= T(d - a/2)/12 =	432.3	ft-k	3) p = **0.5** pb Max. permitted upper limit when excessive deflections are not predicted In ACI 318
ϕ Mn=	389.1	ft-k	4) p = >**0.5** pb but ≤ 0.375 pb permitted only if detailed serviceability analysis incl. deflect. Calc.
			b) Use of compression reinf. shall be per ACI 318
			> Mu O.K.

CHECK SHEAR REINFORCEMENT (ACI 11.3 & EM 110-2-2104 3-3a)

Vuh =	14.9	k	**NO SHEAR REINF. REQUIRED**
Vn = Vuh / ϕ =	19.8	k	
Vc = 2*sqrt(Fc') bw * d =	65.9	k	**11.3.1.1**
Vs =Vuh / f - 1.3Vc =	No Shear Reinf. Req.	k	NG Vs(max) ≤ 8*sqrt(fc')bd = 263.7 k

Trial Stirrup Sizes:

# of stirrup legs =	2	(single stirrup = 2, Dbl stirrup = 4……)
Stirrup bar size =	4	
Av=	0.393	in^2
s=		in s = Av * fy * d / (Vu / f - Vc)

11.5.5 - Spacing limits for shear reinforcement

s = d/2 =	21.719	in	OR 24	in
s(max)=	10.859	in		
4*sqrt(Fc')*bw*d=	131.9	k	< Vs Reduce Spacing	
USE s=	**10.86**	in		
Vs = (Av * Fy * d) / s =	0.0	k		

11.5.6 - MINIMUM SHEAR REINFORCEMENT

A minimum area of shear reinforcement, Av,min shall be provided in all reinforced concrete flexural members where **Vu** exceeds **0.5 f Vc**

NOT REQUIRED IF:

a) SLAB OR FOOTING, vc>vn **O.K.**

b) CONCRETE JOIST ACI 8.11

c) BEAMS W/ h <= 10"

h <= 2.5*Bf

h <= 0.5*tw

d) WALLS (SEE ACI 11.10.1); vc>vn **O.K.**

11.5.6.3

Av,min = 0.75 sqrt(fc') bw*s/fy =	0.40	* s
but not less than 50bw*s/ fy =	13.33333333	* s
s max = Av fy / 0.75 sqrt(fc') bw =	0.00	in
s max = Av fy /50 bw =	0.00	in

11.5.5.3

Where Vs exceeds 4*sqrt(Fc')*bw*d maximum spacings shall be reduced by one-half