APPENDIX B

HEC-RAS SEDIMENT TRANSPORT MODEL OUTPUT

2-YEAR SEDIMENT TRANSPORT ANALSIS

CUMULATIVE SEDIMENT MASS FOR 2-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

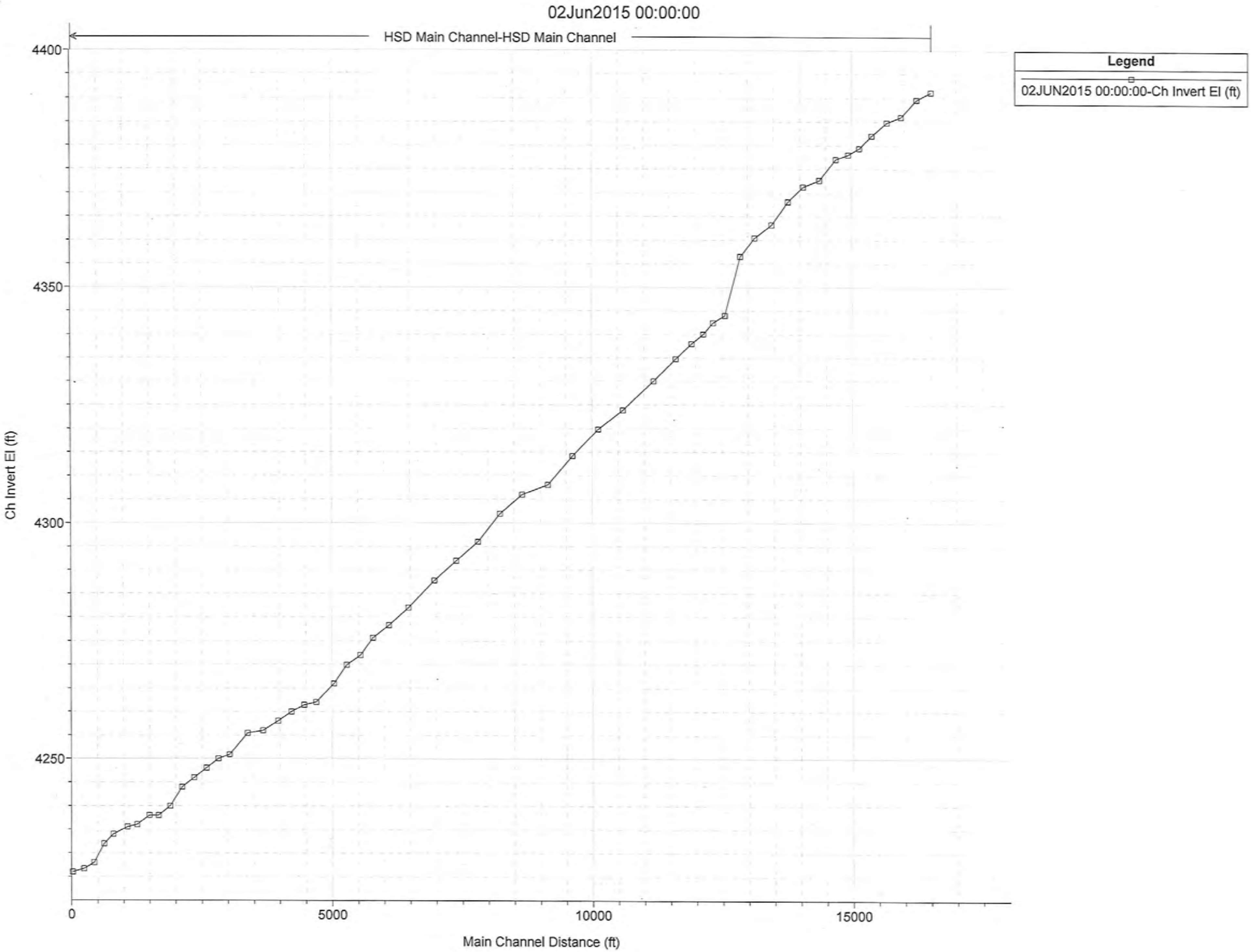
HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

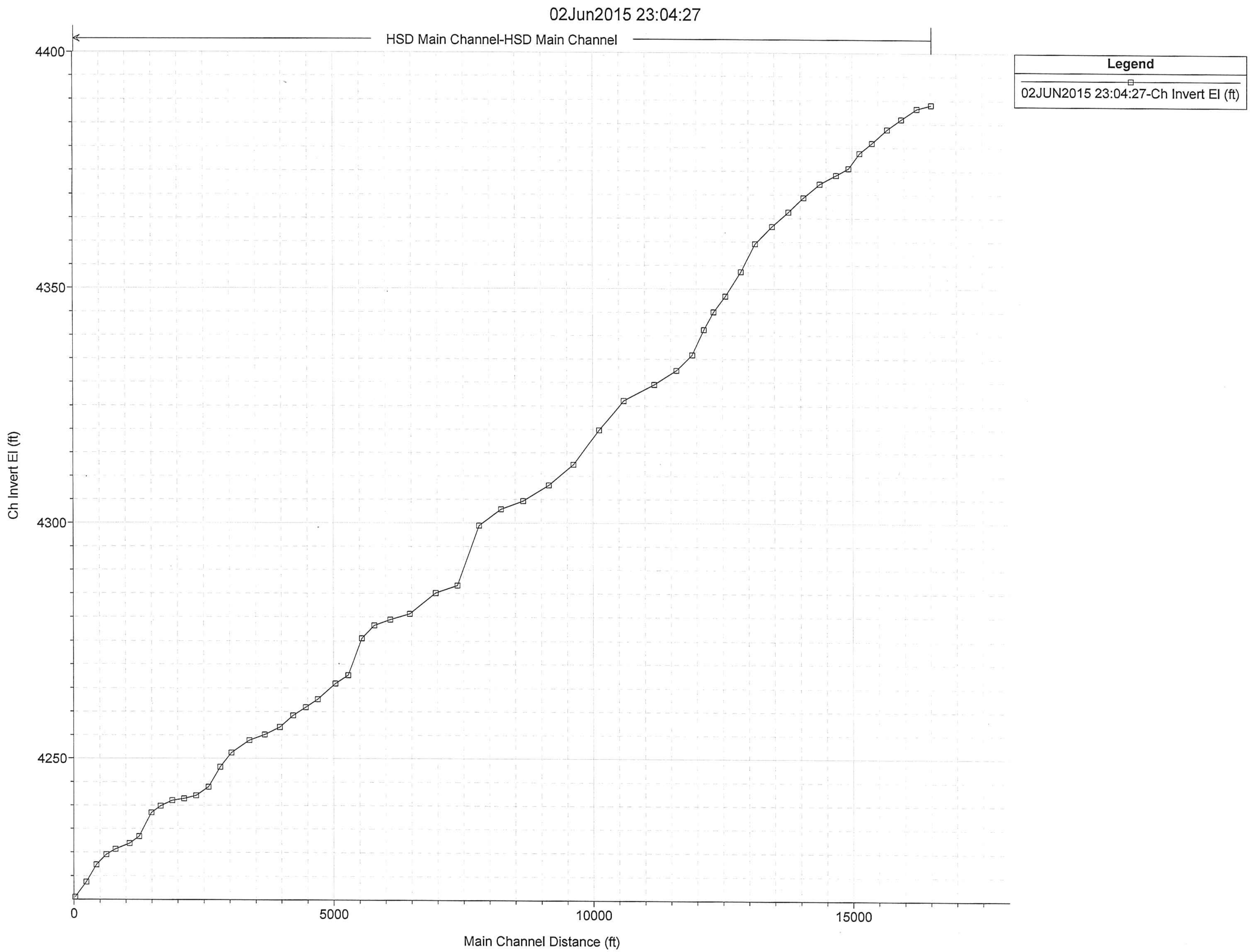
River Station	Cumulative Sediment Mass [TONS]
16520.00	1,682
16246.06	4,468
15946.84	4,377
15673.03	7,410
15381.93	9,042
15141.09	9,202
14931.77	12,382
14692.54	15,587
14379.42	16,214
14066.58	23,953
13772.72	27,086
13457.43	26,382
13130.33	30,121
12856.26	34,515
12556.85*	31,668
12329.17	29,722
12141.33	27,506
11917.10	28,178
11610.72	30,746
11182.79	32,487
10592.60	28,953
10118.27	27,971
9624.29	33,051
9149.64	36,602
8654.43	38,369
8227.06	37,484
7805.03	32,561
7385.40	35,905
6964.05	39,136
6467.25	40,667
6090.97	40,031
5785.22	38,195
5546.66	35,338
5283.29	38,129
5034.86	38,370
4695.55	36,889
4462.68	37,192
4219.43	37,364
3967.44	37,457
3674.39	37,954
3379.10	39,028
3030.67	38,829
2816.21	39,071
2587.35	40,381
2350.58	41,551
2118.63	42,407
1888.92	40,887
1668.12	40,222
1490.38	39,845
1255.37	40,042
1071.27	42,156
800.36	44,048
623.07	44,738
432.97	41,308
239.99	42,193
20.29	43,358

NOTES:

Station totals are cumulative sum of sediment going out of control volume at each cross-section

*Location of proposed impoundment structure


02Jun2015 00:00:00
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 00:00:00-Ch Invert El (ft)
Ch Invert El (ft)
4400
4350
4300
4250
0
5000
10000
15000
Main Channel Distance (ft)


02Jun2015 23:04:27
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 23:04:27-Ch Invert El (ft)
4400
4350
4300
4250
Ch Invert El (ft)
0
5000
10000
15000
Main Channel Distance (ft)

TIME SERIES AND FLOW CHANGE STATION LOCATION - 2-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0
2:05	0.0	0.0	0.0	0.0
2:10	0.0	0.0	0.0	0.0
2:15	0.0	0.0	0.0	0.0
2:20	0.0	0.0	0.0	0.0
2:25	0.0	0.0	0.0	0.0
2:30	0.0	0.0	0.0	0.0
2:35	0.0	0.0	0.0	0.0
2:40	0.0	0.0	0.0	0.0
2:45	0.0	0.0	0.0	0.0
2:50	0.0	0.0	0.0	0.0
2:55	0.0	0.0	0.0	0.0
3:00	0.0	0.0	0.0	0.0
3:05	0.0	0.0	0.0	0.0
3:10	0.0	0.0	0.0	0.0
3:15	0.0	0.1	0.0	0.0
3:20	0.2	0.7	0.0	0.2
3:25	0.9	2.4	0.0	0.6
3:30	2.4	6.1	0.0	1.8
3:35	5.4	13.3	0.0	4.0
3:40	11.9	27.2	0.1	8.2
3:45	23.5	50.3	0.5	15.9
3:50	42.1	84.1	1.2	28.1
3:55	69.7	128.2	2.3	45.8

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
4:00	109.1	180.8	3.8	70.6
4:05	160.7	237.5	5.3	101.9
4:10	222.4	292.3	6.7	139.7
4:15	291.0	340.5	8.0	182.7
4:20	362.1	378.7	9.0	229.4
4:25	429.9	405.6	9.6	277.6
4:30	488.0	423.1	10.0	326.0
4:35	533.6	433.4	10.3	372.6
4:40	565.5	441.1	10.5	415.9
4:45	583.8	449.7	10.5	453.9
4:50	590.6	461.6	10.5	485.3
4:55	589.0	477.5	10.3	509.5
5:00	583.1	497.8	10.1	525.6
5:05	574.6	522.7	10.0	534.3
5:10	563.0	547.5	9.6	535.5
5:15	548.5	566.6	9.1	529.9
5:20	532.3	579.4	8.8	518.9
5:25	514.2	585.5	8.4	503.4
5:30	493.3	585.7	8.0	484.7
5:35	470.5	583.2	7.7	464.4
5:40	447.1	580.4	7.4	442.9
5:45	424.3	577.4	7.1	420.7
5:50	403.0	573.3	6.9	398.8
5:55	383.5	567.2	6.7	377.3
6:00	365.1	557.8	6.4	356.6
6:05	347.8	545.4	6.1	336.9
6:10	331.5	530.5	5.8	317.7
6:15	314.9	511.7	5.4	299.0
6:20	298.0	488.7	5.0	280.7
6:25	281.2	463.7	4.7	262.7
6:30	263.3	439.3	4.3	245.3
6:35	244.7	415.7	4.0	228.4
6:40	226.4	393.6	3.7	212.0
6:45	208.6	372.5	3.5	195.9
6:50	192.0	351.6	3.2	180.4
6:55	177.4	331.9	3.0	165.6
7:00	163.7	314.4	2.8	151.4
7:05	151.0	297.4	2.6	138.2
7:10	139.3	281.3	2.4	125.6
7:15	128.1	265.5	2.2	114.0
7:20	117.5	249.1	2.1	103.2
7:25	107.8	232.7	1.9	93.5
7:30	98.9	217.4	1.8	84.7
7:35	90.7	202.8	1.7	76.7
7:40	83.2	188.8	1.5	69.6
7:45	76.3	175.5	1.4	63.0
7:50	70.0	162.4	1.3	57.1
7:55	64.2	149.8	1.2	51.7
8:00	58.9	138.1	1.2	46.9
8:05	54.0	127.2	1.1	42.4
8:10	49.5	117.3	1.0	38.4
8:15	45.4	108.2	0.9	34.8
8:20	41.7	99.8	0.9	31.4

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
8:25	38.2	92.1	0.8	28.6
8:30	35.0	84.7	0.7	25.8
8:35	32.1	78.2	0.7	23.4
8:40	29.3	72.1	0.6	21.1
8:45	26.8	66.3	0.6	18.7
8:50	24.4	61.2	0.6	16.7
8:55	22.2	56.2	0.5	14.8
9:00	20.1	51.6	0.5	13.0
9:05	18.2	47.4	0.4	11.4
9:10	16.5	43.5	0.4	9.9
9:15	14.8	39.9	0.4	8.5
9:20	13.3	36.3	0.4	7.4
9:25	11.9	33.2	0.3	6.3
9:30	10.6	30.5	0.3	5.3
9:35	9.3	27.7	0.3	4.5
9:40	8.1	25.3	0.3	3.9
9:45	7.2	23.2	0.2	3.3
9:50	6.3	21.2	0.2	2.8
9:55	5.5	19.4	0.2	2.4
10:00	4.9	17.6	0.2	2.1
10:05	4.3	16.1	0.2	1.6
10:10	3.8	14.7	0.1	1.5
10:15	3.3	13.2	0.1	1.3
10:20	2.9	12.1	0.1	1.1
10:25	2.6	10.8	0.1	0.9
10:30	2.3	9.8	0.1	0.8
10:35	2.0	8.9	0.1	0.5
10:40	1.8	7.8	0.1	0.5
10:45	1.6	7.0	0.1	0.4
10:50	1.4	6.2	0.0	0.3
10:55	1.2	5.5	0.0	0.1
11:00	1.1	4.9	0.0	0.1
11:05	0.9	4.4	0.0	0.0
11:10	0.8	3.9	0.0	0.0
11:15	0.7	3.5	0.0	0.0
11:20	0.6	3.1	0.0	0.0
11:25	0.5	2.7	0.0	0.0
11:30	0.4	2.5	0.0	0.0
11:35	0.3	2.2	0.0	0.0
11:40	0.2	1.9	0.0	0.0
11:45	0.2	1.7	0.0	0.0
11:50	0.2	1.5	0.0	0.0
11:55	0.2	1.3	0.0	0.0
12:00	0.1	1.1	0.0	0.0
12:05	0.1	1.0	0.0	0.0
12:10	0.1	0.8	0.0	0.0
12:15	0.1	0.7	0.0	0.0
12:20	0.1	0.6	0.0	0.0
12:25	0.1	0.5	0.0	0.0
12:30	0.1	0.4	0.0	0.0
12:35	0.0	0.3	0.0	0.0
12:40	0.0	0.3	0.0	0.0
12:45	0.0	0.2	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
12:50	0.0	0.2	0.0	0.0
12:55	0.0	0.2	0.0	0.0
13:00	0.0	0.1	0.0	0.0
13:05	0.0	0.1	0.0	0.0
13:10	0.0	0.1	0.0	0.0
13:15	0.0	0.1	0.0	0.0
13:20	0.0	0.1	0.0	0.0
13:25	0.0	0.0	0.0	0.0
13:30	0.0	0.0	0.0	0.0
13:35	0.0	0.0	0.0	0.0
13:40	0.0	0.0	0.0	0.0
13:45	0.0	0.0	0.0	0.0
13:50	0.0	0.0	0.0	0.0
13:55	0.0	0.0	0.0	0.0
14:00	0.0	0.0	0.0	0.0
14:05	0.0	0.0	0.0	0.0
14:10	0.0	0.0	0.0	0.0
14:15	0.0	0.0	0.0	0.0
14:20	0.0	0.0	0.0	0.0
14:25	0.0	0.0	0.0	0.0
14:30	0.0	0.0	0.0	0.0
14:35	0.0	0.0	0.0	0.0
14:40	0.0	0.0	0.0	0.0
14:45	0.0	0.0	0.0	0.0
14:50	0.0	0.0	0.0	0.0
14:55	0.0	0.0	0.0	0.0
15:00	0.0	0.0	0.0	0.0
15:05	0.0	0.0	0.0	0.0
15:10	0.0	0.0	0.0	0.0
15:15	0.0	0.0	0.0	0.0
15:20	0.0	0.0	0.0	0.0
15:25	0.0	0.0	0.0	0.0
15:30	0.0	0.0	0.0	0.0
15:35	0.0	0.0	0.0	0.0
15:40	0.0	0.0	0.0	0.0
15:45	0.0	0.0	0.0	0.0
15:50	0.0	0.0	0.0	0.0
15:55	0.0	0.0	0.0	0.0
16:00	0.0	0.0	0.0	0.0
16:05	0.0	0.0	0.0	0.0
16:10	0.0	0.0	0.0	0.0
16:15	0.0	0.0	0.0	0.0
16:20	0.0	0.0	0.0	0.0
16:25	0.0	0.0	0.0	0.0
16:30	0.0	0.0	0.0	0.0
16:35	0.0	0.0	0.0	0.0
16:40	0.0	0.0	0.0	0.0
16:45	0.0	0.0	0.0	0.0
16:50	0.0	0.0	0.0	0.0
16:55	0.0	0.0	0.0	0.0
17:00	0.0	0.0	0.0	0.0
17:05	0.0	0.0	0.0	0.0
17:10	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
17:15	0.0	0.0	0.0	0.0
17:20	0.0	0.0	0.0	0.0
17:25	0.0	0.0	0.0	0.0
17:30	0.0	0.0	0.0	0.0
17:35	0.0	0.0	0.0	0.0
17:40	0.0	0.0	0.0	0.0
17:45	0.0	0.0	0.0	0.0
17:50	0.0	0.0	0.0	0.0
17:55	0.0	0.0	0.0	0.0
18:00	0.0	0.0	0.0	0.0
18:05	0.0	0.0	0.0	0.0
18:10	0.0	0.0	0.0	0.0
18:15	0.0	0.0	0.0	0.0
18:20	0.0	0.0	0.0	0.0
18:25	0.0	0.0	0.0	0.0
18:30	0.0	0.0	0.0	0.0
18:35	0.0	0.0	0.0	0.0
18:40	0.0	0.0	0.0	0.0
18:45	0.0	0.0	0.0	0.0
18:50	0.0	0.0	0.0	0.0
18:55	0.0	0.0	0.0	0.0
19:00	0.0	0.0	0.0	0.0
19:05	0.0	0.0	0.0	0.0
19:10	0.0	0.0	0.0	0.0
19:15	0.0	0.0	0.0	0.0
19:20	0.0	0.0	0.0	0.0
19:25	0.0	0.0	0.0	0.0
19:30	0.0	0.0	0.0	0.0
19:35	0.0	0.0	0.0	0.0
19:40	0.0	0.0	0.0	0.0
19:45	0.0	0.0	0.0	0.0
19:50	0.0	0.0	0.0	0.0
19:55	0.0	0.0	0.0	0.0
20:00	0.0	0.0	0.0	0.0
20:05	0.0	0.0	0.0	0.0
20:10	0.0	0.0	0.0	0.0
20:15	0.0	0.0	0.0	0.0
20:20	0.0	0.0	0.0	0.0
20:25	0.0	0.0	0.0	0.0
20:30	0.0	0.0	0.0	0.0
20:35	0.0	0.0	0.0	0.0
20:40	0.0	0.0	0.0	0.0
20:45	0.0	0.0	0.0	0.0
20:50	0.0	0.0	0.0	0.0
20:55	0.0	0.0	0.0	0.0
21:00	0.0	0.0	0.0	0.0
21:05	0.0	0.0	0.0	0.0
21:10	0.0	0.0	0.0	0.0
21:15	0.0	0.0	0.0	0.0
21:20	0.0	0.0	0.0	0.0
21:25	0.0	0.0	0.0	0.0
21:30	0.0	0.0	0.0	0.0
21:35	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
21:40	0.0	0.0	0.0	0.0
21:45	0.0	0.0	0.0	0.0
21:50	0.0	0.0	0.0	0.0
21:55	0.0	0.0	0.0	0.0
22:00	0.0	0.0	0.0	0.0
22:05	0.0	0.0	0.0	0.0
22:10	0.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0

Notes:

*Lateral Inflow

25-YEAR SEDIMENT TRANSPORT ANALSIS

CUMULATIVE SEDIMENT MASS FOR 25-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

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ENGINEER | PLAN | SURVEY | MANAGE

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14692.54	36,199
14379.42	43,601
14066.58	56,008
13772.72	62,669
13457.43	63,314
13130.33	64,041
12856.26	63,652
12556.85*	60,853
12329.17	57,437
12141.33	52,624
11917.10	56,823
11610.72	67,607
11182.79	76,409
10592.60	76,104
10118.27	76,908
9624.29	84,092
9149.64	90,659
8654.43	98,126
8227.06	96,744
7805.03	94,345
7385.40	98,260
6964.05	101,486
6467.25	97,493
6090.97	99,324
5785.22	100,456
5546.66	99,595
5283.29	99,511
5034.86	99,207
4695.55	97,389
4462.68	99,496
4219.43	101,174
3967.44	104,238
3674.39	108,581
3379.10	109,209
3030.67	109,271
2816.21	108,082
2587.35	108,393
2350.58	108,696
2118.63	108,696
1888.92	102,105
1668.12	101,655
1490.38	104,390
1255.37	107,261
1071.27	110,818
800.36	114,796
623.07	116,267
432.97	114,715
239.99	114,958
20.29	115,038

NOTES:

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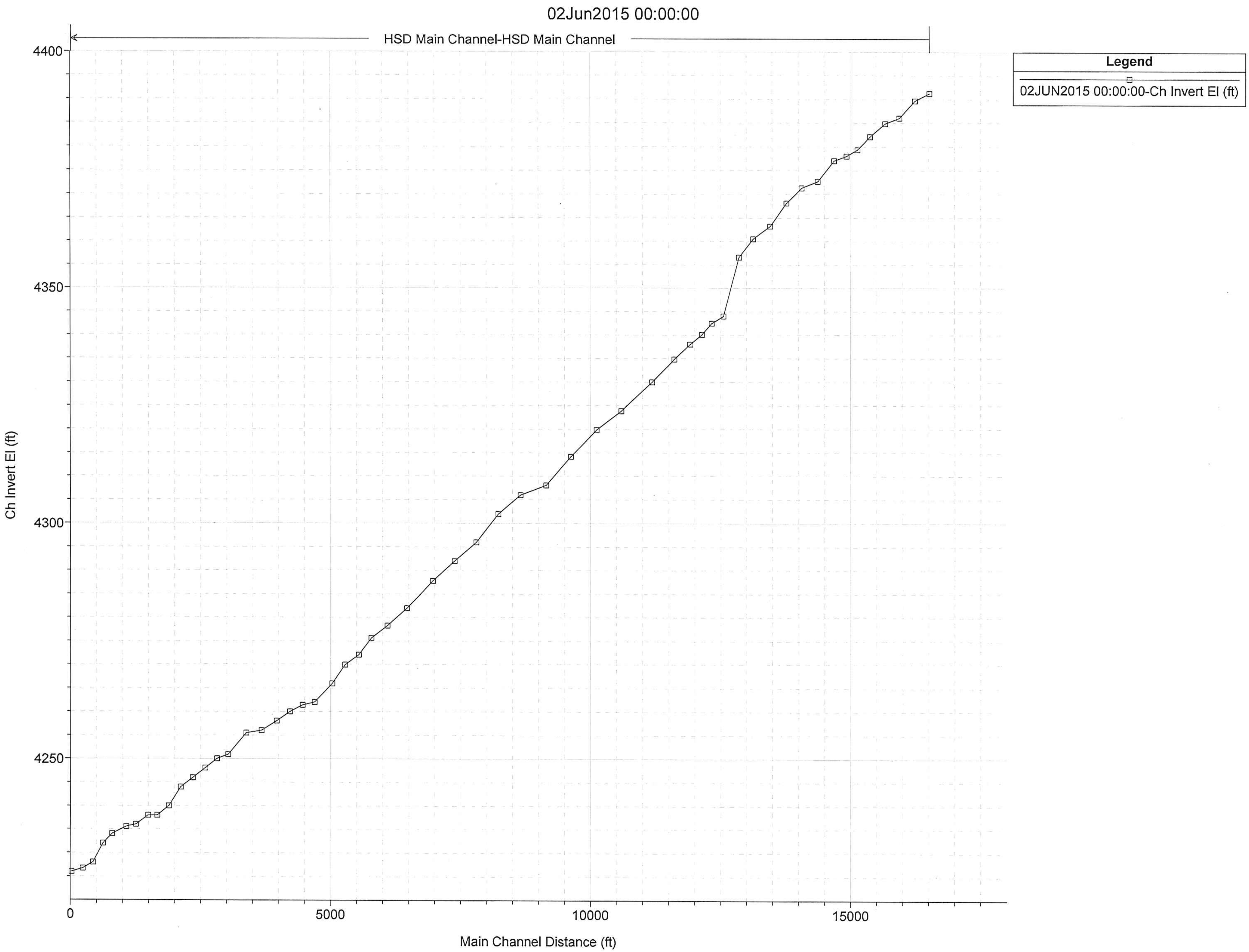
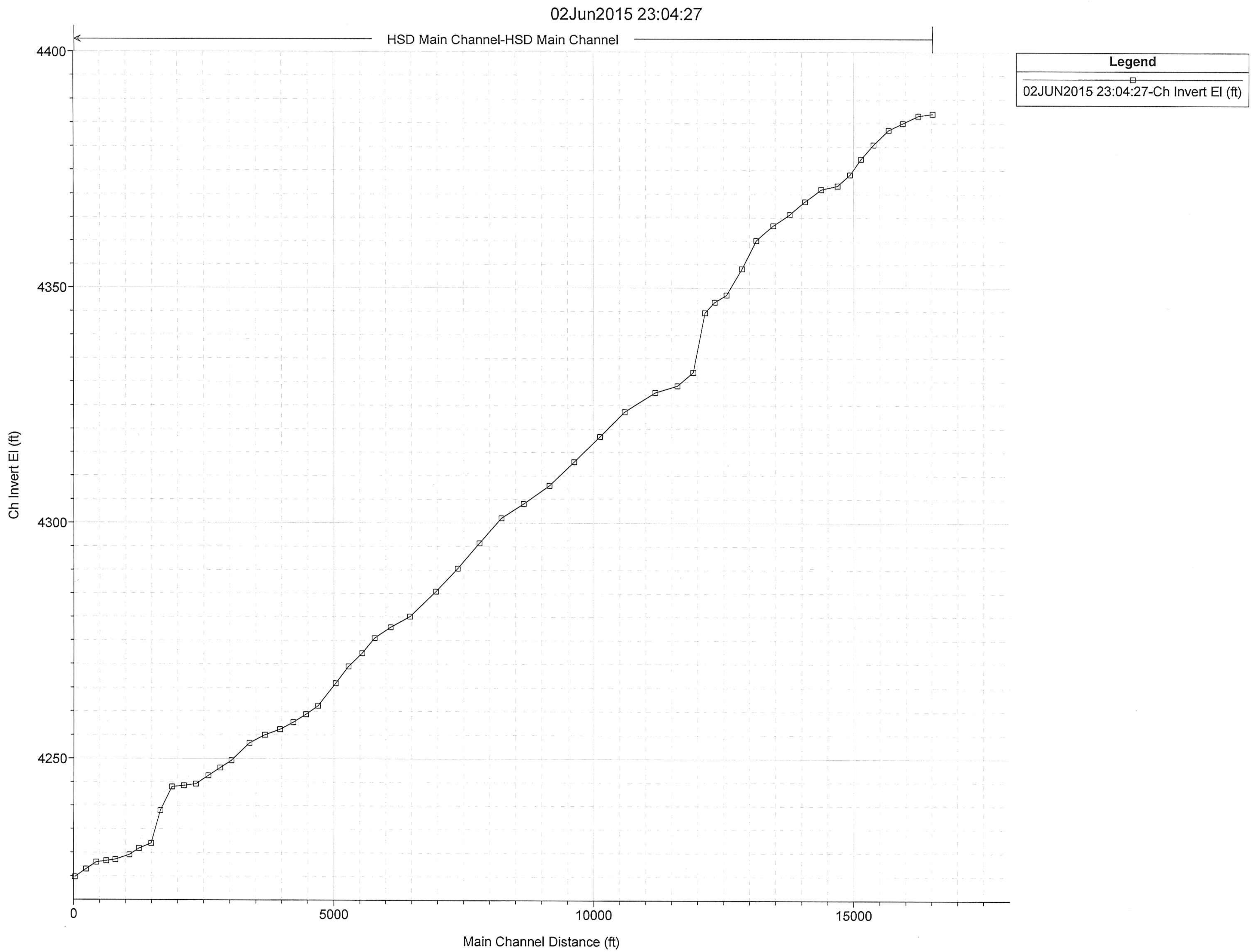
*Location of proposed impoundment structure


02Jun2015 00:00:00
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 00:00:00-Ch Invert El (ft)
Ch Invert El (ft)
4400
4350
4300
4250
Main Channel Distance (ft)
0
5000
10000
15000



02Jun2015 23:04:27
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 23:04:27-Ch Invert El (ft)
Ch Invert El (ft)
4400
4350
4300
4250
Main Channel Distance (ft)
0
5000
10000
15000

TIME SERIES AND FLOW CHANGE STATION LOCATION - 25-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0
2:05	0.0	0.0	0.0	0.0
2:10	0.0	0.0	0.0	0.0
2:15	0.0	0.0	0.0	0.0
2:20	0.1	0.2	0.0	0.0
2:25	0.2	0.5	0.0	0.2
2:30	0.4	1.1	0.0	0.2
2:35	0.9	1.9	0.0	0.6
2:40	1.6	3.3	0.0	1.0
2:45	2.8	5.0	0.0	1.6
2:50	4.4	7.0	0.0	2.3
2:55	6.6	9.5	0.0	3.3
3:00	9.4	12.6	0.0	4.6
3:05	13.2	17.1	0.0	6.3
3:10	18.4	24.5	0.0	9.0
3:15	25.4	35.0	0.1	13.0
3:20	35.1	49.6	0.3	18.8
3:25	49.0	70.4	0.7	27.2
3:30	69.1	98.5	1.4	39.7
3:35	97.6	139.4	2.7	58.4
3:40	137.9	200.6	4.9	87.6
3:45	193.9	286.3	8.1	130.6
3:50	269.1	397.6	12.1	191.5
3:55	368.1	530.5	16.9	272.6

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
4:00	495.9	679.1	22.3	375.8
4:05	650.7	830.6	27.4	498.9
4:10	823.8	967.0	31.2	636.5
4:15	1004.5	1078.3	34.1	783.8
4:20	1182.3	1161.4	36.4	933.8
4:25	1342.8	1218.1	37.6	1080.2
4:30	1469.5	1256.0	38.2	1218.0
4:35	1556.7	1279.5	38.5	1342.0
4:40	1609.1	1296.6	38.2	1447.9
4:45	1634.8	1318.2	37.6	1532.2
4:50	1641.3	1349.9	36.9	1593.3
4:55	1634.1	1393.6	36.0	1631.0
5:00	1619.1	1448.5	35.1	1646.8
5:05	1598.7	1511.0	34.0	1642.1
5:10	1569.6	1570.7	32.4	1618.1
5:15	1530.3	1616.8	30.7	1577.8
5:20	1485.7	1650.1	29.2	1525.0
5:25	1434.4	1678.4	27.9	1463.6
5:30	1374.0	1704.8	26.6	1396.6
5:35	1308.4	1728.4	25.3	1326.3
5:40	1241.0	1745.1	24.1	1254.9
5:45	1176.3	1749.2	23.0	1183.7
5:50	1117.0	1741.9	22.2	1114.4
5:55	1061.0	1725.8	21.3	1048.1
6:00	1006.6	1698.2	20.4	985.5
6:05	955.9	1659.6	19.4	926.0
6:10	908.1	1610.1	18.2	869.0
6:15	860.0	1547.7	16.9	813.7
6:20	811.3	1475.2	15.7	760.3
6:25	762.4	1400.4	14.6	708.9
6:30	712.6	1328.6	13.6	659.2
6:35	661.6	1260.2	12.6	611.2
6:40	611.2	1193.3	11.7	564.9
6:45	563.9	1125.6	10.9	520.2
6:50	521.5	1059.7	10.1	477.7
6:55	483.2	999.4	9.4	437.1
7:00	447.4	945.2	8.7	398.7
7:05	413.9	893.9	8.1	362.9
7:10	382.3	843.0	7.5	329.5
7:15	351.7	792.5	7.0	298.8
7:20	323.0	742.9	6.5	270.6
7:25	296.6	696.2	6.1	245.2
7:30	272.4	652.1	5.6	222.0
7:35	250.1	609.7	5.2	201.1
7:40	229.7	568.8	4.9	182.1
7:45	210.9	528.5	4.5	164.9
7:50	193.7	489.1	4.2	149.3
7:55	177.9	451.7	3.9	135.3
8:00	163.4	416.8	3.6	122.5
8:05	150.0	384.6	3.4	111.0
8:10	137.8	354.9	3.1	100.5
8:15	126.5	327.7	2.9	90.9
8:20	116.1	302.4	2.7	82.3

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
8:25	106.5	279.1	2.5	74.1
8:30	97.7	257.4	2.3	66.7
8:35	89.5	237.4	2.2	60.0
8:40	81.8	219.0	2.0	53.5
8:45	74.7	201.9	1.9	47.4
8:50	68.0	186.0	1.7	41.9
8:55	61.8	171.3	1.6	36.6
9:00	56.0	157.6	1.5	32.0
9:05	50.8	144.7	1.4	27.8
9:10	46.1	132.9	1.3	23.8
9:15	41.5	121.8	1.2	20.5
9:20	37.2	111.6	1.1	17.6
9:25	33.4	102.2	1.0	15.0
9:30	29.7	93.5	1.0	12.7
9:35	26.3	85.8	0.9	10.8
9:40	23.2	78.6	0.8	9.3
9:45	20.6	72.0	0.8	7.8
9:50	18.2	66.1	0.7	6.5
9:55	16.1	60.5	0.6	5.6
10:00	14.4	55.4	0.5	4.7
10:05	12.8	50.5	0.5	4.0
10:10	11.4	46.0	0.4	3.4
10:15	10.3	41.9	0.3	2.8
10:20	9.2	38.0	0.3	2.4
10:25	8.2	34.3	0.3	2.0
10:30	7.4	31.2	0.2	1.6
10:35	6.6	28.2	0.2	1.3
10:40	5.8	25.5	0.2	1.1
10:45	5.2	22.9	0.1	0.6
10:50	4.6	20.6	0.1	0.5
10:55	4.1	18.6	0.1	0.4
11:00	3.5	16.8	0.1	0.4
11:05	3.0	15.1	0.1	0.2
11:10	2.6	13.5	0.1	0.2
11:15	2.2	12.1	0.1	0.0
11:20	1.8	10.7	0.0	0.0
11:25	1.5	9.4	0.0	0.0
11:30	1.2	8.4	0.0	0.0
11:35	1.0	7.3	0.0	0.0
11:40	0.8	6.4	0.0	0.0
11:45	0.7	5.5	0.0	0.0
11:50	0.6	4.7	0.0	0.0
11:55	0.5	4.1	0.0	0.0
12:00	0.4	3.5	0.0	0.0
12:05	0.4	3.0	0.0	0.0
12:10	0.3	2.5	0.0	0.0
12:15	0.3	2.1	0.0	0.0
12:20	0.2	1.8	0.0	0.0
12:25	0.2	1.5	0.0	0.0
12:30	0.2	1.3	0.0	0.0
12:35	0.1	1.1	0.0	0.0
12:40	0.1	0.9	0.0	0.0
12:45	0.1	0.7	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
12:50	0.1	0.6	0.0	0.0
12:55	0.0	0.5	0.0	0.0
13:00	0.0	0.4	0.0	0.0
13:05	0.0	0.4	0.0	0.0
13:10	0.0	0.3	0.0	0.0
13:15	0.0	0.2	0.0	0.0
13:20	0.0	0.2	0.0	0.0
13:25	0.0	0.1	0.0	0.0
13:30	0.0	0.1	0.0	0.0
13:35	0.0	0.1	0.0	0.0
13:40	0.0	0.0	0.0	0.0
13:45	0.0	0.0	0.0	0.0
13:50	0.0	0.0	0.0	0.0
13:55	0.0	0.0	0.0	0.0
14:00	0.0	0.0	0.0	0.0
14:05	0.0	0.0	0.0	0.0
14:10	0.0	0.0	0.0	0.0
14:15	0.0	0.0	0.0	0.0
14:20	0.0	0.0	0.0	0.0
14:25	0.0	0.0	0.0	0.0
14:30	0.0	0.0	0.0	0.0
14:35	0.0	0.0	0.0	0.0
14:40	0.0	0.0	0.0	0.0
14:45	0.0	0.0	0.0	0.0
14:50	0.0	0.0	0.0	0.0
14:55	0.0	0.0	0.0	0.0
15:00	0.0	0.0	0.0	0.0
15:05	0.0	0.0	0.0	0.0
15:10	0.0	0.0	0.0	0.0
15:15	0.0	0.0	0.0	0.0
15:20	0.0	0.0	0.0	0.0
15:25	0.0	0.0	0.0	0.0
15:30	0.0	0.0	0.0	0.0
15:35	0.0	0.0	0.0	0.0
15:40	0.0	0.0	0.0	0.0
15:45	0.0	0.0	0.0	0.0
15:50	0.0	0.0	0.0	0.0
15:55	0.0	0.0	0.0	0.0
16:00	0.0	0.0	0.0	0.0
16:05	0.0	0.0	0.0	0.0
16:10	0.0	0.0	0.0	0.0
16:15	0.0	0.0	0.0	0.0
16:20	0.0	0.0	0.0	0.0
16:25	0.0	0.0	0.0	0.0
16:30	0.0	0.0	0.0	0.0
16:35	0.0	0.0	0.0	0.0
16:40	0.0	0.0	0.0	0.0
16:45	0.0	0.0	0.0	0.0
16:50	0.0	0.0	0.0	0.0
16:55	0.0	0.0	0.0	0.0
17:00	0.0	0.0	0.0	0.0
17:05	0.0	0.0	0.0	0.0
17:10	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
17:15	0.0	0.0	0.0	0.0
17:20	0.0	0.0	0.0	0.0
17:25	0.0	0.0	0.0	0.0
17:30	0.0	0.0	0.0	0.0
17:35	0.0	0.0	0.0	0.0
17:40	0.0	0.0	0.0	0.0
17:45	0.0	0.0	0.0	0.0
17:50	0.0	0.0	0.0	0.0
17:55	0.0	0.0	0.0	0.0
18:00	0.0	0.0	0.0	0.0
18:05	0.0	0.0	0.0	0.0
18:10	0.0	0.0	0.0	0.0
18:15	0.0	0.0	0.0	0.0
18:20	0.0	0.0	0.0	0.0
18:25	0.0	0.0	0.0	0.0
18:30	0.0	0.0	0.0	0.0
18:35	0.0	0.0	0.0	0.0
18:40	0.0	0.0	0.0	0.0
18:45	0.0	0.0	0.0	0.0
18:50	0.0	0.0	0.0	0.0
18:55	0.0	0.0	0.0	0.0
19:00	0.0	0.0	0.0	0.0
19:05	0.0	0.0	0.0	0.0
19:10	0.0	0.0	0.0	0.0
19:15	0.0	0.0	0.0	0.0
19:20	0.0	0.0	0.0	0.0
19:25	0.0	0.0	0.0	0.0
19:30	0.0	0.0	0.0	0.0
19:35	0.0	0.0	0.0	0.0
19:40	0.0	0.0	0.0	0.0
19:45	0.0	0.0	0.0	0.0
19:50	0.0	0.0	0.0	0.0
19:55	0.0	0.0	0.0	0.0
20:00	0.0	0.0	0.0	0.0
20:05	0.0	0.0	0.0	0.0
20:10	0.0	0.0	0.0	0.0
20:15	0.0	0.0	0.0	0.0
20:20	0.0	0.0	0.0	0.0
20:25	0.0	0.0	0.0	0.0
20:30	0.0	0.0	0.0	0.0
20:35	0.0	0.0	0.0	0.0
20:40	0.0	0.0	0.0	0.0
20:45	0.0	0.0	0.0	0.0
20:50	0.0	0.0	0.0	0.0
20:55	0.0	0.0	0.0	0.0
21:00	0.0	0.0	0.0	0.0
21:05	0.0	0.0	0.0	0.0
21:10	0.0	0.0	0.0	0.0
21:15	0.0	0.0	0.0	0.0
21:20	0.0	0.0	0.0	0.0
21:25	0.0	0.0	0.0	0.0
21:30	0.0	0.0	0.0	0.0
21:35	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
21:40	0.0	0.0	0.0	0.0
21:45	0.0	0.0	0.0	0.0
21:50	0.0	0.0	0.0	0.0
21:55	0.0	0.0	0.0	0.0
22:00	0.0	0.0	0.0	0.0
22:05	0.0	0.0	0.0	0.0
22:10	0.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0

Notes:

*Lateral Inflow

50-YEAR SEDIMENT TRANSPORT ANALSIS

CUMULATIVE SEDIMENT MASS FOR 50-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

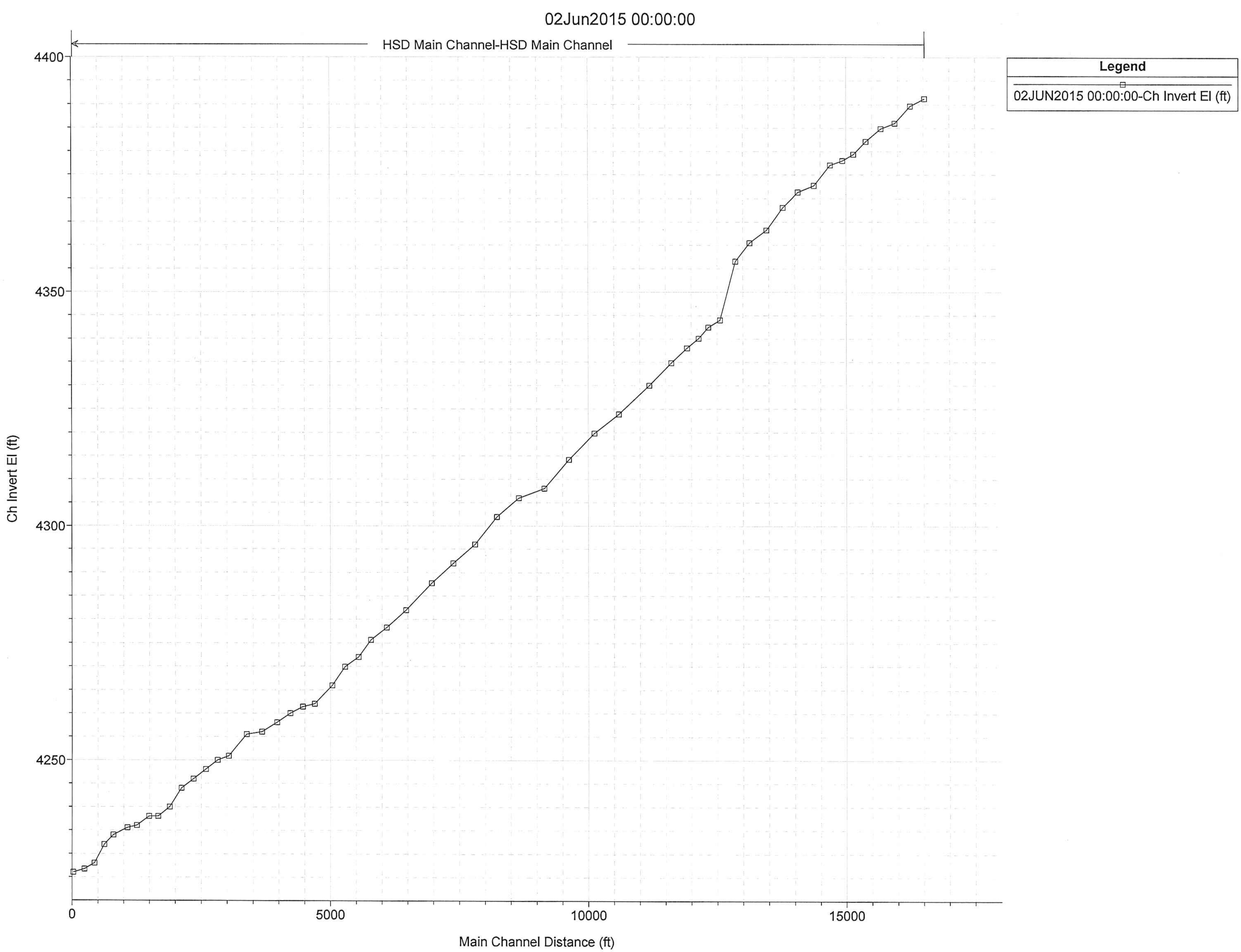
HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

River Station	Cumulative Sediment Mass [TONS]
16520.00	4,170
16246.06	13,047
15946.84	16,605
15673.03	23,862
15381.93	26,086
15141.09	28,060
14931.77	37,223
14692.54	43,103
14379.42	52,824
14066.58	67,594
13772.72	74,616
13457.43	75,562
13130.33	77,383
12856.26	72,905
12556.85*	67,888
12329.17	63,256
12141.33	59,292
11917.10	63,315
11610.72	71,670
11182.79	72,519
10592.60	71,876
10118.27	73,503
9624.29	80,805
9149.64	94,655
8654.43	107,191
8227.06	108,507
7805.03	112,535
7385.40	111,405
6964.05	114,099
6467.25	116,572
6090.97	112,754
5785.22	107,438
5546.66	103,131
5283.29	116,758
5034.86	116,497
4695.55	110,393
4462.68	111,754
4219.43	116,362
3967.44	123,849
3674.39	130,819
3379.10	130,241
3030.67	129,813
2816.21	130,077
2587.35	135,873
2350.58	136,642
2118.63	136,461
1888.92	127,732
1668.12	127,763
1490.38	129,428
1255.37	131,553
1071.27	133,992
800.36	136,865
623.07	137,751
432.97	129,587
239.99	129,456
20.29	129,804

NOTES:

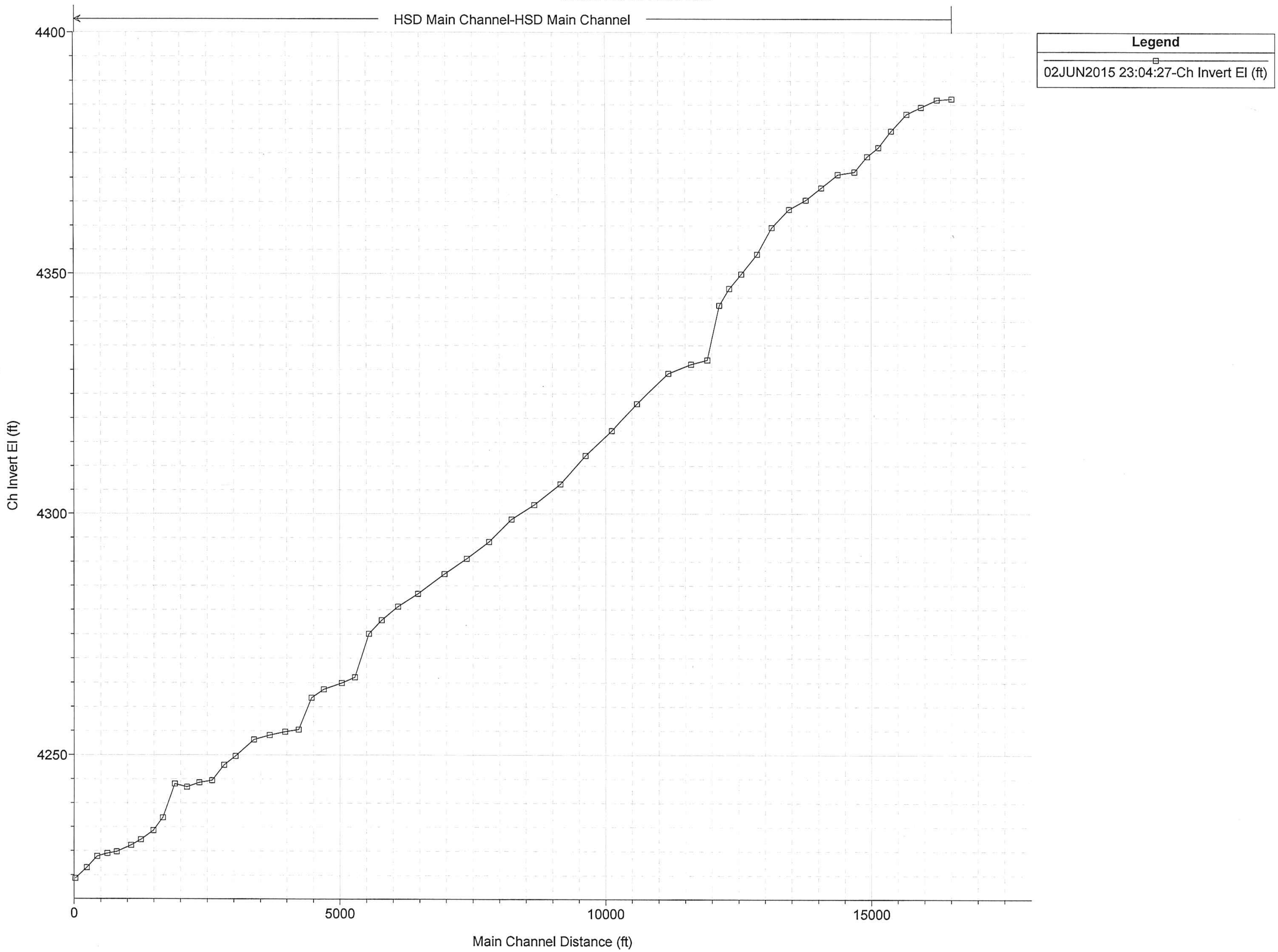
Station totals are cumulative sum of sediment going out of control volume at each cross-section

*Location of proposed impoundment structure



02Jun2015 00:00:00
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 00:00:00-Ch Invert El (ft)
Ch Invert El (ft)
4400
4350
4300
4250
Main Channel Distance (ft)
0
5000
10000
15000

02Jun2015 23:04:27



TIME SERIES AND FLOW CHANGE STATION LOCATION - 50-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0
2:05	0.1	0.2	0.0	0.0
2:10	0.2	0.6	0.0	0.2
2:15	0.5	1.3	0.0	0.4
2:20	1.0	2.4	0.0	0.7
2:25	1.9	3.9	0.0	1.2
2:30	3.2	5.6	0.0	1.8
2:35	5.0	7.7	0.0	2.6
2:40	7.3	10.1	0.0	3.6
2:45	10.2	12.9	0.0	4.7
2:50	13.7	16.4	0.0	6.2
2:55	17.8	20.7	0.0	8.2
3:00	22.6	26.1	0.0	10.7
3:05	28.7	33.4	0.1	14.0
3:10	36.7	43.7	0.2	18.3
3:15	47.2	57.7	0.4	24.5
3:20	61.2	77.6	0.9	33.3
3:25	80.6	106.5	1.7	46.4
3:30	107.3	145.9	2.8	65.2
3:35	144.3	201.1	4.7	92.8
3:40	196.9	281.4	7.8	134.3
3:45	270.3	391.2	12.1	193.7
3:50	367.0	529.2	17.2	275.0
3:55	491.2	689.6	23.1	380.3

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
4:00	649.0	865.7	29.7	511.5
4:05	838.0	1045.1	36.0	666.3
4:10	1046.3	1207.3	40.6	837.8
4:15	1259.9	1340.1	44.2	1020.1
4:20	1467.9	1438.9	46.9	1205.3
4:25	1655.9	1506.8	48.4	1384.5
4:30	1805.2	1552.0	48.9	1551.3
4:35	1908.7	1580.0	49.0	1699.9
4:40	1971.8	1600.7	48.5	1825.0
4:45	2003.6	1625.9	47.5	1922.5
4:50	2010.8	1663.3	46.4	1990.5
4:55	2000.1	1713.4	45.2	2029.7
5:00	1980.1	1776.0	44.0	2041.9
5:05	1953.9	1850.3	42.6	2030.1
5:10	1917.0	1925.7	40.8	1996.0
5:15	1868.9	1990.4	38.8	1943.2
5:20	1815.3	2040.1	36.8	1875.7
5:25	1754.7	2080.3	34.9	1797.6
5:30	1683.2	2115.7	33.3	1712.8
5:35	1604.8	2146.2	31.7	1624.7
5:40	1523.3	2169.9	30.1	1535.6
5:45	1442.1	2178.2	28.9	1447.6
5:50	1365.2	2167.8	27.6	1361.5
5:55	1294.0	2143.8	26.3	1279.0
6:00	1228.1	2106.8	25.3	1201.1
6:05	1166.8	2058.3	24.2	1127.5
6:10	1107.1	1998.1	22.6	1057.0
6:15	1047.0	1922.9	21.1	989.4
6:20	988.0	1834.6	19.6	923.9
6:25	928.9	1741.2	18.2	860.7
6:30	868.9	1649.9	16.9	799.9
6:35	807.6	1563.2	15.7	741.4
6:40	746.2	1480.4	14.6	685.2
6:45	689.3	1398.6	13.6	631.3
6:50	637.7	1318.8	12.6	579.4
6:55	589.5	1242.6	11.7	530.2
7:00	545.8	1170.6	10.9	483.8
7:05	506.2	1105.4	10.1	440.5
7:10	468.0	1043.9	9.4	399.9
7:15	430.7	982.7	8.7	362.8
7:20	395.6	922.1	8.1	328.5
7:25	363.3	862.8	7.5	297.6
7:30	333.7	806.7	7.0	269.3
7:35	306.5	755.1	6.5	244.0
7:40	281.5	705.8	6.1	220.9
7:45	258.6	656.5	5.6	200.1
7:50	237.5	607.8	5.2	181.3
7:55	218.2	561.3	4.9	164.3
8:00	200.4	518.1	4.5	148.7
8:05	184.1	478.3	4.2	134.6
8:10	169.0	441.4	3.9	121.9
8:15	155.2	407.4	3.6	110.1
8:20	142.5	376.0	3.4	99.6

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
8:25	130.7	347.0	3.1	89.9
8:30	119.9	320.2	2.9	80.8
8:35	109.8	295.6	2.7	72.3
8:40	100.4	272.5	2.5	64.6
8:45	91.6	251.3	2.3	57.1
8:50	83.5	231.6	2.2	50.4
8:55	76.0	213.3	2.0	44.0
9:00	68.9	196.2	1.9	38.4
9:05	62.4	180.3	1.7	33.3
9:10	56.6	165.5	1.6	28.6
9:15	50.9	151.8	1.5	24.7
9:20	45.8	139.0	1.4	20.9
9:25	41.0	127.3	1.3	17.9
9:30	36.6	116.9	1.2	15.3
9:35	32.4	107.0	1.1	12.9
9:40	28.6	98.0	1.0	11.0
9:45	25.5	89.9	0.9	9.4
9:50	22.6	82.5	0.8	7.9
9:55	20.0	75.6	0.8	6.7
10:00	17.8	69.2	0.7	5.6
10:05	16.0	63.2	0.6	4.7
10:10	14.3	57.7	0.5	4.0
10:15	12.8	52.4	0.4	3.4
10:20	11.5	47.7	0.4	2.8
10:25	10.4	43.1	0.3	2.4
10:30	9.3	39.1	0.3	2.0
10:35	8.3	35.4	0.2	1.5
10:40	7.3	31.9	0.2	1.3
10:45	6.6	29.0	0.2	0.9
10:50	5.8	26.0	0.1	0.6
10:55	5.1	23.5	0.1	0.5
11:00	4.4	21.2	0.1	0.4
11:05	3.7	19.0	0.1	0.3
11:10	3.2	17.2	0.1	0.2
11:15	2.7	15.3	0.1	0.0
11:20	2.2	13.6	0.1	0.0
11:25	1.9	11.8	0.0	0.0
11:30	1.6	10.5	0.0	0.0
11:35	1.3	9.2	0.0	0.0
11:40	1.0	8.0	0.0	0.0
11:45	0.9	6.9	0.0	0.0
11:50	0.8	5.9	0.0	0.0
11:55	0.6	5.1	0.0	0.0
12:00	0.6	4.4	0.0	0.0
12:05	0.5	3.7	0.0	0.0
12:10	0.4	3.2	0.0	0.0
12:15	0.3	2.7	0.0	0.0
12:20	0.3	2.2	0.0	0.0
12:25	0.3	1.9	0.0	0.0
12:30	0.2	1.6	0.0	0.0
12:35	0.2	1.3	0.0	0.0
12:40	0.1	1.1	0.0	0.0
12:45	0.1	0.9	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
12:50	0.1	0.7	0.0	0.0
12:55	0.1	0.6	0.0	0.0
13:00	0.0	0.5	0.0	0.0
13:05	0.0	0.4	0.0	0.0
13:10	0.0	0.4	0.0	0.0
13:15	0.0	0.3	0.0	0.0
13:20	0.0	0.2	0.0	0.0
13:25	0.0	0.2	0.0	0.0
13:30	0.0	0.1	0.0	0.0
13:35	0.0	0.1	0.0	0.0
13:40	0.0	0.0	0.0	0.0
13:45	0.0	0.0	0.0	0.0
13:50	0.0	0.0	0.0	0.0
13:55	0.0	0.0	0.0	0.0
14:00	0.0	0.0	0.0	0.0
14:05	0.0	0.0	0.0	0.0
14:10	0.0	0.0	0.0	0.0
14:15	0.0	0.0	0.0	0.0
14:20	0.0	0.0	0.0	0.0
14:25	0.0	0.0	0.0	0.0
14:30	0.0	0.0	0.0	0.0
14:35	0.0	0.0	0.0	0.0
14:40	0.0	0.0	0.0	0.0
14:45	0.0	0.0	0.0	0.0
14:50	0.0	0.0	0.0	0.0
14:55	0.0	0.0	0.0	0.0
15:00	0.0	0.0	0.0	0.0
15:05	0.0	0.0	0.0	0.0
15:10	0.0	0.0	0.0	0.0
15:15	0.0	0.0	0.0	0.0
15:20	0.0	0.0	0.0	0.0
15:25	0.0	0.0	0.0	0.0
15:30	0.0	0.0	0.0	0.0
15:35	0.0	0.0	0.0	0.0
15:40	0.0	0.0	0.0	0.0
15:45	0.0	0.0	0.0	0.0
15:50	0.0	0.0	0.0	0.0
15:55	0.0	0.0	0.0	0.0
16:00	0.0	0.0	0.0	0.0
16:05	0.0	0.0	0.0	0.0
16:10	0.0	0.0	0.0	0.0
16:15	0.0	0.0	0.0	0.0
16:20	0.0	0.0	0.0	0.0
16:25	0.0	0.0	0.0	0.0
16:30	0.0	0.0	0.0	0.0
16:35	0.0	0.0	0.0	0.0
16:40	0.0	0.0	0.0	0.0
16:45	0.0	0.0	0.0	0.0
16:50	0.0	0.0	0.0	0.0
16:55	0.0	0.0	0.0	0.0
17:00	0.0	0.0	0.0	0.0
17:05	0.0	0.0	0.0	0.0
17:10	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
17:15	0.0	0.0	0.0	0.0
17:20	0.0	0.0	0.0	0.0
17:25	0.0	0.0	0.0	0.0
17:30	0.0	0.0	0.0	0.0
17:35	0.0	0.0	0.0	0.0
17:40	0.0	0.0	0.0	0.0
17:45	0.0	0.0	0.0	0.0
17:50	0.0	0.0	0.0	0.0
17:55	0.0	0.0	0.0	0.0
18:00	0.0	0.0	0.0	0.0
18:05	0.0	0.0	0.0	0.0
18:10	0.0	0.0	0.0	0.0
18:15	0.0	0.0	0.0	0.0
18:20	0.0	0.0	0.0	0.0
18:25	0.0	0.0	0.0	0.0
18:30	0.0	0.0	0.0	0.0
18:35	0.0	0.0	0.0	0.0
18:40	0.0	0.0	0.0	0.0
18:45	0.0	0.0	0.0	0.0
18:50	0.0	0.0	0.0	0.0
18:55	0.0	0.0	0.0	0.0
19:00	0.0	0.0	0.0	0.0
19:05	0.0	0.0	0.0	0.0
19:10	0.0	0.0	0.0	0.0
19:15	0.0	0.0	0.0	0.0
19:20	0.0	0.0	0.0	0.0
19:25	0.0	0.0	0.0	0.0
19:30	0.0	0.0	0.0	0.0
19:35	0.0	0.0	0.0	0.0
19:40	0.0	0.0	0.0	0.0
19:45	0.0	0.0	0.0	0.0
19:50	0.0	0.0	0.0	0.0
19:55	0.0	0.0	0.0	0.0
20:00	0.0	0.0	0.0	0.0
20:05	0.0	0.0	0.0	0.0
20:10	0.0	0.0	0.0	0.0
20:15	0.0	0.0	0.0	0.0
20:20	0.0	0.0	0.0	0.0
20:25	0.0	0.0	0.0	0.0
20:30	0.0	0.0	0.0	0.0
20:35	0.0	0.0	0.0	0.0
20:40	0.0	0.0	0.0	0.0
20:45	0.0	0.0	0.0	0.0
20:50	0.0	0.0	0.0	0.0
20:55	0.0	0.0	0.0	0.0
21:00	0.0	0.0	0.0	0.0
21:05	0.0	0.0	0.0	0.0
21:10	0.0	0.0	0.0	0.0
21:15	0.0	0.0	0.0	0.0
21:20	0.0	0.0	0.0	0.0
21:25	0.0	0.0	0.0	0.0
21:30	0.0	0.0	0.0	0.0
21:35	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
21:40	0.0	0.0	0.0	0.0
21:45	0.0	0.0	0.0	0.0
21:50	0.0	0.0	0.0	0.0
21:55	0.0	0.0	0.0	0.0
22:00	0.0	0.0	0.0	0.0
22:05	0.0	0.0	0.0	0.0
22:10	0.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0

Notes:

*Lateral Inflow

100-YEAR SEDIMENT TRANSPORT ANALSIS

CUMULATIVE SEDIMENT MASS FOR 100-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

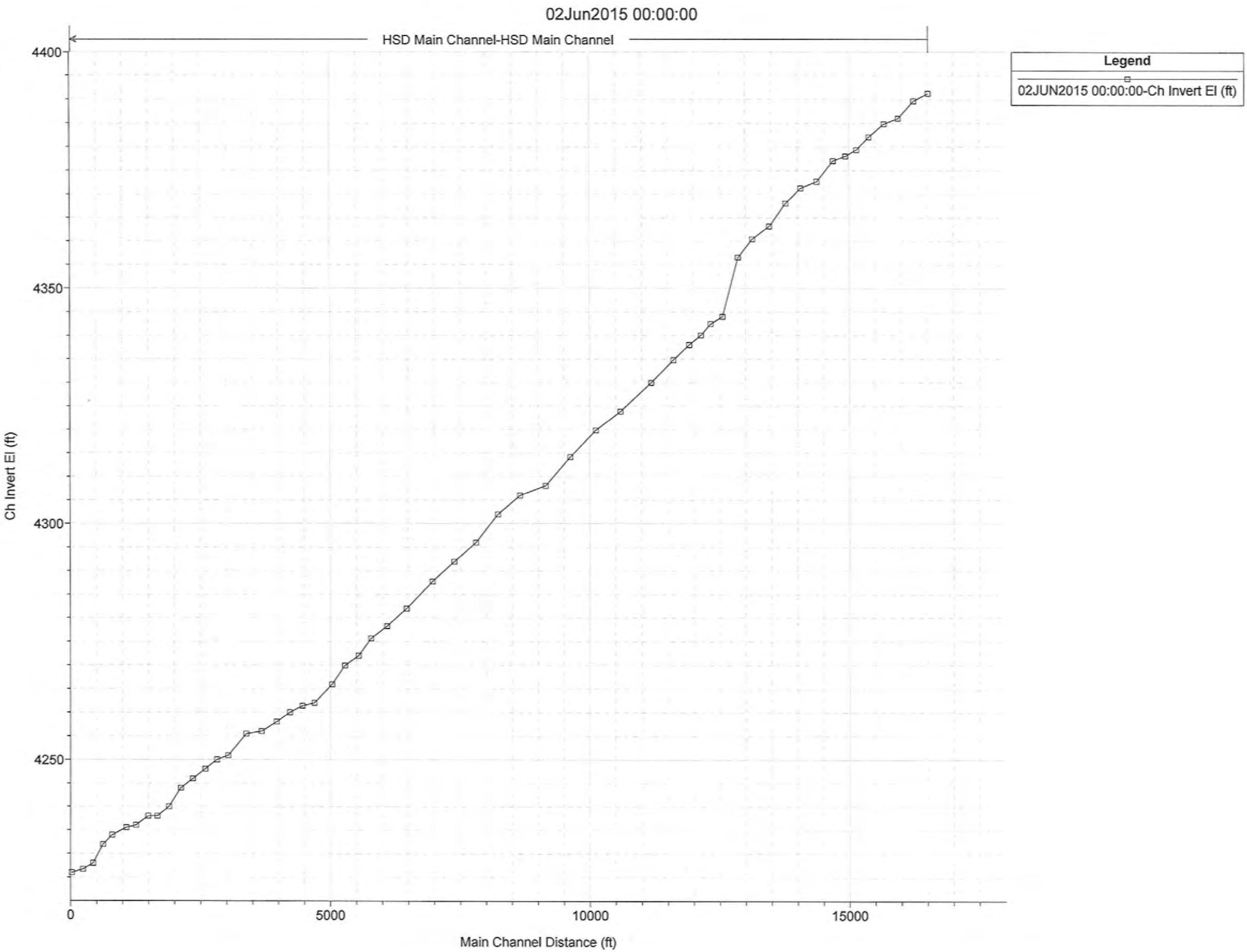
HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

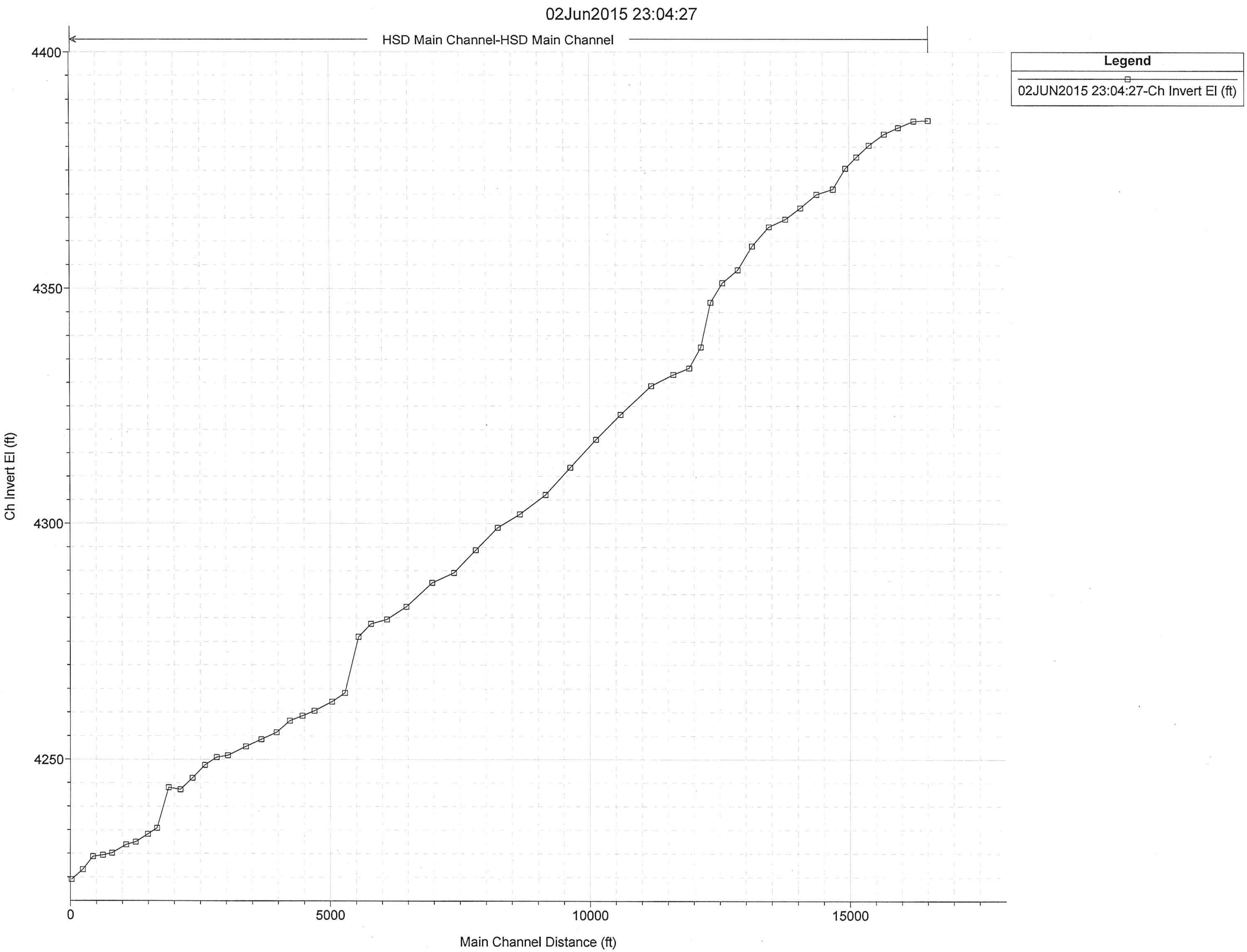
River Station	Cumulative Sediment Mass [TONS]
16520.00	4,763
16246.06	15,292
15946.84	20,074
15673.03	29,069
15381.93	29,674
15141.09	27,847
14931.77	32,193
14692.54	37,961
14379.42	51,089
14066.58	70,074
13772.72	82,399
13457.43	87,057
13130.33	91,578
12856.26	86,908
12556.85*	80,326
12329.17	74,700
12141.33	76,006
11917.10	78,970
11610.72	85,729
11182.79	86,463
10592.60	85,613
10118.27	86,710
9624.29	94,584
9149.64	111,484
8654.43	126,154
8227.06	128,495
7805.03	131,559
7385.40	138,259
6964.05	140,258
6467.25	136,028
6090.97	132,592
5785.22	125,943
5546.66	120,400
5283.29	120,776
5034.86	125,503
4695.55	123,678
4462.68	127,190
4219.43	132,668
3967.44	141,072
3674.39	149,220
3379.10	148,372
3030.67	147,661
2816.21	146,764
2587.35	145,883
2350.58	155,560
2118.63	155,409
1888.92	144,754
1668.12	145,392
1490.38	147,139
1255.37	149,102
1071.27	151,144
800.36	153,709
623.07	154,487
432.97	144,746
239.99	144,577
20.29	144,882

NOTES:

Station totals are cumulative sum of sediment going out of control volume at each cross-section

*Location of proposed impoundment structure


02Jun2015 00:00:00
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 00:00:00-Ch Invert El (ft)
Ch Invert El (ft)
4400
4350
4300
4250
0
5000
10000
15000
Main Channel Distance (ft)


02Jun2015 23:04:27
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 23:04:27-Ch Invert El (ft)
Ch Invert El (ft)
4400
4350
4300
4250
0
5000
10000
15000
Main Channel Distance (ft)

TIME SERIES AND FLOW CHANGE STATION LOCATION - 100-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0
1:50	0.0	0.1	0.0	0.0
1:55	0.1	0.2	0.0	0.0
2:00	0.3	0.8	0.0	0.2
2:05	0.7	1.8	0.0	0.6
2:10	1.4	3.3	0.0	1.0
2:15	2.6	5.2	0.0	1.6
2:20	4.3	7.5	0.0	2.5
2:25	6.7	10.1	0.0	3.5
2:30	9.7	13.1	0.0	4.6
2:35	13.4	16.5	0.0	6.2
2:40	17.6	20.6	0.0	8.1
2:45	22.4	25.2	0.0	10.2
2:50	27.8	30.2	0.0	12.7
2:55	34.0	36.0	0.1	15.9
3:00	41.3	43.0	0.1	19.6
3:05	50.1	52.9	0.3	24.5
3:10	60.7	67.4	0.6	31.5
3:15	74.2	87.1	1.1	40.9
3:20	92.3	114.9	1.8	54.4
3:25	117.5	153.1	3.0	73.4
3:30	152.1	203.1	4.6	99.6
3:35	199.6	272.2	7.1	137.2
3:40	266.4	371.5	11.2	191.9
3:45	357.3	506.1	16.7	268.7
3:50	475.0	673.5	23.0	371.6
3:55	625.5	866.2	30.3	504.1

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
4:00	816.0	1076.2	38.5	667.3
4:05	1042.5	1288.3	45.9	857.8
4:10	1289.6	1477.6	51.3	1067.3
4:15	1541.6	1629.8	55.4	1287.9
4:20	1785.9	1742.7	58.5	1510.2
4:25	2004.7	1820.8	60.1	1723.9
4:30	2176.3	1873.0	60.6	1921.2
4:35	2293.1	1904.5	60.6	2095.3
4:40	2364.0	1926.4	59.7	2239.8
4:45	2400.6	1956.2	58.4	2350.7
4:50	2409.3	2001.7	57.1	2425.8
4:55	2397.2	2063.1	55.6	2466.5
5:00	2374.1	2140.9	54.1	2475.6
5:05	2343.7	2232.2	52.2	2455.6
5:10	2300.6	2323.8	49.8	2409.2
5:15	2243.0	2401.4	47.2	2340.6
5:20	2177.8	2462.4	44.8	2255.0
5:25	2103.3	2514.3	42.5	2157.6
5:30	2014.9	2562.0	40.4	2052.7
5:35	1918.2	2604.5	38.5	1944.3
5:40	1818.6	2636.1	36.6	1835.3
5:45	1721.2	2646.7	35.1	1728.0
5:50	1630.5	2635.8	33.7	1624.0
5:55	1546.5	2608.9	32.2	1525.0
6:00	1468.2	2565.5	30.9	1431.7
6:05	1396.1	2505.0	29.3	1343.4
6:10	1325.5	2428.4	27.4	1259.1
6:15	1253.6	2332.5	25.5	1177.9
6:20	1181.9	2222.6	23.7	1099.6
6:25	1109.9	2109.6	22.0	1024.3
6:30	1036.5	1999.3	20.5	951.7
6:35	962.1	1894.2	19.0	881.8
6:40	889.5	1792.9	17.7	814.5
6:45	822.0	1692.3	16.4	749.9
6:50	761.2	1594.8	15.3	688.0
6:55	705.0	1503.3	14.2	629.2
7:00	653.0	1418.0	13.2	573.8
7:05	605.3	1338.4	12.3	522.2
7:10	559.3	1262.5	11.4	474.1
7:15	514.7	1188.0	10.6	429.8
7:20	472.8	1114.6	9.8	389.3
7:25	434.3	1044.8	9.1	352.4
7:30	399.0	978.2	8.5	319.1
7:35	366.5	915.4	7.9	289.1
7:40	336.7	854.9	7.3	261.8
7:45	309.3	794.6	6.8	237.1
7:50	284.2	735.4	6.3	214.7
7:55	261.1	679.3	5.9	194.4
8:00	239.8	627.1	5.5	176.1
8:05	220.3	578.9	5.1	159.3
8:10	202.3	534.3	4.7	144.2
8:15	185.8	493.3	4.4	130.3
8:20	170.6	455.3	4.1	117.7

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
8:25	156.5	420.3	3.8	106.2
8:30	143.6	387.9	3.5	95.3
8:35	131.5	357.9	3.3	85.4
8:40	120.2	330.2	3.0	76.1
8:45	109.8	304.4	2.8	67.3
8:50	100.0	280.6	2.6	59.3
8:55	90.9	258.4	2.4	51.8
9:00	82.5	237.6	2.3	45.0
9:05	74.8	218.3	2.1	39.1
9:10	67.8	200.7	2.0	33.5
9:15	61.1	184.1	1.8	28.7
9:20	54.9	168.7	1.7	24.5
9:25	49.2	154.5	1.6	21.0
9:30	43.9	141.7	1.4	17.8
9:35	38.9	130.0	1.3	15.2
9:40	34.4	119.1	1.2	12.8
9:45	30.7	109.2	1.1	10.9
9:50	27.3	100.1	1.0	9.1
9:55	24.2	91.9	0.9	7.7
10:00	21.6	84.1	0.8	6.6
10:05	19.3	76.7	0.7	5.5
10:10	17.3	70.2	0.6	4.7
10:15	15.6	63.9	0.5	4.0
10:20	14.0	58.1	0.4	3.4
10:25	12.6	52.5	0.4	2.8
10:30	11.3	47.7	0.3	2.2
10:35	10.1	43.3	0.3	1.9
10:40	8.9	39.1	0.2	1.4
10:45	8.0	35.3	0.2	1.1
10:50	7.1	32.0	0.2	0.8
10:55	6.2	28.8	0.1	0.5
11:00	5.3	25.9	0.1	0.4
11:05	4.5	23.3	0.1	0.3
11:10	3.9	20.9	0.1	0.2
11:15	3.3	18.7	0.1	0.1
11:20	2.7	16.6	0.1	0.0
11:25	2.3	14.6	0.1	0.0
11:30	1.9	12.8	0.0	0.0
11:35	1.5	11.2	0.0	0.0
11:40	1.3	9.7	0.0	0.0
11:45	1.1	8.4	0.0	0.0
11:50	0.9	7.2	0.0	0.0
11:55	0.8	6.2	0.0	0.0
12:00	0.7	5.3	0.0	0.0
12:05	0.5	4.5	0.0	0.0
12:10	0.5	3.8	0.0	0.0
12:15	0.4	3.2	0.0	0.0
12:20	0.4	2.7	0.0	0.0
12:25	0.3	2.3	0.0	0.0
12:30	0.3	1.9	0.0	0.0
12:35	0.2	1.6	0.0	0.0
12:40	0.2	1.4	0.0	0.0
12:45	0.1	1.1	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
12:50	0.1	0.9	0.0	0.0
12:55	0.1	0.8	0.0	0.0
13:00	0.0	0.7	0.0	0.0
13:05	0.0	0.5	0.0	0.0
13:10	0.0	0.4	0.0	0.0
13:15	0.0	0.3	0.0	0.0
13:20	0.0	0.3	0.0	0.0
13:25	0.0	0.2	0.0	0.0
13:30	0.0	0.1	0.0	0.0
13:35	0.0	0.1	0.0	0.0
13:40	0.0	0.0	0.0	0.0
13:45	0.0	0.0	0.0	0.0
13:50	0.0	0.0	0.0	0.0
13:55	0.0	0.0	0.0	0.0
14:00	0.0	0.0	0.0	0.0
14:05	0.0	0.0	0.0	0.0
14:10	0.0	0.0	0.0	0.0
14:15	0.0	0.0	0.0	0.0
14:20	0.0	0.0	0.0	0.0
14:25	0.0	0.0	0.0	0.0
14:30	0.0	0.0	0.0	0.0
14:35	0.0	0.0	0.0	0.0
14:40	0.0	0.0	0.0	0.0
14:45	0.0	0.0	0.0	0.0
14:50	0.0	0.0	0.0	0.0
14:55	0.0	0.0	0.0	0.0
15:00	0.0	0.0	0.0	0.0
15:05	0.0	0.0	0.0	0.0
15:10	0.0	0.0	0.0	0.0
15:15	0.0	0.0	0.0	0.0
15:20	0.0	0.0	0.0	0.0
15:25	0.0	0.0	0.0	0.0
15:30	0.0	0.0	0.0	0.0
15:35	0.0	0.0	0.0	0.0
15:40	0.0	0.0	0.0	0.0
15:45	0.0	0.0	0.0	0.0
15:50	0.0	0.0	0.0	0.0
15:55	0.0	0.0	0.0	0.0
16:00	0.0	0.0	0.0	0.0
16:05	0.0	0.0	0.0	0.0
16:10	0.0	0.0	0.0	0.0
16:15	0.0	0.0	0.0	0.0
16:20	0.0	0.0	0.0	0.0
16:25	0.0	0.0	0.0	0.0
16:30	0.0	0.0	0.0	0.0
16:35	0.0	0.0	0.0	0.0
16:40	0.0	0.0	0.0	0.0
16:45	0.0	0.0	0.0	0.0
16:50	0.0	0.0	0.0	0.0
16:55	0.0	0.0	0.0	0.0
17:00	0.0	0.0	0.0	0.0
17:05	0.0	0.0	0.0	0.0
17:10	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
17:15	0.0	0.0	0.0	0.0
17:20	0.0	0.0	0.0	0.0
17:25	0.0	0.0	0.0	0.0
17:30	0.0	0.0	0.0	0.0
17:35	0.0	0.0	0.0	0.0
17:40	0.0	0.0	0.0	0.0
17:45	0.0	0.0	0.0	0.0
17:50	0.0	0.0	0.0	0.0
17:55	0.0	0.0	0.0	0.0
18:00	0.0	0.0	0.0	0.0
18:05	0.0	0.0	0.0	0.0
18:10	0.0	0.0	0.0	0.0
18:15	0.0	0.0	0.0	0.0
18:20	0.0	0.0	0.0	0.0
18:25	0.0	0.0	0.0	0.0
18:30	0.0	0.0	0.0	0.0
18:35	0.0	0.0	0.0	0.0
18:40	0.0	0.0	0.0	0.0
18:45	0.0	0.0	0.0	0.0
18:50	0.0	0.0	0.0	0.0
18:55	0.0	0.0	0.0	0.0
19:00	0.0	0.0	0.0	0.0
19:05	0.0	0.0	0.0	0.0
19:10	0.0	0.0	0.0	0.0
19:15	0.0	0.0	0.0	0.0
19:20	0.0	0.0	0.0	0.0
19:25	0.0	0.0	0.0	0.0
19:30	0.0	0.0	0.0	0.0
19:35	0.0	0.0	0.0	0.0
19:40	0.0	0.0	0.0	0.0
19:45	0.0	0.0	0.0	0.0
19:50	0.0	0.0	0.0	0.0
19:55	0.0	0.0	0.0	0.0
20:00	0.0	0.0	0.0	0.0
20:05	0.0	0.0	0.0	0.0
20:10	0.0	0.0	0.0	0.0
20:15	0.0	0.0	0.0	0.0
20:20	0.0	0.0	0.0	0.0
20:25	0.0	0.0	0.0	0.0
20:30	0.0	0.0	0.0	0.0
20:35	0.0	0.0	0.0	0.0
20:40	0.0	0.0	0.0	0.0
20:45	0.0	0.0	0.0	0.0
20:50	0.0	0.0	0.0	0.0
20:55	0.0	0.0	0.0	0.0
21:00	0.0	0.0	0.0	0.0
21:05	0.0	0.0	0.0	0.0
21:10	0.0	0.0	0.0	0.0
21:15	0.0	0.0	0.0	0.0
21:20	0.0	0.0	0.0	0.0
21:25	0.0	0.0	0.0	0.0
21:30	0.0	0.0	0.0	0.0
21:35	0.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]			
	165+20.00	146+92.54*	125+56.85*	44+62.68*
21:40	0.0	0.0	0.0	0.0
21:45	0.0	0.0	0.0	0.0
21:50	0.0	0.0	0.0	0.0
21:55	0.0	0.0	0.0	0.0
22:00	0.0	0.0	0.0	0.0
22:05	0.0	0.0	0.0	0.0
22:10	0.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0

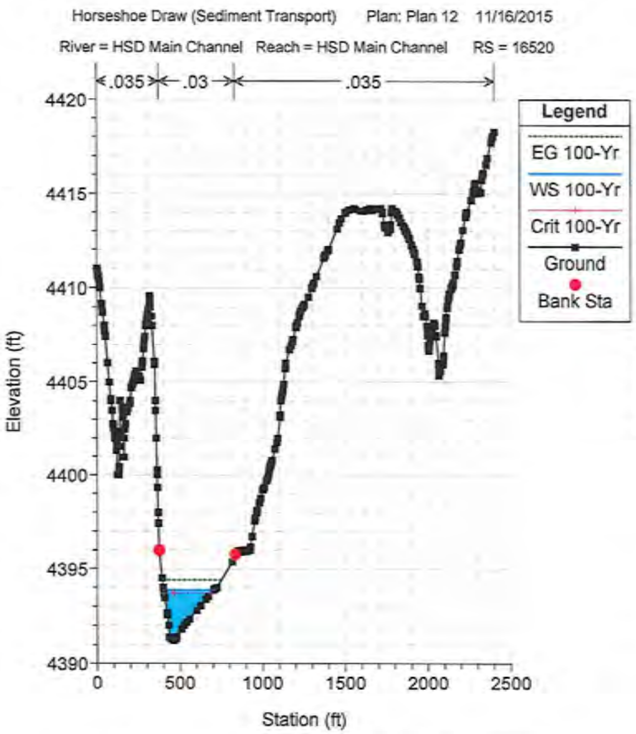
Notes:

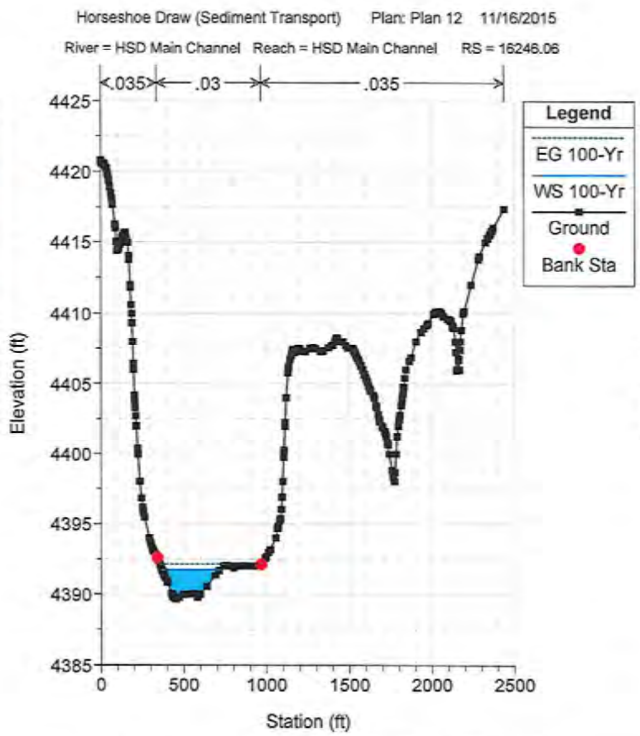
*Lateral Inflow

HEC-RAS STEADY STATE OUTPUT

HEC-RAS Plan: Plan 16 River: HSD Main Channel Reach: HSD Main Channel Profile: 100-Yr

Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
HSD Main Channel	16520	100-Yr	2409.00	2.66	4391.22	4393.88	4394.40	0.008895	5.77	417.42	303.84
HSD Main Channel	16246.06	100-Yr	2409.00	2.10	4389.64	4391.74	4392.15	0.007372	5.15	467.57	350.60
HSD Main Channel	15946.84	100-Yr	2409.00	2.59	4386.00	4388.59	4389.39	0.011513	7.20	334.64	212.07
HSD Main Channel	15673.03	100-Yr	2409.00	1.77	4384.82	4386.59	4386.88	0.005418	4.35	554.24	425.65
HSD Main Channel	15381.93	100-Yr	2409.00	2.05	4382.06	4384.11	4384.51	0.013605	5.06	475.89	579.99
HSD Main Channel	15141.09	100-Yr	2409.00	2.06	4379.34	4381.40	4381.72	0.006604	4.54	530.71	443.00
HSD Main Channel	14931.77	100-Yr	2409.00	2.77	4377.97	4380.75	4380.91	0.002310	3.23	746.26	472.51
HSD Main Channel	14692.54	100-Yr	2409.00	2.09	4377.03	4379.12	4379.79	0.012131	6.55	368.01	279.91
HSD Main Channel	14379.42	100-Yr	2409.00	2.50	4372.65	4375.15	4375.50	0.005587	4.72	510.86	355.33
HSD Main Channel	14066.58	100-Yr	2409.00	1.73	4371.27	4373.01	4373.35	0.008583	4.71	511.14	491.04
HSD Main Channel	13772.72	100-Yr	2409.00	1.69	4368.04	4369.73	4370.16	0.013983	5.24	459.71	543.17
HSD Main Channel	13457.43	100-Yr	2409.00	1.73	4363.18	4364.91	4365.48	0.015387	6.07	396.73	403.76
HSD Main Channel	13130.33	100-Yr	2409.00	1.56	4360.46	4362.02	4362.28	0.006985	4.08	590.96	604.72
HSD Main Channel	12856.26	100-Yr	4820.00	2.31	4356.52	4358.83	4359.42	0.012943	6.16	782.16	683.72
HSD Main Channel	12556.85	100-Yr	4820.00	5.13	4344.00	4349.13	4354.07	0.022336	17.83	270.36	70.36
HSD Main Channel	12329.17	100-Yr	4820.00	6.13	4342.48	4348.61	4350.39	0.009172	10.70	450.48	128.87
HSD Main Channel	12141.33	100-Yr	4820.00	3.65	4340.05	4343.70	4347.46	0.026472	15.57	309.56	114.32
HSD Main Channel	11917.1	100-Yr	4820.00	5.35	4338.00	4343.35	4344.82	0.009215	9.73	495.31	166.48
HSD Main Channel	11610.72	100-Yr	4820.00	4.35	4334.81	4339.16	4341.27	0.014462	11.66	413.50	149.81
HSD Main Channel	11182.79	100-Yr	4820.00	4.52	4330.00	4334.52	4335.12	0.003592	6.21	775.73	253.05
HSD Main Channel	10592.6	100-Yr	4820.00	7.93	4323.90	4331.83	4333.07	0.003172	8.91	540.72	88.06
HSD Main Channel	10118.27	100-Yr	4820.00	7.92	4320.00	4327.78	4330.62	0.008170	13.53	356.34	61.97
HSD Main Channel	9624.29	100-Yr	4820.00	8.94	4317.98	4323.10	4325.58	0.012494	12.63	381.51	109.65
HSD Main Channel	9149.64	100-Yr	4820.00	10.30	4312.29	4318.38	4319.46	0.011539	8.37	576.10	290.23
HSD Main Channel	8654.43	100-Yr	4820.00	5.37	4306.00	4311.37	4312.04	0.005094	6.56	734.82	294.07
HSD Main Channel	8227.06	100-Yr	4820.00	5.83	4301.98	4307.81	4308.92	0.010851	8.48	568.39	267.41
HSD Main Channel	7805.03	100-Yr	4820.00	4.83	4296.00	4300.83	4303.41	0.016101	12.87	374.38	126.66
HSD Main Channel	7385.4	100-Yr	4820.00	6.31	4291.98	4298.29	4299.24	0.011311	7.80	617.77	341.58
HSD Main Channel	6964.05	100-Yr	4820.00	5.91	4287.78	4293.69	4294.62	0.011319	7.74	622.39	348.80
HSD Main Channel	6467.25	100-Yr	4820.00	6.99	4282.00	4288.99	4289.47	0.005296	5.58	863.84	447.40
HSD Main Channel	6090.97	100-Yr	4820.00	7.34	4278.26	4285.60	4286.78	0.009569	8.70	553.97	229.47
HSD Main Channel	5785.22	100-Yr	4820.00	6.74	4275.65	4282.39	4283.86	0.009363	9.72	495.91	170.33
HSD Main Channel	5546.66	100-Yr	4820.00	6.44	4271.99	4278.43	4281.25	0.011552	13.47	357.75	85.93
HSD Main Channel	5283.29	100-Yr	4820.00	7.64	4269.93	4276.91	4277.59	0.009039	6.63	727.03	431.93
HSD Main Channel	5034.86	100-Yr	4820.00	8.26	4267.96	4274.21	4275.17	0.010271	7.86	613.49	311.64
HSD Main Channel	4695.55	100-Yr	4820.00	11.46	4262.00	4273.46	4273.58	0.000721	2.68	1799.45	621.11
HSD Main Channel	4462.68	100-Yr	4820.00	11.44	4261.39	4272.84	4273.27	0.002153	5.31	907.95	254.11
HSD Main Channel	4219.43	100-Yr	6592.00	12.08	4259.99	4272.07	4272.55	0.003854	5.57	1183.13	478.37
HSD Main Channel	3967.44	100-Yr	6592.00	12.29	4258.00	4270.29	4271.13	0.008535	7.35	896.87	430.32
HSD Main Channel	3674.39	100-Yr	6592.00	11.27	4256.00	4267.27	4268.25	0.011261	7.96	828.51	436.16
HSD Main Channel	3379.1	100-Yr	6592.00	9.54	4255.47	4265.01	4265.75	0.006296	6.87	959.31	408.17
HSD Main Channel	3030.67	100-Yr	6592.00	11.70	4250.87	4262.57	4263.06	0.009061	5.63	1170.59	888.44
HSD Main Channel	2816.21	100-Yr	6592.00	10.62	4250.00	4260.62	4261.16	0.008713	5.92	1113.63	757.84
HSD Main Channel	2587.35	100-Yr	6592.00	11.94	4248.00	4259.94	4260.17	0.002219	3.81	1728.09	817.65
HSD Main Channel	2350.58	100-Yr	6592.00	12.54	4245.98	4258.52	4259.17	0.009475	6.47	1018.43	642.71
HSD Main Channel	2118.63	100-Yr	6592.00	9.23	4243.99	4253.22	4256.81	0.008434	15.20	433.61	61.03
HSD Main Channel	1888.92	100-Yr	6592.00	11.62	4240.00	4251.62	4251.84	0.000296	3.76	1751.11	182.60
HSD Main Channel	1668.12	100-Yr	6592.00	9.34	4238.00	4247.34	4251.29	0.008038	15.94	413.68	53.02
HSD Main Channel	1490.38	100-Yr	6592.00	7.02	4238.00	4245.02	4249.51	0.011940	17.00	387.66	61.77
HSD Main Channel	1255.37	100-Yr	6592.00	9.41	4236.00	4245.41	4247.54	0.004165	11.71	562.79	70.43
HSD Main Channel	1071.27	100-Yr	6592.00	7.52	4235.51	4243.03	4246.37	0.008200	14.68	449.04	66.48
HSD Main Channel	800.36	100-Yr	6592.00	9.09	4233.98	4243.07	4244.02	0.001767	7.82	843.35	107.67
HSD Main Channel	623.07	100-Yr	6592.00	11.78	4232.00	4239.78	4243.19	0.007947	14.83	444.53	63.97
HSD Main Channel	432.97	100-Yr	6592.00	9.92	4228.00	4237.51	4237.62	0.000217	2.59	2542.46	369.11
HSD Main Channel	239.99	100-Yr	6592.00	9.01	4226.73	4235.74	4237.35	0.004484	10.21	645.71	113.54
HSD Main Channel	20.29	100-Yr	6592.00	7.92	4226.00	4233.59	4236.13	0.006003	12.79	515.25	77.64


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 16520
.035 .03 .035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)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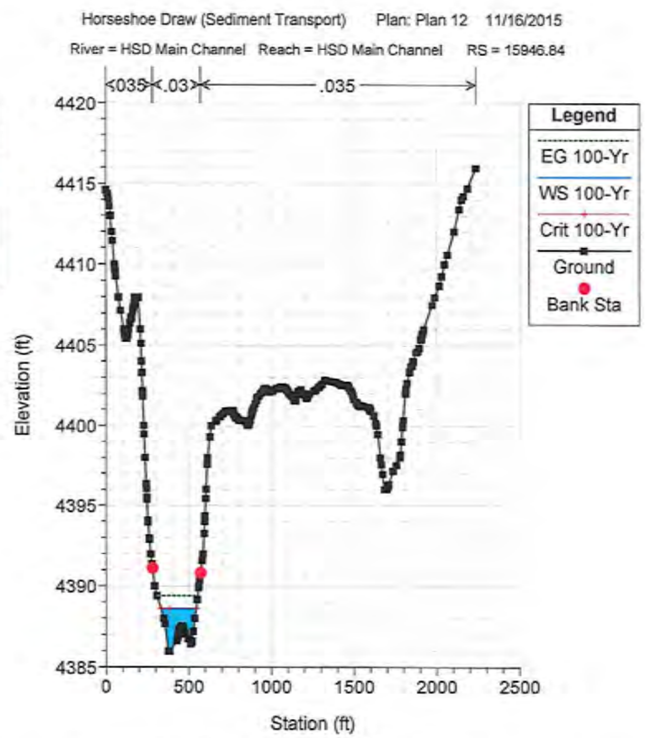
River = HSD Main Channel Reach = HSD Main Channel RS = 16246.06
.035 .03 .035
Legend
EG 100-Yr
WS 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 15946.84
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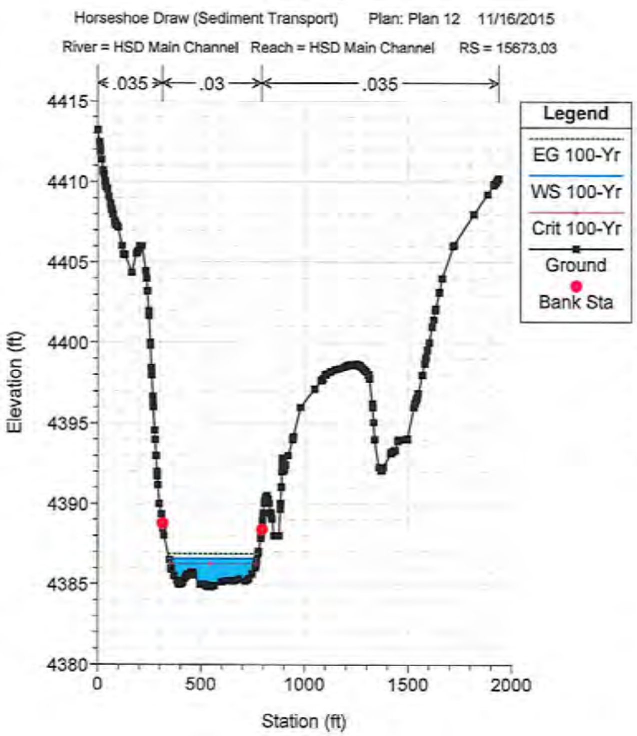
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 15673.03
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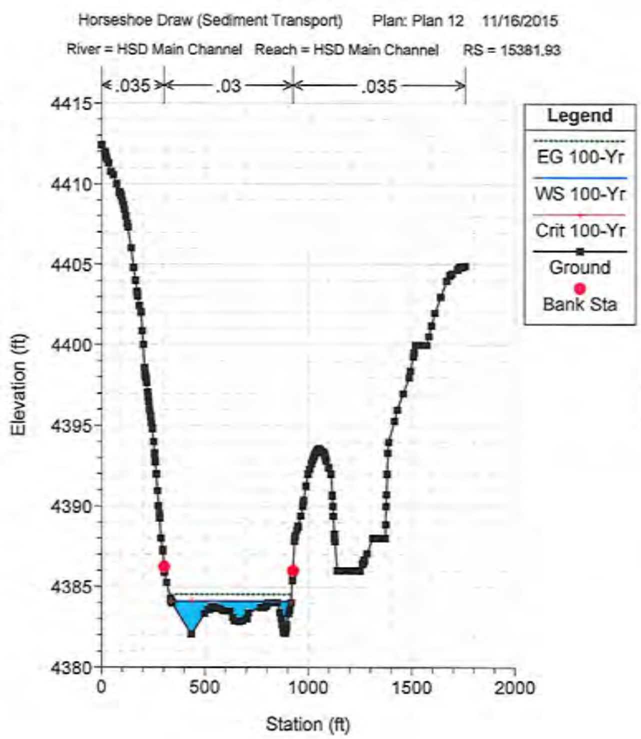
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 15381.93
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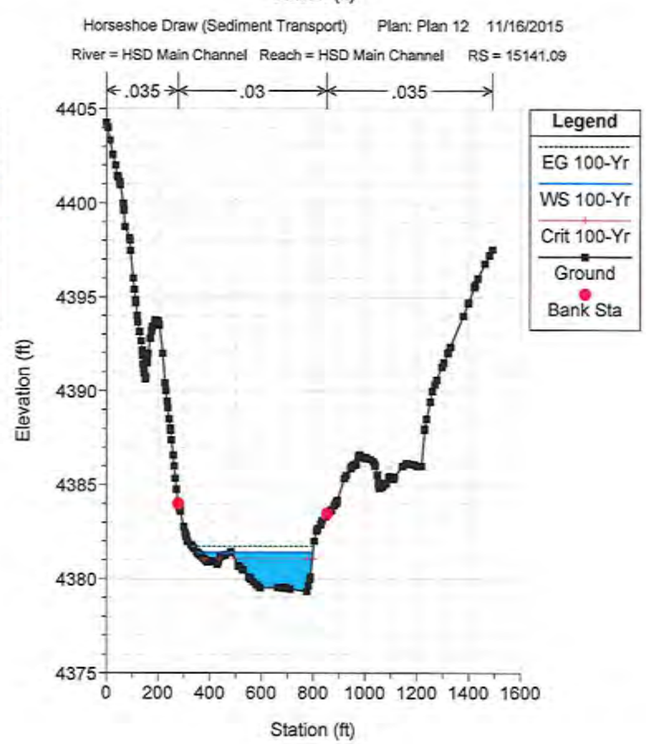
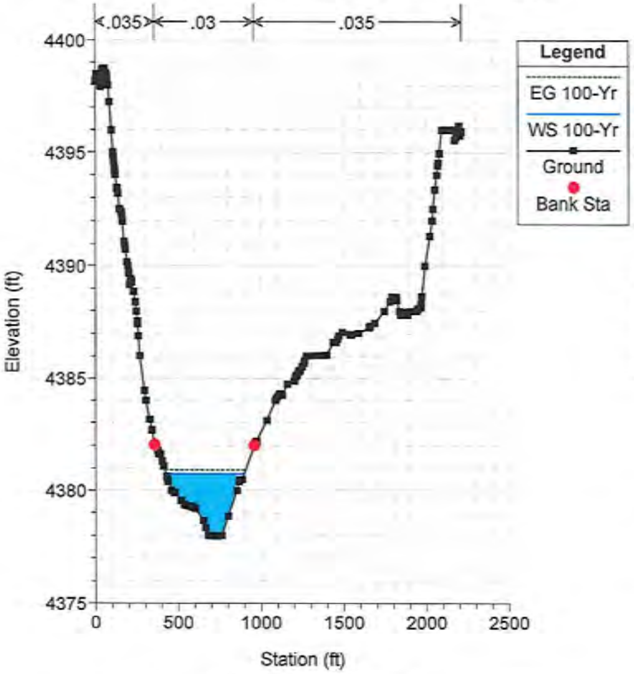
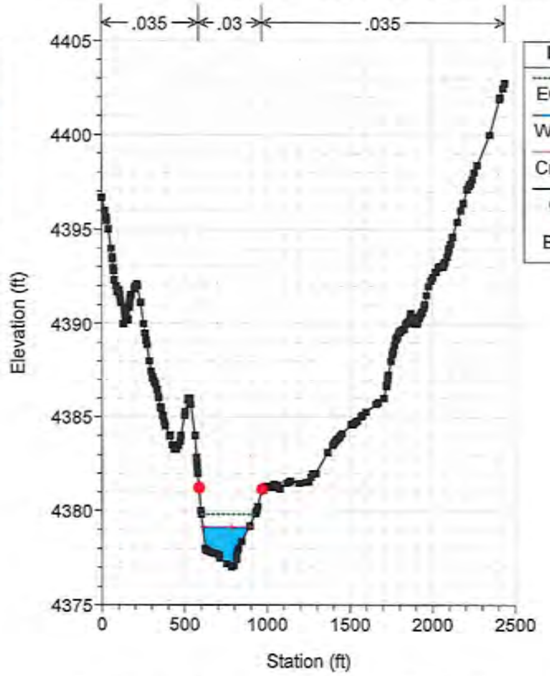
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 15141.09
.035 .03 .035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

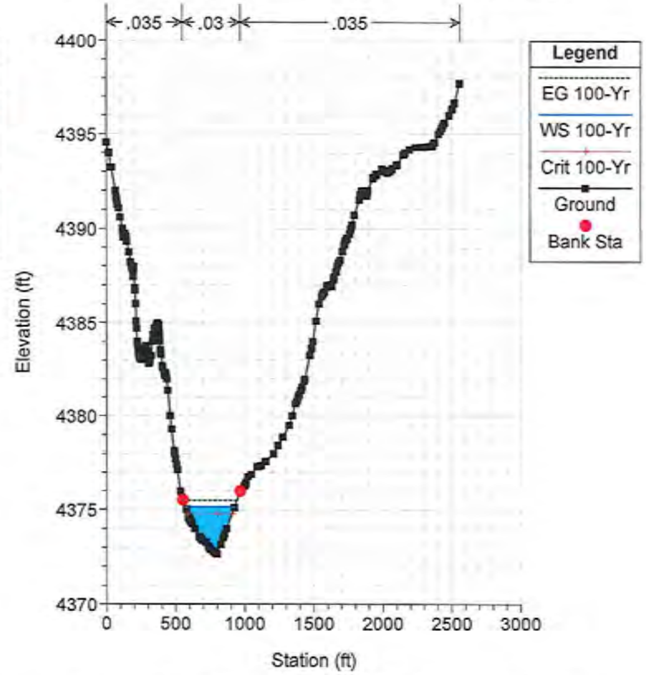
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 14931.77



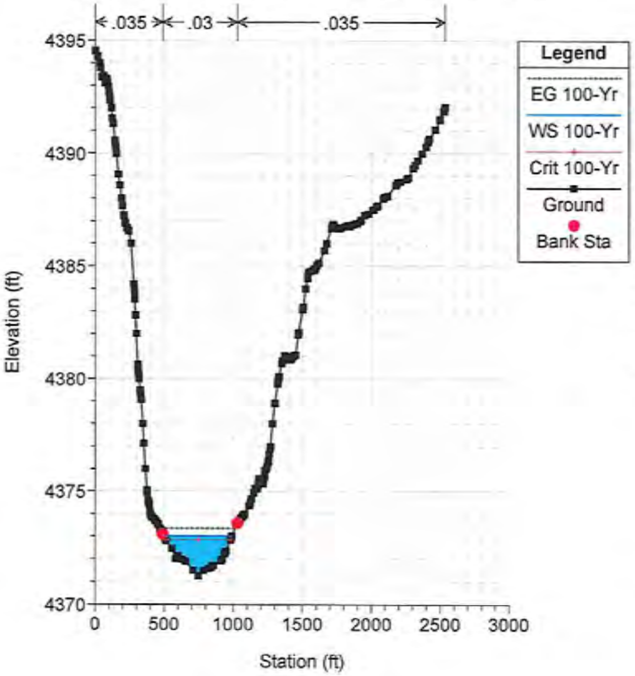
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 14692.54



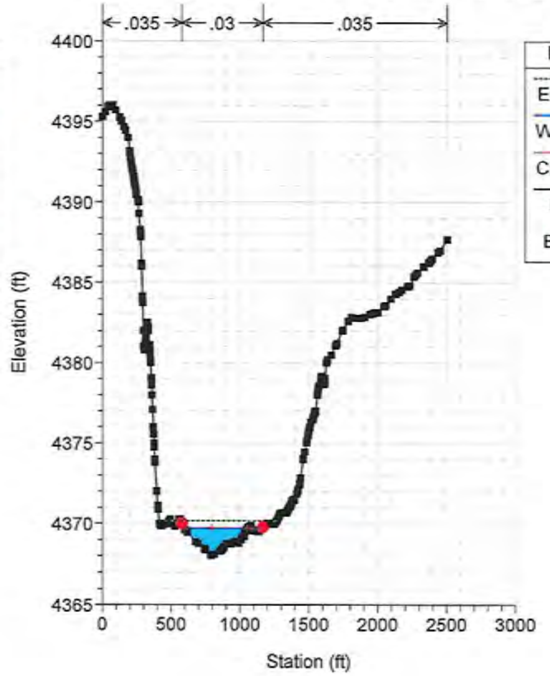
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 14379.42



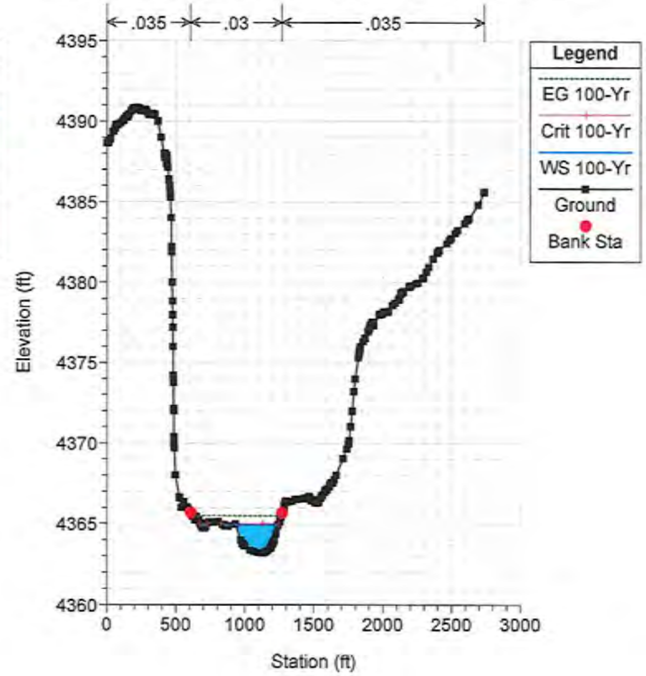
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 14066.58

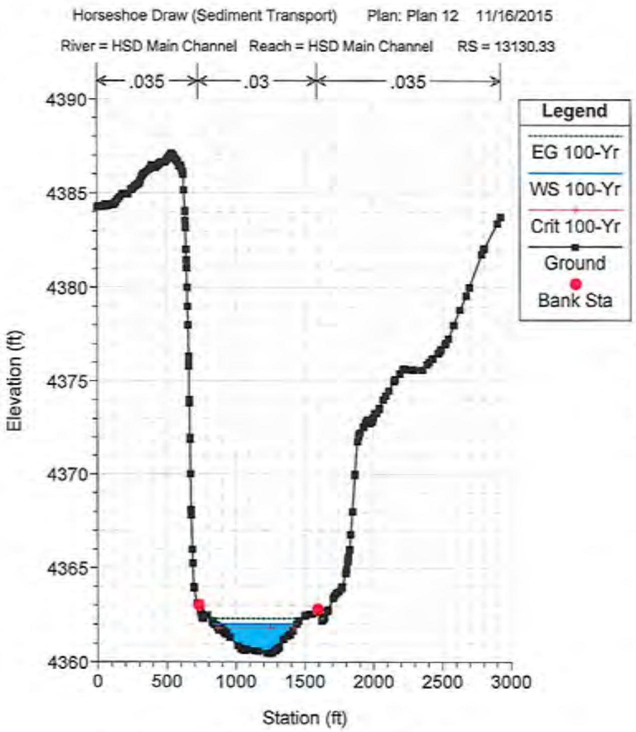


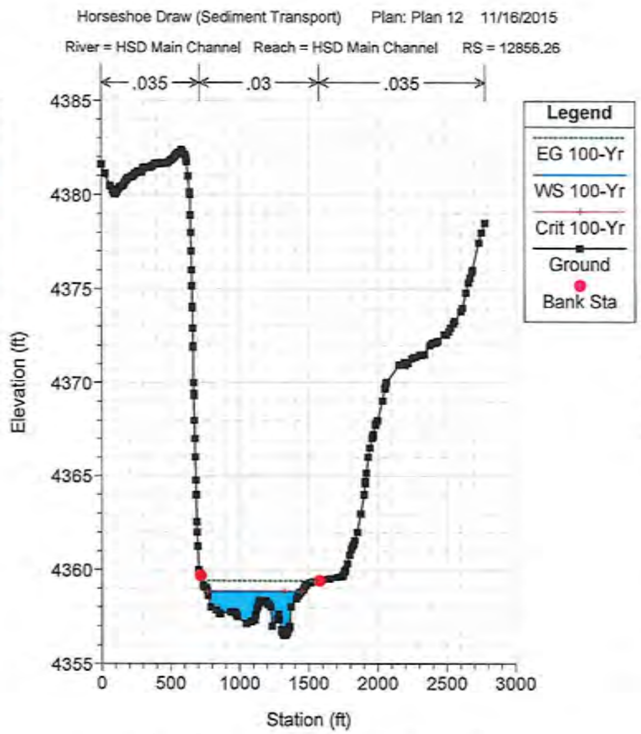
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 13772.72



Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 13457.43




Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 13130.33
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 12856.26
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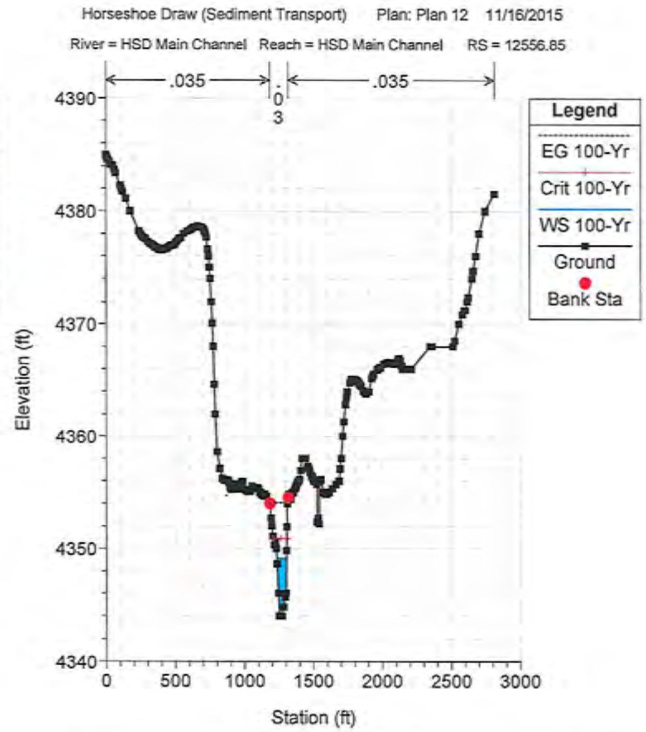
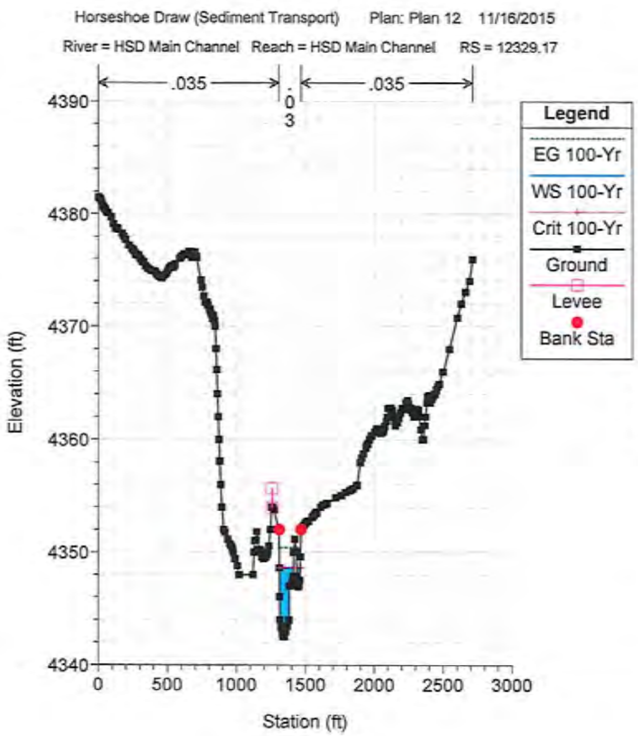
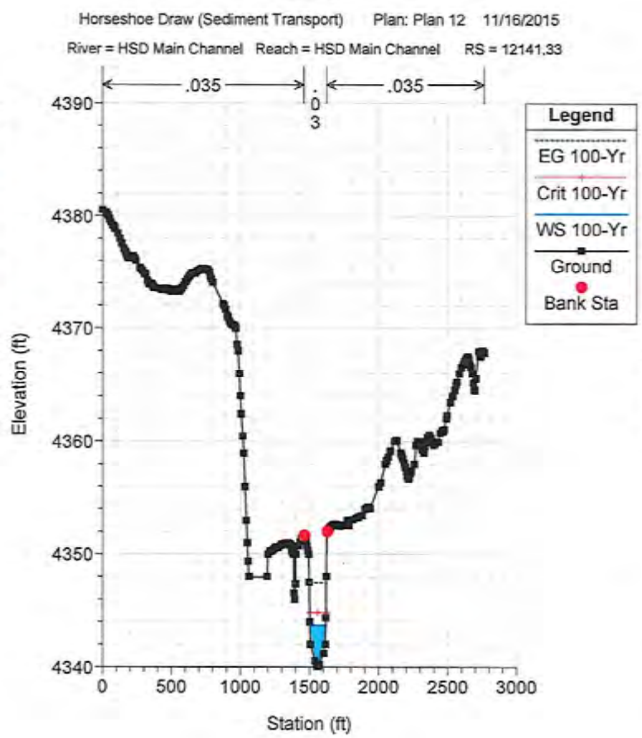
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 12556.85
.035
.03
.035
Legend
EG 100-Yr
Crit 100-Yr
WS 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 12329.17
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 12141.33
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.03
.035
Legend
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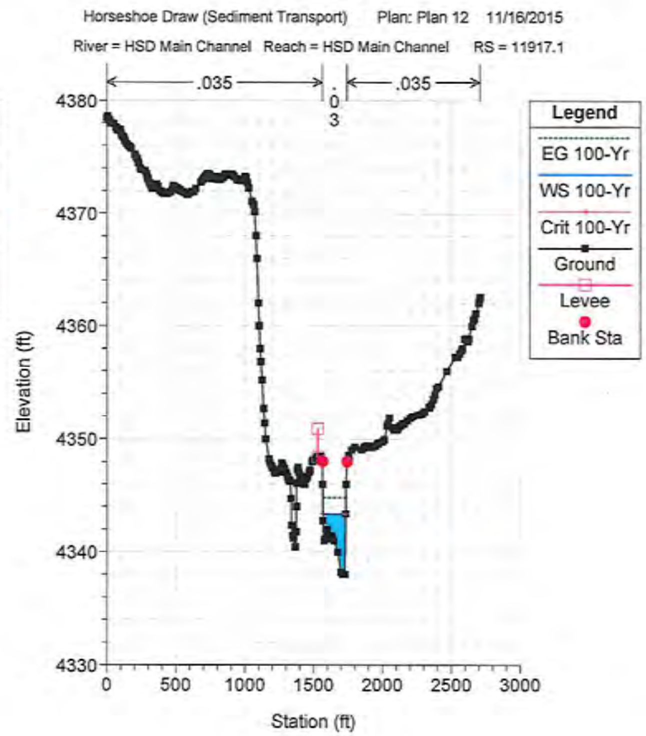
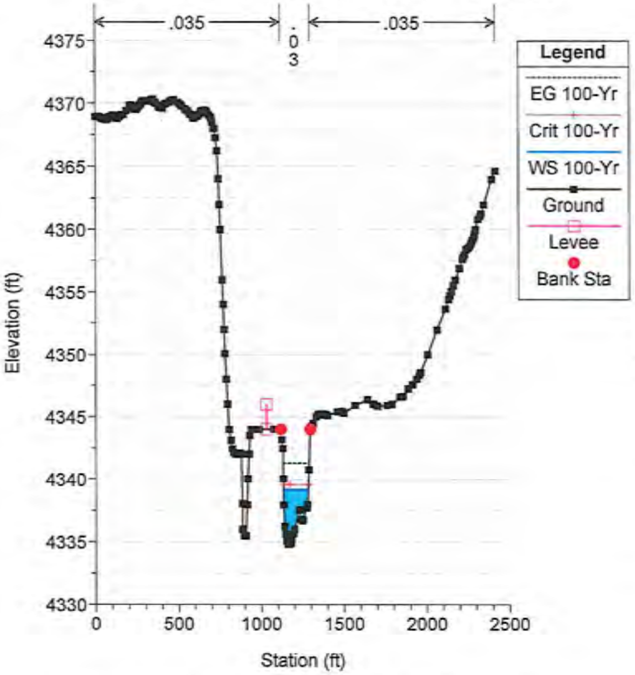
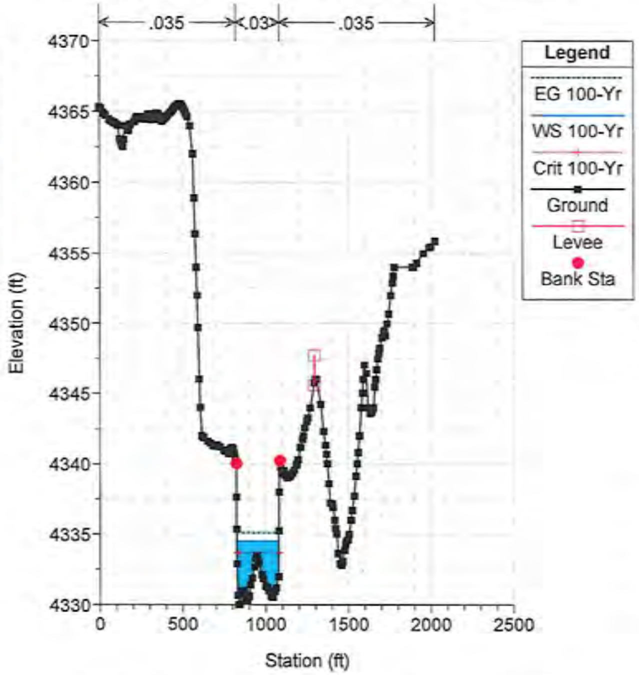
Crit 100-Yr
WS 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 11917.1
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

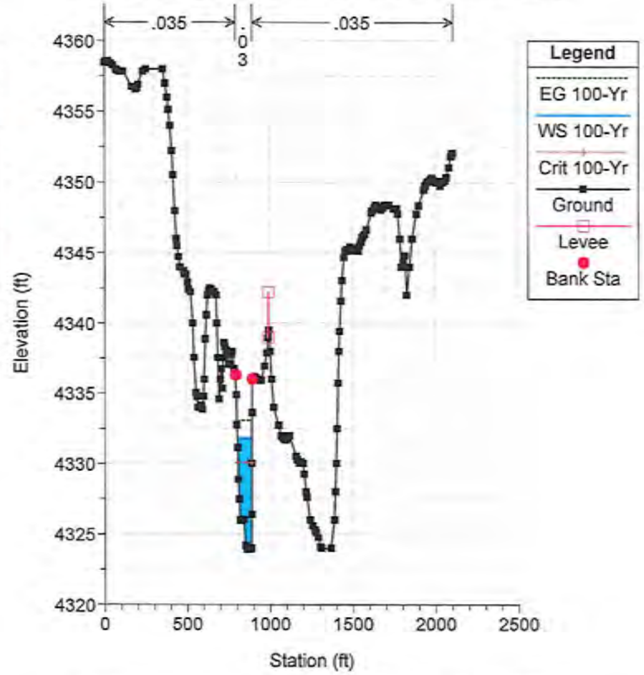
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 11610.72



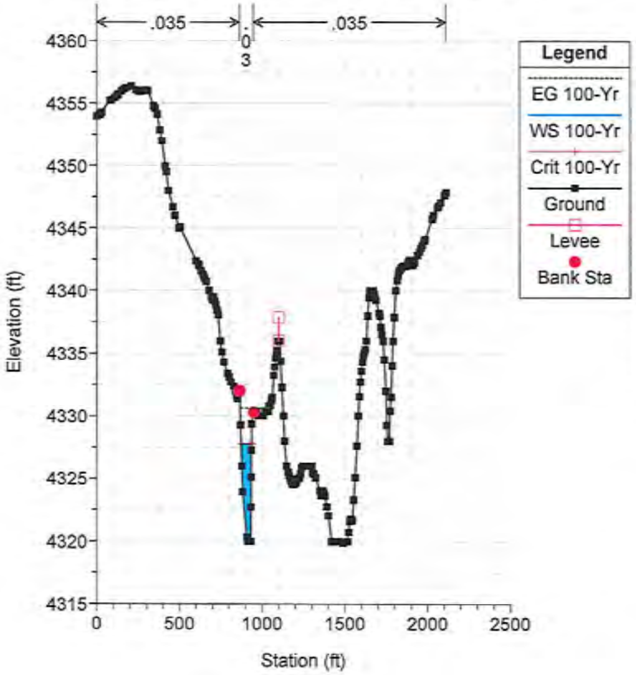
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 11182.79



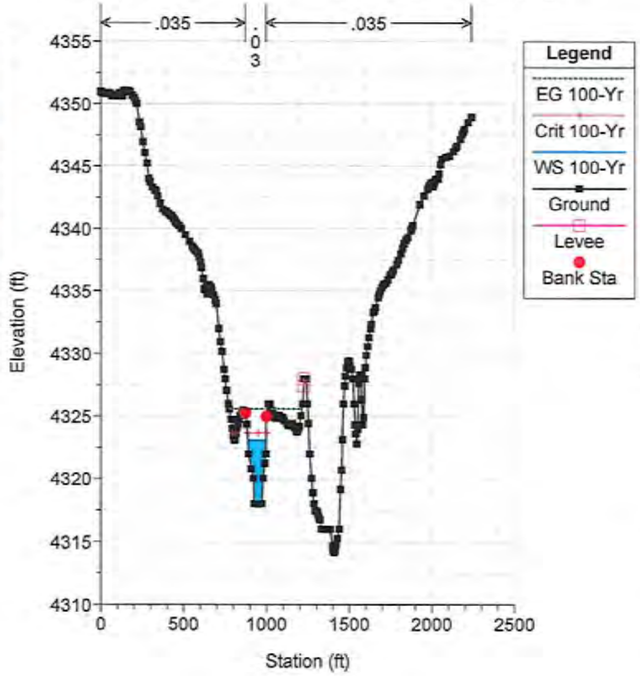
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 10592.6



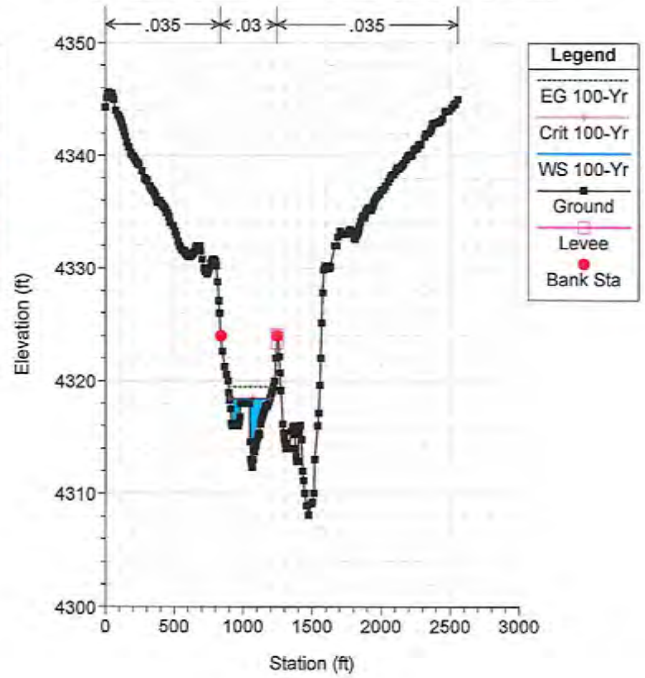
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 10118.27



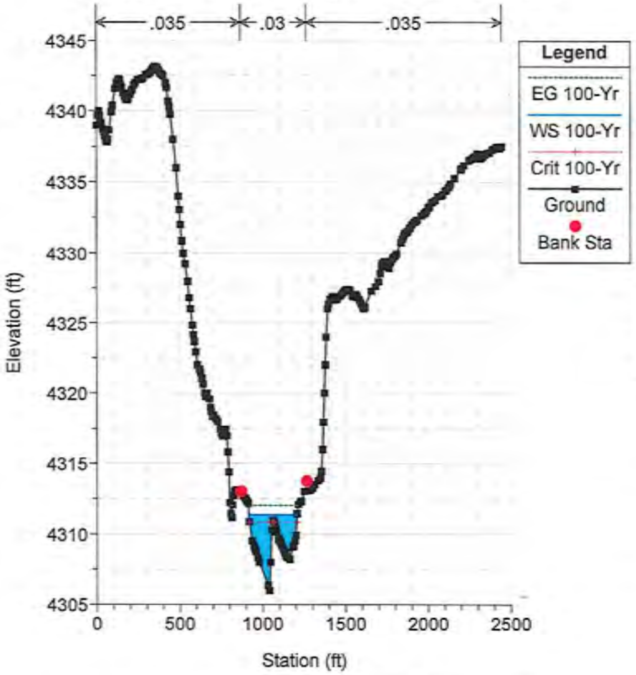
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 9624.29



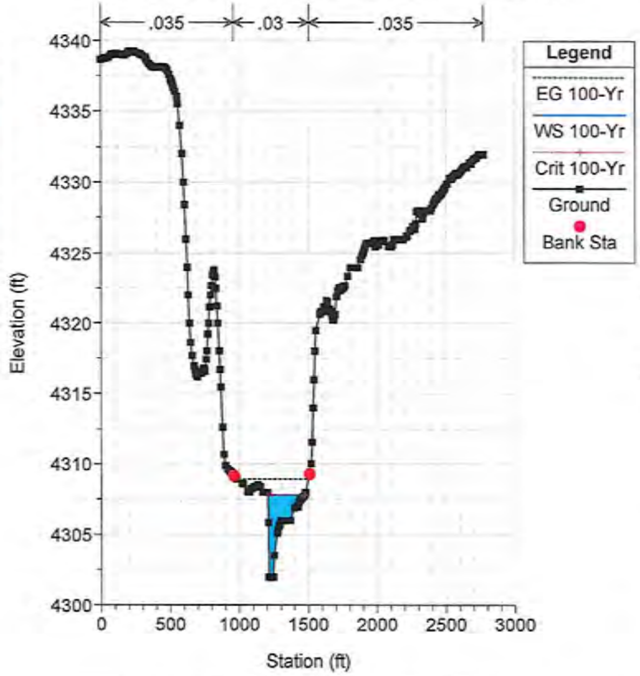
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 9149.64



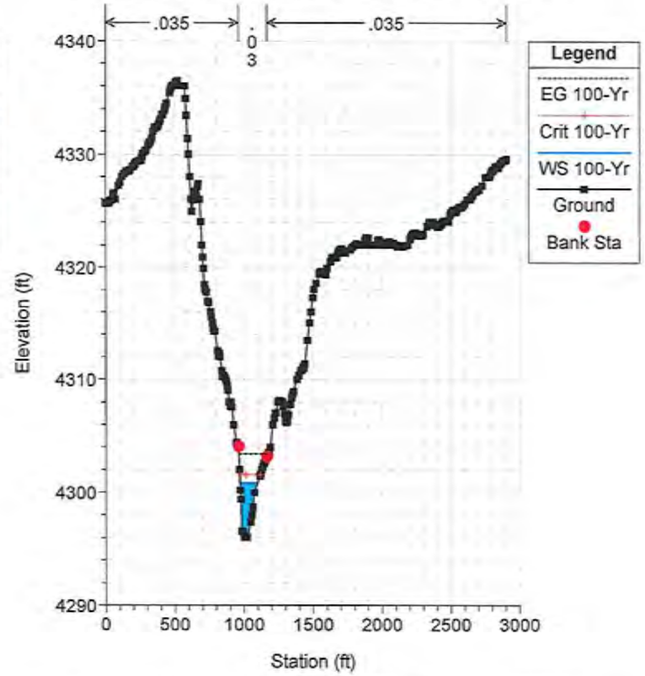
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 8654.43



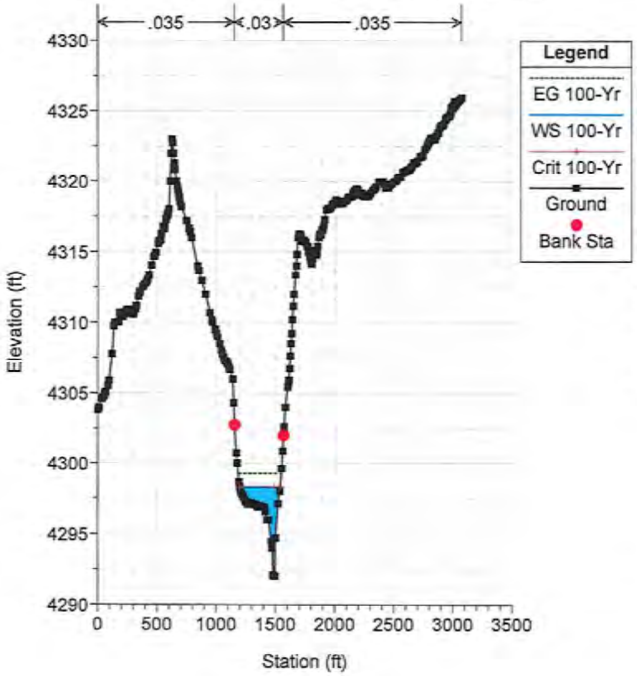
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 8227.06



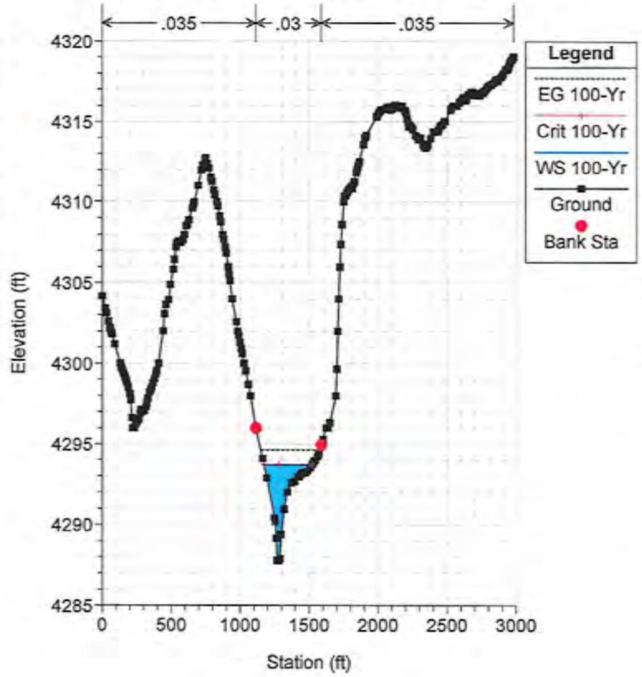
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 7805.03



Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 7385.4



Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 6964.05



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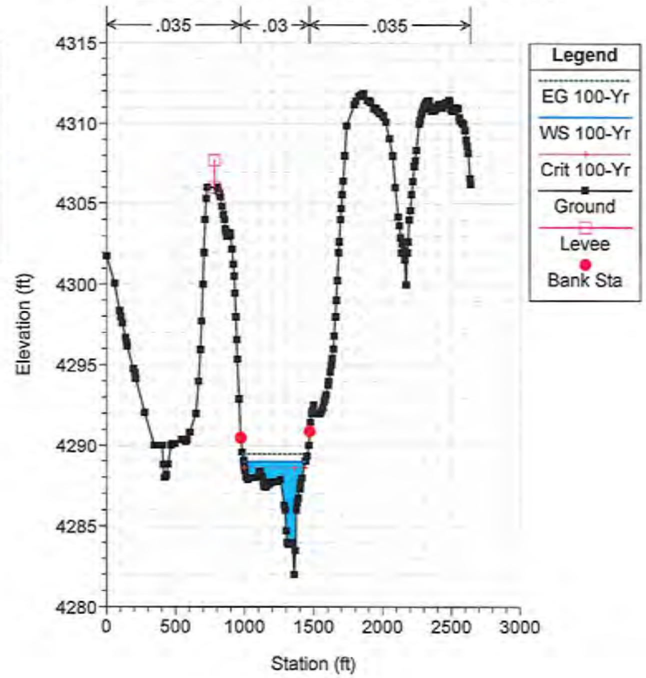
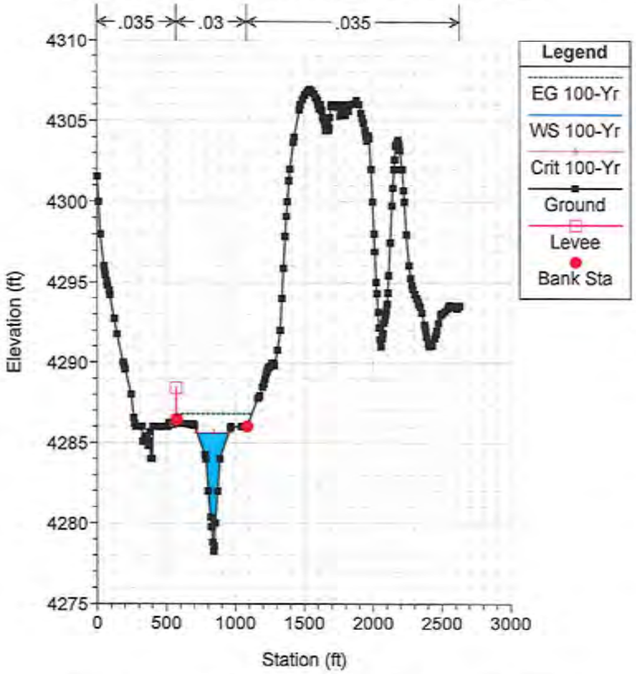
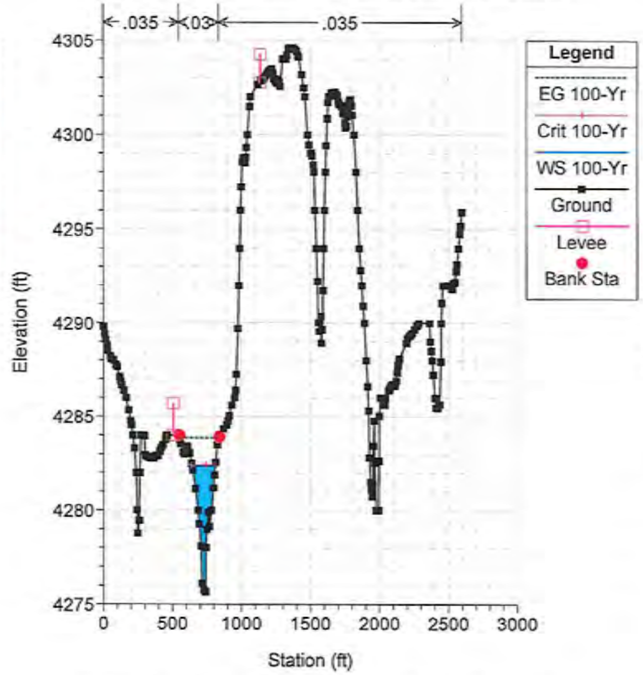
River = HSD Main Channel Reach = HSD Main Channel RS = 6467.25



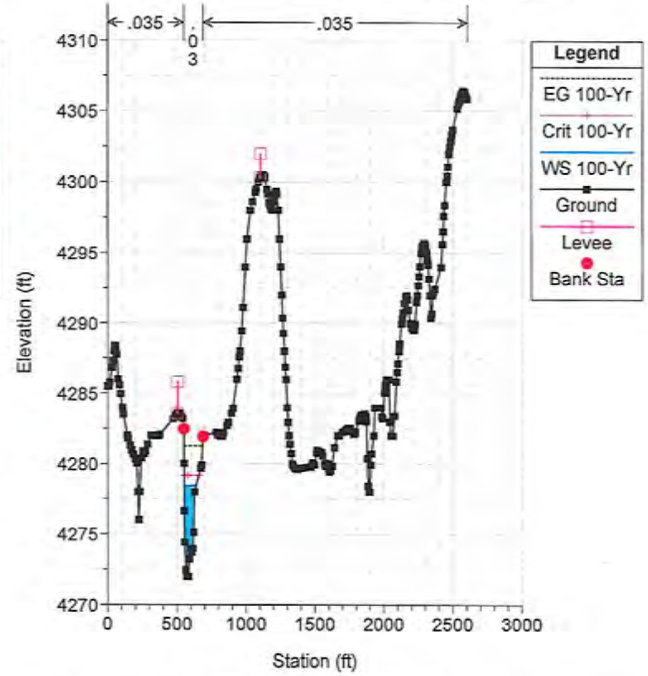
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 6090.97



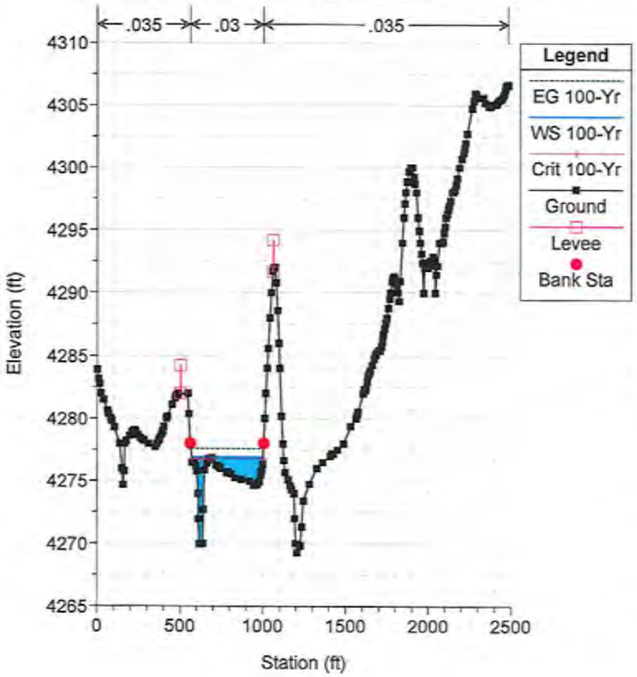
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 5785.22



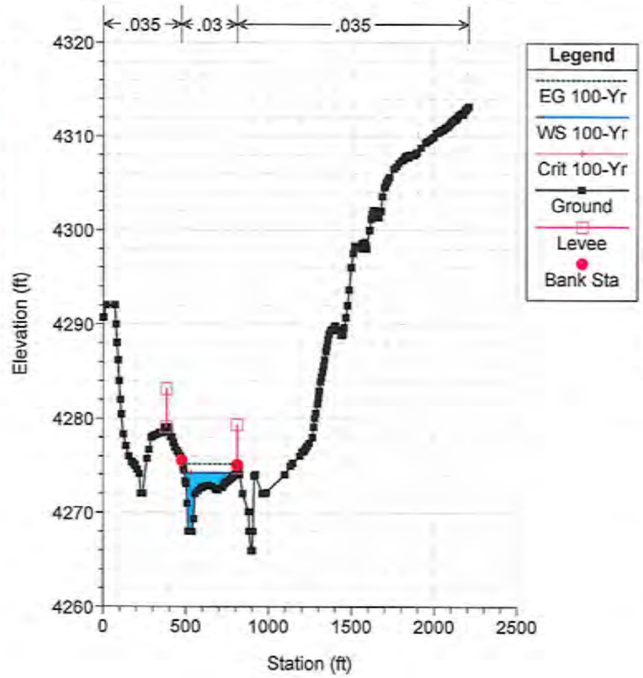
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 5546.66



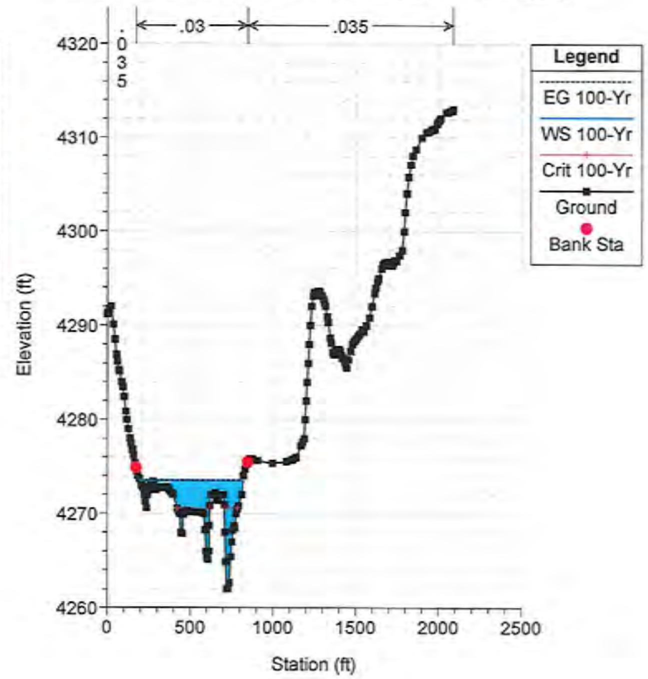
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 5283.29



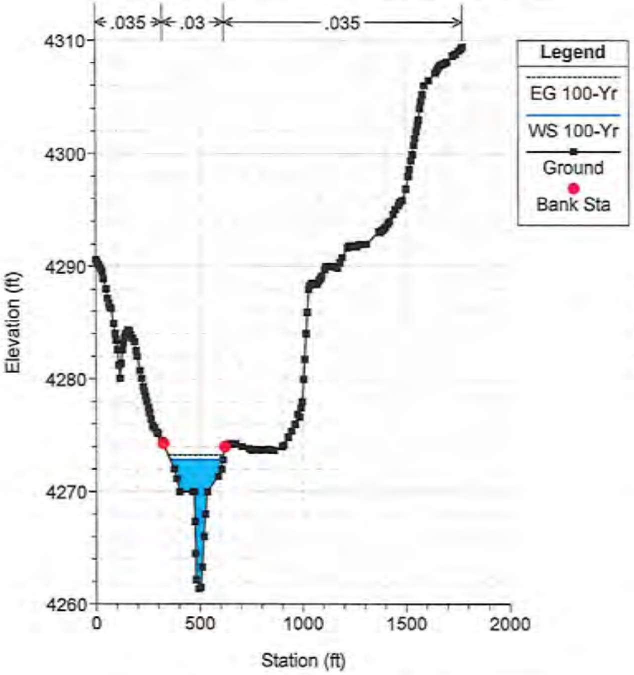
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 5034.86



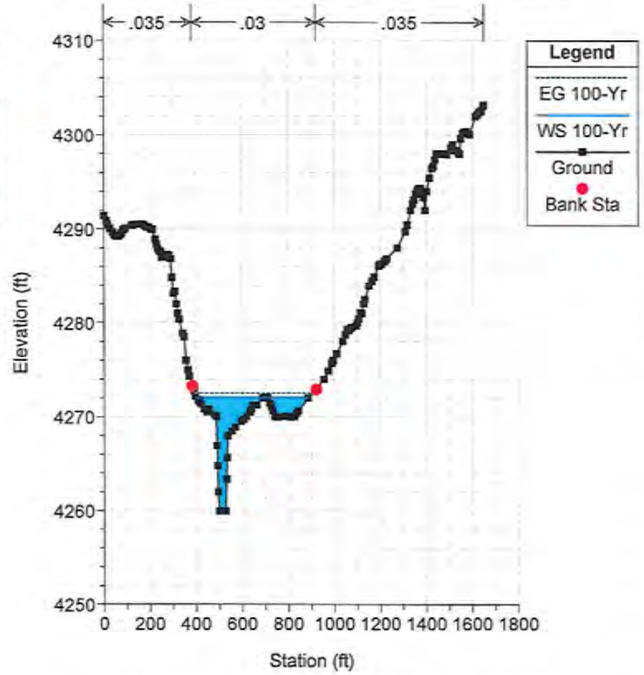
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 4695.55



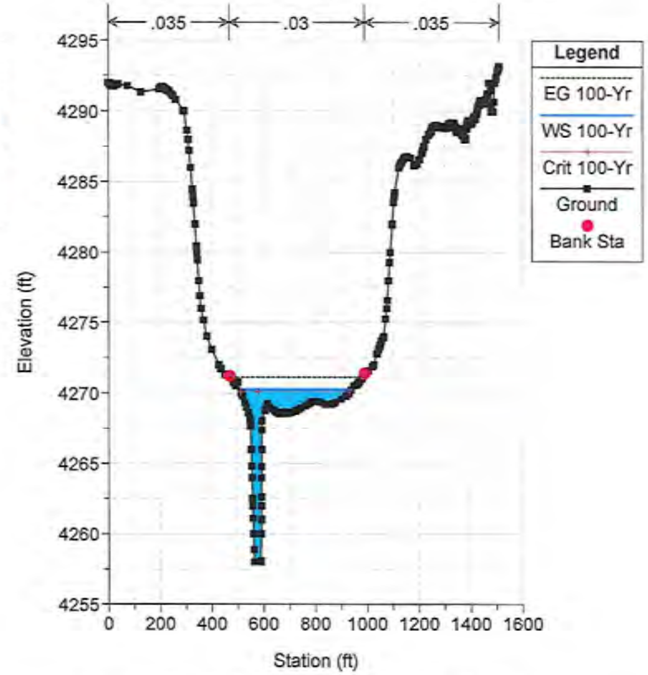
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 4462.68



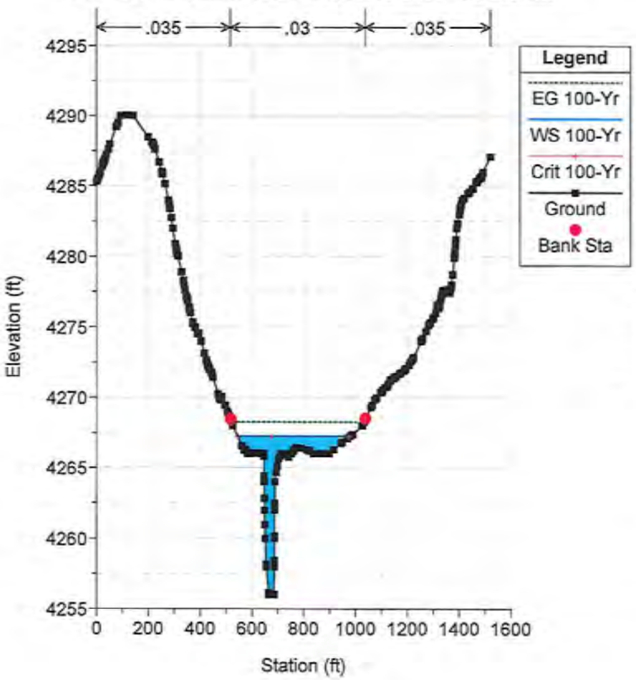
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 4219.43



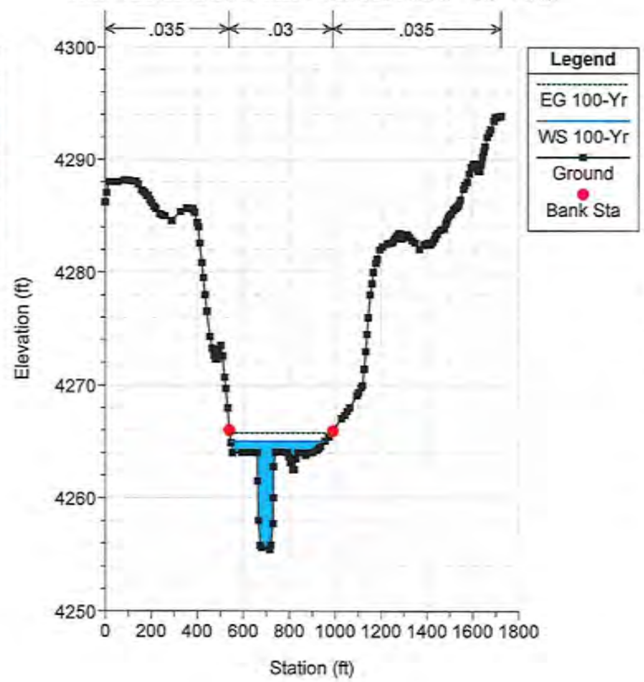
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 3967.44



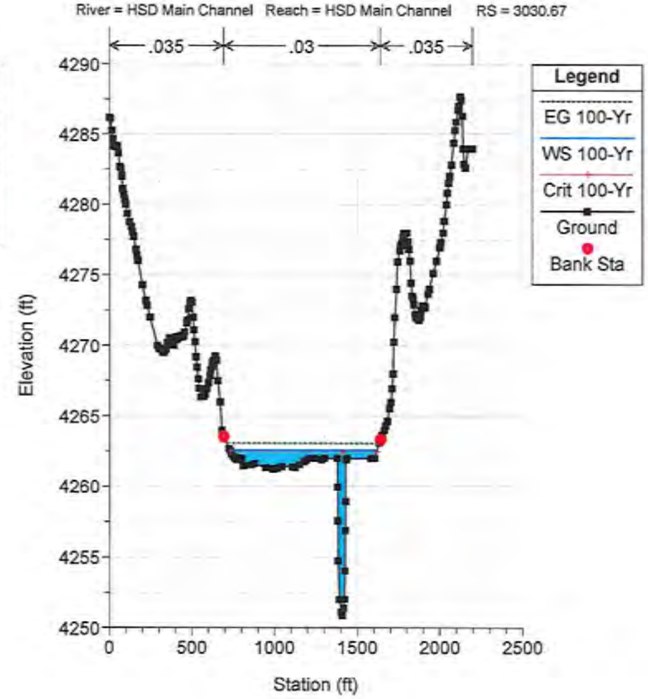
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 3674.39

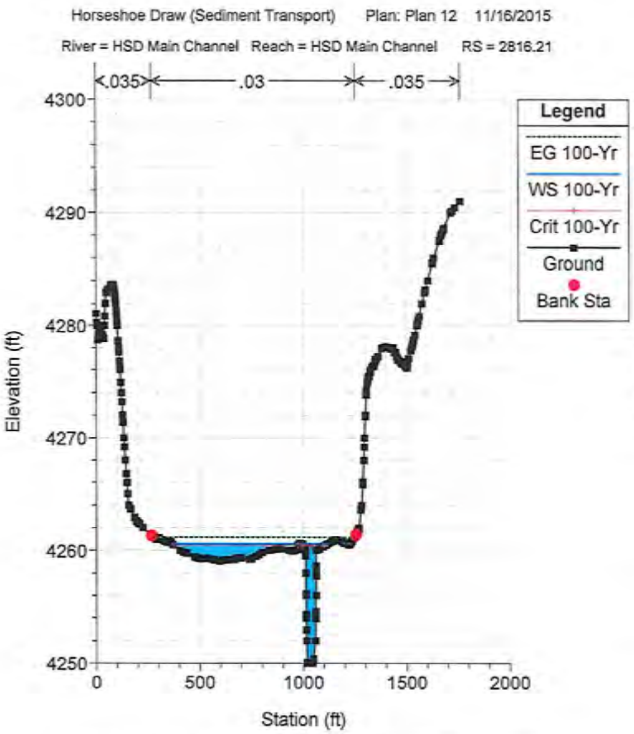


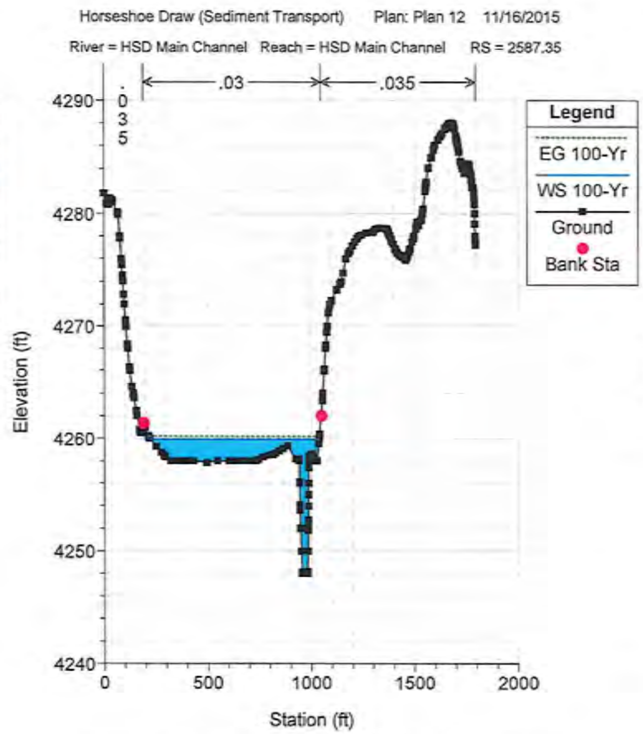
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 3379.1

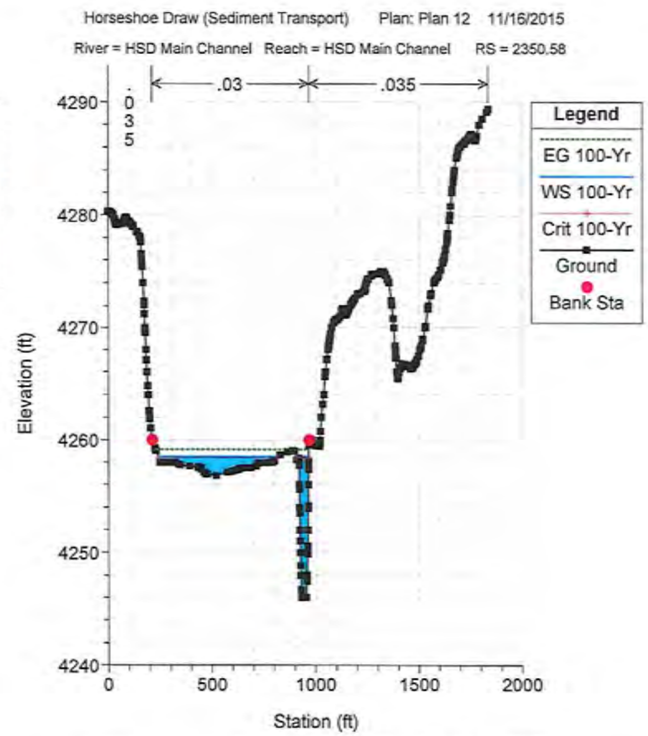


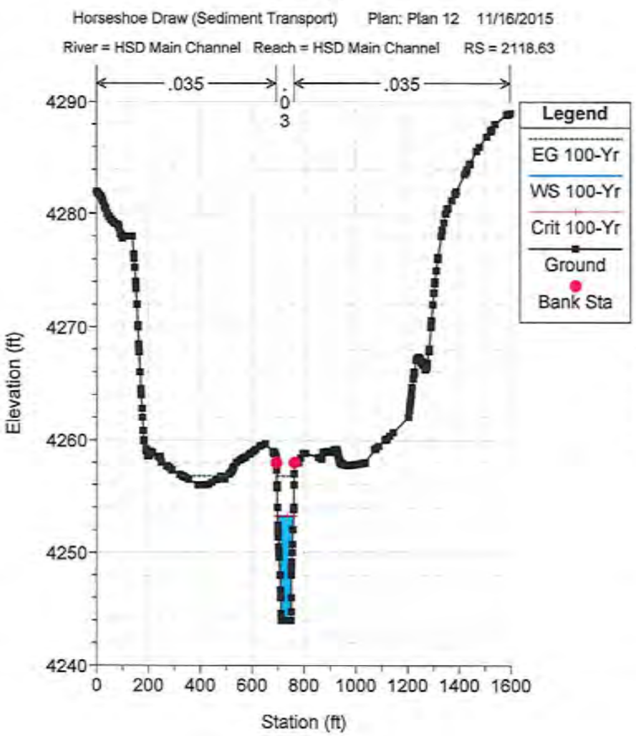
Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 3030.67




Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 2816.21
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 2587.35
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 2350.58
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 2118.63
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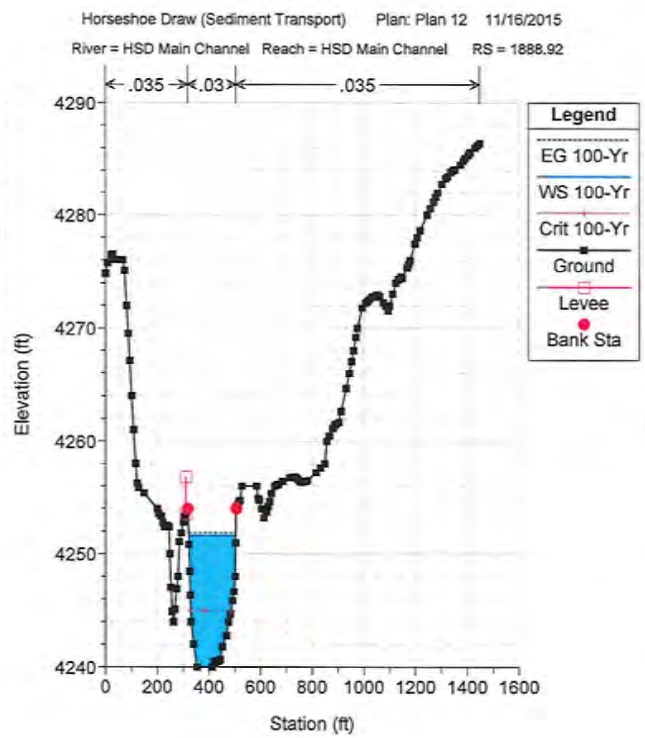
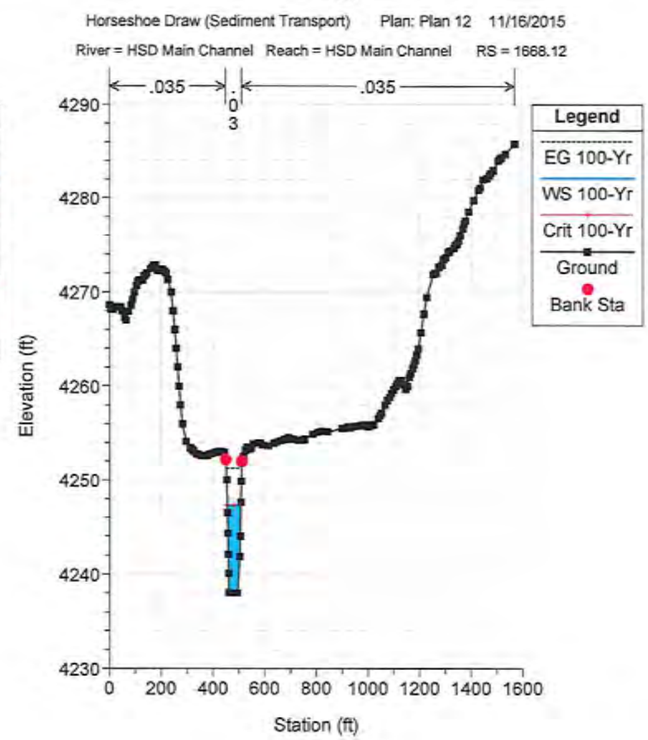
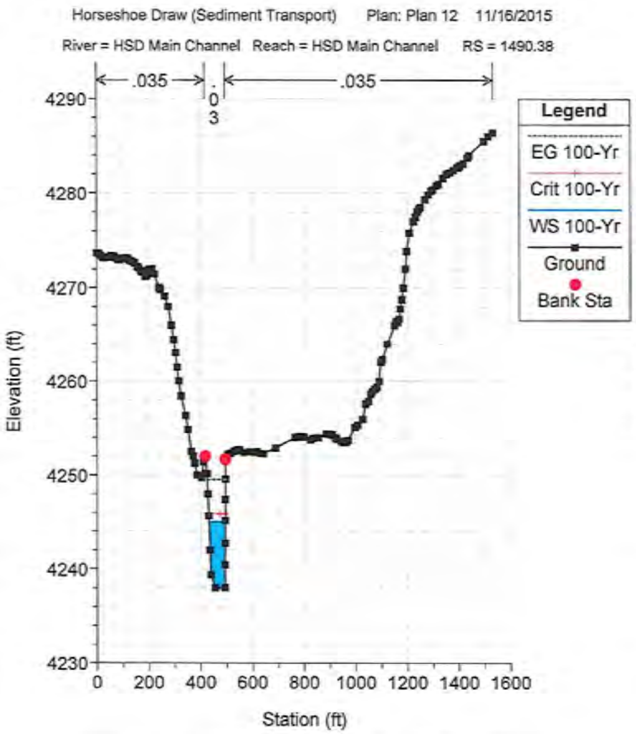
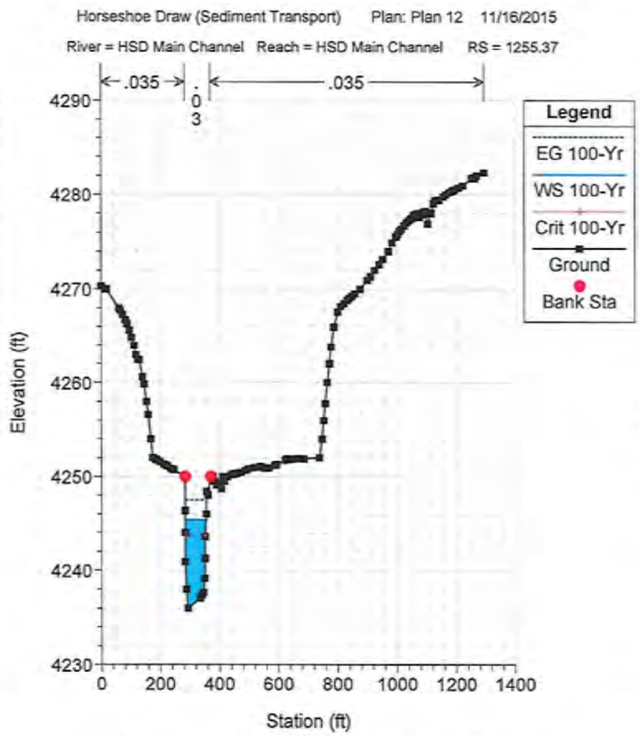
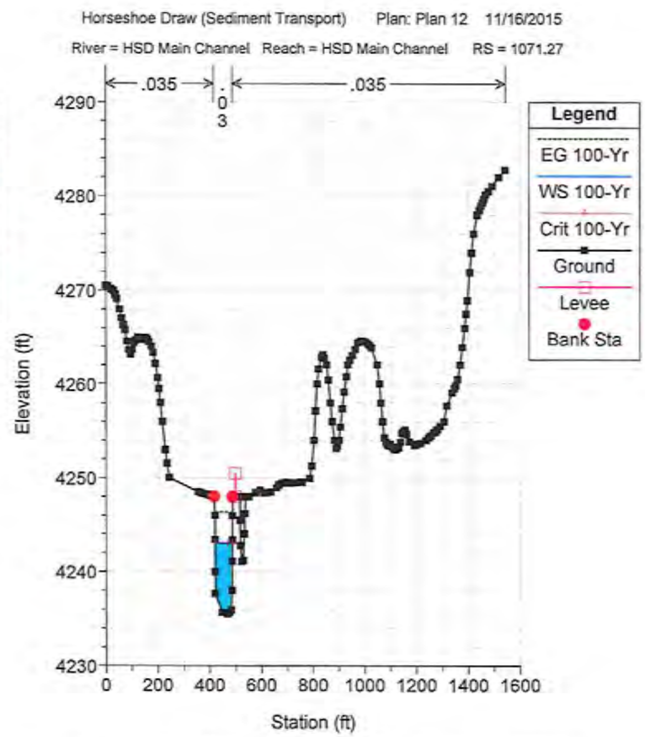
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

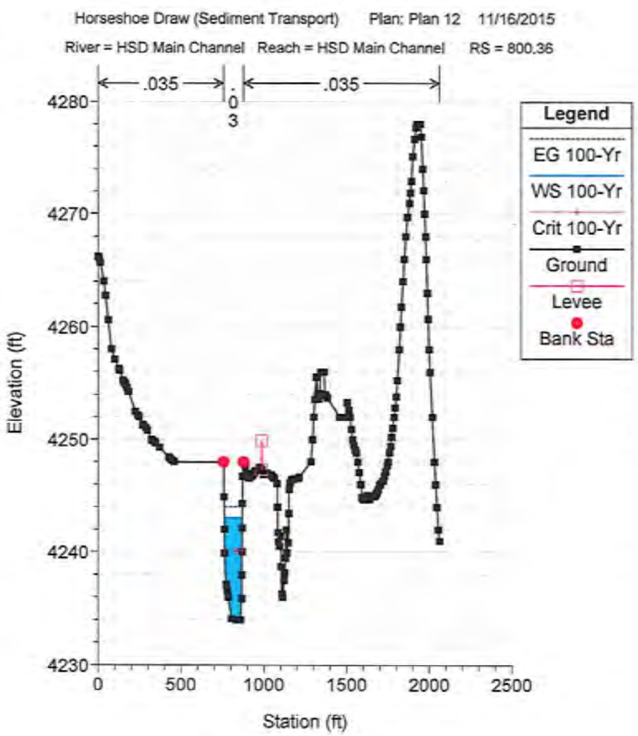

Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 1888.92
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

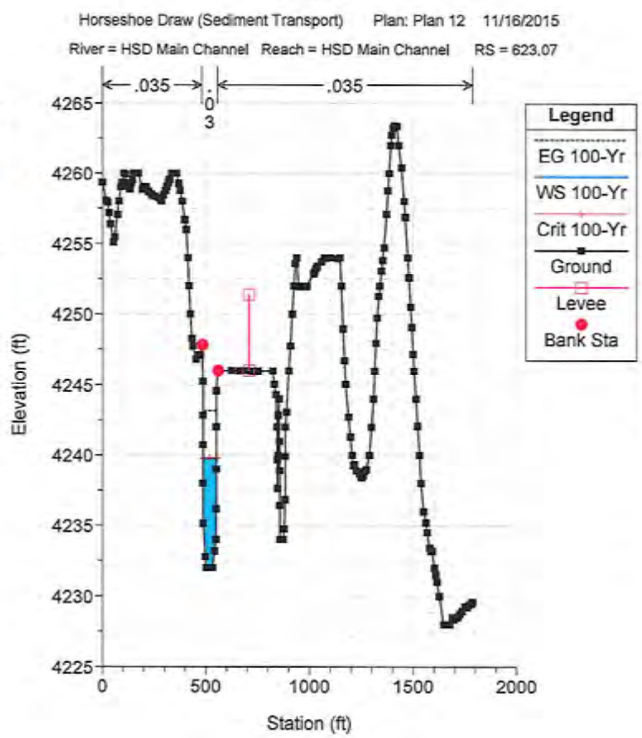

Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 1668.12
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

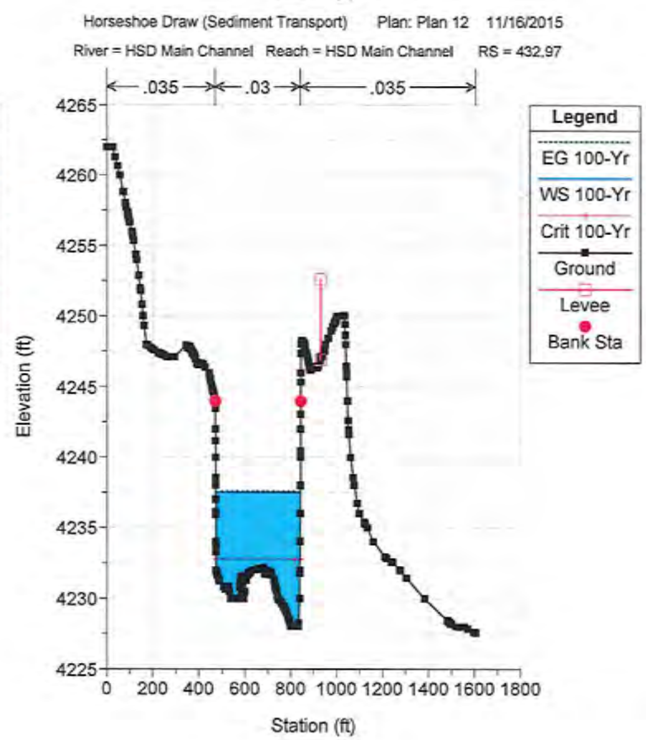

Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 1490.38
.035
.035
Legend
EG 100-Yr
Crit 100-Yr
WS 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 1255.37
.035
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

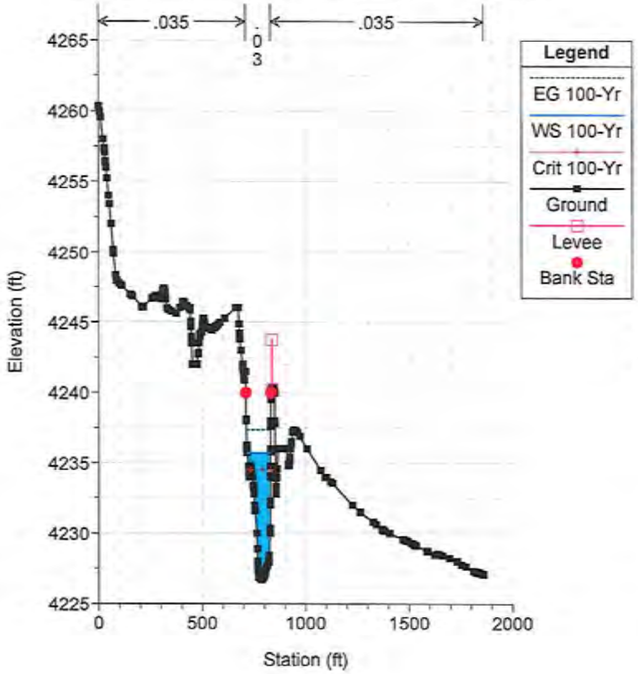

Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 1071.27
.035
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 800.36
.035
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

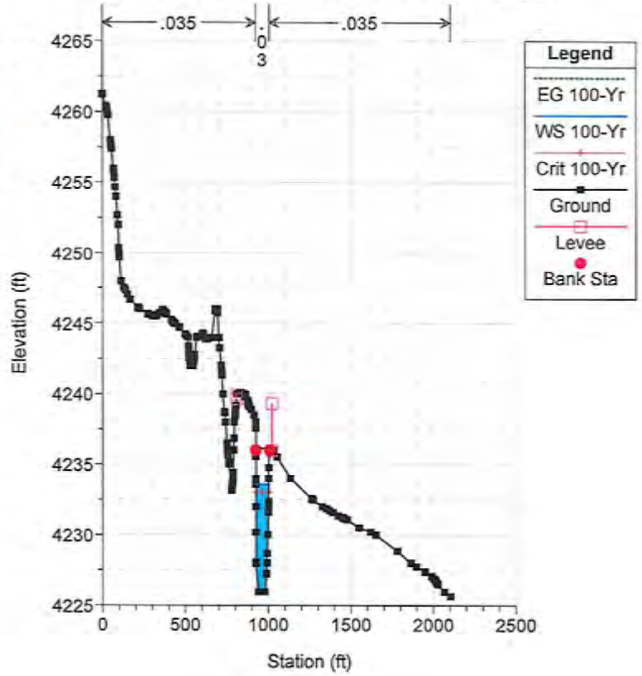

Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 623.07
.035
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw (Sediment Transport) Plan: Plan 12 11/16/2015
River = HSD Main Channel Reach = HSD Main Channel RS = 432.97
.035
.03
.035
Legend
EG 100-Yr
WS 100-Yr
Crit 100-Yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

Horseshoe Draw (Sediment Transport)   Plan: Plan 12   11/16/2015
River = HSD Main Channel   Reach = HSD Main Channel   RS = 239.99



Horseshoe Draw (Sediment Transport)   Plan: Plan 12   11/16/2015
River = HSD Main Channel   Reach = HSD Main Channel   RS = 20.29



APPENDIX C
EMPIRICAL SEDIMENT TRANSPORT EQUATIONS

STEADY FLOW SEDIMENT YIELD: YANG'S EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 165+20

Date: 11/19/2015

HILGARTWILSON

Yang's Equation-

Sand Equation: median sizes less than 2.0 mm

$$\log C_t = 5.435 - 0.286 \log(\omega D_{50}/v) - 0.457 \log(V_*/\omega) + [1.799 - 0.409 \log(\omega D_{50}/v) - 0.314 \log(V_*/\omega)] \log[(VS/\omega) - (V_{cr}S/\omega)]$$

where:

C_t = Sediment concentration in parts per million by weight
ω = Fall velocity of the sediment, m/s (ft/s)
v = Kinematic viscosity, m^2/s (ft^2/s)
V_* = Shear velocity $(\rho RS)^{0.5}$, m/s (ft/s)
t = Shear stress, (lb/ft2)
V = Velocity, m/s (ft/s) → HEC-RAS Channel XC Data
V_{cr} = Critical velocity, m/s (ft/s)
S = Energy slope, m/m (ft/ft)
R = Hydraulic radius (ft)
ρ = density of water (lb/ft3)
Q = Design flow rate (ft^3/s)
Q_s = Sediment Yield (tons/day)

In the above equations, the dimensionless critical velocity is given by:

$V_{cr}/\omega = [2.5 / (\log((V_* D_{50})/v) - 0.06] + 0.66$ for $1.2 < (V_* D_{50})/v < 70$

and

$V_{cr}/\omega = 2.05$ for $(V_* D_{50})/v >= 70$

Return Yr Storm	Q (ft^3/s)	ρ (lb/ft^3)	R (ft)	S (ft/ft)	τ_o (lb/ft^2)	V_* (ft/s)	v (ft^2/s)	D_{50} (ft)	$(V_* D_{50})/v$ (ft)	ω (ft/s)	V_{cr}	V (ft/s)	V_{cr}/ω	$V_{cr}S/\omega$	VS/ω	V^*/ω	$\omega D_{50}/v$	log C_t	C_t ppm	Q (ft^3/s)	Q_s (tons/day)	Q_s (tons/hour)	Volume (ac-ft/day)
100-yr	2,409	62.4	1.37	0.009	0.769	0.630	1.08E-05	0.00020	11.66	0.489	6.01	5.77	3.14	0.02829	0.10611	1.29	9.1	3.59	3877	2,409	25,178	1,049	10
50-yr	2,010	62.4	1.29	0.008	0.644	0.576	1.08E-05	0.00020	10.67	0.489	6.19	5.47	3.24	0.02594	0.08941	1.18	9.1	3.47	2952	2,010	15,997	667	6
25-yr	1,641	62.4	1.20	0.008	0.599	0.556	1.08E-05	0.00020	10.29	0.489	6.27	5.14	3.28	0.02628	0.08402	1.14	9.1	3.41	2596	1,641	11,483	478	4
10-yr	1,204	62.4	1.08	0.008	0.539	0.527	1.08E-05	0.00020	9.76	0.489	6.39	4.71	3.35	0.02680	0.07699	1.08	9.1	3.33	2142	1,204	6,952	290	3
2-yr	590	62.4	0.87	0.006	0.326	0.410	1.08E-05	0.00020	7.59	0.489	7.03	3.64	3.71	0.02225	0.04462	0.84	9.1	2.83	682	590	1,085	45	0
	500	*62.4*	*0.83*	*0.006*	*0.311*	*0.400*	*1.08E-05*	*0.00020*	*7.41*	*0.489*	*7.10*	*3.40*	*3.75*	*0.02248*	*0.04168*	*0.82*	*9.1*	*2.74*	*547*	*500*	*737*	*31*	*0*
	250	*62.4*	*0.70*	*0.004*	*0.175*	*0.300*	*1.08E-05*	*0.00020*	*5.56*	*0.489*	*8.08*	*2.49*	*4.31*	*0.01724*	*0.02035*	*0.61*	*9.1*	*1.56*	*36*	*250*	*25*	*1*	*0*

Assumptions-

1) R - is extracted from HEC-RAS, and assumed as to be for effective flow area only or main channel area (between bank stations)
2) v - based upon temperature of 15.5 degrees C
3) ω - Fall velocity based upon D_{50} particle size
4) V - is extracted from HEC-RAS (channel velocity)
5) Q - is for the 2-yr, 10-yr, 25-yr, 50-yr and 100-year storm events
6) Italicized rows show smaller flow rates used for calibrating the HEC-RAS model.

STEADY FLOW SEDIMENT YIELD: ZELLER AND FULLERTON EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 165+20

Date: 11/19/2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Zeller and Fullerton Equation-

$$q_s = 0.0064 * (n^{1.77} * V^{4.32} * G^{0.45}) / (Y_h^{0.30} * D_{50}^{0.61})$$

where:
q_s = Sediment transport rate (cfs / unit width)
n = Manning's roughness coefficient
V = Mean velocity (ft/s)
G = Gradation coefficient
Y_h = Hydraulic depth (ft)
D_{50} = Median diameter (mm)
ρ = Particle Density (lb/ft³)

HEC-RAS Channel XC Data

In the above equation, the gradation coefficient is given by:

$$G = 1/2\ (D_{84.1} / D_{50} + D_{50} / D_{15.9})$$

Return Yr Storm	Q (ft³/s)	n	V (ft/s)	$D_{15.9}$ (mm)	D_{50} (mm)	$D_{84.1}$ (mm)	G	Y_h (ft)	q_s (ft³/s/ft)	Width (ft)	Q_s (ft³/s)	Q_s (ft³/hr)	ρ (lb/ft³)	Q_s (lb/hr)	Q_s (tons/hr)	Q_s (tons/day)
100-yr	2,409	0.03	5.77	0.05	0.07	0.6	5.0	1.37	0.24	304	72	260,370	101	26,297,406	13,149	315,569
50-yr	2,010	0.03	5.47	0.05	0.07	0.6	5.0	1.29	0.19	285	55	197,346	101	19,931,922	9,966	239,183
25-yr	1,641	0.03	5.14	0.05	0.07	0.6	5.0	1.20	0.15	265	40	143,320	101	14,475,320	7,238	173,704
10-yr	1,204	0.03	4.71	0.05	0.07	0.6	5.0	1.08	0.11	236	25	90,321	101	9,122,444	4,561	109,469
2-yr	590	0.03	3.64	0.05	0.07	0.6	5.0	0.87	0.04	186	7	24,950	101	2,519,945	1,260	30,239
	500	*0.03*	*3.40*	*0.05*	*0.07*	*0.6*	*5.0*	*0.83*	*0.03*	*176*	*5*	*17,833*	*101*	*1,801,168*	*901*	*21,614*
	250	*0.03*	*2.49*	*0.05*	*0.07*	*0.6*	*5.0*	*0.70*	*0.01*	*144*	*1*	*3,998*	*101*	*403,822*	*202*	*4,846*

Assumptions-
1) V - is extracted from HEC-RAS (channel velocity)
2) Q - is for the 2-yr, 10-yr, 25-yr, 50-yr and 100-year storm events
3) Italicized rows show smaller flow rates used for calibrating the HEC-RAS model.

UNSTEADY FLOW SEDIMENT YIELD: ZELLER AND FULLERTON EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 165+20
Storm Frequency: 100-Year
Date 19-Nov

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Zeller and Fullerton Equation-

$$q_s = 0.0064 * (n^{1.77} * V^{4.32} * G^{0.45}) / (Y_h^{0.30} * D_{50}^{0.61})$$

where:

q_s = Sediment transport rate (cfs / unit width)
n = Manning's roughness coefficient
V = Mean velocity (ft/s)
G = Gradation coefficient
Y_h = Hydraulic depth (ft)
D_{50} = Median diameter (mm)
ρ = Particle Density (lb/ft³)

HEC-RAS Channel XC Data

In the above equation, the gradation coefficient is given by:

$$G = 1/2\,(D_{84.1} / D_{50} + D_{50} / D_{15.9})$$

Q (ft³/ s)	n	V (ft / s)	$D_{15.9}$ (mm)	D_{50} (mm)	$D_{84.1}$ (mm)	G	Y_h (ft)	q_s (ft³/ s/ ft)	Width (ft)	Q_s (ft³/ s)	Q_s (ft³/ hr)	ρ (lb/ft³)	Q_s (lb/ hr)	Q_s (tons/ hr)	Q_s (tons/ day)	Q_s (tons/(5-min))
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	18	101	1,775	1	21	0
1.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	25	101	2,538	1	30	0
1.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	35	101	3,527	2	42	0
2.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	48	101	4,820	2	58	0
3.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	60	101	6,100	3	73	0
4.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	73	101	7,386	4	89	0
6.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	90	101	9,102	5	109	0
8.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	109	101	10,975	5	132	0
10.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	128	101	12,897	6	155	1
12.7	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	149	101	15,036	8	180	1
15.9	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	174	101	17,598	9	211	1
19.6	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	202	101	20,373	10	244	1
24.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	236	101	23,817	12	286	1
31.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	281	101	28,398	14	341	1
40.9	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	338	101	34,094	17	409	1
54.4	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	412	101	41,629	21	500	2
73.4	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	508	101	51,341	26	616	2
99.6	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	10	0	629	101	63,571	32	763	3

137.2	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	13	0	788	101	79,547	40	955	3
191.9	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	19	0	996	101	100,607	50	1,207	4
268.7	0.03	2.50	0.05	0.07	0.6	5.0	0.12	0.01	26	0	1,261	101	127,340	64	1,528	5
371.6	0.03	2.50	0.05	0.07	0.6	5.0	0.17	0.01	36	0	1,582	101	159,782	80	1,917	7
504.1	0.03	3.40	0.05	0.07	0.6	5.0	0.23	0.04	49	2	7,393	101	746,665	373	8,960	31
667.3	0.03	3.40	0.05	0.07	0.6	5.0	0.30	0.04	65	2	8,996	101	908,634	454	10,904	38
857.8	0.03	3.40	0.05	0.07	0.6	5.0	0.38	0.04	84	3	10,725	101	1,083,264	542	12,999	45
1067.3	0.03	3.40	0.05	0.07	0.6	5.0	0.48	0.03	105	3	12,498	101	1,262,306	631	15,148	53
1287.9	0.03	3.60	0.05	0.07	0.6	5.0	0.58	0.04	126	5	18,247	101	1,842,975	921	22,116	77
1510.2	0.03	3.60	0.05	0.07	0.6	5.0	0.68	0.04	148	6	20,399	101	2,060,279	1,030	24,723	86
1723.9	0.03	3.60	0.05	0.07	0.6	5.0	0.77	0.04	169	6	22,379	101	2,260,270	1,130	27,123	94
1921.2	0.03	3.60	0.05	0.07	0.6	5.0	0.86	0.04	188	7	24,142	101	2,438,387	1,219	29,261	102
2095.3	0.03	3.60	0.05	0.07	0.6	5.0	0.94	0.03	205	7	25,654	101	2,591,041	1,296	31,092	108
2239.8	0.03	4.70	0.05	0.07	0.6	5.0	1.00	0.11	219	24	85,048	101	8,589,825	4,295	103,078	358
2350.7	0.03	4.70	0.05	0.07	0.6	5.0	1.05	0.11	230	24	87,974	101	8,885,378	4,443	106,625	370
2425.8	0.03	4.70	0.05	0.07	0.6	5.0	1.09	0.11	238	25	89,932	101	9,083,147	4,542	108,998	378
2466.5	0.03	4.70	0.05	0.07	0.6	5.0	1.11	0.10	242	25	90,986	101	9,189,558	4,595	110,275	383
2475.6	0.03	4.70	0.05	0.07	0.6	5.0	1.11	0.10	243	25	91,221	101	9,213,278	4,607	110,559	384
2455.6	0.03	4.70	0.05	0.07	0.6	5.0	1.10	0.10	241	25	90,704	101	9,161,112	4,581	109,933	382
2409.2	0.03	4.70	0.05	0.07	0.6	5.0	1.08	0.11	236	25	89,501	101	9,039,592	4,520	108,475	377
2340.6	0.03	4.70	0.05	0.07	0.6	5.0	1.05	0.11	229	24	87,709	101	8,858,637	4,429	106,304	369
2255.0	0.03	4.70	0.05	0.07	0.6	5.0	1.01	0.11	221	24	85,451	101	8,630,589	4,315	103,567	360
2157.6	0.03	4.70	0.05	0.07	0.6	5.0	0.97	0.11	211	23	82,851	101	8,367,920	4,184	100,415	349
2052.7	0.03	3.60	0.05	0.07	0.6	5.0	0.92	0.03	201	7	25,288	101	2,554,052	1,277	30,649	106
1944.3	0.03	3.60	0.05	0.07	0.6	5.0	0.87	0.04	190	7	24,345	101	2,458,874	1,229	29,506	102
1835.3	0.03	3.60	0.05	0.07	0.6	5.0	0.82	0.04	180	6	23,382	101	2,361,548	1,181	28,339	98
1728.0	0.03	3.60	0.05	0.07	0.6	5.0	0.77	0.04	169	6	22,416	101	2,264,032	1,132	27,168	94
1624.0	0.03	3.60	0.05	0.07	0.6	5.0	0.73	0.04	159	6	21,463	101	2,167,765	1,084	26,013	90
1525.0	0.03	3.60	0.05	0.07	0.6	5.0	0.68	0.04	149	6	20,539	101	2,074,392	1,037	24,893	86
1431.7	0.03	3.60	0.05	0.07	0.6	5.0	0.64	0.04	140	5	19,651	101	1,984,716	992	23,817	83
1343.4	0.03	3.60	0.05	0.07	0.6	5.0	0.60	0.04	132	5	18,794	101	1,898,216	949	22,779	79
1259.1	0.03	3.60	0.05	0.07	0.6	5.0	0.56	0.04	123	5	17,961	101	1,814,028	907	21,768	76
1177.9	0.03	3.60	0.05	0.07	0.6	5.0	0.53	0.04	115	5	17,142	101	1,731,322	866	20,776	72
1099.6	0.03	3.60	0.05	0.07	0.6	5.0	0.49	0.04	108	5	16,336	101	1,649,933	825	19,799	69
1024.3	0.03	3.60	0.05	0.07	0.6	5.0	0.46	0.04	100	4	15,545	101	1,570,005	785	18,840	65
951.7	0.03	3.40	0.05	0.07	0.6	5.0	0.43	0.03	93	3	11,534	101	1,164,968	582	13,980	49
881.8	0.03	3.40	0.05	0.07	0.6	5.0	0.40	0.04	86	3	10,935	101	1,104,392	552	13,253	46
814.5	0.03	3.40	0.05	0.07	0.6	5.0	0.37	0.04	80	3	10,343	101	1,044,691	522	12,536	44
749.9	0.03	3.40	0.05	0.07	0.6	5.0	0.34	0.04	73	3	9,762	101	985,976	493	11,832	41
688.0	0.03	3.40	0.05	0.07	0.6	5.0	0.31	0.04	67	3	9,191	101	928,273	464	11,139	39
629.2	0.03	3.40	0.05	0.07	0.6	5.0	0.28	0.04	62	2	8,634	101	871,999	436	10,464	36
573.8	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	56	2	8,094	101	817,516	409	9,810	34
522.2	0.03	3.40	0.05	0.07	0.6	5.0	0.23	0.04	51	2	7,578	101	765,332	383	9,184	32
474.1	0.03	3.40	0.05	0.07	0.6	5.0	0.21	0.04	46	2	7,082	101	715,275	358	8,583	30
429.8	0.03	2.50	0.05	0.07	0.6	5.0	0.19	0.01	42	0	1,752	101	176,914	88	2,123	7
389.3	0.03	2.50	0.05	0.07	0.6	5.0	0.17	0.01	38	0	1,634	101	165,073	83	1,981	7
352.4	0.03	2.50	0.05	0.07	0.6	5.0	0.16	0.01	35	0	1,524	101	153,958	77	1,847	6
319.1	0.03	2.50	0.05	0.07	0.6	5.0	0.14	0.01	31	0	1,422	101	143,623	72	1,723	6
289.1	0.03	2.50	0.05	0.07	0.6	5.0	0.13	0.01	28	0	1,327	101	134,032	67	1,608	6
261.8	0.03	2.50	0.05	0.07	0.6	5.0	0.12	0.01	26	0	1,238	101	125,042	63	1,500	5
237.1	0.03	2.50	0.05	0.07	0.6	5.0	0.11	0.01	23	0	1,155	101	116,662	58	1,400	5
214.7	0.03	2.50	0.05	0.07	0.6	5.0	0.10	0.01	21	0	1,078	101	108,832	54	1,306	5
194.4	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	19	0	1,005	101	101,523	51	1,218	4
176.1	0.03	2.50	0.05	0.07	0.6	5.0	0.08	0.02	17	0	938	101	94,734	47	1,137	4
159.3	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	16	0	874	101	88,313	44	1,060	4
144.2	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	14	0	816	101	82,367	41	988	3
130.3	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	13	0	760	101	76,725	38	921	3
117.7	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	12	0	707	101	71,453	36	857	3
106.2	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	10	0	658	101	66,491	33	798	3

95.3	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	9	0	610	101	61,637	31	740	3
85.4	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	8	0	565	101	57,082	29	685	2
76.1	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	521	101	52,656	26	632	2
67.3	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	478	101	48,316	24	580	2
59.3	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	438	101	44,220	22	531	2
51.8	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	398	101	40,226	20	483	2
45.0	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	361	101	36,452	18	437	2
39.1	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	327	101	33,037	17	396	1
33.5	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	3	0	294	101	29,649	15	356	1
28.7	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	263	101	26,607	13	319	1
24.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	236	101	23,817	12	286	1
21.0	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	212	101	21,381	11	257	1
17.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	189	101	19,045	10	229	1
15.2	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	169	101	17,052	9	205	1
12.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	150	101	15,119	8	181	1
10.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.03	1	0	134	101	13,511	7	162	1
9.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	118	101	11,907	6	143	0
7.7	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	105	101	10,593	5	127	0
6.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	94	101	9,509	5	114	0
5.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	83	101	8,370	4	100	0
4.7	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	0	0	74	101	7,498	4	90	0
4.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	66	101	6,698	3	80	0
3.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	59	101	5,977	3	72	0
2.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	52	101	5,218	3	63	0
2.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	44	101	4,407	2	53	0
1.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	39	101	3,977	2	48	0
1.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	32	101	3,212	2	39	0
1.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	27	101	2,713	1	33	0
0.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	21	101	2,171	1	26	0
0.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	15	101	1,562	1	19	0
0.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	13	101	1,336	1	16	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	101	1,093	1	13	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	101	506	0	6	0

Total **5,846**

Assumptions-

1) V - is extracted from HEC-RAS (channel velocity) and assumed to remain relatively unchanged between different flow rates.
2) Yh and W, the hydraulic depth and flow width, were iterated based on a linear ratio of the values determend in the HEC-RAS model.

UNSTEADY FLOW SEDIMENT YIELD: ZELLER AND FULLERTON EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 165+20
Storm Frequency: 50-Year
Date 19-Nov

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Zeller and Fullerton Equation-

$$q_s = 0.0064 * (n^{\wedge 1.77} * V^{\wedge 4.32} * G^{\wedge 0.45}) / (Y_h{}^{\wedge 0.30} * D_{50}{}^{\wedge 0.61})$$

where:
q_s = Sediment transport rate (cfs / unit width)
n = Manning's roughness coefficient
V = Mean velocity (ft/s)
G = Gradation coefficient
Y_h = Hydraulic depth (ft)
D_{50} = Median diameter (mm)
ρ = Particle Density (lb/ft^3)

HEC-RAS Channel XC Data

In the above equation, the gradation coefficient is given by:

$$G = 1/2\ (D_{84.1} / D_{50} + D_{50} / D_{15.9})$$

Q (ft^3/ s)	n	V (ft / s)	$D_{15.9}$ (mm)	D_{50} (mm)	$D_{84.1}$ (mm)	G	Y_h (ft)	q_s (ft^3/ s/ ft)	Width (ft)	Q_s (ft^3/ s)	Q_s (ft^3/ hr)	ρ (lb/ft^3)	Q_s (lb/ hr)	Q_s (tons/ hr)	Q_s (tons/ day)	Q_s (tons/(5-min))
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	101	506	0	6	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	15	101	1,562	1	19	0
1.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	25	101	2,538	1	30	0
1.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	39	101	3,977	2	48	0
3.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	57	101	5,729	3	69	0
5.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	0	0	78	101	7,830	4	94	0
7.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	101	101	10,205	5	122	0
10.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	128	101	12,897	6	155	1
13.7	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	157	101	15,856	8	190	1
17.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	189	101	19,045	10	229	1
22.6	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	223	101	22,509	11	270	1
28.7	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	263	101	26,607	13	319	1
36.7	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	313	101	31,604	16	379	1
47.2	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	373	101	37,691	19	452	2
61.2	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	448	101	45,207	23	542	2
80.6	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	8	0	543	101	54,816	27	658	2
107.3	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	11	0	663	101	66,972	33	804	3
144.3	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	14	0	816	101	82,407	41	989	3

196.9	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	19	0	1,014	101	102,435	51	1,229	4
270.3	0.03	2.50	0.05	0.07	0.6	5.0	0.12	0.01	26	0	1,266	101	127,870	64	1,534	5
367.0	0.03	2.50	0.05	0.07	0.6	5.0	0.16	0.01	36	0	1,568	101	158,395	79	1,901	7
491.2	0.03	2.50	0.05	0.07	0.6	5.0	0.22	0.01	48	1	1,923	101	194,248	97	2,331	8
649.0	0.03	3.40	0.05	0.07	0.6	5.0	0.29	0.04	64	2	8,823	101	891,118	446	10,693	37
838.0	0.03	3.40	0.05	0.07	0.6	5.0	0.38	0.04	82	3	10,551	101	1,065,700	533	12,788	44
1046.3	0.03	3.60	0.05	0.07	0.6	5.0	0.47	0.04	103	4	15,778	101	1,593,534	797	19,122	66
1259.9	0.03	3.60	0.05	0.07	0.6	5.0	0.56	0.04	123	5	17,969	101	1,814,835	907	21,778	76
1467.9	0.03	3.60	0.05	0.07	0.6	5.0	0.66	0.04	144	6	19,997	101	2,019,712	1,010	24,237	84
1655.9	0.03	3.60	0.05	0.07	0.6	5.0	0.74	0.04	162	6	21,757	101	2,197,484	1,099	26,370	92
1805.2	0.03	3.60	0.05	0.07	0.6	5.0	0.81	0.04	177	6	23,113	101	2,334,370	1,167	28,012	97
1908.7	0.03	3.60	0.05	0.07	0.6	5.0	0.86	0.04	187	7	24,032	101	2,427,271	1,214	29,127	101
1971.8	0.03	3.60	0.05	0.07	0.6	5.0	0.88	0.04	193	7	24,586	101	2,483,167	1,242	29,798	103
2003.6	0.03	4.70	0.05	0.07	0.6	5.0	0.90	0.11	196	22	78,665	101	7,945,213	3,973	95,343	331
2010.8	0.03	4.70	0.05	0.07	0.6	5.0	0.90	0.11	197	22	78,863	101	7,965,189	3,983	95,582	332
2000.1	0.03	4.70	0.05	0.07	0.6	5.0	0.90	0.11	196	22	78,569	101	7,935,495	3,968	95,226	331
1980.1	0.03	3.60	0.05	0.07	0.6	5.0	0.89	0.04	194	7	24,658	101	2,490,479	1,245	29,886	104
1953.9	0.03	3.60	0.05	0.07	0.6	5.0	0.88	0.04	191	7	24,429	101	2,467,366	1,234	29,608	103
1917.0	0.03	3.60	0.05	0.07	0.6	5.0	0.86	0.04	188	7	24,105	101	2,434,655	1,217	29,216	101
1868.9	0.03	3.60	0.05	0.07	0.6	5.0	0.84	0.04	183	7	23,680	101	2,391,730	1,196	28,701	100
1815.3	0.03	3.60	0.05	0.07	0.6	5.0	0.81	0.04	178	6	23,203	101	2,343,505	1,172	28,122	98
1754.7	0.03	3.60	0.05	0.07	0.6	5.0	0.79	0.04	172	6	22,658	101	2,288,463	1,144	27,462	95
1683.2	0.03	3.60	0.05	0.07	0.6	5.0	0.75	0.04	165	6	22,008	101	2,222,782	1,111	26,673	93
1604.8	0.03	3.60	0.05	0.07	0.6	5.0	0.72	0.04	157	6	21,285	101	2,149,793	1,075	25,798	90
1523.3	0.03	3.60	0.05	0.07	0.6	5.0	0.68	0.04	149	6	20,523	101	2,072,773	1,036	24,873	86
1442.1	0.03	3.60	0.05	0.07	0.6	5.0	0.65	0.04	141	5	19,750	101	1,994,797	997	23,938	83
1365.2	0.03	3.60	0.05	0.07	0.6	5.0	0.61	0.04	134	5	19,007	101	1,919,726	960	23,037	80
1294.0	0.03	3.60	0.05	0.07	0.6	5.0	0.58	0.04	127	5	18,308	101	1,849,081	925	22,189	77
1228.1	0.03	3.60	0.05	0.07	0.6	5.0	0.55	0.04	120	5	17,650	101	1,782,648	891	21,392	74
1166.8	0.03	3.60	0.05	0.07	0.6	5.0	0.52	0.04	114	5	17,029	101	1,719,885	860	20,639	72
1107.1	0.03	3.60	0.05	0.07	0.6	5.0	0.50	0.04	108	5	16,414	101	1,657,802	829	19,894	69
1047.0	0.03	3.60	0.05	0.07	0.6	5.0	0.47	0.04	103	4	15,785	101	1,594,280	797	19,131	66
988.0	0.03	3.40	0.05	0.07	0.6	5.0	0.44	0.03	97	3	11,841	101	1,195,897	598	14,351	50
928.9	0.03	3.40	0.05	0.07	0.6	5.0	0.42	0.03	91	3	11,340	101	1,145,361	573	13,744	48
868.9	0.03	3.40	0.05	0.07	0.6	5.0	0.39	0.04	85	3	10,822	101	1,093,057	547	13,117	46
807.6	0.03	3.40	0.05	0.07	0.6	5.0	0.36	0.04	79	3	10,282	101	1,038,488	519	12,462	43
746.2	0.03	3.40	0.05	0.07	0.6	5.0	0.33	0.04	73	3	9,728	101	982,568	491	11,791	41
689.3	0.03	3.40	0.05	0.07	0.6	5.0	0.31	0.04	68	3	9,203	101	929,501	465	11,154	39
637.7	0.03	3.40	0.05	0.07	0.6	5.0	0.29	0.04	62	2	8,715	101	880,229	440	10,563	37
589.5	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	58	2	8,249	101	833,111	417	9,997	35
545.8	0.03	3.40	0.05	0.07	0.6	5.0	0.24	0.04	53	2	7,816	101	789,383	395	9,473	33
506.2	0.03	3.40	0.05	0.07	0.6	5.0	0.23	0.04	50	2	7,414	101	748,841	374	8,986	31
468.0	0.03	2.50	0.05	0.07	0.6	5.0	0.21	0.01	46	1	1,859	101	187,779	94	2,253	8
430.7	0.03	2.50	0.05	0.07	0.6	5.0	0.19	0.01	42	0	1,754	101	177,173	89	2,126	7
395.6	0.03	2.50	0.05	0.07	0.6	5.0	0.18	0.01	39	0	1,653	101	166,938	83	2,003	7
363.3	0.03	2.50	0.05	0.07	0.6	5.0	0.16	0.01	36	0	1,557	101	157,276	79	1,887	7
333.7	0.03	2.50	0.05	0.07	0.6	5.0	0.15	0.01	33	0	1,467	101	148,192	74	1,778	6
306.5	0.03	2.50	0.05	0.07	0.6	5.0	0.14	0.01	30	0	1,382	101	139,630	70	1,676	6
281.5	0.03	2.50	0.05	0.07	0.6	5.0	0.13	0.01	28	0	1,303	101	131,556	66	1,579	5
258.6	0.03	2.50	0.05	0.07	0.6	5.0	0.12	0.01	25	0	1,227	101	123,970	62	1,488	5
237.5	0.03	2.50	0.05	0.07	0.6	5.0	0.11	0.01	23	0	1,156	101	116,799	58	1,402	5
218.2	0.03	2.50	0.05	0.07	0.6	5.0	0.10	0.01	21	0	1,090	101	110,071	55	1,321	5
200.4	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	20	0	1,027	101	103,706	52	1,244	4
184.1	0.03	2.50	0.05	0.07	0.6	5.0	0.08	0.01	18	0	968	101	97,727	49	1,173	4
169.0	0.03	2.50	0.05	0.07	0.6	5.0	0.08	0.02	17	0	911	101	92,044	46	1,105	4
155.2	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	15	0	859	101	86,716	43	1,041	4
142.5	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	14	0	809	101	81,686	41	980	3
130.7	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	13	0	761	101	76,890	38	923	3
119.9	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	12	0	717	101	72,385	36	869	3

109.8	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	11	0	674	101	68,061	34	817	3
100.4	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	10	0	633	101	63,928	32	767	3
91.6	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	9	0	594	101	59,952	30	719	2
83.5	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	8	0	556	101	56,190	28	674	2
76.0	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	521	101	52,607	26	631	2
68.9	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	486	101	49,117	25	589	2
62.4	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	454	101	45,825	23	550	2
56.6	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	424	101	42,800	21	514	2
50.9	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	393	101	39,735	20	477	2
45.8	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	365	101	36,905	18	443	2
41.0	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	338	101	34,153	17	410	1
36.6	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	312	101	31,544	16	379	1
32.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	287	101	28,964	14	348	1
28.6	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	263	101	26,542	13	319	1
25.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	243	101	24,494	12	294	1
22.6	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	223	101	22,509	11	270	1
20.0	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	205	101	20,663	10	248	1
17.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	189	101	19,045	10	229	1
16.0	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	175	101	17,675	9	212	1
14.3	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	162	101	16,338	8	196	1
12.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	150	101	15,119	8	181	1
11.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	139	101	14,027	7	168	1
10.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	129	101	13,074	7	157	1
9.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	120	101	12,090	6	145	1
8.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	111	101	11,164	6	134	0
7.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	101	101	10,205	5	122	0
6.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	94	101	9,509	5	114	0
5.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	86	101	8,687	4	104	0
5.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	0	0	79	101	7,939	4	95	0
4.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	71	102	7,231	4	87	0
3.7	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	63	103	6,467	3	78	0
3.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	57	104	5,899	3	71	0
2.7	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	50	105	5,288	3	63	0
2.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	44	106	4,625	2	56	0
1.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	39	107	4,214	2	51	0
1.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	35	108	3,771	2	45	0
1.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	30	109	3,291	2	39	0
1.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	25	110	2,764	1	33	0
0.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	23	111	2,591	1	31	0
0.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	21	112	2,407	1	29	0
0.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	18	113	1,986	1	24	0
0.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	18	114	2,003	1	24	0
0.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	15	115	1,779	1	21	0
0.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	13	116	1,535	1	18	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	117	1,266	1	15	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	118	1,277	1	15	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	119	1,287	1	15	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	120	977	0	12	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	121	986	0	12	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	122	612	0	7	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	123	617	0	7	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	124	622	0	7	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0										

Total **3,655**

Assumptions-

1) V - is extracted from HEC-RAS (channel velocity) and assumed to remain relatively unchanged between different flow rates.
2) Yh and W, the hydraulic depth and flow width, were iterated based on a linear ratio of the values determend in the HEC-RAS model.

UNSTEADY FLOW SEDIMENT YIELD: ZELLER AND FULLERTON EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 165+20
Storm Frequency: 25-Year
Date 19-Nov

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Zeller and Fullerton Equation-

$$q_s = 0.0064 * (n^{\wedge 1.77} * V^{\wedge 4.32} * G^{\wedge 0.45}) / (Y_h{}^{\wedge 0.30} * D_{50}{}^{\wedge 0.61})$$

where:

q_s = Sediment transport rate (cfs / unit width)
n = Manning's roughness coefficient
V = Mean velocity (ft/s)
G = Gradation coefficient
Y_h = Hydraulic depth (ft)
D_{50} = Median diameter (mm)
ρ = Particle Density (lb/ft³)

HEC-RAS Channel XC Data

In the above equation, the gradation coefficient is given by:

$$G = 1/2\ (D_{84.1} / D_{50} + D_{50} / D_{15.9})$$

Q (ft^3/s)	n	V (ft / s)	$D_{15.9}$ (mm)	D_{50} (mm)	$D_{84.1}$ (mm)	G	Y_h (ft)	q_s ($ft^3/s/ft$)	Width (ft)	Q_s (ft^3/s)	Q_s (ft^3/hr)	ρ (lb/ft^3)	Q_s (lb/ hr)	Q_s (tons/ hr)	Q_s (tons/ day)	Q_s (tons/(5-min))
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	101	506	0	6	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	13	101	1,336	1	16	0
0.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	23	101	2,357	1	28	0
1.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	35	101	3,527	2	42	0
2.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	52	101	5,218	3	63	0
4.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	71	101	7,160	4	86	0
6.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	94	101	9,509	5	114	0
9.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	121	101	12,181	6	146	1
13.2	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	153	101	15,448	8	185	1
18.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	193	101	19,492	10	234	1
25.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	242	101	24,426	12	293	1
35.1	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	3	0	303	101	30,633	15	368	1
49.0	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	383	101	38,691	19	464	2
69.1	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	487	101	49,216	25	591	2
97.6	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	10	0	621	101	62,674	31	752	3
137.9	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	14	0	790	101	79,831	40	958	3
193.9	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	19	0	1,003	101	101,340	51	1,216	4
269.1	0.03	2.50	0.05	0.07	0.6	5.0	0.12	0.01	26	0	1,262	101	127,472	64	1,530	5

368.1	0.03	2.50	0.05	0.07	0.6	5.0	0.17	0.01	36	0	1,572	101	158,727	79	1,905	7
495.9	0.03	2.50	0.05	0.07	0.6	5.0	0.22	0.01	49	1	1,936	101	195,547	98	2,347	8
650.7	0.03	3.40	0.05	0.07	0.6	5.0	0.29	0.04	64	2	8,839	101	892,752	446	10,713	37
823.8	0.03	3.40	0.05	0.07	0.6	5.0	0.37	0.04	81	3	10,426	101	1,053,026	527	12,636	44
1004.5	0.03	3.40	0.05	0.07	0.6	5.0	0.45	0.03	98	3	11,979	101	1,209,843	605	14,518	50
1182.3	0.03	3.60	0.05	0.07	0.6	5.0	0.53	0.04	116	5	17,187	101	1,735,846	868	20,830	72
1342.8	0.03	3.60	0.05	0.07	0.6	5.0	0.60	0.04	132	5	18,788	101	1,897,623	949	22,771	79
1469.5	0.03	3.60	0.05	0.07	0.6	5.0	0.66	0.04	144	6	20,012	101	2,021,253	1,011	24,255	84
1556.7	0.03	3.60	0.05	0.07	0.6	5.0	0.70	0.04	153	6	20,836	101	2,104,483	1,052	25,254	88
1609.1	0.03	3.60	0.05	0.07	0.6	5.0	0.72	0.04	158	6	21,325	101	2,153,823	1,077	25,846	90
1634.8	0.03	3.60	0.05	0.07	0.6	5.0	0.73	0.04	160	6	21,563	101	2,177,846	1,089	26,134	91
1641.3	0.03	3.60	0.05	0.07	0.6	5.0	0.74	0.04	161	6	21,623	101	2,183,904	1,092	26,207	91
1634.1	0.03	3.60	0.05	0.07	0.6	5.0	0.73	0.04	160	6	21,556	101	2,177,193	1,089	26,126	91
1619.1	0.03	3.60	0.05	0.07	0.6	5.0	0.73	0.04	159	6	21,418	101	2,163,184	1,082	25,958	90
1598.7	0.03	3.60	0.05	0.07	0.6	5.0	0.72	0.04	157	6	21,228	101	2,144,069	1,072	25,729	89
1569.6	0.03	3.60	0.05	0.07	0.6	5.0	0.70	0.04	154	6	20,957	101	2,116,675	1,058	25,400	88
1530.3	0.03	3.60	0.05	0.07	0.6	5.0	0.69	0.04	150	6	20,588	101	2,079,436	1,040	24,953	87
1485.7	0.03	3.60	0.05	0.07	0.6	5.0	0.67	0.04	146	6	20,167	101	2,036,825	1,018	24,442	85
1434.4	0.03	3.60	0.05	0.07	0.6	5.0	0.64	0.04	141	5	19,677	101	1,987,335	994	23,848	83
1374.0	0.03	3.60	0.05	0.07	0.6	5.0	0.62	0.04	135	5	19,093	101	1,928,380	964	23,141	80
1308.4	0.03	3.60	0.05	0.07	0.6	5.0	0.59	0.04	128	5	18,450	101	1,863,461	932	22,362	78
1241.0	0.03	3.60	0.05	0.07	0.6	5.0	0.56	0.04	122	5	17,780	101	1,795,735	898	21,549	75
1176.3	0.03	3.60	0.05	0.07	0.6	5.0	0.53	0.04	115	5	17,125	101	1,729,675	865	20,756	72
1117.0	0.03	3.60	0.05	0.07	0.6	5.0	0.50	0.04	109	5	16,516	101	1,668,165	834	20,018	70
1061.0	0.03	3.60	0.05	0.07	0.6	5.0	0.48	0.04	104	4	15,932	101	1,609,173	805	19,310	67
1006.6	0.03	3.60	0.05	0.07	0.6	5.0	0.45	0.04	99	4	15,356	101	1,550,964	775	18,612	65
955.9	0.03	3.60	0.05	0.07	0.6	5.0	0.43	0.04	94	4	14,810	101	1,495,859	748	17,950	62
908.1	0.03	3.60	0.05	0.07	0.6	5.0	0.41	0.04	89	4	14,288	101	1,443,097	722	17,317	60
860.0	0.03	3.60	0.05	0.07	0.6	5.0	0.39	0.05	84	4	13,754	101	1,389,155	695	16,670	58
811.3	0.03	3.60	0.05	0.07	0.6	5.0	0.36	0.05	79	4	13,204	101	1,333,610	667	16,003	56
762.4	0.03	3.60	0.05	0.07	0.6	5.0	0.34	0.05	75	4	12,642	101	1,276,821	638	15,322	53
712.6	0.03	3.60	0.05	0.07	0.6	5.0	0.32	0.05	70	3	12,058	101	1,217,851	609	14,614	51
661.6	0.03	3.60	0.05	0.07	0.6	5.0	0.30	0.05	65	3	11,447	101	1,156,162	578	13,874	48
611.2	0.03	3.60	0.05	0.07	0.6	5.0	0.27	0.05	60	3	10,830	101	1,093,781	547	13,125	46
563.9	0.03	3.60	0.05	0.07	0.6	5.0	0.25	0.05	55	3	10,236	101	1,033,816	517	12,406	43
521.5	0.03	3.40	0.05	0.07	0.6	5.0	0.23	0.04	51	2	7,570	101	764,614	382	9,175	32
483.2	0.03	3.40	0.05	0.07	0.6	5.0	0.22	0.04	47	2	7,177	101	724,858	362	8,698	30
447.4	0.03	3.40	0.05	0.07	0.6	5.0	0.20	0.04	44	2	6,800	101	686,833	343	8,242	29
413.9	0.03	3.40	0.05	0.07	0.6	5.0	0.19	0.04	41	2	6,440	101	650,415	325	7,805	27
382.3	0.03	3.40	0.05	0.07	0.6	5.0	0.17	0.05	37	2	6,092	101	615,244	308	7,383	26
351.7	0.03	3.40	0.05	0.07	0.6	5.0	0.16	0.05	34	2	5,746	101	580,343	290	6,964	24
323.0	0.03	3.40	0.05	0.07	0.6	5.0	0.14	0.05	32	2	5,414	101	546,771	273	6,561	23
296.6	0.03	3.40	0.05	0.07	0.6	5.0	0.13	0.05	29	1	5,100	101	515,091	258	6,181	21
272.4	0.03	3.40	0.05	0.07	0.6	5.0	0.12	0.05	27	1	4,805	101	485,299	243	5,824	20
250.1	0.03	2.50	0.05	0.07	0.6	5.0	0.11	0.01	25	0	1,199	101	121,103	61	1,453	5
229.7	0.03	2.50	0.05	0.07	0.6	5.0	0.10	0.01	23	0	1,130	101	114,101	57	1,369	5
210.9	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	21	0	1,064	101	107,480	54	1,290	4
193.7	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	19	0	1,003	101	101,267	51	1,215	4
177.9	0.03	2.50	0.05	0.07	0.6	5.0	0.08	0.02	17	0	945	101	95,411	48	1,145	4
163.4	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	16	0	890	101	89,898	45	1,079	4
150.0	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	15	0	838	101	84,672	42	1,016	4
137.8	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	13	0	790	101	79,790	40	957	3
126.5	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	12	0	744	101	75,152	38	902	3
116.1	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	11	0	701	101	70,772	35	849	3
106.5	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	10	0	660	101	66,622	33	799	3
97.7	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	10	0	621	101	62,719	31	753	3
89.5	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	9	0	584	101	58,986	29	708	2
81.8	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	8	0	548	101	55,386	28	665	2
74.7	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	515	101	51,976	26	624	2

68.0	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	482	101	48,667	24	584	2
61.8	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	451	101	45,516	23	546	2
56.0	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	5	0	421	101	42,482	21	510	2
50.8	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	393	101	39,681	20	476	2
46.1	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	367	101	37,074	19	445	2
41.5	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	341	101	34,444	17	413	1
37.2	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	316	101	31,905	16	383	1
33.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.02	3	0	293	101	29,587	15	355	1
29.7	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	270	101	27,252	14	327	1
26.3	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	248	101	25,029	13	300	1
23.2	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	227	101	22,925	11	275	1
20.6	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	209	101	21,095	11	253	1
18.2	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	192	101	19,343	10	232	1
16.1	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	176	101	17,752	9	213	1
14.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	163	101	16,418	8	197	1
12.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	150	101	15,119	8	181	1
11.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	138	101	13,941	7	167	1
10.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	129	101	12,986	6	156	1
9.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	119	101	11,999	6	144	0
8.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	110	101	11,070	6	133	0
7.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	102	101	10,302	5	124	0
6.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	94	101	9,509	5	114	0
5.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	86	101	8,687	4	104	0
5.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	80	101	8,048	4	97	0
4.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	73	101	7,386	4	89	0
4.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	67	101	6,814	3	82	0
3.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	60	101	6,100	3	73	0
3.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	54	101	5,476	3	66	0
2.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	49	101	4,954	2	59	0
2.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	44	102	4,451	2	53	0
1.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	38	103	3,906	2	47	0
1.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	33	104	3,471	2	42	0
1.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	29	105	2,998	1	36	0
1.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	25	106	2,664	1	32	0
0.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	21	107	2,300	1	28	0
0.7	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	20	108	2,114	1	25	0
0.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	18	109	1,916	1	23	0
0.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	15	110	1,701	1	20	0
0.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	13	111	1,469	1	18	0
0.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	13	112	1,482	1	18	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	113	1,222	1	15	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	114	1,233	1	15	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	115	937	0	11	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	116	945	0	11	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	117	953	0	11	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	118	592	0	7	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	119	597	0	7	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	120	602	0	7	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	121	607	0	7	0

Total 2,671

Assumptions-

1) V - is extracted from HEC-RAS (channel velocity) and assumed to remain relatively unchanged between different flow rates.
2) Yh and W, the hydraulic depth and flow width, were iterated based on a linear ratio of the values determend in the HEC-RAS model.

UNSTEADY FLOW SEDIMENT YIELD: ZELLER AND FULLERTON EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 165+20
Storm Frequency: 2-Year
Date 19-Nov

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Zeller and Fullerton Equation-

$$q_s = 0.0064 * (n^{\wedge 1.77} * V^{\wedge 4.32} * G^{\wedge 0.45}) / (Y_h{}^{\wedge 0.30} * D_{50}{}^{\wedge 0.61})$$

where:

q_s = Sediment transport rate (cfs / unit width)
n = Manning's roughness coefficient
V = Mean velocity (ft/s)
G = Gradation coefficient
Y_h = Hydraulic depth (ft)
D_{50} = Median diameter (mm)
ρ = Particle Density (lb/ft^3)

HEC-RAS Channel XC Data

In the above equation, the gradation coefficient is given by:

$$G = 1/2\ (D_{84.1} / D_{50} + D_{50} / D_{15.9})$$

Q (ft^3/s)	n	V (ft / s)	$D_{15.9}$ (mm)	D_{50} (mm)	$D_{84.1}$ (mm)	G	Y_h (ft)	q_s ($ft^2/s/ft$)	Width (ft)	Q_s (ft^3/s)	Q_s (ft^3/hr)	ρ (lb/ft^3)	Q_s (lb/ hr)	Q_s (tons/ hr)	Q_s (tons/ day)	Q_s (tons/(5-min))
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	23	101	2,357	1	28	0
2.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	46	101	4,684	2	56	0
5.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	82	101	8,263	4	99	0
11.9	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	142	101	14,367	7	172	1
23.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	229	101	23,133	12	278	1
42.1	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	344	101	34,792	17	417	1
69.7	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	490	101	49,515	25	594	2
109.1	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	11	0	671	101	67,757	34	813	3
160.7	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	16	0	880	101	88,856	44	1,066	4
222.4	0.03	2.50	0.05	0.07	0.6	5.0	0.10	0.01	22	0	1,104	101	111,550	56	1,339	5
291.0	0.03	2.50	0.05	0.07	0.6	5.0	0.13	0.01	29	0	1,333	101	134,648	67	1,616	6
362.1	0.03	2.50	0.05	0.07	0.6	5.0	0.16	0.01	35	0	1,554	101	156,912	78	1,883	7
429.9	0.03	2.50	0.05	0.07	0.6	5.0	0.19	0.01	42	0	1,752	101	176,943	88	2,123	7
488.0	0.03	2.50	0.05	0.07	0.6	5.0	0.22	0.01	48	1	1,914	101	193,361	97	2,320	8
533.6	0.03	3.40	0.05	0.07	0.6	5.0	0.24	0.04	52	2	7,693	101	776,989	388	9,324	32
565.5	0.03	3.40	0.05	0.07	0.6	5.0	0.25	0.04	55	2	8,012	101	809,220	405	9,711	34
583.8	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	57	2	8,193	101	827,464	414	9,930	34
590.6	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	58	2	8,259	101	834,199	417	10,010	35

589.0	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	58	2	8,244	101	832,616	416	9,991	35
583.1	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	57	2	8,186	101	826,769	413	9,921	34
574.6	0.03	3.40	0.05	0.07	0.6	5.0	0.26	0.04	56	2	8,102	101	818,314	409	9,820	34
563.0	0.03	3.40	0.05	0.07	0.6	5.0	0.25	0.04	55	2	7,987	101	806,715	403	9,681	34
548.5	0.03	3.40	0.05	0.07	0.6	5.0	0.25	0.04	54	2	7,843	101	792,114	396	9,505	33
532.3	0.03	3.40	0.05	0.07	0.6	5.0	0.24	0.04	52	2	7,680	101	775,664	388	9,308	32
514.2	0.03	3.40	0.05	0.07	0.6	5.0	0.23	0.04	50	2	7,496	101	757,106	379	9,085	32
493.3	0.03	2.50	0.05	0.07	0.6	5.0	0.22	0.01	48	1	1,929	101	194,829	97	2,338	8
470.5	0.03	2.50	0.05	0.07	0.6	5.0	0.21	0.01	46	1	1,866	101	188,481	94	2,262	8
447.1	0.03	2.50	0.05	0.07	0.6	5.0	0.20	0.01	44	1	1,801	101	181,889	91	2,182	8
424.3	0.03	2.50	0.05	0.07	0.6	5.0	0.19	0.01	42	0	1,736	101	175,326	88	2,104	7
403.0	0.03	2.50	0.05	0.07	0.6	5.0	0.18	0.01	39	0	1,674	101	169,118	85	2,029	7
383.5	0.03	2.50	0.05	0.07	0.6	5.0	0.17	0.01	38	0	1,617	101	163,347	82	1,960	7
365.1	0.03	2.50	0.05	0.07	0.6	5.0	0.16	0.01	36	0	1,563	101	157,821	79	1,894	7
347.8	0.03	2.50	0.05	0.07	0.6	5.0	0.16	0.01	34	0	1,510	101	152,548	76	1,831	6
331.5	0.03	2.50	0.05	0.07	0.6	5.0	0.15	0.01	32	0	1,460	101	147,508	74	1,770	6
314.9	0.03	2.50	0.05	0.07	0.6	5.0	0.14	0.01	31	0	1,409	101	142,297	71	1,708	6
298.0	0.03	2.50	0.05	0.07	0.6	5.0	0.13	0.01	29	0	1,356	101	136,908	68	1,643	6
281.2	0.03	2.50	0.05	0.07	0.6	5.0	0.13	0.01	28	0	1,302	101	131,458	66	1,577	5
263.3	0.03	2.50	0.05	0.07	0.6	5.0	0.12	0.01	26	0	1,243	101	125,543	63	1,507	5
244.7	0.03	2.50	0.05	0.07	0.6	5.0	0.11	0.01	24	0	1,181	101	119,267	60	1,431	5
226.4	0.03	2.50	0.05	0.07	0.6	5.0	0.10	0.01	22	0	1,118	101	112,951	56	1,355	5
208.6	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	20	0	1,056	101	106,659	53	1,280	4
192.0	0.03	2.50	0.05	0.07	0.6	5.0	0.09	0.01	19	0	996	101	100,644	50	1,208	4
177.4	0.03	2.50	0.05	0.07	0.6	5.0	0.08	0.02	17	0	943	101	95,223	48	1,143	4
163.7	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	16	0	891	101	90,014	45	1,080	4
151.0	0.03	2.50	0.05	0.07	0.6	5.0	0.07	0.02	15	0	842	101	85,067	43	1,021	4
139.3	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	14	0	796	101	80,397	40	965	3
128.1	0.03	2.50	0.05	0.07	0.6	5.0	0.06	0.02	13	0	751	101	75,816	38	910	3
117.5	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	12	0	707	101	71,368	36	856	3
107.8	0.03	2.50	0.05	0.07	0.6	5.0	0.05	0.02	11	0	665	101	67,191	34	806	3
98.9	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	10	0	626	101	63,258	32	759	3
90.7	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	9	0	589	101	59,539	30	714	2
83.2	0.03	2.50	0.05	0.07	0.6	5.0	0.04	0.02	8	0	555	101	56,048	28	673	2
76.3	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	522	101	52,753	26	633	2
70.0	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	7	0	492	101	49,684	25	596	2
64.2	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	463	101	46,747	23	561	2
58.9	0.03	2.50	0.05	0.07	0.6	5.0	0.03	0.02	6	0	436	101	44,011	22	528	2
54.0	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	410	101	41,414	21	497	2
49.5	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	5	0	386	101	38,967	19	468	2
45.4	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	363	101	36,679	18	440	2
41.7	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	342	101	34,560	17	415	1
38.2	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	4	0	322	101	32,503	16	390	1
35.0	0.03	2.50	0.05	0.07	0.6	5.0	0.02	0.02	3	0	303	101	30,572	15	367	1
32.1	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	285	101	28,776	14	345	1
29.3	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	267	101	26,995	13	324	1
26.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	3	0	251	101	25,361	13	304	1
24.4	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	235	101	23,749	12	285	1
22.2	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	220	101	22,229	11	267	1
20.1	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	205	101	20,735	10	249	1
18.2	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	192	101	19,343	10	232	1
16.5	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	2	0	179	101	18,060	9	217	1
14.8	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	166	101	16,736	8	201	1
13.3	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	154	101	15,530	8	186	1
11.9	0.03	2.50	0.05	0.07	0.6	5.0	0.01	0.03	1	0	142	101	14,367	7	172	1
10.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	131	101	13,249	7	159	1
9.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	120	101	12,090	6	145	1
8.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	109	101	10,975	5	132	0
7.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	100	101	10,107	5	121	0

6.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	91	101	9,205	5	110	0
5.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	1	0	83	101	8,370	4	100	0
4.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.04	0	0	76	101	7,720	4	93	0
4.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	70	101	7,045	4	85	0
3.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	64	101	6,461	3	78	0
3.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	58	101	5,854	3	70	0
2.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	53	101	5,348	3	64	0
2.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.05	0	0	49	101	4,954	2	59	0
2.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	45	101	4,547	2	55	0
2.0	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	41	101	4,123	2	49	0
1.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	38	101	3,830	2	46	0
1.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	35	101	3,527	2	42	0
1.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.06	0	0	32	101	3,212	2	39	0
1.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	29	101	2,883	1	35	0
1.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	27	101	2,713	1	33	0
0.9	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.07	0	0	23	101	2,357	1	28	0
0.8	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	21	101	2,171	1	26	0
0.7	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	20	101	1,977	1	24	0
0.6	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.08	0	0	18	101	1,775	1	21	0
0.5	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	15	101	1,562	1	19	0
0.4	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.09	0	0	13	101	1,336	1	16	0
0.3	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.10	0	0	11	101	1,093	1	13	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.2	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.12	0	0	8	101	823	0	10	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	101	506	0	6	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	101	506	0	6	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	101	506	0	6	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	102	511	0	6	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	103	516	0	6	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	104	521	0	6	0
0.1	0.03	2.50	0.05	0.07	0.6	5.0	0.00	0.14	0	0	5	105	526	0	6	0
															Total	**582**

Assumptions-

1) V - is extracted from HEC-RAS (channel velocity) and assumed to remain relatively unchanged between different flow rates.
2) Yh and W, the hydraulic depth and flow width, were iterated based on a linear ratio of the values determend in the HEC-RAS model.

SEDIMENT YIELD: ZELLER AND FULLERTON EQUATION

Project: Horseshoe Draw
Prepared by: JM
Cross Section: 128+56

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Date: 11/19/2015

Zeller and Fullerton Equation-

$$q_s = 0.0064 * (n^{1.77} * V^{4.32} * G^{0.45}) / (Y_h^{0.30} * D_{50}^{0.61})$$

where:

q_s = Sediment transport rate (cfs / unit width)
n = Manning's roughness coefficient
V = Mean velocity (ft/s)
G = Gradation coefficient
Y_h = Hydraulic depth (ft)
D_{50} = Median diameter (mm)
ρ = Particle Density (lb/ft^3)

HEC-RAS Channel XC Data

In the above equation, the gradation coefficient is given by:

$$G = 1/2\ (D_{84.1} / D_{50} + D_{50} / D_{15.9})$$

Q (ft³/s)	n	V (ft/s)	$D_{15.9}$ (mm)	D_{50} (mm)	$D_{84.1}$ (mm)	G	Y_h (ft)	q_s (ft³/s/ft)	Width (ft)	Q_s (ft³/s)	Q_s (ft³/hr)	ρ (lb/ft³)	Q_s (lb/hr)	Q_s (tons/hr)
4,780	0.03	6.1	0.05	0.07	0.6	5.0	1.2	0.32	685	220	791,833	101	79,975,182	39,988
4,006	0.03	5.8	0.05	0.07	0.6	5.0	1.0	0.27	657	178	639,143	101	64,553,458	32,277
3,256	0.03	5.5	0.05	0.07	0.6	5.0	0.9	0.22	640	144	517,529	101	52,270,394	26,135
2,368	0.03	5.0	0.05	0.07	0.6	5.0	0.8	0.16	597	93	336,233	101	33,959,564	16,980
1,154	0.03	4.4	0.05	0.07	0.6	5.0	0.6	0.10	466	45	160,262	101	16,186,473	8,093

Assumptions-

1) V - is extracted from HEC-RAS (channel velocity)
2) Q - is for the 2-yr, 10-yr, 25-yr, 50-yr and 100-year storm events

APPENDIX D
GEOTECHNICAL EVALUATION
EXCERPTS

GEOTECHNICAL EVALUATION
HORSESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PREPARED FOR:
HILGARTWILSON, LLC.
2141 East Highland Avenue, Suite 250
Phoenix, Arizona 85016

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

October 30, 2015
Project No. 604915001

October 30, 2015
Project No. 604915001

Mr. Brian Brockman
HILGARTWILSON, LLC
2141 East Highland Avenue, Suite 250
Phoenix, Arizona 85016

Subject: Geotechnical Evaluation
Horseshoe Draw Basin
Cochise County, Arizona

Dear Mr. Brockman:

In accordance with our proposal dated August 28, 2015 and your authorization dated September 11, 2015, Ninyo & Moore has performed a geotechnical evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO.
43704
MAREK J.
KASZTALSKI
Date Signed 10.30.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer

Steven D. Nowaczyk, PE
Managing Principal Engineer

MJK/SDN/tlp

Distribution: (1) Addressee (Electronic Copy)

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4. PROPOSED CONSTRUCTION

We understand the project includes the design and construct of a detention basin measuring about 13 acre-feet in size. We further understand that the new fill embankment associated with this project does not constitute a jurisdictional dam. The conceptual design drawings provided by HilgartWilson call for the construction of an unlined earthen embankment along the northern boundary of the future detention basin across the Horseshoe Draw Wash. Based on the available information, we understand that fill embankment will be up to about 36 feet in height (in the area of the principal spillway), with planned 3 horizontal to 1 vertical (H:V) side slopes and approximately 12-foot wide crest. However, at the time of writing this report, we had not review cross-sections along the embankment and across the basin.

The basin will be fed by the Horseshoe Draw which is oriented generally in a south-east to north-west direction. It is understood that the basin will drain through the berm by mans of a principal outlet, which will consist of a pipe or box culvert. It will outfall into a concrete apron that will transition to the wash. The basin will also have an emergency spillway near the east end on the new fill embankment. We further understand that the new fill embankment will not be lined except at the emergency spillway, which may be lined with grouted rock. We were not provided with any hydraulic information at the time of writing this report that is related to the project, such as the peak water elevation, hydrograph or the total basin impoundment time.

5. FIELD EXPLORATION AND LABORATORY TESTING

On October 7, 2014, Ninyo & Moore conducted a subsurface evaluation at the site in order to assess the existing subsurface conditions and to collect soil samples for laboratory testing. Our evaluation consisted of the drilling, logging, and sampling of six borings, denoted as B-1 through B-6 using a CME-75 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths ranging from approximately 5 to 25 feet bgs. Bulk and relatively undisturbed soil samples were collected at selected depth intervals in our borings. Detailed descriptions of the soils encountered are presented on the boring logs in Appendix A. The approximate locations of the borings are depicted on Figure 2.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory for geotechnical laboratory testing. The testing included in-situ moisture content and dry density, gradation, Atterberg limits, consolidation (response-to-wetting), and corrosivity characteristics (including pH, minimum electrical resistivity, and soluble sulfate and chloride contents). The results of the in-situ moisture content and dry density testing are presented on the excavation logs in Appendix A. A description of each laboratory test method and the remainder of the test results are presented in Appendix B.

In order to assist in obtaining percolation rate information, Ninyo & Moore conducted two shallow percolation tests within the proposed retention basin. The procedures utilized for the percolation test consisted of the insertion of an open-ended, 10-inch diameter casing into undisturbed soil, to a depth of about 5 feet, followed by pre-wetting of the soil. The test continued after the pre-wetting period by refilling the casing and monitoring the drop in water level as a function of time until steady-state conditions were achieved. The test locations are depicted on Figure 2, and the results of the tests are presented in Appendix C.

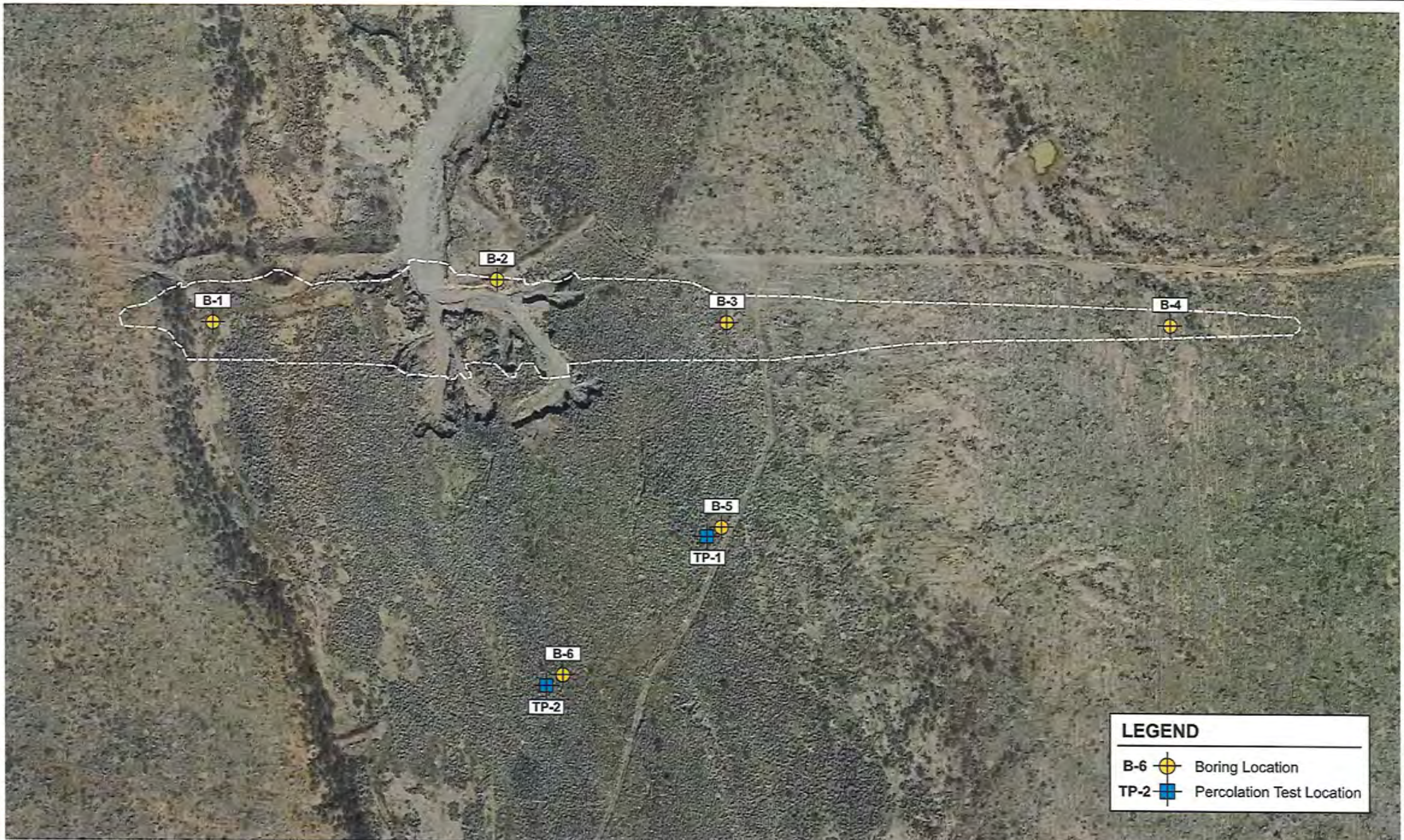
6. GEOLOGY AND SUBSURFACE CONDITIONS

The following sections describe the geologic conditions at the site.

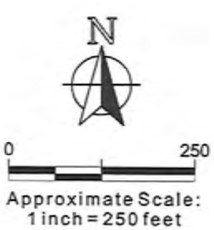
6.1. Geologic Setting

The project site is located in the Southern San Pedro Valley Section of the Basin and Range physiographic province, which is typified by broad alluvial valleys separated by steep, discontinuous subparallel mountain ranges. The mountain ranges generally trend north-south and northwest-southeast. The basins consist of alluvium with thicknesses extending to several thousands of feet.

The basins and surrounding mountains were formed approximately 10 to 18 million years ago during the mid- to late-Tertiary. Extensional tectonics resulted in the formation of horsts (mountains) and grabens (basins) with vertical displacement along high-angle normal faults. Intermittent volcanic activity also occurred during this time. The surrounding basins filled



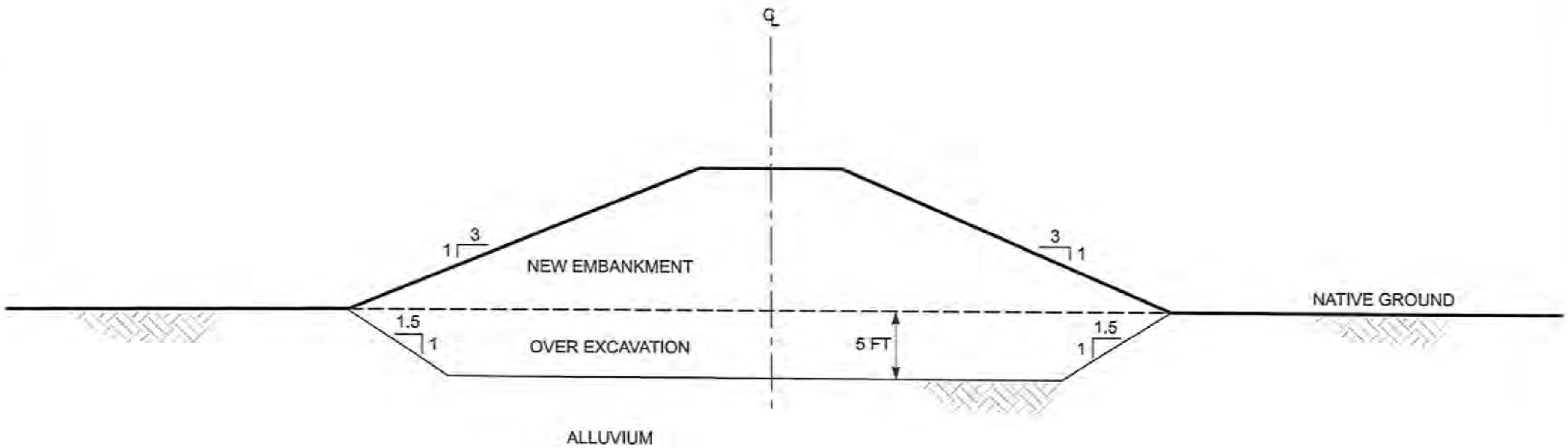
Source: HilgartWilson, 2015, NAVTEQ, 01/03/15.



Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		EXPLORATION LOCATIONS	FIGURE
PROJECT NO: 604915001	DATE: 10/15	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	2

file no: 4915blm1015



NOT TO SCALE

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		NEW EMBANKMENT CONSTRUCTION GUIDELINES	FIGURE
PROJECT NO: 604915001	DATE: 10/15	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	3

file no: 4915sec1015

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples
Disturbed soil samples were obtained in the field using the following methods.

Bulk Samples
Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

The Standard Penetration Test (SPT) Sampler
Disturbed drive samples of earth materials were obtained by means of a Standard Penetration Test sampler. The sampler is composed of a split barrel with an external diameter of 2 inches and an unlined internal diameter of 1-3/8 inches. The sampler was driven into the ground 12 to 18 inches with a 140-pound hammer falling freely from a height of 30 inches in general accordance with ASTM D 1586. The blow counts were recorded for every 6 inches of penetration; the blow counts reported on the logs are those for the last 12 inches of penetration. Soil samples were observed and removed from the sampler, bagged, sealed and transported to the laboratory for testing.

Field Procedure for the Collection of Relatively Undisturbed Samples
Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler
The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

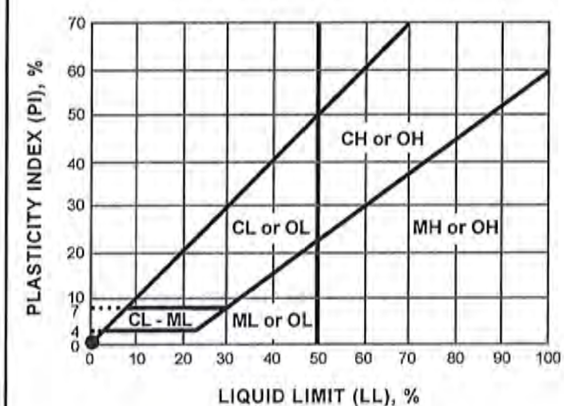
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DATE DRILLED 10/7/15 BORING NO. B-1

GROUND ELEVATION 4,356' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 6" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							CL	ALLUVIUM: Reddish brown, moist, very stiff, sandy CLAY.
			23	6.0	96.4			
			15					
5								
			60					Hard; trace gravel.
			40					
10								
			41					
15								Total Depth = 15 feet.
20								

Total Depth = 15 feet.
Groundwater not encountered during drilling.
Backfilled on 10/6/15 shortly after completion of drilling.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

Ninyo & Moore

BORING LOG

HORESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PROJECT NO.	DATE	FIGURE
604915001	10/15	A-1

DEPTH (feet)	SAMPLES Bulk / Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						SC	ALLUVIUM: Brown, moist, dense, clayey SAND.
		28					
		31	5.0	105.3			Medium dense.
5							
		42					Very dense.
		27					Medium dense; with gravel; cobbles; possible boulders.
10							
		25					Dense.
15							Total Depth = 15 feet. Groundwater not encountered during drilling. Backfilled on 10/6/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
20							

DATE DRILLED 10/7/15 BORING NO. B-2

GROUND ELEVATION 4,350' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 6" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY SDN

Ninyo & Moore

BORING LOG

HORESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PROJECT NO.	DATE	FIGURE
604915001	10/15	A-2

DATE DRILLED 10/7/15 BORING NO. B-3

GROUND ELEVATION 4,358' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 6" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SC	ALLUVIUM: Brown, moist, dense, clayey SAND; trace gravel.
			61	4.7	104.6			
			59					Very dense.
5								
			69				SM	Light brown, moist, dense, silty SAND; few gravel.
			50				SC	Brown, dry, dense, clayey SAND; trace gravel.
10								
			32					Very dense.
15								Total Depth = 15 feet. Groundwater not encountered during drilling. Backfilled on 10/6/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
20								

Ninyo & Moore

BORING LOG

HORESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PROJECT NO.	DATE	FIGURE
604915001	10/15	A-3

DATE DRILLED	10/7/15	BORING NO.	B-4
GROUND ELEVATION	4,373' ± (MSL)	SHEET	1 OF 1
METHOD OF DRILLING	CME-45, 6" Hollow-Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. (Automatic)	DROP	30"
SAMPLED BY	NAG	LOGGED BY	NAG
REVIEWED BY	SDN		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SC-SM	ALLUVIUM: Brown, dry, very dense, silty, clayey SAND.
			36					
			64					Dense.
5								
			29					With gravel; cobbles; and possible boulders.
							SC	Brown, moist, dense, clayey SAND with gravel.
			55					
10								
			32					Very dense.
15								Total Depth = 15 feet. Groundwater not encountered during drilling. Backfilled on 10/6/15 shortly after completion of drilling.
20								

Notes:

Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

Ninyo & Moore

BORING LOG

HORESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PROJECT NO.	DATE	FIGURE
604915001	10/15	A-4

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							CL	ALLUVIUM: Brown, moist, stiff, sandy CLAY.
			7					
			50	8.2	97.7			Hard.
5								Total Depth = 5 feet. Groundwater not encountered during drilling. Backfilled on 10/6/15 shortly after completion of drilling.
								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

DATE DRILLED 10/7/15 BORING NO. B-5

GROUND ELEVATION 4,362' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 6" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY SDN

Ninyo & Moore

BORING LOG

HORESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PROJECT NO.	DATE	FIGURE
604915001	10/15	A-5

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							CL	ALLUVIUM: Dark brown, firm, sandy CLAY.
			5					
			10					Stiff; with gravel; cobbles; and possible boulders.
5								Total Depth = 5 feet. Groundwater not encountered during drilling. Backfilled on 10/6/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

DATE DRILLED 10/7/15 BORING NO. B-6

GROUND ELEVATION 4,362' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 6" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY SDN

Ninyo & Moore

BORING LOG

HORESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

PROJECT NO.	DATE	FIGURE
604915001	10/15	A-6

APPENDIX B

LABORATORY TESTING

Classification
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

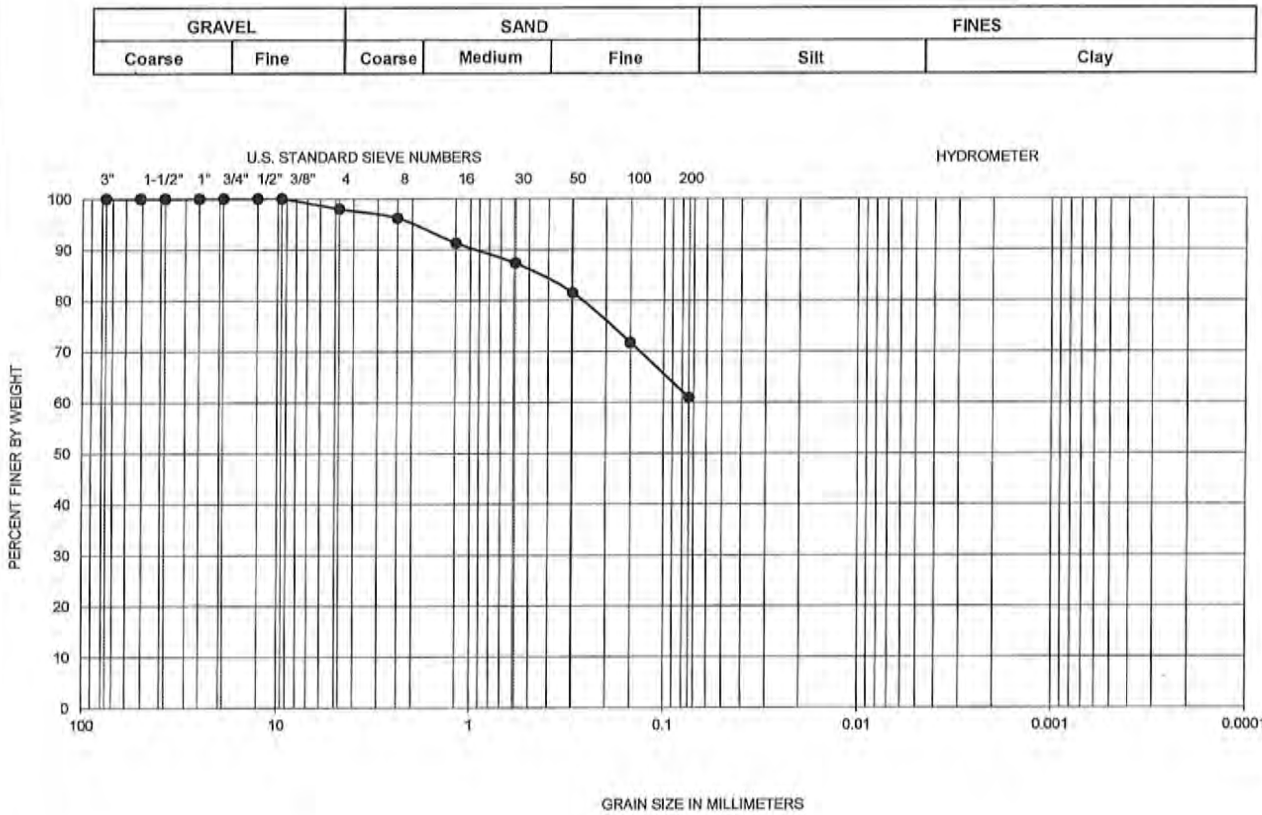
In-Place Moisture and Density Tests
The moisture content and dry density of relatively undisturbed samples obtained from the exploratory borings were evaluated in general accordance with ASTM D 2937. The test results are presented on the logs of the exploratory borings in Appendix A.

Gradation Analysis
Gradation analysis tests were performed on selected representative soil samples in general accordance with ASTM D 422. The grain-size distribution curves are shown on Figures B-1 through B-4. These test results were utilized in evaluating the soil classifications in accordance with the USCS.

Atterberg Limits
Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-5.

Consolidation Tests
One consolidation test was performed on selected relatively undisturbed soil samples in general accordance with ASTM D 2435. The samples were inundated during testing to represent adverse field conditions. The percent of consolidation for each load cycle was recorded as a ratio of the amount of vertical compression to the original height of the samples. The results of the tests are summarized on Figures B-6 and B-7.

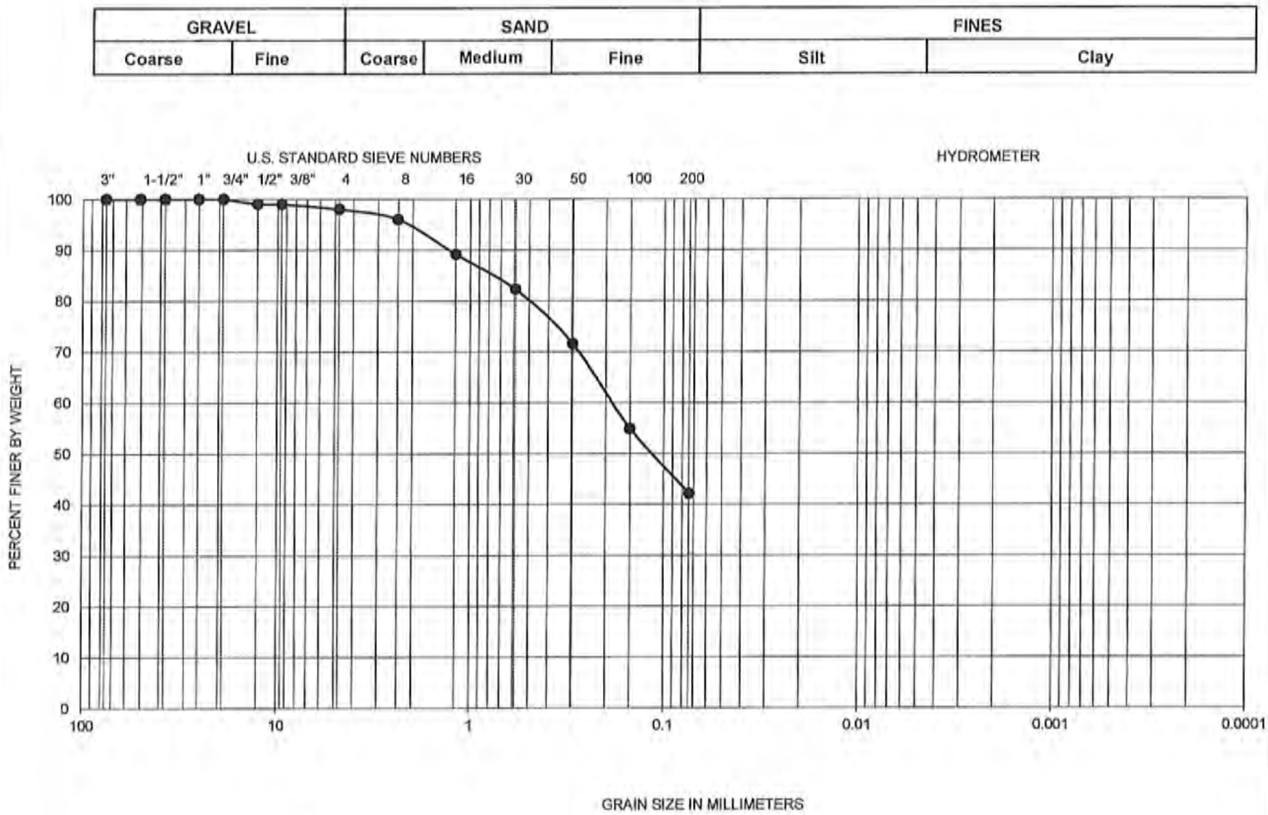
Soil Corrosivity Tests
Soil pH and minimum resistivity tests were performed on one representative sample in general accordance with Arizona Test 236c. The chloride content of selected sample was evaluated in general accordance with Arizona Test 736. The sulfate content of selected sample was evaluated in general accordance with Arizona Test 733. The test results are presented on Figure B-8.



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-1	1.0-5.0	29	14	15	--	--	--	--	--	61	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore	GRADATION TEST RESULTS	FIGURE
PROJECT NO. / DATE	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	B-1
604915001 / 10/15		

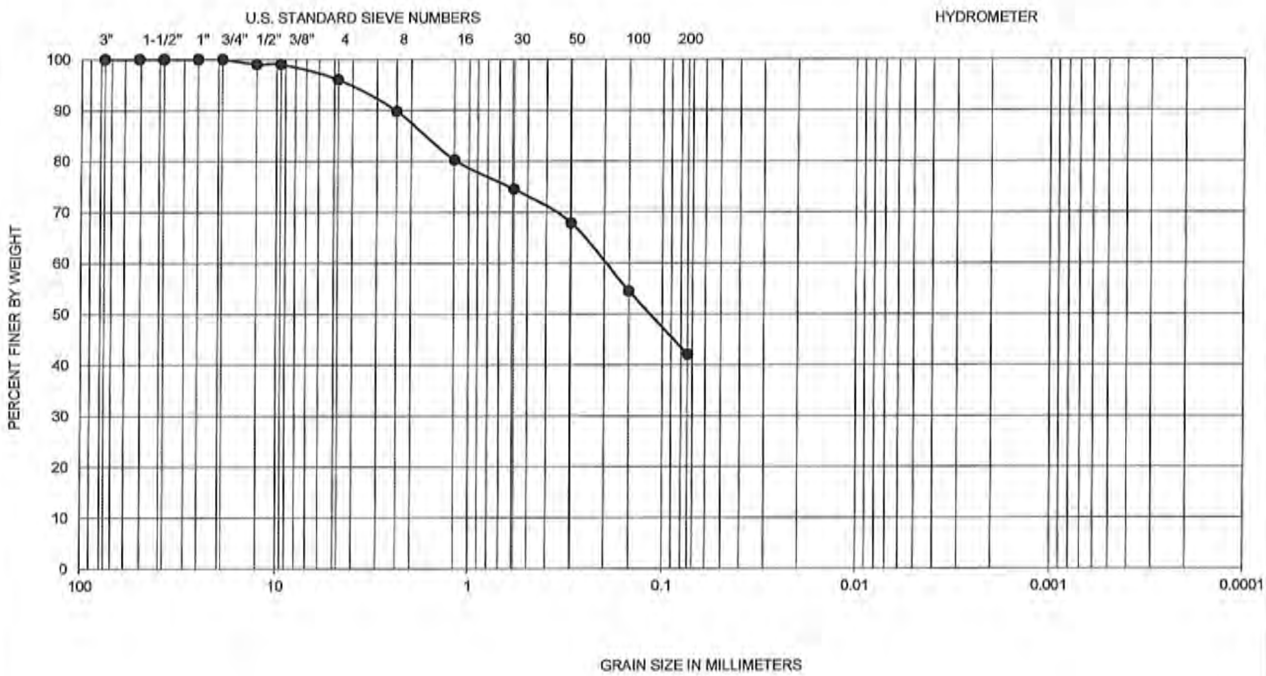


Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-3	1.0-5.0	25	12	13	--	--	--	--	--	42	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore	GRADATION TEST RESULTS	FIGURE
PROJECT NO. 604915001 / DATE 10/15	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	B-2

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

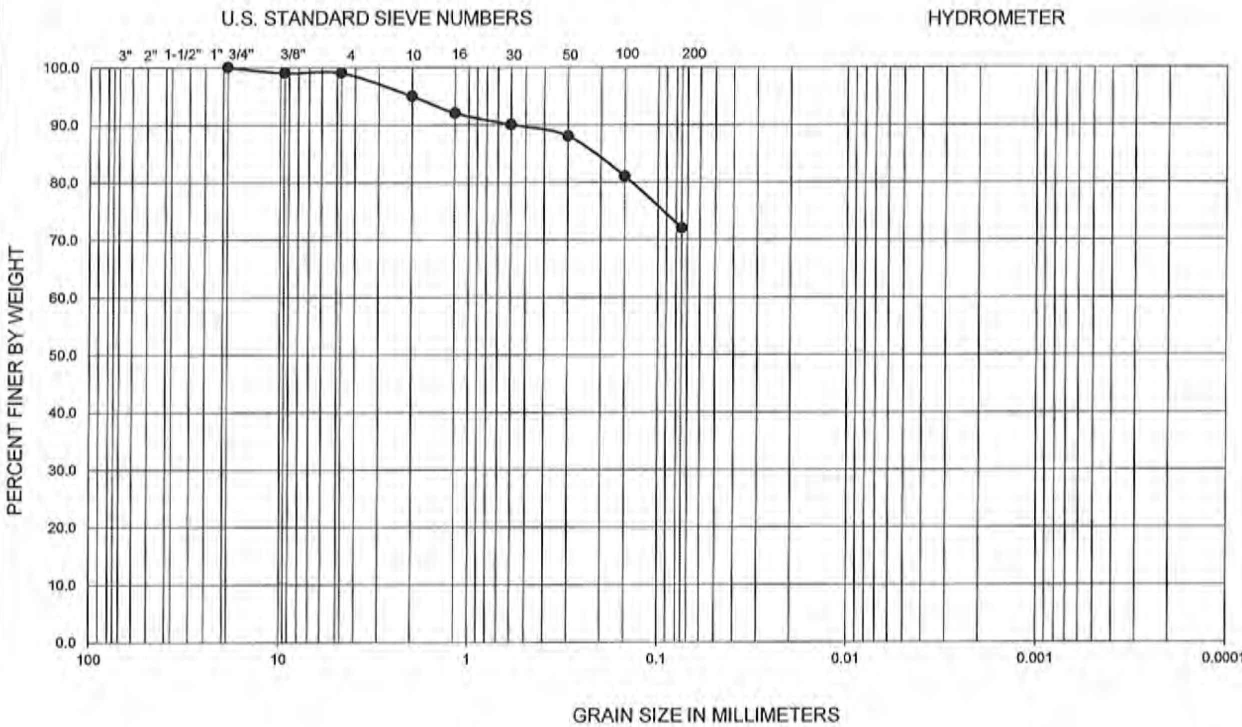


Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-4	1.0-5.0	22	15	7	--	--	--	--	--	42	SC-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	B-3
604915001	10/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

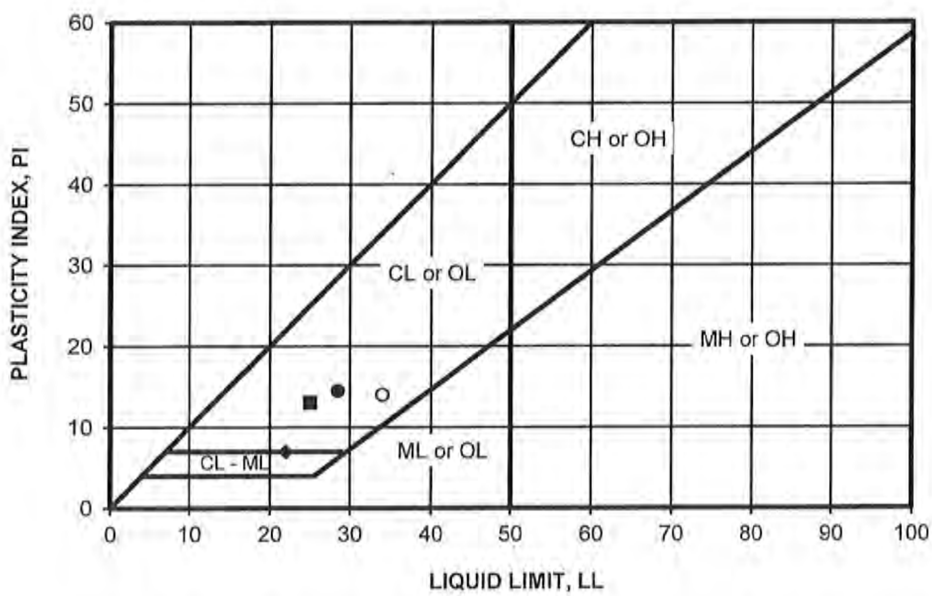


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-5	3.5-5.0	34	20	14	--	--	--	--	--	72	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

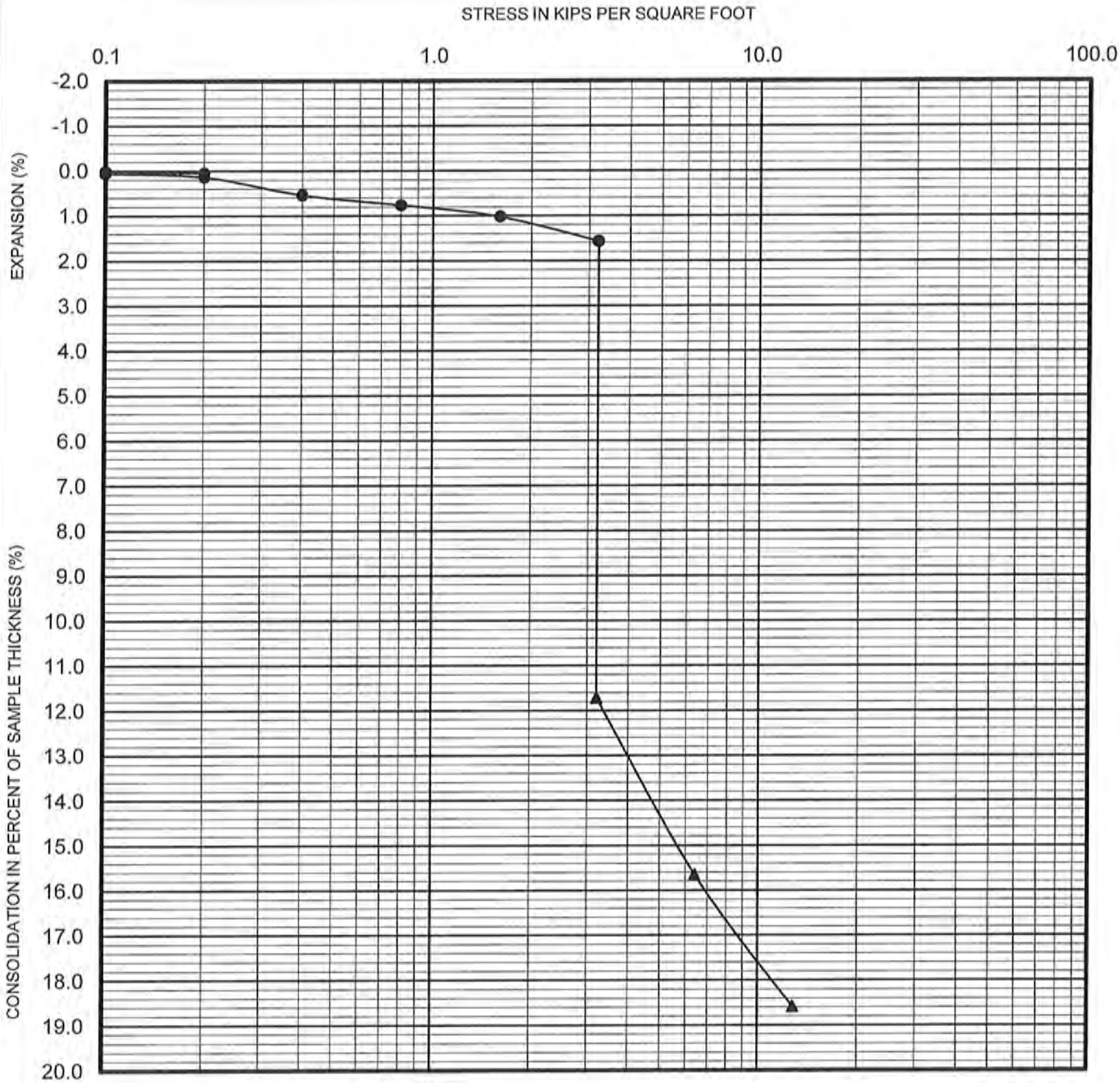
Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	B-4
604915001	10/15		

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.0-5.0	29	14	15	CL	CL
■	B-3	1.0-5.0	25	12	13	CL	SC
◆	B-4	1.0-5.0	22	15	7	CL-ML	SC-SM
○	B-5	3.5-5.0	34	20	14	CL	CL



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore	ATTERBERG LIMITS TEST RESULTS	FIGURE
PROJECT NO. 604915001	HORSESHOE DRAW BASIN	B-5
DATE 10/15	COCHISE COUNTY, ARIZONA	



Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

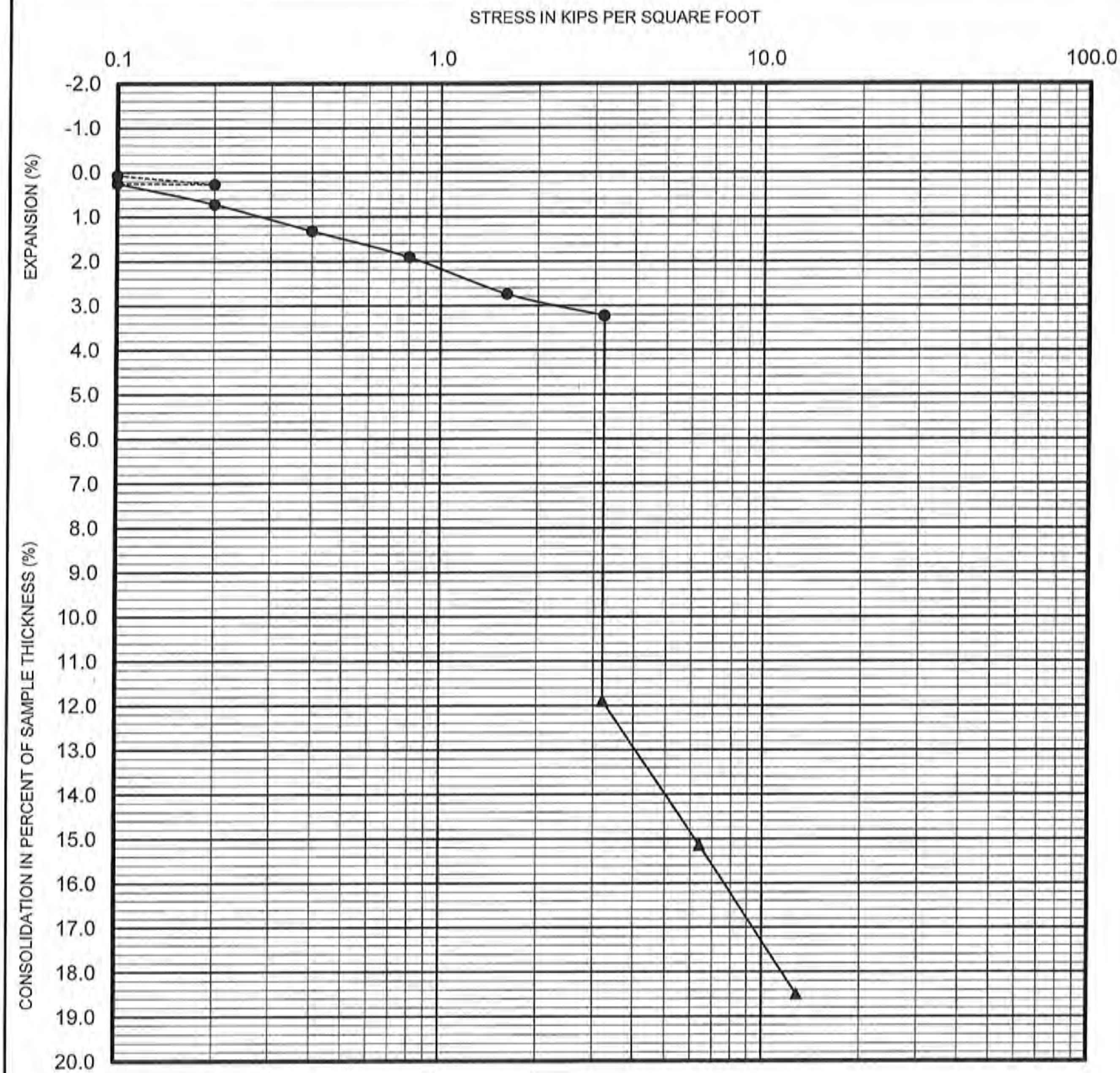
Sample Location	B-1
Depth (ft.)	1.0-2.5
Soil Type	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

Ninyo & Moore

CONSOLIDATION TEST RESULTS

PROJECT NO.	DATE		FIGURE
604915001	10/15	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	B-6



---●---	Seating Cycle	Sample Location	B-3
——●——	Loading Prior to Inundation	Depth (ft.)	1.0-2.5
——▲——	Loading After Inundation	Soil Type	SC
--▲--	Rebound Cycle		

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

Ninyo & Moore		CONSOLIDATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	B-7
604915001	10/15		

SAMPLE LOCATION	SAMPLE DEPTH (FT)	pH [1]	RESISTIVITY [1] (Ohm-cm)	SULFATE CONTENT [2]		CHLORIDE CONTENT [3] (ppm)
				(ppm)	(%)	
B-2	1.0-5.0	7.7	600	50	0.005	20

[1] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 236c

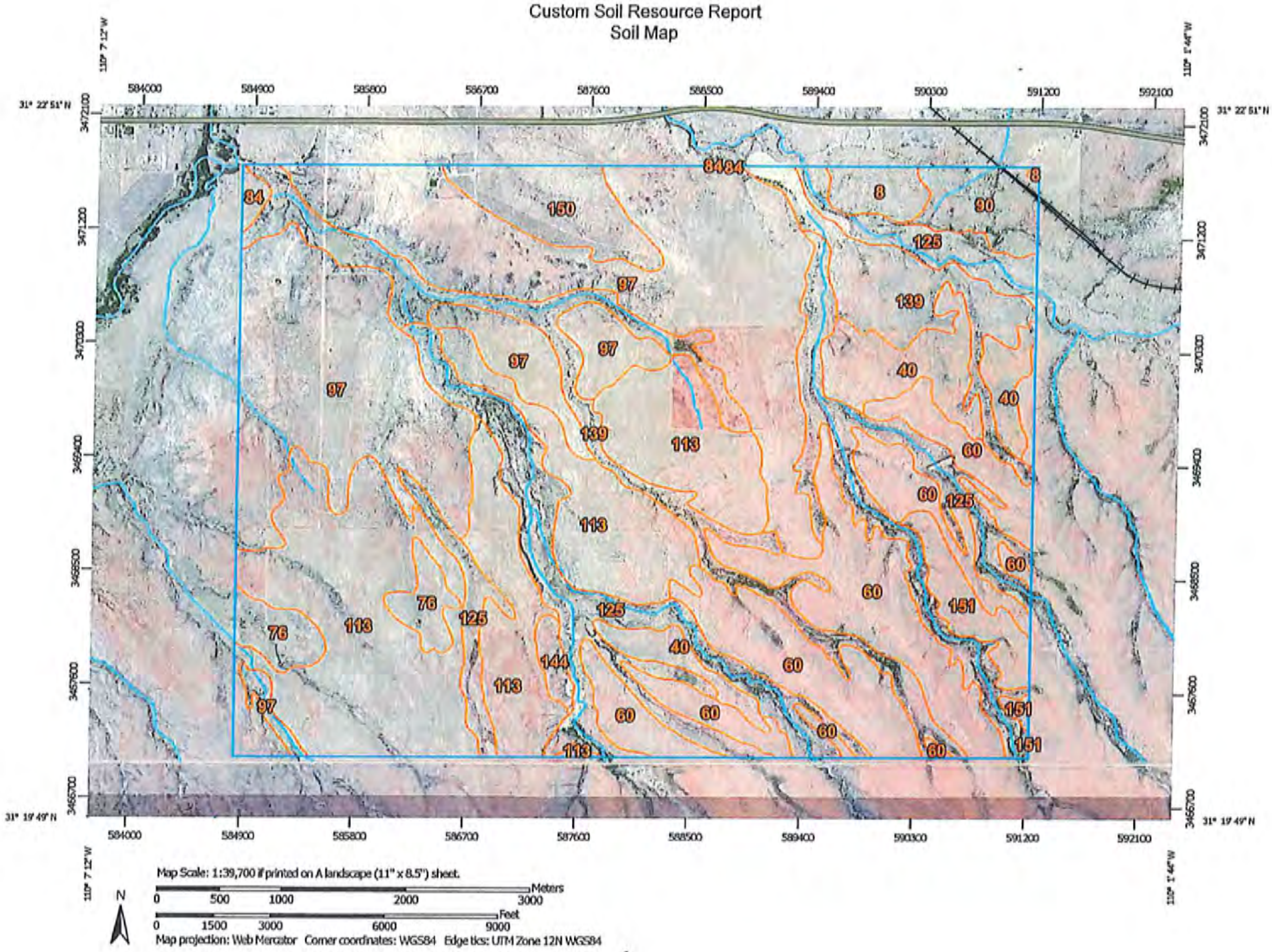
[2] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 733

[3] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 736

APPENDIX E

NRCS SOIL RESOURCE MAP

Custom Soil Resource Report
Soil Map



Parent material: Mixed fan alluvium

Typical profile

A - 0 to 1 inches: gravelly fine sandy loam
Btk - 1 to 8 inches: sandy loam
Bkm - 8 to 23 inches: cemented material
Ck - 23 to 47 inches: extremely cobbly sandy loam
2Btkb - 47 to 60 inches: sandy clay loam

Properties and qualities

Slope: 1 to 10 percent
Depth to restrictive feature: 5 to 15 inches to petrocalcic
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 0.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: D
Ecological site: Limy upland 12-16" p.z. (R041XC309AZ)

125—Riveroad and Ubik soils, 0 to 5 percent slopes

Map Unit Setting

National map unit symbol: 1v7p
Elevation: 3,900 to 4,600 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 60 to 67 degrees F
Frost-free period: 180 to 230 days
Farmland classification: Not prime farmland

Map Unit Composition

Riveroad and similar soils: 0 percent
Ubik and similar soils: 0 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubik

Setting

Landform: Alluvial fans, flood plains
Landform position (two-dimensional): Summit

Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

A - 0 to 5 inches: loam
C1 - 5 to 16 inches: silt loam
C2 - 16 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Gypsum, maximum in profile: 3 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Moderate (about 8.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: Loamy swale 12-16" p.z. (R041XC311AZ)

Description of Riveroad

Setting

Landform: Alluvial fans, flood plains
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stream alluvium

Typical profile

A - 0 to 1 inches: silt loam
C1 - 1 to 21 inches: silt loam
C2 - 21 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent

Gypsum, maximum in profile: 4 percent
Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: Loamy bottom 12-16" p.z. (R041XC312AZ)

139—Tenneco fine sandy loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 1v7k
Elevation: 3,800 to 4,700 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 60 to 67 degrees F
Frost-free period: 180 to 230 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Tenneco and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tenneco

Setting
Landform: Flood plains, alluvial fans
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed fan alluvium

Typical profile
A - 0 to 2 inches: fine sandy loam
Bw - 2 to 11 inches: sandy clay loam
Bk - 11 to 41 inches: loam
C - 41 to 60 inches: sandy loam

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent

Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: Loamy swale 12-16" p.z. (R041XC311AZ)

144—Ubik complex, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 1v71
Elevation: 3,900 to 4,600 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 60 to 67 degrees F
Frost-free period: 180 to 230 days
Farmland classification: Not prime farmland

Map Unit Composition

Ubik, silt loam, and similar soils: 50 percent
Ubik, fine sandy loam, and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubik, Silt Loam

Setting

Landform: Flood plains, alluvial fans
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

C1 - 0 to 10 inches: silt loam
C2 - 10 to 32 inches: loam
C3 - 32 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Gypsum, maximum in profile: 3 percent
Sodium adsorption ratio, maximum in profile: 13.0

APPENDIX F
PREVIOUS DRAINAGE
REPORT EXCERPTS

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

HORSESHOE DRAW FLOOD CONTROL, RESTORATION AND EROSION MITIGATION STUDY AND DESIGN PROJECT

VOLUME 1

EXISTING CONDITIONS HYDROLOGIC STUDY

COCHISE COUNTY, ARIZONA

Prepared for:

Hereford Natural Resource Conservation District
2136 N. Truman Rd.
Huachuca City, AZ 85616

Prepared by:

HILGARTWILSON
2141 East Highland Avenue, Suite 250
Phoenix, AZ 85016
Phone: (602) 490-0535
Fax: (602) 368-2436

Registered Professional Engineer (Civil)
CERTIFICATE NO.
AUBREY J. THOMAS
Date Signed 5/7/15
ARIZONA, U.S.A.
Expires 12/31/17

May 2015
HilgartWilson Project No. 1472

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

VOLUME 1
EXISTING CONDITIONS HYDROLOGIC STUDY

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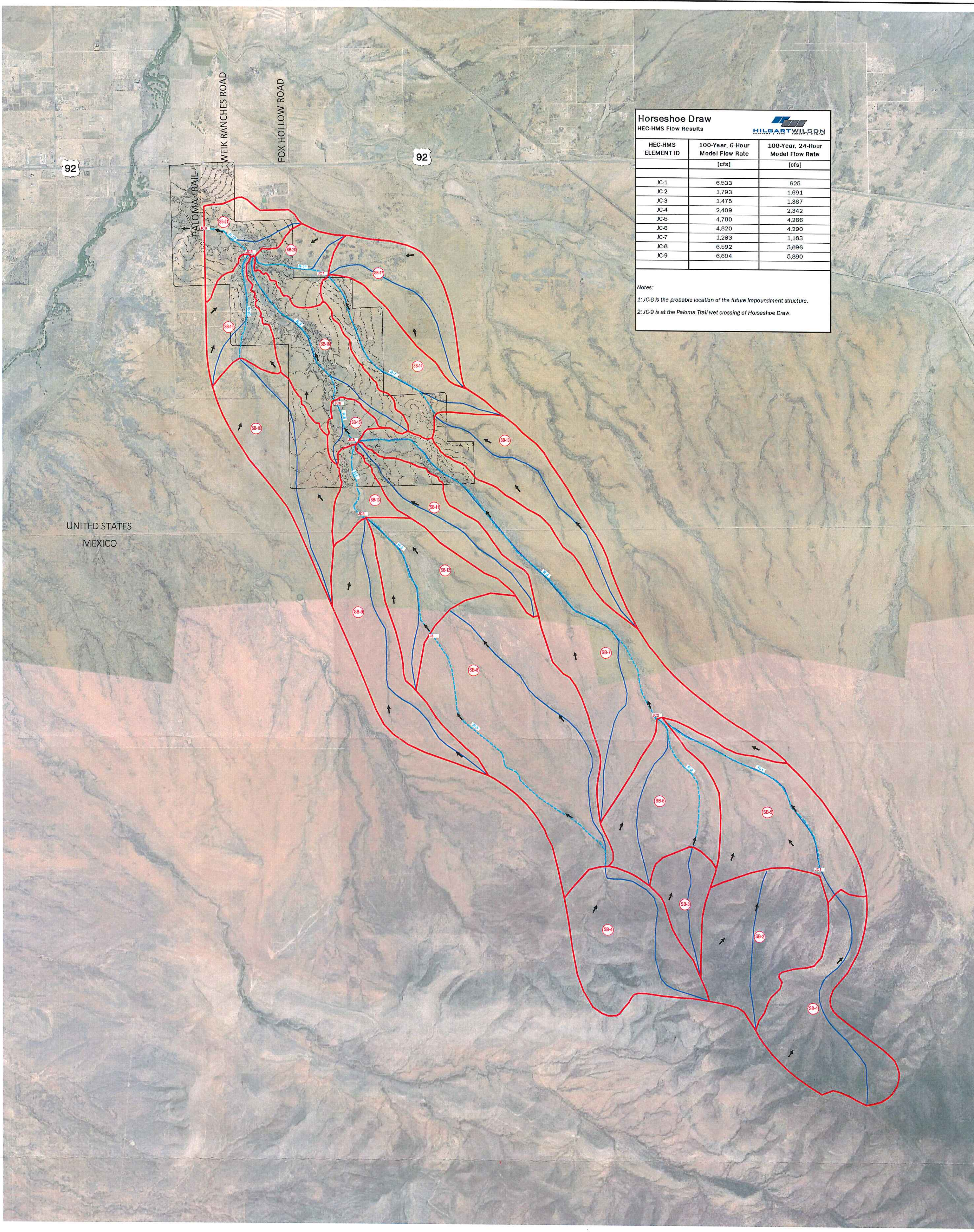
APPENDICES

Registered Professional Engineer (Civil)
CERTIFICATE NO. 46011
AUBREY J. THOMAS
Date Signed 5/7/15
ARIZONA, U.S.A.
Expires 12/31/17

FIGURES



Horseshoe Draw
HEC-HMS Flow Results

HILGARTWILSON

HEC-HMS ELEMENT ID	100-Year, 6-Hour Model Flow Rate	100-Year, 24-Hour Model Flow Rate
	[cfs]	[cfs]
JC-1	6,533	625
JC-2	1,793	1,691
JC-3	1,475	1,387
JC-4	2,409	2,342
JC-5	4,780	4,266
JC-6	4,820	4,290
JC-7	1,283	1,183
JC-8	6,592	5,896
JC-9	6,604	5,890

Notes:

1: JC-6 is the probable location of the future impoundment structure.

2: JC-9 is at the Paloma Trail wet crossing of Horseshoe Draw.

LEGEND

- SUB BASIN BOUNDARY
- SUB BASIN LABEL
- LONGEST FLOW PATH
- ROUTING
- FLOW ARROW
- JUNCTION
- 100-YEAR FLOWRATE

N

2000 1000 0 2000 4000
SCALE FEET

HILGARTWILSON

PROJ NO.: 1472
DATE: APR. 2015
SCALE: 1" = 2000'
DRAWN: JM
DESIGNED: HW
APPROVED: AT

DWG. NO.
SHT. OF

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

FIG 3. HYDROLOGY EXHIBIT

HILGARTWILSON
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PHOENIX, AZ 85016
P: 602.490.0535 / F: 602.368.2436
www.hilgartwilson.com

REV.:

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

HORSESHOE DRAW FLOOD CONTROL, RESTORATION AND EROSION MITIGATION STUDY AND DESIGN PROJECT

VOLUME 2

EXISTING CONDITIONS HYDRAULIC REPORT

COCHISE COUNTY, ARIZONA

Prepared for:

Hereford Natural Resource Conservation District
2136 N. Truman Rd.
Huachuca City, AZ 85616

Prepared by:

HILGARTWILSON
2141 East Highland Avenue, Suite 250
Phoenix, AZ 85016
Phone: (602) 490-0535
Fax: (602) 368-2436

Registered Professional Engineer
CERTIFICATE NO.
AUBREY J. THOMAS
Date Signed 10/2/15
ARIZONA, U.S.A.
Expires 12/31/17

October, 2015
HilgartWilson Project No. 1472

VOLUME 2

HYDRAULIC DESIGN REPORT

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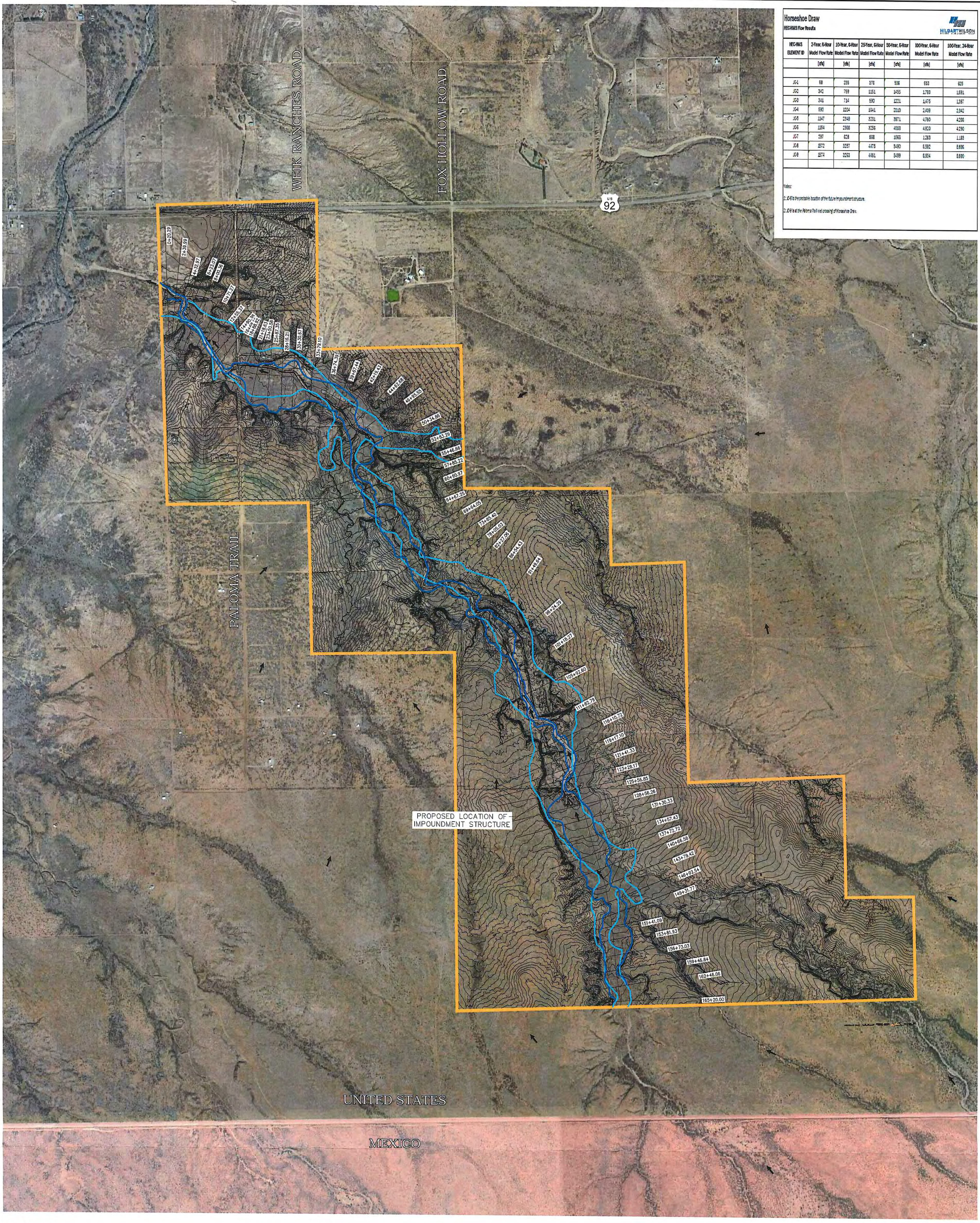
FIGURES

Registered Professional Engineer CERTIFICATE NO. AUBREY THOMAS Date Signed 10/2/15 ARIZONA, U.S.A. Expires 12/31/17



Horseshoe Draw

HEC-HMS Flow Results

HILGARTWILSON

HEC-HMS ELEMENT ID	2-Year, 6-Hour Model Flow Rate	10-Year, 6-Hour Model Flow Rate	25-Year, 6-Hour Model Flow Rate	50-Year, 6-Hour Model Flow Rate	100-Year, 6-Hour Model Flow Rate	100-Year, 24-Hour Model Flow Rate
	[cfs]	[cfs]	[cfs]	[cfs]	[cfs]	[cfs]
JC-1	69	235	376	506	653	625
JC-2	342	799	1151	1455	1,793	1,691
JC-3	341	714	990	1221	1,475	1,397
JC-4	590	1204	1641	2010	2,409	2,342
JC-5	1147	2349	3231	3971	4,760	4,266
JC-6	1154	2368	3256	4003	4,820	4,290
JC-7	297	628	868	1066	1,283	1,183
JC-8	1572	3257	4475	5490	6,592	5,896
JC-9	1574	3263	4481	5499	6,604	5,890

Notes:

1: JC-6 is the probable location of the future impoundment structure.

2: JC-9 is at the Paloma Trail wet crossing of Horseshoe Draw.

LEGEND

- PROJECT BOUNDARY
- EXISTING FEMA FLOODPLAIN
- PROPOSED 100-YEAR FLOODPLAIN
- FLOW ARROW

N

800 400 0 800 1600
SCALE FEET

HILGARTWILSON	
PROJ NO.:	1472
DATE:	OCT. 2015
SCALE:	1" = 800'
DRAWN:	JM
DESIGNED:	HW
APPROVED:	AT

DWG. NO.

SHT. OF

EXISTING CONDITIONS HYDRAULIC EXHIBIT

COCHISE COUNTY, ARIZONA

FIG 3. HYDROLOGY EXHIBIT

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE
2141 E. HIGHLAND AVE., STE. 250
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P: 602.490.0535 / F: 602.368.2436
www.hilgartwilson.com

REV.:

U:\1400\1472\REPORTS\DRAINAGE\Exhibits\1472 Existing Hydraulics 15-1002.dwg 10/2/2015 2:58 PM