VILLAGE 14 & PA 16/19
SPECIFIC PLAN BOUNDARY

SEE MAP 2 OF 4 FOR CONTINUATION

VILLAGE 14 & PA 16/19
SPECIFIC PLAN BOUNDARY

VILLAGE 14 & PA 16/19
SPECIFIC PLAN BOUNDARY

North
WQ
Basin

South
WQ
Basin

PROCTOR
VALLEY ROAD

PROCTOR
VALLEY ROAD

PROCTOR
VALLEY ROAD

SUBJECT TO
INUNDATION BY THE
100 YEAR FLOOD.

SUBJECT TO
INUNDATION BY THE
100 YEAR FLOOD.

CROSSING
J006
Q100 = 799.67 cfs

Q100 = 292.80 cfs

SEE MAP 4 OF 4 FOR CONTINUATION

LEGEND

- PROJECT BOUNDARY
- DRAINAGE BOUNDARY
- INITIAL SUBAREA
- FLOW DIRECTION
- NODE #
- SUBAREA ACREAGE — X ACRES

SCALE 1" = 200'

PREPARED BY:

HUNSAKER & ASSOCIATES SAN DIEGO, INC

PLANNING 9707 Waples Street
ENGINEERING San Diego, Ca 92121
SURVEYING PH(858)558-4500 · FX(858)558-1414

PROPOSED CONDITION
DRAINAGE MAP

OTAY RANCH
VILLAGE 14 & P.A. 16/19

COUNTY OF SAN DIEGO, CALIFORNIA

SHEET 3 OF 4

R:\1235\Hyd\ACAD\HYDRO\TM-SRP\1235- HYDRO V14- PROP-SRP.dwg Jan-16-2018,17:

SEE MAP 3 OF 4 FOR CONTINUATION

Q100 = 520.54 CFS
A = 475.57 AC
Tc = 28.17 MIN

Q100 = 292.80 cfs

Q100 = 292.80 CFS
A = 312.09 AC
Tc = 28.13 MIN

PROCTOR
VALLEY ROAD

Q100 = 20.22 CFS
A = 4.59 AC
Tc = 8.83 MIN

CROSSING
J008
Q100 = 11,597 cfs

PROCTOR
VALLEY ROAD

SUBJECT TO
INUNDATION BY THE
100 YEAR FLOOD.

Q100 = 15.98 CFS
A = 3.41 AC
Tc = 8.92 MIN

Q100 = 27.85 CFS
A = 14.23 AC
Tc = 9.00 MIN

Q100 = 13.91 CFS
A = 7.95 AC
Tc = 10.52 MIN

Q50 = 161.63 CFS
A = 97.06 AC
Tc = 17.90 MIN

PER HYDROLOGY STUDY FOR
ROLLING HILLS RANCH NEIGHBORHOOD 9-12
(OCTOBER 10, 2003)
Q100 = 1373.90 CFS
A = 718.66 AC
Tc = 20.04 MIN

Q50 = 964.54 CFS
A = 557.50 AC
Tc = 20.01 MIN

PROCTOR
VALLEY ROAD

PROCTOR VALLEY ROAD

CROSSING
PVR3
Q100 = 1,425.80 CFS
A = 788.54 AC
Tc = 22.06 MIN

Q100 = 29.92 CFS
A = 6.61 AC
Tc = 10.34 MIN

Q100 = 470.50 CFS
A = 263.81 AC
Tc = 22.46 MIN

PER HYDROLOGY STUDY FOR
ROLLING HILLS RANCH NEIGHBORHOOD 9-12
(OCTOBER 10, 2003)
Q100 = 468.76 CFS
A = 261.03 AC
Tc = 22.29 MIN

LEGEND

- PROJECT BOUNDARY
- DRAINAGE BOUNDARY
- INITIAL SUBAREA
- FLOW DIRECTION
- NODE #
- SUBAREA ACREAGE — X ACRES

200 0 200 400 600
SCALE 1"= 200'

PREPARED BY:

HUNSAKER & ASSOCIATES SAN DIEGO, INC
PLANNING 9707 Waples Street
ENGINEERING San Diego, Ca 92121
SURVEYING PH(858)558-4500 FX(858)558-1414

PROPOSED CONDITION
DRAINAGE MAP
OTAY RANCH
VILLAGE 14 & P.A. 16/19
COUNTY OF SAN DIEGO, CALIFORNIA

SHEET 4 OF 4

R:\1235\Hyd\ACAD\HYDRO\TM-SRP\1235- HYDRO V14- PROP-SRP.dwg Jan-16-2018,17:16

CHAPTER 6

Preliminary Hydraulic Analysis along Proctor Valley and at Major PVR Crossings

HEC-RAS Plan: Plan 02 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
V14 North	Alignment - (V14	19772.8	PF 1	219.12	1902.93	1906.87	1906.87	1907.88	0.027680	8.05	27.21	13.80	1.01
V14 North	Alignment - (V14	19700	PF 1	219.12	1887.49	1888.33	1888.33	1888.62	0.028637	4.37	50.13	85.67	1.01
V14 North	Alignment - (V14	19600	PF 1	219.12	1835.85	1837.76	1837.76	1838.24	0.026132	5.56	39.41	42.30	1.02
V14 North	Alignment - (V14	19500	PF 1	219.12	1779.59	1781.98	1781.98	1782.65	0.024201	6.57	33.35	25.41	1.01
V14 North	Alignment - (V14	19400	PF 1	219.12	1720.80	1722.65	1722.65	1723.29	0.022497	6.42	34.14	27.17	1.01
V14 North	Alignment - (V14	19300	PF 1	219.12	1666.65	1668.08	1668.08	1668.47	0.026478	4.96	44.14	59.14	1.01
V14 North	Alignment - (V14	19200	PF 1	219.12	1617.70	1619.04	1619.04	1619.46	0.025510	5.19	42.18	51.35	1.01
V14 North	Alignment - (V14	19100	PF 1	219.12	1569.62	1571.69	1571.69	1572.38	0.022010	6.66	32.88	24.10	1.01
V14 North	Alignment - (V14	19000	PF 1	219.12	1540.10	1541.98	1541.98	1542.53	0.023540	5.95	36.84	34.27	1.01
V14 North	Alignment - (V14	18900	PF 1	219.12	1499.72	1502.11	1502.11	1502.96	0.021379	7.40	29.61	17.64	1.01
V14 North	Alignment - (V14	18800	PF 1	219.12	1468.66	1471.87	1471.87	1472.72	0.021430	7.40	29.63	17.48	1.00
V14 North	Alignment - (V14	18700	PF 1	219.12	1444.46	1446.76	1446.76	1447.54	0.021765	7.06	31.02	20.43	1.01
V14 North	Alignment - (V14	18600	PF 1	219.12	1421.28	1424.72	1424.72	1425.63	0.021620	7.64	28.67	15.86	1.00
V14 North	Alignment - (V14	18500	PF 1	219.12	1393.83	1396.55	1396.55	1397.39	0.021326	7.35	29.83	17.99	1.01
V14 North	Alignment - (V14	18400	PF 1	219.12	1369.21	1370.98	1370.98	1371.65	0.022498	6.54	33.52	25.73	1.01
V14 North	Alignment - (V14	18300	PF 1	219.12	1342.64	1344.96	1344.96	1345.71	0.021890	6.92	31.66	21.76	1.01
V14 North	Alignment - (V14	18200	PF 1	219.12	1329.68	1330.93	1330.93	1331.44	0.024643	5.69	38.49	39.67	1.02
V14 North	Alignment - (V14	18100	PF 1	219.12	1315.58	1317.44	1317.44	1317.99	0.023572	5.93	36.92	34.49	1.01
V14 North	Alignment - (V14	18000	PF 1	219.12	1299.98	1302.17	1302.17	1302.82	0.022513	6.46	33.91	26.64	1.01
V14 North	Alignment - (V14	17900	PF 1	219.12	1295.58	1297.49	1297.49	1298.02	0.024003	5.86	37.41	36.13	1.01
V14 North	Alignment - (V14	17800	PF 1	219.12	1289.43	1290.74	1290.74	1291.23	0.024377	5.65	38.80	40.05	1.01
V14 North	Alignment - (V14	17700	PF 1	219.12	1278.42	1280.66	1280.66	1281.37	0.022224	6.72	32.63	23.86	1.01
V14 North	Alignment - (V14	17600	PF 1	219.12	1269.14	1271.07	1271.07	1271.76	0.022157	6.65	32.94	24.33	1.01
V14 North	Alignment - (V14	17500	PF 1	219.12	1259.21	1261.25	1261.25	1261.98	0.021826	6.87	31.88	22.06	1.01
V14 North	Alignment - (V14	17400	PF 1	219.12	1249.38	1251.15	1251.15	1251.82	0.022298	6.55	33.45	25.48	1.01
V14 North	Alignment - (V14	17300	PF 1	219.12	1239.15	1240.36	1240.36	1240.77	0.025955	5.13	42.72	53.69	1.01
V14 North	Alignment - (V14	17200	PF 1	219.12	1229.70	1230.64	1230.64	1231.04	0.025490	5.05	43.43	54.99	1.00
V14 North	Alignment - (V14	17100	PF 1	219.12	1219.62	1222.44	1222.44	1223.25	0.021521	7.20	30.43	19.11	1.01
V14 North	Alignment - (V14	17000	PF 1	219.12	1202.23	1205.16	1205.16	1205.99	0.021624	7.32	29.93	18.32	1.01
V14 North	Alignment - (V14	16900	PF 1	219.12	1189.37	1191.50	1191.50	1192.23	0.021755	6.86	31.96	22.22	1.01
V14 North	Alignment - (V14	16800	PF 1	219.12	1179.07	1180.85	1180.85	1181.46	0.022763	6.29	34.83	28.86	1.01
V14 North	Alignment - (V14	16700	PF 1	219.12	1169.58	1171.60	1171.60	1172.34	0.021851	6.90	31.75	21.86	1.01
V14 North	Alignment - (V14	16600	PF 1	219.12	1163.45	1165.46	1165.46	1166.20	0.021695	6.87	31.89	21.99	1.01
V14 North	Alignment - (V14	16500	PF 1	219.12	1150.00	1152.35	1152.35	1153.14	0.021598	7.12	30.77	19.90	1.01
V14 North	Alignment - (V14	16400	PF 1	219.12	1140.10	1143.14	1143.14	1143.96	0.021369	7.25	30.22	18.53	1.00
V14 North	Alignment - (V14	16300	PF 1	219.12	1135.56	1137.14	1137.14	1137.67	0.023684	5.83	37.59	36.30	1.01
V14 North	Alignment - (V14	16200	PF 1	219.12	1129.23	1131.23	1131.23	1131.93	0.022062	6.71	32.63	23.65	1.01
V14 North	Alignment - (V14	16100	PF 1	219.12	1119.66	1121.88	1121.88	1122.69	0.021592	7.20	30.44	19.20	1.01
V14 North	Alignment - (V14	16000	PF 1	219.12	1109.70	1112.05	1112.05	1112.95	0.021623	7.60	28.82	16.28	1.01
V14 North	Alignment - (V14	15900	PF 1	219.12	1099.98	1103.56	1103.56	1104.58	0.022317	8.10	27.05	13.27	1.00
V14 North	Alignment - (V14	15800	PF 1	219.12	1089.25	1091.65	1091.65	1092.52	0.021444	7.49	29.25	17.02	1.01
V14 North	Alignment - (V14	15700	PF 1	219.12	1069.81	1072.37	1072.37	1073.30	0.021648	7.74	28.31	15.45	1.01
V14 North	Alignment - (V14	15600	PF 1	219.12	1058.18	1060.32	1060.32	1060.94	0.023069	6.33	34.63	28.71	1.02
V14 North	Alignment - (V14	15500	PF 1	219.12	1039.18	1041.03	1041.03	1041.71	0.022360	6.59	33.23	25.08	1.01
V14 North	Alignment - (V14	15400	PF 1	219.12	1018.83	1020.92	1020.92	1021.65	0.022128	6.84	32.03	22.50	1.01
V14 North	Alignment - (V14	15300	PF 1	219.12	1008.49	1010.32	1010.32	1010.90	0.023384	6.15	35.66	31.20	1.01
V14 North	Alignment - (V14	15200	PF 1	219.12	988.34	990.36	990.36	990.99	0.022828	6.37	34.40	27.59	1.01

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
V14 North	Alignment - (V14	15100	PF 1	219.12	969.87	971.22	971.22	971.81	0.022789	6.15	35.62	30.48	1.00
V14 North	Alignment - (V14	15000	PF 1	219.12	959.58	961.10	961.10	961.68	0.022894	6.13	35.73	30.96	1.01
V14 North	Alignment - (V14	14900	PF 1	219.12	949.12	950.49	950.49	950.94	0.024959	5.41	40.47	45.49	1.01
V14 North	Alignment - (V14	14800	PF 1	219.12	938.86	940.63	940.63	941.21	0.023248	6.08	36.03	32.04	1.01
V14 North	Alignment - (V14	14700	PF 1	219.12	923.11	925.83	925.83	926.62	0.021789	7.16	30.61	19.63	1.01
V14 North	Alignment - (V14	14600	PF 1	219.12	909.94	912.32	912.32	913.18	0.021510	7.45	29.40	17.28	1.01
V14 North	Alignment - (V14	14500	PF 1	219.12	898.92	900.74	900.74	901.36	0.022861	6.34	34.59	28.23	1.01
V14 North	Alignment - (V14	14400	PF 1	219.12	879.78	881.81	881.81	882.61	0.021643	7.16	30.60	19.49	1.01
V14 North	Alignment - (V14	14300	PF 1	219.12	869.38	871.21	871.21	871.86	0.022352	6.46	33.92	26.59	1.01
V14 North	Alignment - (V14	14200	PF 1	219.12	847.77	850.24	850.24	850.95	0.022379	6.75	32.48	23.64	1.01
V14 North	Alignment - (V14	14100	PF 1	219.12	829.93	832.27	832.27	833.11	0.021518	7.39	29.65	17.74	1.01
V14 North	Alignment - (V14	14000	PF 1	219.12	828.57	830.02	830.02	830.48	0.025014	5.44	40.26	44.89	1.01
V14 North	Alignment - (V14	13900	PF 1	219.12	819.63	820.65	820.65	821.05	0.025813	5.07	43.22	55.02	1.01
V14 North	Alignment - (V14	13800	PF 1	219.12	809.92	811.08	811.08	811.45	0.026396	4.92	44.50	60.09	1.01
V14 North	Alignment - (V14	13700	PF 1	219.12	800.85	802.46	802.46	803.03	0.022932	6.04	36.26	32.25	1.00
V14 North	Alignment - (V14	13600	PF 1	219.12	779.69	794.63	781.64	794.63	0.000005	0.32	684.79	80.87	0.02
V14 North	Alignment - (V14	13375		Culvert									
V14 North	Alignment - (V14	13200	PF 1	301.88	759.00	760.24	760.24	760.67	0.025154	5.27	57.23	67.40	1.01
V14 North	Alignment - (V14	13100	PF 1	301.88	749.82	751.77		752.03	0.006716	4.09	73.77	46.82	0.57
V14 North	Alignment - (V14	13000	PF 1	301.88	749.53	750.48	750.48	750.83	0.026896	4.76	63.47	91.89	1.01
V14 North	Alignment - (V14	12900	PF 1	301.88	739.88	741.54		741.76	0.006630	3.75	80.47	57.94	0.56
V14 North	Alignment - (V14	12800	PF 1	301.88	739.16	740.10	740.10	740.44	0.037589	4.37	64.79	98.84	1.12
V14 North	Alignment - (V14	12700	PF 1	301.88	729.97	732.00		732.28	0.007929	4.21	71.75	49.73	0.62
V14 North	Alignment - (V14	12600	PF 1	301.88	729.51	730.56	730.56	730.95	0.026271	4.99	60.53	80.18	1.01
V14 North	Alignment - (V14	12500	PF 1	301.88	726.51	727.56	727.56	727.93	0.026462	4.86	62.09	85.97	1.01
V14 North	Alignment - (V14	12400	PF 1	301.88	719.85	721.01		721.22	0.010996	3.62	83.37	92.92	0.67
V14 North	Alignment - (V14	12300	PF 1	301.88	717.85	719.20	719.20	719.56	0.027355	4.77	63.22	92.24	1.02
V14 North	Alignment - (V14	12200	PF 1	301.88	710.95	712.54	712.39	712.82	0.015881	4.27	70.77	81.29	0.81
V14 North	Alignment - (V14	12100	PF 1	301.88	709.95	710.42	710.42	710.64	0.031163	3.76	80.21	184.35	1.01
V14 North	Alignment - (V14	12000	PF 1	301.88	705.36	706.95	706.95	707.35	0.026069	5.08	59.45	76.24	1.01
V14 North	Alignment - (V14	11900	PF 1	301.88	699.99	701.65		701.80	0.007574	3.09	97.65	103.80	0.56
V14 North	Alignment - (V14	11800	PF 1	301.88	699.77	700.29	700.28	700.46	0.029730	3.30	91.58	247.91	0.96
V14 North	Alignment - (V14	11700	PF 1	301.88	695.56	697.20	697.20	697.52	0.028803	4.56	66.20	107.43	1.02
V14 North	Alignment - (V14	11600	PF 1	301.88	691.48	693.03	693.03	693.48	0.024673	5.37	56.20	63.38	1.01
V14 North	Alignment - (V14	11500	PF 1	301.88	689.98	691.03		691.08	0.002962	1.79	168.70	202.22	0.35
V14 North	Alignment - (V14	11400	PF 1	301.88	689.76	690.43		690.55	0.011378	2.75	109.85	190.06	0.64
V14 North	Alignment - (V14	11300	PF 1	301.88	687.44	688.52	688.52	688.83	0.028316	4.48	67.38	111.00	1.01
V14 North	Alignment - (V14	11200	PF 1	301.88	679.99	681.62	681.62	682.07	0.025069	5.34	56.58	65.27	1.01
V14 North	Alignment - (V14	11100	PF 1	425.29	679.34	680.86		680.95	0.003150	2.29	185.82	161.44	0.38
V14 North	Alignment - (V14	11000	PF 1	425.29	678.65	679.89	679.89	680.22	0.027745	4.59	92.57	144.68	1.01
V14 North	Alignment - (V14	10900	PF 1	425.29	674.83	676.24	676.24	676.65	0.025346	5.16	82.43	101.12	1.01
V14 North	Alignment - (V14	10800	PF 1	425.29	669.80	671.88		672.38	0.013717	5.70	74.65	49.50	0.82
V14 North	Alignment - (V14	10700	PF 1	425.29	669.43	671.48		671.62	0.003822	3.03	140.18	92.11	0.43
V14 North	Alignment - (V14	10600	PF 1	425.29	669.06	671.29		671.35	0.001652	2.05	207.17	130.50	0.29
V14 North	Alignment - (V14	10500	PF 1	425.29	668.69	671.20		671.23	0.000793	1.49	285.04	167.23	0.20
V14 North	Alignment - (V14	10400	PF 1	425.29	668.31	671.16		671.18	0.000347	1.06	400.92	210.99	0.14
V14 North	Alignment - (V14	10300	PF 1	425.29	663.88	671.17		671.17	0.000011	0.37	1145.15	223.99	0.03

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
V14 North	Alignment - (V14	10200	PF 1	425.29	659.96	671.17		671.17	0.000002	0.22	1891.75	237.91	0.01
V14 North	Alignment - (V14	10100	PF 1	425.29	659.87	671.17		671.17	0.000002	0.21	2066.80	224.82	0.01
V14 North	Alignment - (V14	10000	PF 1	425.29	656.87	671.17	658.14	671.17	0.000001	0.14	3144.31	278.71	0.01
V14 Branch238	Alignment - (V14	30436.9	PF 1	273.60	1061.22	1063.20	1063.20	1063.81	0.022658	6.26	43.74	36.72	1.01
V14 Branch238	Alignment - (V14	30400	PF 1	273.60	1059.93	1061.80		1061.95	0.004021	3.08	88.90	59.21	0.44
V14 Branch238	Alignment - (V14	30300	PF 1	273.60	1059.63	1060.67	1060.67	1061.10	0.025278	5.24	52.24	62.34	1.01
V14 Branch238	Alignment - (V14	30200	PF 1	273.60	1052.79	1055.08	1055.08	1055.75	0.021939	6.55	41.77	31.75	1.01
V14 Branch238	Alignment - (V14	30100	PF 1	273.60	1039.93	1042.22	1042.22	1043.04	0.020869	7.26	37.68	23.19	1.00
V14 Branch238	Alignment - (V14	30000	PF 1	273.60	1034.13	1036.63	1036.63	1037.37	0.021696	6.92	39.56	27.14	1.01
V14 Branch238	Alignment - (V14	29900	PF 1	273.60	1029.48	1030.95	1030.95	1031.52	0.023087	6.06	45.15	40.19	1.01
V14 Branch238	Alignment - (V14	29800	PF 1	273.60	1019.69	1020.69	1020.69	1021.11	0.025399	5.17	52.91	64.60	1.01
V14 Branch238	Alignment - (V14	29700	PF 1	273.60	1011.60	1013.18	1013.18	1013.72	0.023161	5.89	46.43	43.39	1.00
V14 Branch238	Alignment - (V14	29600	PF 1	273.60	1009.74	1010.79	1010.79	1011.24	0.024708	5.39	50.73	56.81	1.01
V14 Branch238	Alignment - (V14	29500	PF 1	273.60	999.46	1000.91		1001.23	0.012555	4.54	60.30	52.56	0.75
V14 Branch238	Alignment - (V14	29400	PF 1	273.60	995.81	1001.07		1001.09	0.000171	1.11	246.68	69.47	0.10
V14 Branch238	Alignment - (V14	29300	PF 1	273.60	999.68	1000.61	1000.61	1000.99	0.026039	4.98	54.95	72.29	1.01
V14 Branch238	Alignment - (V14	29200	PF 1	273.60	989.94	991.99		992.22	0.005160	3.84	71.22	40.50	0.51
V14 Branch238	Alignment - (V14	29100	PF 1	273.60	989.59	991.60		991.76	0.003761	3.21	85.33	50.27	0.43
V14 Branch238	Alignment - (V14	29000	PF 1	273.60	989.20	990.50	990.50	990.95	0.024904	5.38	50.87	57.59	1.01
V14 Branch238	Alignment - (V14	28900	PF 1	273.60	979.63	981.09	981.09	981.69	0.022769	6.21	44.09	37.38	1.01
V14 Branch238	Alignment - (V14	28800	PF 1	273.60	973.91	976.22	976.22	976.88	0.022139	6.51	42.05	32.51	1.01
V14 Branch238	Alignment - (V14	28700	PF 1	273.60	969.92	971.61		971.93	0.008861	4.52	60.48	40.44	0.65
V14 Branch238	Alignment - (V14	28600	PF 1	273.60	967.82	970.13	970.13	970.54	0.025045	5.11	53.55	65.66	1.00
V14 Branch238	Alignment - (V14	28500	PF 1	341.00	959.85	961.28	961.28	961.90	0.022273	6.34	53.80	43.60	1.01
V14 Branch238	Alignment - (V14	28400	PF 1	341.00	951.60	954.60	954.60	955.57	0.020331	7.91	43.11	22.58	1.01
V14 Branch238	Alignment - (V14	28300	PF 1	341.00	949.43	950.78	950.78	951.30	0.023653	5.79	58.94	57.57	1.01
V14 Branch238	Alignment - (V14	28200	PF 1	341.00	944.70	946.37	946.37	946.94	0.022543	6.07	56.17	49.27	1.00
V14 Branch238	Alignment - (V14	28100	PF 1	341.00	939.81	941.51		941.64	0.003369	2.82	120.73	80.01	0.41
V14 Branch238	Alignment - (V14	28000	PF 1	341.00	939.18	940.46	940.46	940.89	0.024741	5.26	64.78	75.58	1.00
V14 Branch238	Alignment - (V14	27900	PF 1	341.00	929.97	931.74	931.74	932.45	0.021435	6.77	50.35	35.71	1.01
V14 Branch238	Alignment - (V14	27800	PF 1	341.00	929.86	931.39		931.49	0.003175	2.61	130.67	93.38	0.39
V14 Branch238	Alignment - (V14	27700	PF 1	341.00	929.63	930.45	930.45	930.76	0.027871	4.51	75.59	121.70	1.01
V14 Branch238	Alignment - (V14	27600	PF 1	341.00	923.42	924.99	924.99	925.45	0.024383	5.41	63.00	69.68	1.00
V14 Branch238	Alignment - (V14	27500	PF 1	341.00	919.65	920.80	920.80	921.27	0.024346	5.51	61.92	66.60	1.01
V14 Branch238	Alignment - (V14	27400	PF 1	341.00	910.69	913.13	913.13	913.89	0.021032	6.98	48.86	32.66	1.01
V14 Branch238	Alignment - (V14	27300	PF 1	341.00	909.74	911.57		911.73	0.004311	3.22	106.01	69.63	0.46
V14 Branch238	Alignment - (V14	27200	PF 1	609.28	909.45	910.27	910.27	910.51	0.030950	3.98	153.15	322.35	1.02
V14 Branch238	Alignment - (V14	27100	PF 1	609.28	902.49	904.54	904.54	905.26	0.021189	6.83	89.26	62.68	1.01
V14 Branch238	Alignment - (V14	27000	PF 1	609.28	899.82	902.05		902.32	0.005721	4.13	147.56	82.50	0.54
V14 Branch238	Alignment - (V14	26900	PF 1	609.28	899.60	900.80	900.80	901.26	0.024082	5.47	111.33	120.27	1.00
V14 Branch238	Alignment - (V14	26800	PF 1	609.28	894.07	896.04	896.04	896.60	0.023198	6.00	101.46	92.67	1.01
V14 Branch238	Alignment - (V14	26700	PF 1	609.28	890.00	892.92	892.46	893.33	0.009613	5.15	118.28	70.00	0.70
V14 Branch238	Alignment - (V14	26600	PF 1	609.28	889.97	891.40	891.40	891.88	0.024389	5.53	110.09	117.43	1.01
V14 Branch238	Alignment - (V14	26500	PF 1	609.28	889.80	890.99		891.03	0.001546	1.58	386.50	343.50	0.26
V14 Branch238	Alignment - (V14	26400	PF 1	760.00	889.59	890.47		890.63	0.012440	3.19	238.41	352.75	0.68
V14 Branch238	Alignment - (V14	26300	PF 1	760.00	887.68	888.51	888.51	888.81	0.028253	4.43	171.41	286.40	1.01
V14 Branch238	Alignment - (V14	26200	PF 1	760.00	880.44	886.57		886.58	0.000085	0.77	982.77	288.57	0.07

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
V14 Branch238	Alignment - (V14	26100	PF 1	760.00	880.00	886.56	882.25	886.57	0.000103	0.78	979.95	332.99	0.08
V14 Branch238	Alignment - (V14	26050		Culvert									
V14 Branch238	Alignment - (V14	26000	PF 1	783.60	879.92	882.44		882.50	0.001357	2.07	378.61	203.48	0.27
V14 Branch238	Alignment - (V14	25900	PF 1	840.00	879.67	882.18		882.32	0.002461	2.94	285.37	140.97	0.36
V14 Branch238	Alignment - (V14	25800	PF 1	840.00	879.32	881.06	881.06	881.71	0.021818	6.51	129.12	99.79	1.01
V14 Branch238	Alignment - (V14	25700	PF 1	840.00	869.98	874.86		875.73	0.011918	7.48	112.33	43.73	0.82
V14 Branch238	Alignment - (V14	25600	PF 1	840.00	869.69	873.02	873.02	874.23	0.018226	8.83	95.15	39.77	1.01
V14 Branch238	Alignment - (V14	25500	PF 1	840.00	859.94	864.14	864.03	865.35	0.015853	8.81	95.34	35.53	0.95
V14 Branch238	Alignment - (V14	25400	PF 1	840.00	859.51	863.19		863.97	0.010147	7.05	119.22	45.04	0.76
V14 Branch238	Alignment - (V14	25300	PF 1	840.00	859.12	862.44		863.00	0.008050	6.01	139.74	56.87	0.68
V14 Branch238	Alignment - (V14	25200	PF 1	840.00	858.70	860.98	860.98	861.75	0.020771	7.07	118.76	77.88	1.01
V14 Branch238	Alignment - (V14	25100	PF 1	840.00	849.96	853.79	853.79	854.97	0.018118	8.69	96.67	41.22	1.00
V14 Branch238	Alignment - (V14	25000	PF 1	840.00	849.64	851.72	851.72	852.61	0.019847	7.55	111.22	63.56	1.01
V14 Branch238	Alignment - (V14	24900	PF 1	840.00	847.39	849.68	849.68	850.52	0.020206	7.36	114.08	68.93	1.01
V14 Branch238	Alignment - (V14	24800	PF 1	840.00	839.93	843.04		843.81	0.013151	7.05	119.18	55.43	0.85
V14 Branch238	Alignment - (V14	24700	PF 1	840.00	839.70	842.45		842.82	0.006192	4.94	169.97	76.74	0.59
V14 Branch238	Alignment - (V14	24600	PF 1	840.00	838.86	840.99	840.99	841.75	0.020985	6.99	120.20	80.85	1.01
V14 Branch238	Alignment - (V14	24500	PF 1	840.00	829.98	833.69	833.69	834.81	0.018370	8.52	98.61	43.84	1.00
V14 Branch238	Alignment - (V14	24400	PF 1	840.00	829.86	833.54		833.84	0.003437	4.42	190.15	64.79	0.45
V14 Branch238	Alignment - (V14	24300	PF 1	840.00	829.75	833.07		833.43	0.004847	4.84	173.52	67.00	0.53
V14 Branch238	Alignment - (V14	24200	PF 1	840.00	829.64	831.70	831.70	832.51	0.020303	7.23	116.20	72.50	1.01
V14 Branch238	Alignment - (V14	24100	PF 1	840.00	827.23	828.99	828.99	829.57	0.022926	6.09	137.87	122.22	1.01
V14 Branch238	Alignment - (V14	24000	PF 1	840.00	820.00	826.58		826.58	0.000030	0.61	1386.40	263.28	0.05
V14 Branch238	Alignment - (V14	23900	PF 1	840.00	819.99	826.58		826.58	0.000004	0.24	3437.20	600.00	0.02
V14 Branch238	Alignment - (V14	23863.83	PF 1	840.00	819.92	826.58	820.44	826.58	0.000004	0.23	3624.44	600.00	0.02
Branch130	Alignment - (V14	18330.44	PF 1	800.00	799.62	802.17		802.43	0.004735	4.08	196.03	96.82	0.51
Branch130	Alignment - (V14	18300	PF 1	800.00	799.49	802.06		802.29	0.004020	3.79	211.04	102.94	0.47
Branch130	Alignment - (V14	18200	PF 1	800.00	799.08	800.83	800.83	801.45	0.022348	6.33	126.38	103.67	1.01
Branch130	Alignment - (V14	18100	PF 1	800.00	789.72	791.48	791.48	792.22	0.020806	6.88	116.33	79.62	1.00
Branch130	Alignment - (V14	18000	PF 1	800.00	781.61	784.46	784.46	785.37	0.019806	7.64	104.65	58.80	1.01
Branch130	Alignment - (V14	17900	PF 1	800.00	779.64	781.38		781.56	0.004648	3.33	240.30	159.13	0.48
Branch130	Alignment - (V14	17800	PF 1	800.00	777.37	780.11	780.11	780.64	0.023389	5.82	137.40	132.20	1.01
Branch130	Alignment - (V14	17700	PF 1	800.00	769.97	772.51		772.97	0.008660	5.43	147.46	74.57	0.68
Branch130	Alignment - (V14	17600	PF 1	800.00	769.84	771.08	771.08	771.63	0.022989	5.97	134.10	122.81	1.01
Branch130	Alignment - (V14	17500	PF 1	800.00	759.99	763.35	763.35	764.27	0.019343	7.69	103.99	56.60	1.00
Branch130	Alignment - (V14	17400	PF 1	800.00	759.81	762.46		762.74	0.004539	4.24	188.71	85.06	0.50
Branch130	Alignment - (V14	17300	PF 1	800.00	759.32	761.15	761.15	761.85	0.021423	6.71	119.27	86.80	1.01
Branch130	Alignment - (V14	17200	PF 1	800.00	753.73	756.95	756.95	757.86	0.019908	7.63	104.85	59.34	1.01
Branch130	Alignment - (V14	17100	PF 1	800.00	732.21	737.15	737.15	738.45	0.018039	9.16	87.30	33.47	1.00
Branch130	Alignment - (V14	17000	PF 1	800.00	723.23	727.16	727.16	728.42	0.017989	9.03	88.60	34.98	1.00
Branch130	Alignment - (V14	16900	PF 1	800.00	719.93	722.42	722.42	723.49	0.018768	8.28	96.63	45.64	1.00
Branch130	Alignment - (V14	16800	PF 1	800.00	709.78	714.39	714.39	715.84	0.017837	9.65	82.90	28.71	1.00
Branch130	Alignment - (V14	16700	PF 1	800.00	699.99	705.17	705.17	706.43	0.018669	9.03	88.60	35.04	1.00
Branch130	Alignment - (V14	16600	PF 1	800.00	686.87	690.50	690.50	691.49	0.019163	7.97	100.37	50.93	1.00
Branch130	Alignment - (V14	16500	PF 1	800.00	679.33	682.65	682.63	683.73	0.017996	8.32	96.12	43.71	0.99
Branch130	Alignment - (V14	16400	PF 1	800.00	678.43	680.92	680.92	681.73	0.020444	7.23	110.63	69.32	1.01
Branch130	Alignment - (V14	16300	PF 1	800.00	669.99	673.37	673.21	674.21	0.015454	7.33	109.11	53.99	0.91

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Branch130	Alignment - (V14	16200	PF 1	800.00	669.93	671.64	671.64	672.40	0.020780	6.98	114.54	76.53	1.01
Branch130	Alignment - (V14	16100	PF 1	800.00	664.13	667.62	667.62	668.53	0.019323	7.67	104.26	57.06	1.00
Branch130	Alignment - (V14	16000	PF 1	800.00	658.68	661.09	661.09	661.93	0.020134	7.32	109.35	66.46	1.01
Branch130	Alignment - (V14	15900	PF 1	800.00	649.89	653.04		653.91	0.012895	7.48	106.92	44.32	0.85
Branch130	Alignment - (V14	15800	PF 1	800.00	649.72	652.21		652.71	0.009351	5.63	142.20	72.10	0.71
Branch130	Alignment - (V14	15700	PF 1	800.00	649.53	650.79	650.79	651.30	0.023701	5.72	139.95	139.94	1.01
Branch130	Alignment - (V14	15600	PF 1	800.00	644.04	645.85	645.85	646.46	0.022229	6.29	127.24	105.06	1.01
Branch130	Alignment - (V14	15500	PF 1	800.00	639.95	642.63		643.04	0.009063	5.12	156.28	89.39	0.68
Branch130	Alignment - (V14	15400	PF 1	800.00	639.85	641.14	641.14	641.65	0.023764	5.69	140.51	141.56	1.01
Branch130	Alignment - (V14	15300	PF 1	800.00	636.32	638.25	638.25	638.80	0.023423	5.94	134.67	126.03	1.01
Branch130	Alignment - (V14	15200	PF 1	800.00	630.74	633.31	633.15	633.86	0.015919	5.97	134.04	93.11	0.88
Branch130	Alignment - (V14	15100	PF 1	800.00	629.96	632.21		632.58	0.009797	4.85	165.02	108.85	0.69
Branch130	Alignment - (V14	15000	PF 1	800.00	629.78	631.72		631.89	0.004379	3.24	246.56	162.41	0.46
Branch130	Alignment - (V14	14900	PF 1	800.00	629.46	630.57	630.57	630.98	0.025484	5.16	155.16	191.34	1.01
Branch130	Alignment - (V14	14800	PF 1	800.00	622.85	624.80	624.80	625.46	0.021935	6.50	123.11	95.79	1.01
Branch130	Alignment - (V14	14700	PF 1	800.00	620.00	622.34	622.34	623.06	0.020884	6.83	117.10	81.38	1.00
Branch130	Alignment - (V14	14600	PF 1	800.00	619.99	621.77		621.86	0.002223	2.37	337.19	213.71	0.33
Branch130	Alignment - (V14	14500	PF 1	800.00	619.97	621.51		621.60	0.002908	2.43	329.38	246.50	0.37
Branch130	Alignment - (V14	14400	PF 1	800.00	619.85	620.61	620.61	620.92	0.027785	4.45	179.81	294.65	1.00
Branch130	Alignment - (V14	14300	PF 1	800.00	612.57	614.54	614.54	615.13	0.022842	6.15	130.04	113.28	1.01
Branch130	Alignment - (V14	14200	PF 1	800.00	609.99	611.51		611.80	0.011973	4.36	183.57	165.30	0.73
Branch130	Alignment - (V14	14100	PF 1	800.00	609.95	611.33		611.38	0.001654	1.78	448.75	349.45	0.28
Branch130	Alignment - (V14	14000	PF 1	800.00	609.00	610.60	610.60	610.93	0.026212	4.56	175.27	264.72	0.99
Branch130	Alignment - (V14	13900	PF 1	800.00	602.00	607.67	604.10	607.70	0.000189	1.33	600.77	140.96	0.11
Branch130	Alignment - (V14	13725		Culvert									
Branch130	Alignment - (V14	13600	PF 1	1726.00	599.95	601.46		601.53	0.002173	2.19	788.96	554.20	0.32
Branch130	Alignment - (V14	13500	PF 1	1726.00	599.89	601.11		601.22	0.004605	2.70	639.41	575.89	0.45
Branch130	Alignment - (V14	13400	PF 1	1726.00	597.63	599.82	599.82	600.27	0.026075	5.39	320.09	373.24	1.03
Branch130	Alignment - (V14	13300	PF 1	1726.00	594.67	596.34	596.34	596.73	0.026644	5.00	345.40	461.40	1.02
Branch130	Alignment - (V14	13200	PF 1	1726.00	590.25	593.03		593.13	0.003868	2.52	685.80	600.00	0.42
Branch130	Alignment - (V14	13100	PF 1	1726.00	589.77	593.05		593.06	0.000138	0.92	1869.46	600.00	0.09
Branch130	Alignment - (V14	13018.25	PF 1	1726.00	589.28	593.04	590.37	593.05	0.000134	0.92	1880.86	600.00	0.09
Alignment - (PVR	Alignment - (PVR	36232.63	PF 1	1529.00	1069.69	1081.20		1081.23	0.000123	1.30	1172.90	199.28	0.09
Alignment - (PVR	Alignment - (PVR	36200	PF 1	1529.00	1075.90	1079.84	1079.84	1081.09	0.017795	8.98	170.22	69.08	1.01
Alignment - (PVR	Alignment - (PVR	35800	PF 1	1529.00	1067.72	1077.42		1077.58	0.000931	3.26	468.89	85.70	0.25
Alignment - (PVR	Alignment - (PVR	35700	PF 1	1529.00	1073.76	1076.52	1076.52	1077.27	0.020724	6.95	219.95	146.63	1.00
Alignment - (PVR	Alignment - (PVR	35600	PF 1	1529.00	1063.95	1066.97	1066.97	1067.73	0.020447	6.99	218.79	144.63	1.00
Alignment - (PVR	Alignment - (PVR	35572.15	PF 1	1529.00	1062.00	1065.42	1065.42	1066.36	0.019185	7.75	197.19	106.22	1.00
Alignment - (PVR	Alignment - (PVR	35400	PF 1	1529.00	1051.96	1054.64	1054.64	1055.55	0.019445	7.66	199.70	110.93	1.01
Alignment - (PVR	Alignment - (PVR	35303.27	PF 1	1529.00	1049.23	1052.25	1052.25	1053.10	0.019419	7.43	205.92	119.59	1.00
Alignment - (PVR	Alignment - (PVR	35300	PF 1	1529.00	1049.01	1052.04	1052.04	1052.92	0.019945	7.54	202.90	117.62	1.01
Alignment - (PVR	Alignment - (PVR	35200	PF 1	1529.00	1044.00	1047.74	1047.74	1048.65	0.020241	7.67	199.30	113.62	1.02
Alignment - (PVR	Alignment - (PVR	35100	PF 1	1529.00	1038.08	1040.59	1040.59	1041.51	0.019623	7.66	199.49	111.34	1.01
Alignment - (PVR	Alignment - (PVR	35038.7	PF 1	1529.00	1034.84	1037.28	1037.28	1038.10	0.020490	7.25	210.76	131.98	1.01
Alignment - (PVR	Alignment - (PVR	35000	PF 1	1529.00	1032.10	1034.91	1034.91	1035.72	0.020005	7.19	212.68	132.66	1.00
Alignment - (PVR	Alignment - (PVR	34900	PF 1	1529.00	1027.29	1029.42	1029.42	1030.19	0.020684	7.03	217.49	143.96	1.01
Alignment - (PVR	Alignment - (PVR	34800	PF 1	1529.00	1022.61	1025.53	1025.53	1026.48	0.019316	7.80	195.96	105.18	1.01

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	34723.08	PF 1	1529.00	1016.82	1018.75	1018.75	1019.52	0.020883	7.03	217.49	143.36	1.01
Alignment - (PVR	Alignment - (PVR	34700	PF 1	1529.00	1015.66	1017.58	1017.58	1018.32	0.021218	6.92	220.98	150.87	1.01
Alignment - (PVR	Alignment - (PVR	34600	PF 1	1529.00	1009.35	1017.88		1017.91	0.000163	1.18	1290.75	316.85	0.10
Alignment - (PVR	Alignment - (PVR	34537.13	PF 1	1529.00	1014.78	1017.03	1017.03	1017.80	0.020752	7.01	218.09	145.24	1.01
Alignment - (PVR	Alignment - (PVR	34500	PF 1	1529.00	1012.17	1014.94	1014.94	1015.80	0.020070	7.45	205.19	121.57	1.01
Alignment - (PVR	Alignment - (PVR	34400	PF 1	1529.00	1009.29	1011.90	1011.90	1012.81	0.019505	7.65	199.93	111.49	1.01
Alignment - (PVR	Alignment - (PVR	34300	PF 1	1529.00	1006.52	1008.78	1008.78	1009.57	0.020575	7.12	214.66	138.63	1.01
Alignment - (PVR	Alignment - (PVR	34202.82	PF 1	1529.00	1002.63	1005.79	1005.79	1006.61	0.019908	7.24	211.11	129.72	1.00
Alignment - (PVR	Alignment - (PVR	34200	PF 1	1529.00	1002.45	1005.72	1005.72	1006.49	0.020019	7.01	218.07	141.27	0.99
Alignment - (PVR	Alignment - (PVR	34100	PF 1	1529.00	999.98	1002.18	1002.18	1002.76	0.023013	6.13	249.54	219.91	1.01
Alignment - (PVR	Alignment - (PVR	34000	PF 1	1529.00	998.00	999.65	999.65	1000.13	0.024008	5.61	272.75	283.61	1.01
Alignment - (PVR	Alignment - (PVR	33900	PF 1	1529.00	995.72	997.72		997.90	0.007594	3.32	461.04	444.48	0.57
Alignment - (PVR	Alignment - (PVR	33856.32	PF 1	1529.00	994.00	996.94	996.94	997.32	0.025129	4.97	307.53	395.79	0.99
Alignment - (PVR	Alignment - (PVR	33800	PF 1	1529.00	993.63	995.18	995.18	995.69	0.023927	5.71	267.79	270.10	1.01
Alignment - (PVR	Alignment - (PVR	33700	PF 1	1529.00	990.52	992.49	992.49	992.90	0.024406	5.12	298.61	360.21	0.99
Alignment - (PVR	Alignment - (PVR	33600	PF 1	1529.00	988.75	990.54	990.30	990.87	0.011909	4.58	333.67	277.55	0.74
Alignment - (PVR	Alignment - (PVR	33501.47	PF 1	1529.00	986.33	989.16		989.49	0.016648	4.63	330.59	348.40	0.84
Alignment - (PVR	Alignment - (PVR	33500	PF 1	1529.00	986.00	989.11	989.00	989.46	0.017619	4.73	323.31	343.76	0.86
Alignment - (PVR	Alignment - (PVR	33400	PF 1	1529.00	984.00	986.90	986.90	987.34	0.025429	5.37	284.94	329.20	1.02
Alignment - (PVR	Alignment - (PVR	33300	PF 1	1529.00	981.95	983.70	983.70	984.31	0.022254	6.29	243.17	200.71	1.01
Alignment - (PVR	Alignment - (PVR	33282.53	PF 1	1529.00	979.98	982.87		983.45	0.014525	6.14	249.21	154.76	0.85
Alignment - (PVR	Alignment - (PVR	33200	PF 1	1529.00	978.00	982.00		982.48	0.009116	5.58	274.10	137.62	0.70
Alignment - (PVR	Alignment - (PVR	33100	PF 1	1529.00	976.00	980.34	980.34	981.11	0.021794	7.05	216.92	148.07	1.03
Alignment - (PVR	Alignment - (PVR	33000	PF 1	1529.00	974.00	977.33	977.33	978.17	0.020409	7.32	208.89	128.47	1.01
Alignment - (PVR	Alignment - (PVR	32900.52	PF 1	1529.00	970.99	974.33	974.31	974.83	0.022975	5.66	270.33	268.28	0.99
Alignment - (PVR	Alignment - (PVR	32900	PF 1	1529.00	970.94	974.29	974.29	974.81	0.024268	5.76	265.45	267.09	1.02
Alignment - (PVR	Alignment - (PVR	32800	PF 1	1529.00	967.88	969.92	969.92	970.64	0.021073	6.82	224.26	157.65	1.01
Alignment - (PVR	Alignment - (PVR	32700	PF 1	1529.00	964.25	966.48	966.48	967.18	0.021329	6.72	227.41	164.65	1.01
Alignment - (PVR	Alignment - (PVR	32600	PF 1	1529.00	961.98	963.97		964.45	0.012487	5.57	274.39	176.32	0.79
Alignment - (PVR	Alignment - (PVR	32564.34	PF 1	1529.00	961.02	963.20	963.17	963.88	0.019922	6.59	231.95	164.44	0.98
Alignment - (PVR	Alignment - (PVR	32500	PF 1	1529.00	959.95	961.82	961.82	962.57	0.020551	6.91	221.19	149.41	1.00
Alignment - (PVR	Alignment - (PVR	32400	PF 1	1529.00	958.00	959.77	959.77	960.24	0.024542	5.50	277.76	301.52	1.01
Alignment - (PVR	Alignment - (PVR	32300	PF 1	1529.00	954.81	957.15	957.13	957.70	0.021276	5.95	256.78	222.36	0.98
Alignment - (PVR	Alignment - (PVR	32200	PF 1	1529.00	952.00	956.41		956.69	0.005147	4.26	358.71	177.05	0.53
Alignment - (PVR	Alignment - (PVR	32153.27	PF 1	1529.00	952.00	956.16		956.45	0.005237	4.34	352.36	171.55	0.53
Alignment - (PVR	Alignment - (PVR	32100	PF 1	1529.00	951.98	955.08	955.08	955.91	0.020358	7.29	209.75	129.82	1.01
Alignment - (PVR	Alignment - (PVR	32000	PF 1	1529.00	950.00	953.78	953.26	954.18	0.008845	5.05	302.61	173.78	0.68
Alignment - (PVR	Alignment - (PVR	31900	PF 1	1529.00	949.88	952.44		952.96	0.017297	5.82	262.59	201.74	0.90
Alignment - (PVR	Alignment - (PVR	31800	PF 1	1529.00	948.00	951.82		952.08	0.004614	4.10	372.95	179.75	0.50
Alignment - (PVR	Alignment - (PVR	31700	PF 1	1529.00	948.00	950.83		951.38	0.010601	5.97	256.19	131.17	0.75
Alignment - (PVR	Alignment - (PVR	31630	PF 1	1529.00	946.00	949.83		950.55	0.012708	6.82	224.19	107.24	0.83
Alignment - (PVR	Alignment - (PVR	31600	PF 1	1529.00	946.00	949.81		950.21	0.005661	5.09	300.51	121.98	0.57
Alignment - (PVR	Alignment - (PVR	31500	PF 1	1529.00	945.95	949.19		949.62	0.006073	5.26	290.66	117.95	0.59
Alignment - (PVR	Alignment - (PVR	31400	PF 1	1529.00	945.54	947.74	947.74	948.57	0.020129	7.33	208.48	126.82	1.01
Alignment - (PVR	Alignment - (PVR	31300	PF 1	1529.00	942.00	945.33	945.33	946.25	0.019689	7.70	198.45	110.11	1.01
Alignment - (PVR	Alignment - (PVR	31213.08	PF 1	1529.00	940.00	944.77		945.14	0.006052	4.84	315.98	144.87	0.58
Alignment - (PVR	Alignment - (PVR	31200	PF 1	1529.00	940.00	944.08	944.08	944.95	0.019976	7.48	204.37	119.01	1.01

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	31100	PF 1	1529.00	939.96	942.13	942.07	942.83	0.018479	6.68	228.79	150.16	0.95
Alignment - (PVR	Alignment - (PVR	31000	PF 1	1529.00	937.95	940.18	940.18	940.82	0.021536	6.44	237.54	185.05	1.00
Alignment - (PVR	Alignment - (PVR	30900	PF 1	1529.00	935.93	938.46		938.94	0.011959	5.58	274.03	170.12	0.78
Alignment - (PVR	Alignment - (PVR	30846.71	PF 1	1529.00	934.00	937.18	937.18	938.09	0.019684	7.66	199.67	111.85	1.01
Alignment - (PVR	Alignment - (PVR	30800	PF 1	1529.00	933.99	936.16	936.13	936.94	0.019261	7.09	215.67	133.60	0.98
Alignment - (PVR	Alignment - (PVR	30700	PF 1	1529.00	932.63	935.06		935.46	0.010193	5.11	298.96	187.64	0.71
Alignment - (PVR	Alignment - (PVR	30600	PF 1	1529.00	931.94	933.38	933.38	934.00	0.022098	6.31	242.34	198.34	1.01
Alignment - (PVR	Alignment - (PVR	30500	PF 1	1529.00	929.17	930.97	930.97	931.59	0.022150	6.34	241.00	195.97	1.01
Alignment - (PVR	Alignment - (PVR	30400	PF 1	1529.00	924.40	927.27		927.73	0.008522	5.39	283.47	143.50	0.68
Alignment - (PVR	Alignment - (PVR	30300	PF 1	1529.00	921.98	926.08	925.51	926.82	0.009175	6.86	222.92	82.57	0.74
Alignment - (PVR	Alignment - (PVR	30293.59	PF 1	1529.00	921.96	925.51	925.51	926.69	0.017791	8.73	175.12	74.03	1.00
Alignment - (PVR	Alignment - (PVR	30200	PF 1	1529.00	920.38	923.71	923.71	924.52	0.020638	7.23	211.55	133.62	1.01
Alignment - (PVR	Alignment - (PVR	30100	PF 1	1529.00	917.98	920.91	920.91	921.48	0.023657	6.05	252.69	231.54	1.02
Alignment - (PVR	Alignment - (PVR	30000	PF 1	1529.00	916.00	918.50	918.50	919.16	0.021359	6.55	233.44	176.00	1.00
Alignment - (PVR	Alignment - (PVR	29900	PF 1	1529.00	911.98	916.89		917.26	0.010188	4.88	313.60	210.12	0.70
Alignment - (PVR	Alignment - (PVR	29853.03	PF 1	1529.00	910.00	916.29	916.03	916.70	0.013532	5.17	295.74	223.83	0.79
Alignment - (PVR	Alignment - (PVR	29800	PF 1	1529.00	910.00	914.98	914.98	915.79	0.020623	7.23	211.52	132.69	1.01
Alignment - (PVR	Alignment - (PVR	29700	PF 1	1529.00	908.32	912.70	912.70	913.42	0.021314	6.84	223.48	156.90	1.01
Alignment - (PVR	Alignment - (PVR	29638.03	PF 1	1529.00	908.00	911.72		912.19	0.012076	5.49	278.34	177.25	0.77
Alignment - (PVR	Alignment - (PVR	29600	PF 1	1529.00	907.97	911.29		911.74	0.011523	5.32	287.16	185.89	0.76
Alignment - (PVR	Alignment - (PVR	29500	PF 1	1529.00	906.00	910.01		910.40	0.015303	5.06	302.35	260.99	0.83
Alignment - (PVR	Alignment - (PVR	29400	PF 1	1529.00	906.00	908.98		909.24	0.008555	4.12	370.82	281.95	0.63
Alignment - (PVR	Alignment - (PVR	29300	PF 1	1529.00	906.00	908.04		908.27	0.010943	3.89	392.69	391.49	0.69
Alignment - (PVR	Alignment - (PVR	29218.4	PF 1	1529.00	904.00	907.14		907.39	0.010513	4.03	379.31	348.19	0.68
Alignment - (PVR	Alignment - (PVR	29200	PF 1	1529.00	904.00	906.93		907.19	0.011169	4.09	374.05	351.94	0.70
Alignment - (PVR	Alignment - (PVR	29100	PF 1	1529.00	904.00	905.83		906.08	0.011180	4.04	378.51	362.87	0.70
Alignment - (PVR	Alignment - (PVR	29000	PF 1	1529.00	902.00	904.64		904.91	0.012317	4.15	368.21	364.13	0.73
Alignment - (PVR	Alignment - (PVR	28900	PF 1	1529.00	901.99	903.96		904.12	0.005108	3.24	471.91	349.92	0.49
Alignment - (PVR	Alignment - (PVR	28800	PF 1	1529.00	901.81	903.37		903.55	0.006375	3.38	452.23	371.55	0.54
Alignment - (PVR	Alignment - (PVR	28700	PF 1	1529.00	900.00	902.47		902.73	0.010628	4.15	368.01	325.53	0.69
Alignment - (PVR	Alignment - (PVR	28679.96	PF 1	1529.00	899.98	902.16	901.96	902.48	0.014885	4.54	336.44	334.96	0.80
Alignment - (PVR	Alignment - (PVR	28600	PF 1	1529.00	899.77	901.27		901.52	0.009590	3.99	383.68	334.59	0.66
Alignment - (PVR	Alignment - (PVR	28500	PF 1	1529.00	898.49	900.44		900.65	0.007655	3.71	412.66	338.97	0.59
Alignment - (PVR	Alignment - (PVR	28400	PF 1	1529.00	898.00	900.10		900.21	0.002588	2.71	564.09	328.28	0.36
Alignment - (PVR	Alignment - (PVR	28300	PF 1	1529.00	897.68	899.67		899.85	0.005065	3.43	445.29	300.73	0.50
Alignment - (PVR	Alignment - (PVR	28215.3	PF 1	1529.00	896.62	899.29		899.48	0.003944	3.44	443.99	247.41	0.45
Alignment - (PVR	Alignment - (PVR	28200	PF 1	1529.00	896.43	899.23		899.42	0.003717	3.49	438.44	229.33	0.44
Alignment - (PVR	Alignment - (PVR	28100	PF 1	1529.00	895.57	897.90	897.83	898.65	0.018096	6.94	220.20	134.26	0.96
Alignment - (PVR	Alignment - (PVR	28000	PF 1	1529.00	892.00	897.35		897.53	0.005863	3.39	451.50	346.71	0.52
Alignment - (PVR	Alignment - (PVR	27975.38	PF 1	1529.00	892.00	896.85		897.32	0.009489	5.51	277.27	146.59	0.71
Alignment - (PVR	Alignment - (PVR	27900	PF 1	1529.00	892.00	895.56	895.48	896.34	0.017434	7.08	216.00	124.16	0.95
Alignment - (PVR	Alignment - (PVR	27800	PF 1	1529.00	892.00	894.56		894.82	0.011010	4.10	372.52	344.56	0.70
Alignment - (PVR	Alignment - (PVR	27704.08	PF 1	1529.00	892.00	893.65		893.90	0.008329	4.02	380.29	294.22	0.62
Alignment - (PVR	Alignment - (PVR	27700	PF 1	1529.00	891.99	893.59		893.86	0.009874	4.21	362.93	297.45	0.67
Alignment - (PVR	Alignment - (PVR	27600	PF 1	1529.00	890.00	892.76	892.24	893.03	0.007199	4.12	370.89	247.87	0.59
Alignment - (PVR	Alignment - (PVR	27500	PF 1	1529.00	889.79	891.93		892.27	0.007833	4.64	329.34	195.95	0.63
Alignment - (PVR	Alignment - (PVR	27426.82	PF 1	1529.00	888.00	891.91		892.02	0.001204	2.58	591.64	207.72	0.27

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	27400	PF 1	1529.00	887.59	891.84		891.97	0.002361	2.93	521.22	251.22	0.36
Alignment - (PVR	Alignment - (PVR	27300	PF 1	1529.00	886.00	891.81		891.86	0.000422	1.71	893.03	265.01	0.16
Alignment - (PVR	Alignment - (PVR	27200	PF 1	1529.00	886.00	891.79		891.82	0.000285	1.54	992.71	257.34	0.14
Alignment - (PVR	Alignment - (PVR	27176.82	PF 1	1529.00	886.00	891.78		891.81	0.000262	1.48	1033.55	267.66	0.13
Alignment - (PVR	Alignment - (PVR	27100	PF 1	1529.00	885.99	891.77		891.80	0.000146	1.20	1277.19	292.15	0.10
Alignment - (PVR	Alignment - (PVR	27062.24	PF 1	1529.00	885.30	891.77		891.79	0.000103	1.07	1433.65	301.21	0.09
Alignment - (PVR	Alignment - (PVR	27000	PF 1	1529.00	884.00	891.77	886.70	891.78	0.000088	1.03	1478.30	288.66	0.08
Alignment - (PVR	Alignment - (PVR	26925		Culvert									
Alignment - (PVR	Alignment - (PVR	26800	PF 1	1529.00	881.94	883.76	883.76	884.51	0.020766	6.95	220.02	148.56	1.01
Alignment - (PVR	Alignment - (PVR	26767.52	PF 1	1529.00	881.60	883.50		883.87	0.011458	4.84	315.61	234.47	0.74
Alignment - (PVR	Alignment - (PVR	26700	PF 1	1529.00	880.00	882.91		883.16	0.008887	3.98	383.94	316.43	0.64
Alignment - (PVR	Alignment - (PVR	26600	PF 1	1529.00	879.97	882.07		882.29	0.008387	3.77	405.94	348.25	0.62
Alignment - (PVR	Alignment - (PVR	26572.97	PF 1	1529.00	879.96	881.37	881.37	881.90	0.023053	5.86	261.13	246.84	1.00
Alignment - (PVR	Alignment - (PVR	26500	PF 1	1529.00	878.80	880.56	880.22	880.80	0.008982	3.92	390.36	332.51	0.64
Alignment - (PVR	Alignment - (PVR	26400	PF 1	1529.00	877.53	878.91	878.91	879.39	0.024111	5.58	273.99	287.90	1.01
Alignment - (PVR	Alignment - (PVR	26379.01	PF 1	1529.00	876.70	878.87		879.06	0.006154	3.48	439.39	336.69	0.54
Alignment - (PVR	Alignment - (PVR	26300	PF 1	1529.00	875.78	878.05		878.33	0.015141	4.20	363.84	412.45	0.79
Alignment - (PVR	Alignment - (PVR	26200	PF 1	1529.00	874.31	876.81		877.10	0.010211	4.28	357.53	293.86	0.68
Alignment - (PVR	Alignment - (PVR	26128.43	PF 1	1529.00	873.58	875.78		876.20	0.015390	5.16	296.10	249.44	0.84
Alignment - (PVR	Alignment - (PVR	26100	PF 1	1529.00	871.98	875.48	875.17	875.81	0.010668	4.65	328.60	245.32	0.71
Alignment - (PVR	Alignment - (PVR	26000	PF 1	5021.00	866.58	872.74	872.74	874.21	0.016714	9.72	516.35	177.73	1.01
Alignment - (PVR	Alignment - (PVR	25966.31	PF 1	5021.00	865.98	871.38	871.38	873.01	0.015972	10.23	490.96	151.16	1.00
Alignment - (PVR	Alignment - (PVR	25900	PF 1	5021.00	862.89	869.62	869.62	871.65	0.014908	11.43	439.12	108.50	1.00
Alignment - (PVR	Alignment - (PVR	25841.73	PF 1	5021.00	859.85	869.35		869.87	0.002455	5.80	865.58	152.64	0.43
Alignment - (PVR	Alignment - (PVR	25800	PF 1	5021.00	858.00	869.44		869.73	0.001147	4.33	1158.29	177.47	0.30
Alignment - (PVR	Alignment - (PVR	25700	PF 1	5021.00	859.15	869.06		869.55	0.002362	5.65	888.58	158.71	0.42
Alignment - (PVR	Alignment - (PVR	25665.95	PF 1	5021.00	859.90	868.02	867.27	869.33	0.009322	9.18	546.84	132.29	0.80
Alignment - (PVR	Alignment - (PVR	25600	PF 1	5021.00	859.66	866.33	866.33	868.48	0.014673	11.76	427.08	99.71	1.00
Alignment - (PVR	Alignment - (PVR	25500	PF 1	5021.00	852.45	859.80	859.80	861.92	0.014672	11.69	429.38	101.22	1.00
Alignment - (PVR	Alignment - (PVR	25453.15	PF 1	5021.00	849.98	857.39	857.39	859.54	0.014625	11.76	426.98	99.48	1.00
Alignment - (PVR	Alignment - (PVR	25400	PF 1	5021.00	849.93	854.69	854.69	856.63	0.015222	11.17	449.55	117.18	1.01
Alignment - (PVR	Alignment - (PVR	25300	PF 1	5021.00	846.48	851.32	851.32	852.91	0.016378	10.10	497.23	159.93	1.01
Alignment - (PVR	Alignment - (PVR	25200	PF 1	5021.00	839.98	845.96		846.58	0.004213	6.27	800.35	190.08	0.54
Alignment - (PVR	Alignment - (PVR	25100	PF 1	5021.00	839.89	845.39		846.10	0.005178	6.77	741.66	183.27	0.59
Alignment - (PVR	Alignment - (PVR	25000	PF 1	5021.00	839.59	843.62	843.62	845.17	0.016358	9.97	503.73	165.34	1.01
Alignment - (PVR	Alignment - (PVR	24959.78	PF 1	5021.00	839.22	843.46	842.93	844.47	0.009900	8.04	624.24	194.04	0.79
Alignment - (PVR	Alignment - (PVR	24900	PF 1	5021.00	838.57	842.35	842.35	843.68	0.016900	9.24	543.37	205.02	1.00
Alignment - (PVR	Alignment - (PVR	24800	PF 1	5021.00	830.04	837.51		838.39	0.006554	7.52	667.46	167.99	0.67
Alignment - (PVR	Alignment - (PVR	24700	PF 1	5021.00	829.99	835.80	835.74	837.37	0.015040	10.03	500.41	152.55	0.98
Alignment - (PVR	Alignment - (PVR	24600	PF 1	5021.00	829.93	834.84		835.98	0.010656	8.58	585.06	174.27	0.83
Alignment - (PVR	Alignment - (PVR	24500	PF 1	5021.00	829.79	833.91		834.91	0.009956	8.03	625.40	195.79	0.79
Alignment - (PVR	Alignment - (PVR	24409.65	PF 1	5021.00	828.83	832.42	832.42	833.72	0.017417	9.12	550.36	216.53	1.01
Alignment - (PVR	Alignment - (PVR	24400	PF 1	5021.00	828.15	832.03	832.03	833.32	0.017060	9.10	551.98	214.77	1.00
Alignment - (PVR	Alignment - (PVR	24300	PF 1	5021.00	821.16	828.21		828.93	0.005735	6.82	735.95	194.29	0.62
Alignment - (PVR	Alignment - (PVR	24200	PF 1	5021.00	820.00	828.19		828.49	0.001990	4.40	1140.52	262.84	0.37
Alignment - (PVR	Alignment - (PVR	24152.03	PF 1	5021.00	820.00	828.17		828.39	0.001353	3.79	1326.36	287.15	0.31
Alignment - (PVR	Alignment - (PVR	24100	PF 1	5021.00	820.00	828.16		828.31	0.000896	3.09	1627.17	351.30	0.25

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	24000	PF 1	5021.00	820.00	828.17		828.24	0.000269	2.09	2400.32	376.60	0.15
Alignment - (PVR	Alignment - (PVR	23900	PF 1	5021.00	819.99	827.84		828.16	0.001533	4.56	1102.07	197.64	0.34
Alignment - (PVR	Alignment - (PVR	23800	PF 1	7617.00	819.97	826.58		827.75	0.006485	8.69	876.50	176.02	0.69
Alignment - (PVR	Alignment - (PVR	23737.94	PF 1	7617.00	819.95	826.13		827.34	0.006777	8.83	862.68	174.78	0.70
Alignment - (PVR	Alignment - (PVR	23700	PF 1	7617.00	819.93	825.66		827.04	0.008091	9.41	809.18	169.92	0.76
Alignment - (PVR	Alignment - (PVR	23600	PF 1	7617.00	819.81	824.96		826.18	0.008189	8.84	861.62	201.09	0.75
Alignment - (PVR	Alignment - (PVR	23500	PF 1	7617.00	819.63	823.42	823.42	825.03	0.015848	10.18	748.01	232.18	1.00
Alignment - (PVR	Alignment - (PVR	23400	PF 1	7617.00	813.21	818.41	818.41	820.01	0.015841	10.17	748.79	232.99	1.00
Alignment - (PVR	Alignment - (PVR	23300	PF 1	7617.00	809.97	816.66	816.40	818.09	0.012842	9.61	792.23	229.09	0.91
Alignment - (PVR	Alignment - (PVR	23299.44	PF 1	7617.00	809.97	816.78		818.03	0.010604	8.98	848.46	235.55	0.83
Alignment - (PVR	Alignment - (PVR	23200	PF 1	7617.00	809.92	816.16		817.08	0.007016	7.67	992.45	255.80	0.69
Alignment - (PVR	Alignment - (PVR	23128.45	PF 1	7617.00	809.88	815.94		816.61	0.004467	6.58	1157.35	267.60	0.56
Alignment - (PVR	Alignment - (PVR	23100	PF 1	7617.00	809.86	815.87		816.47	0.003818	6.25	1218.11	270.27	0.52
Alignment - (PVR	Alignment - (PVR	23000	PF 1	7617.00	809.81	815.50		816.09	0.003670	6.17	1234.60	271.29	0.51
Alignment - (PVR	Alignment - (PVR	22936.91	PF 1	7617.00	809.72	815.22		815.85	0.003920	6.36	1196.83	263.70	0.53
Alignment - (PVR	Alignment - (PVR	22900	PF 1	7617.00	809.62	814.99		815.69	0.004571	6.71	1134.62	258.94	0.57
Alignment - (PVR	Alignment - (PVR	22800	PF 1	7617.00	809.23	813.20	813.20	814.82	0.016062	10.21	746.05	233.15	1.01
Alignment - (PVR	Alignment - (PVR	22700.29	PF 1	7617.00	804.47	809.67	809.67	811.47	0.015277	10.76	707.67	196.72	1.00
Alignment - (PVR	Alignment - (PVR	22700	PF 1	7617.00	804.44	809.65	809.65	811.45	0.015270	10.77	707.29	196.39	1.00
Alignment - (PVR	Alignment - (PVR	22600	PF 1	7617.00	800.00	807.62		808.23	0.003532	6.26	1216.92	254.16	0.50
Alignment - (PVR	Alignment - (PVR	22565.02	PF 1	7617.00	799.99	807.10		808.04	0.005435	7.77	979.70	203.99	0.63
Alignment - (PVR	Alignment - (PVR	22500	PF 1	7617.00	799.97	807.09		807.69	0.002845	6.23	1222.79	217.52	0.46
Alignment - (PVR	Alignment - (PVR	22496.74	PF 1	7617.00	799.97	807.01		807.68	0.003260	6.54	1164.98	213.48	0.49
Alignment - (PVR	Alignment - (PVR	22400	PF 1	7617.00	799.94	804.89	804.89	806.95	0.014871	11.51	661.52	162.25	1.01
Alignment - (PVR	Alignment - (PVR	22396.4	PF 1	7617.00	799.93	804.43	804.43	806.36	0.015197	11.13	684.21	179.67	1.01
Alignment - (PVR	Alignment - (PVR	22300	PF 1	7617.00	795.76	801.46	801.46	803.45	0.014812	11.31	673.20	169.33	1.00
Alignment - (PVR	Alignment - (PVR	22260.34	PF 1	7617.00	786.76	794.52	794.52	796.57	0.014915	11.50	662.10	161.23	1.00
Alignment - (PVR	Alignment - (PVR	22200	PF 1	7617.00	779.74	791.79		792.89	0.005386	8.40	907.19	164.38	0.63
Alignment - (PVR	Alignment - (PVR	22147.88	PF 1	7617.00	779.94	790.90	790.45	792.45	0.010820	9.99	762.48	180.71	0.86
Alignment - (PVR	Alignment - (PVR	22100	PF 1	7617.00	779.44	791.45		791.90	0.002518	5.42	1404.63	279.09	0.43
Alignment - (PVR	Alignment - (PVR	22062.04	PF 1	7617.00	780.00	788.60	788.60	791.48	0.013476	13.60	560.18	97.68	1.00
Alignment - (PVR	Alignment - (PVR	22000	PF 1	7617.00	779.70	785.05	785.05	787.42	0.014390	12.35	616.64	131.51	1.01
Alignment - (PVR	Alignment - (PVR	21950.81	PF 1	7617.00	773.90	780.99	780.99	783.46	0.014097	12.61	603.89	123.13	1.00
Alignment - (PVR	Alignment - (PVR	21900	PF 1	7617.00	769.49	775.70	775.70	778.29	0.013865	12.91	590.11	114.03	1.00
Alignment - (PVR	Alignment - (PVR	21800	PF 1	7617.00	767.20	772.87	772.87	774.87	0.015081	11.35	670.89	169.93	1.01
Alignment - (PVR	Alignment - (PVR	21775.46	PF 1	7617.00	763.21	770.36	770.36	772.74	0.014066	12.37	615.87	129.61	1.00
Alignment - (PVR	Alignment - (PVR	21761.64	PF 1	7617.00	760.35	768.95	768.95	771.61	0.013668	13.07	582.58	109.84	1.00
Alignment - (PVR	Alignment - (PVR	21727.87	PF 1	7617.00	759.56	768.85		770.76	0.007184	11.08	687.20	100.78	0.75
Alignment - (PVR	Alignment - (PVR	21700	PF 1	7617.00	759.26	768.85		770.50	0.005894	10.30	739.20	104.19	0.68
Alignment - (PVR	Alignment - (PVR	21687.47	PF 1	7617.00	759.13	767.20	767.20	770.26	0.013540	14.02	543.28	90.05	1.01
Alignment - (PVR	Alignment - (PVR	21600	PF 1	7617.00	749.99	760.71	760.71	764.16	0.013304	14.90	511.34	74.63	1.00
Alignment - (PVR	Alignment - (PVR	21580.89	PF 1	7617.00	749.95	760.33	760.33	763.62	0.013275	14.55	523.63	79.83	1.00
Alignment - (PVR	Alignment - (PVR	21510.4	PF 1	7617.00	749.66	757.24	757.24	760.18	0.013459	13.76	553.63	94.19	1.00
Alignment - (PVR	Alignment - (PVR	21500	PF 1	7617.00	749.59	756.93	756.93	759.81	0.013524	13.61	559.80	97.43	1.00
Alignment - (PVR	Alignment - (PVR	21453.76	PF 1	7617.00	749.29	755.37	755.37	757.95	0.013931	12.87	591.68	115.18	1.00
Alignment - (PVR	Alignment - (PVR	21400	PF 1	7617.00	741.26	749.65	749.65	752.43	0.013647	13.38	569.24	102.27	1.00
Alignment - (PVR	Alignment - (PVR	21351.76	PF 1	7617.00	739.91	749.72		751.22	0.005045	9.82	775.42	104.21	0.63

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	21300	PF 1	7617.00	739.82	747.66	747.66	750.67	0.013435	13.92	547.33	91.38	1.00
Alignment - (PVR	Alignment - (PVR	21234.44	PF 1	7617.00	739.70	746.23	746.23	748.84	0.013805	12.96	587.60	112.83	1.00
Alignment - (PVR	Alignment - (PVR	21200	PF 1	7617.00	739.64	745.52	745.52	747.98	0.014173	12.60	604.66	124.03	1.01
Alignment - (PVR	Alignment - (PVR	21141.46	PF 1	7617.00	731.03	739.95	739.95	742.30	0.014213	12.29	619.80	132.84	1.00
Alignment - (PVR	Alignment - (PVR	21100	PF 1	7617.00	730.00	737.26	737.26	739.58	0.014445	12.22	623.20	136.34	1.01
Alignment - (PVR	Alignment - (PVR	21021.32	PF 1	7617.00	729.99	734.93	734.48	736.58	0.010705	10.31	739.02	166.76	0.86
Alignment - (PVR	Alignment - (PVR	21000	PF 1	7617.00	729.98	734.30	734.30	736.28	0.014890	11.30	674.18	169.96	1.00
Alignment - (PVR	Alignment - (PVR	20943.91	PF 1	7617.00	725.84	731.99	731.99	733.57	0.016195	10.09	754.87	240.83	1.00
Alignment - (PVR	Alignment - (PVR	20900	PF 1	7617.00	723.04	730.85	730.57	732.49	0.012126	10.28	740.74	184.93	0.91
Alignment - (PVR	Alignment - (PVR	20835.06	PF 1	7617.00	720.00	730.36	729.06	731.87	0.007032	9.86	772.46	135.42	0.73
Alignment - (PVR	Alignment - (PVR	20800	PF 1	7617.00	719.90	728.78	728.78	731.42	0.013812	13.03	584.35	111.51	1.00
Alignment - (PVR	Alignment - (PVR	20704.14	PF 1	7617.00	719.29	728.52		729.63	0.004173	8.44	902.11	134.23	0.57
Alignment - (PVR	Alignment - (PVR	20700	PF 1	7617.00	719.26	728.46		729.61	0.004348	8.59	887.20	132.76	0.59
Alignment - (PVR	Alignment - (PVR	20606.91	PF 1	7617.00	718.66	726.14	726.14	728.79	0.013927	13.06	583.35	111.69	1.01
Alignment - (PVR	Alignment - (PVR	20600	PF 1	7617.00	718.61	726.05	726.05	728.61	0.013791	12.84	593.02	115.72	1.00
Alignment - (PVR	Alignment - (PVR	20500	PF 1	7617.00	709.75	716.04	716.04	718.68	0.013909	13.02	585.10	112.06	1.00
Alignment - (PVR	Alignment - (PVR	20445.99	PF 1	7617.00	709.43	714.79	714.61	716.84	0.012784	11.49	662.97	144.92	0.95
Alignment - (PVR	Alignment - (PVR	20400	PF 1	7617.00	709.09	714.16	714.16	716.19	0.014941	11.43	666.42	165.89	1.01
Alignment - (PVR	Alignment - (PVR	20307.01	PF 1	7617.00	700.00	707.70	707.70	710.09	0.014097	12.39	614.73	129.11	1.00
Alignment - (PVR	Alignment - (PVR	20300	PF 1	7617.00	699.99	707.45	707.45	709.86	0.014099	12.46	611.45	127.35	1.00
Alignment - (PVR	Alignment - (PVR	20212.87	PF 1	7617.00	699.91	707.00		708.53	0.007674	9.94	766.58	142.10	0.75
Alignment - (PVR	Alignment - (PVR	20200	PF 1	7617.00	699.89	706.91		708.42	0.007525	9.87	771.88	142.32	0.75
Alignment - (PVR	Alignment - (PVR	20121.28	PF 1	7617.00	699.67	706.51		707.81	0.006441	9.14	833.14	153.48	0.69
Alignment - (PVR	Alignment - (PVR	20100	PF 1	7617.00	699.55	706.38		707.67	0.006475	9.13	834.33	154.81	0.69
Alignment - (PVR	Alignment - (PVR	20000	PF 1	7617.00	698.49	704.48	704.48	706.65	0.014707	11.80	645.32	151.24	1.01
Alignment - (PVR	Alignment - (PVR	19934.69	PF 1	7617.00	696.88	703.05	703.05	705.21	0.014727	11.78	646.51	152.07	1.01
Alignment - (PVR	Alignment - (PVR	19900	PF 1	7617.00	692.56	700.38	700.38	702.71	0.014183	12.24	622.56	134.25	1.00
Alignment - (PVR	Alignment - (PVR	19800	PF 1	7617.00	689.97	697.67	697.67	699.92	0.014268	12.04	632.68	140.53	1.00
Alignment - (PVR	Alignment - (PVR	19780.83	PF 1	7617.00	689.95	697.46	697.37	699.60	0.013587	11.74	649.07	144.52	0.98
Alignment - (PVR	Alignment - (PVR	19700	PF 1	7617.00	689.70	696.84		698.56	0.009451	10.54	722.75	143.52	0.83
Alignment - (PVR	Alignment - (PVR	19600	PF 1	7617.00	689.29	696.19		697.61	0.007970	9.56	796.86	161.75	0.76
Alignment - (PVR	Alignment - (PVR	19598.98	PF 1	7617.00	689.29	696.17		697.60	0.008032	9.59	794.58	161.54	0.76
Alignment - (PVR	Alignment - (PVR	19522.22	PF 1	7617.00	688.99	695.53		696.96	0.008760	9.59	794.29	172.58	0.79
Alignment - (PVR	Alignment - (PVR	19500	PF 1	7617.00	688.90	695.30		696.76	0.009232	9.68	787.25	175.63	0.81
Alignment - (PVR	Alignment - (PVR	19429.9	PF 1	7617.00	688.63	694.86		696.07	0.008267	8.82	863.42	203.98	0.76
Alignment - (PVR	Alignment - (PVR	19400	PF 1	7617.00	688.50	694.57		695.82	0.008744	8.97	849.08	204.02	0.78
Alignment - (PVR	Alignment - (PVR	19300	PF 1	7617.00	688.09	693.87		694.94	0.007843	8.30	917.37	228.28	0.73
Alignment - (PVR	Alignment - (PVR	19282.61	PF 1	7617.00	688.01	693.82		694.78	0.006953	7.85	969.94	239.75	0.69
Alignment - (PVR	Alignment - (PVR	19200	PF 1	7617.00	687.67	692.25	692.25	693.87	0.016151	10.21	745.72	233.84	1.01
Alignment - (PVR	Alignment - (PVR	19100	PF 1	7617.00	680.25	688.67		689.62	0.005895	7.83	972.81	213.16	0.65
Alignment - (PVR	Alignment - (PVR	19029.64	PF 1	7617.00	679.98	688.58		689.23	0.003327	6.46	1179.97	224.82	0.50
Alignment - (PVR	Alignment - (PVR	19000	PF 1	7617.00	679.97	688.50		689.12	0.003069	6.34	1201.37	221.24	0.48
Alignment - (PVR	Alignment - (PVR	18900	PF 1	7617.00	679.92	688.24		688.84	0.002458	6.21	1225.83	196.32	0.44
Alignment - (PVR	Alignment - (PVR	18889.6	PF 1	7617.00	679.90	688.19		688.82	0.002459	6.35	1199.90	185.78	0.44
Alignment - (PVR	Alignment - (PVR	18800	PF 1	7617.00	679.75	687.88		688.58	0.002718	6.68	1139.70	175.45	0.46
Alignment - (PVR	Alignment - (PVR	18700	PF 1	7617.00	679.56	687.51		688.28	0.003157	7.04	1082.28	172.88	0.50
Alignment - (PVR	Alignment - (PVR	18660.92	PF 1	7617.00	679.51	687.40		688.15	0.003110	6.97	1092.84	175.04	0.49

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	18600	PF 1	7617.00	679.21	685.18	685.18	687.63	0.014016	12.56	606.40	123.69	1.00
Alignment - (PVR	Alignment - (PVR	18522.82	PF 1	7617.00	670.00	678.84	678.84	681.85	0.013570	13.92	547.38	91.26	1.00
Alignment - (PVR	Alignment - (PVR	18500	PF 1	7617.00	669.98	679.08		681.09	0.007223	11.37	669.95	93.88	0.75
Alignment - (PVR	Alignment - (PVR	18400	PF 1	7617.00	669.85	677.55	677.22	680.13	0.011493	12.90	590.31	98.57	0.93
Alignment - (PVR	Alignment - (PVR	18343.84	PF 1	7617.00	669.78	677.67		679.36	0.007192	10.42	730.69	118.89	0.74
Alignment - (PVR	Alignment - (PVR	18300	PF 1	7617.00	669.73	677.77		678.95	0.004884	8.73	872.77	139.26	0.61
Alignment - (PVR	Alignment - (PVR	18200	PF 1	7617.00	669.61	677.00		678.38	0.006164	9.42	808.40	137.10	0.68
Alignment - (PVR	Alignment - (PVR	18100	PF 1	7617.00	669.50	675.12	675.12	677.39	0.014300	12.10	629.48	138.59	1.00
Alignment - (PVR	Alignment - (PVR	18039.2	PF 1	7617.00	666.95	673.60	673.60	675.76	0.014500	11.80	645.56	149.42	1.00
Alignment - (PVR	Alignment - (PVR	18000	PF 1	7617.00	663.01	670.56	670.56	672.88	0.014192	12.23	622.81	134.33	1.00
Alignment - (PVR	Alignment - (PVR	17900	PF 1	7617.00	660.00	669.97		670.66	0.002399	6.63	1149.16	162.75	0.44
Alignment - (PVR	Alignment - (PVR	17886.95	PF 1	7617.00	660.00	669.40		670.57	0.004351	8.65	880.17	129.77	0.59
Alignment - (PVR	Alignment - (PVR	17800	PF 1	7617.00	659.99	667.06	667.06	669.79	0.013679	13.25	574.84	105.59	1.00
Alignment - (PVR	Alignment - (PVR	17700	PF 1	7617.00	659.96	665.91	665.91	667.90	0.015560	11.31	673.23	170.15	1.00
Alignment - (PVR	Alignment - (PVR	17600	PF 1	7617.00	651.22	666.76		666.89	0.000547	2.95	2580.76	394.97	0.20
Alignment - (PVR	Alignment - (PVR	17579.52	PF 1	7617.00	659.75	664.60	664.60	666.67	0.014701	11.54	660.09	159.86	1.00
Alignment - (PVR	Alignment - (PVR	17500	PF 1	7617.00	656.15	662.60	662.60	664.59	0.014823	11.31	673.29	169.38	1.00
Alignment - (PVR	Alignment - (PVR	17400	PF 1	7617.00	649.75	657.03		658.10	0.004654	8.30	917.50	152.75	0.60
Alignment - (PVR	Alignment - (PVR	17318	PF 1	7617.00	648.90	655.84	654.92	657.54	0.008283	10.46	728.18	131.75	0.78
Alignment - (PVR	Alignment - (PVR	17300	PF 1	7617.00	648.70	654.84	654.84	657.27	0.014039	12.51	608.93	125.32	1.00
Alignment - (PVR	Alignment - (PVR	17259.51	PF 1	7617.00	645.17	652.26	652.26	654.85	0.013975	12.92	589.62	115.24	1.01
Alignment - (PVR	Alignment - (PVR	17200	PF 1	7617.00	639.99	648.64	648.64	651.45	0.013531	13.44	566.60	101.08	1.00
Alignment - (PVR	Alignment - (PVR	17100	PF 1	7617.00	639.98	647.72	647.14	649.84	0.010143	11.68	652.19	116.39	0.87
Alignment - (PVR	Alignment - (PVR	17000	PF 1	7617.00	639.96	646.36	646.34	648.63	0.014220	12.10	629.64	138.37	1.00
Alignment - (PVR	Alignment - (PVR	16972.18	PF 1	7617.00	639.96	646.03	646.03	648.19	0.014648	11.81	645.22	150.78	1.01
Alignment - (PVR	Alignment - (PVR	16900	PF 1	7617.00	639.94	645.22	645.01	646.92	0.012943	10.43	730.03	187.63	0.93
Alignment - (PVR	Alignment - (PVR	16800	PF 1	7617.00	639.81	645.09		645.84	0.005352	6.93	1099.77	269.83	0.60
Alignment - (PVR	Alignment - (PVR	16793.95	PF 1	7617.00	639.80	644.94		645.79	0.006311	7.42	1027.10	257.35	0.65
Alignment - (PVR	Alignment - (PVR	16700	PF 1	7617.00	639.61	643.63	643.35	644.94	0.012336	9.20	827.97	248.19	0.89
Alignment - (PVR	Alignment - (PVR	16600	PF 1	7617.00	637.13	641.76	641.76	643.52	0.015384	10.64	715.76	203.41	1.00
Alignment - (PVR	Alignment - (PVR	16593.62	PF 1	7617.00	636.08	641.23	641.23	643.05	0.015308	10.83	703.53	194.08	1.00
Alignment - (PVR	Alignment - (PVR	16500	PF 1	7617.00	630.00	639.86		640.87	0.004279	8.05	946.27	155.19	0.57
Alignment - (PVR	Alignment - (PVR	16400	PF 1	7617.00	630.00	638.93		640.32	0.006135	9.45	806.09	135.98	0.68
Alignment - (PVR	Alignment - (PVR	16379.51	PF 1	7617.00	630.00	638.82		640.19	0.006151	9.41	809.63	137.85	0.68
Alignment - (PVR	Alignment - (PVR	16300	PF 1	7617.00	629.99	638.74		639.67	0.003981	7.72	986.76	163.50	0.55
Alignment - (PVR	Alignment - (PVR	16245.87	PF 1	7617.00	629.98	638.59		639.44	0.003647	7.38	1032.44	171.45	0.53
Alignment - (PVR	Alignment - (PVR	16200	PF 1	7617.00	629.97	638.53		639.24	0.003195	6.74	1130.52	195.12	0.49
Alignment - (PVR	Alignment - (PVR	16100	PF 1	7617.00	629.89	638.66		638.95	0.000995	4.27	1784.25	254.53	0.28
Alignment - (PVR	Alignment - (PVR	16089.14	PF 1	7617.00	629.89	638.53		638.92	0.001417	5.00	1522.44	222.84	0.34
Alignment - (PVR	Alignment - (PVR	16000	PF 1	7617.00	629.72	638.48		638.79	0.001080	4.43	1718.43	246.00	0.30
Alignment - (PVR	Alignment - (PVR	15937.88	PF 1	7617.00	629.64	638.53		638.70	0.000678	3.30	2306.49	361.77	0.23
Alignment - (PVR	Alignment - (PVR	15900	PF 1	7617.00	629.58	638.53		638.66	0.000546	2.90	2622.74	424.84	0.21
Alignment - (PVR	Alignment - (PVR	15800.75	PF 1	7617.00	620.00	638.58		638.61	0.000095	1.59	4786.28	515.96	0.09
Alignment - (PVR	Alignment - (PVR	15800	PF 1	7617.00	620.00	638.58	629.55	638.61	0.000095	1.59	4790.40	515.66	0.09
Alignment - (PVR	Alignment - (PVR	15725		Culvert									
Alignment - (PVR	Alignment - (PVR	15626.78	PF 1	7617.00	619.98	628.56		628.76	0.000724	3.61	2108.00	305.05	0.24
Alignment - (PVR	Alignment - (PVR	15600	PF 1	7617.00	619.97	628.51		628.74	0.000799	3.82	1992.72	285.18	0.25

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	15558.76	PF 1	7617.00	619.96	628.51		628.70	0.000684	3.50	2178.28	316.65	0.24
Alignment - (PVR	Alignment - (PVR	15500	PF 1	7617.00	619.91	628.30		628.63	0.001274	4.65	1637.06	246.58	0.32
Alignment - (PVR	Alignment - (PVR	15485.89	PF 1	7617.00	619.90	628.19		628.60	0.001536	5.15	1480.22	220.51	0.35
Alignment - (PVR	Alignment - (PVR	15400	PF 1	10170.00	619.84	627.17		628.29	0.005550	8.49	1198.42	222.26	0.64
Alignment - (PVR	Alignment - (PVR	15395.33	PF 1	10170.00	619.83	627.11		628.26	0.005612	8.59	1184.23	217.47	0.65
Alignment - (PVR	Alignment - (PVR	15300	PF 1	10170.00	619.30	625.15	625.15	627.34	0.014399	11.88	856.22	196.03	1.00
Alignment - (PVR	Alignment - (PVR	15251.18	PF 1	10170.00	611.52	621.52	621.52	624.28	0.013620	13.32	763.73	139.93	1.00
Alignment - (PVR	Alignment - (PVR	15200	PF 1	10170.00	610.00	621.14		623.24	0.009493	11.64	873.52	149.35	0.85
Alignment - (PVR	Alignment - (PVR	15188.42	PF 1	10170.00	610.00	621.05	620.23	623.13	0.009656	11.58	878.57	153.64	0.85
Alignment - (PVR	Alignment - (PVR	15120.18	PF 1	10170.00	610.00	621.02		622.43	0.005651	9.50	1070.05	168.36	0.66
Alignment - (PVR	Alignment - (PVR	15100	PF 1	10170.00	609.99	621.04		622.27	0.004951	8.89	1144.32	180.39	0.62
Alignment - (PVR	Alignment - (PVR	15033.58	PF 1	10170.00	609.99	621.09		621.84	0.003680	6.93	1466.73	269.85	0.52
Alignment - (PVR	Alignment - (PVR	15000	PF 1	10170.00	609.98	620.83	617.95	621.65	0.008925	7.27	1399.23	467.28	0.74
Alignment - (PVR	Alignment - (PVR	14923.16	PF 1	10170.00	609.97	619.15		620.96	0.006664	10.80	941.25	137.57	0.73
Alignment - (PVR	Alignment - (PVR	14900	PF 1	10170.00	609.96	618.76		620.78	0.007596	11.39	893.05	132.95	0.77
Alignment - (PVR	Alignment - (PVR	14800	PF 1	10170.00	609.86	617.29	617.19	619.75	0.013270	12.58	808.27	158.81	0.98
Alignment - (PVR	Alignment - (PVR	14798.21	PF 1	10170.00	609.86	617.47	617.15	619.63	0.011779	11.78	863.19	171.33	0.93
Alignment - (PVR	Alignment - (PVR	14705.56	PF 1	10170.00	609.76	617.37		618.25	0.009901	7.51	1354.67	465.37	0.78
Alignment - (PVR	Alignment - (PVR	14700	PF 1	10170.00	609.75	617.33		618.19	0.009654	7.42	1370.52	470.05	0.77
Alignment - (PVR	Alignment - (PVR	14628.82	PF 1	10170.00	609.61	615.93	615.93	617.24	0.017570	9.18	1107.74	433.21	1.01
Alignment - (PVR	Alignment - (PVR	14600	PF 1	10170.00	608.78	615.28	615.28	616.61	0.017434	9.26	1098.44	421.74	1.01
Alignment - (PVR	Alignment - (PVR	14500	PF 1	10170.00	600.00	612.13		613.47	0.008232	9.29	1094.35	236.26	0.76
Alignment - (PVR	Alignment - (PVR	14442.59	PF 1	10170.00	600.00	611.20	610.79	612.88	0.011859	10.38	980.04	235.95	0.90
Alignment - (PVR	Alignment - (PVR	14400	PF 1	10170.00	599.99	609.36	609.36	612.20	0.014151	13.53	751.41	138.35	1.02
Alignment - (PVR	Alignment - (PVR	14309.39	PF 1	10170.00	599.97	608.88		610.33	0.006929	9.64	1054.69	190.38	0.72
Alignment - (PVR	Alignment - (PVR	14300	PF 1	10170.00	599.96	608.84		610.26	0.006800	9.56	1063.66	191.69	0.72
Alignment - (PVR	Alignment - (PVR	14200	PF 1	10170.00	599.94	606.85	606.85	609.22	0.014058	12.34	824.05	174.12	1.00
Alignment - (PVR	Alignment - (PVR	14130.86	PF 1	10170.00	599.85	605.58	605.38	607.69	0.013391	11.64	873.47	194.46	0.97
Alignment - (PVR	Alignment - (PVR	14100	PF 1	10170.00	599.79	605.86		607.07	0.009314	8.81	1154.00	297.98	0.79
Alignment - (PVR	Alignment - (PVR	14000	PF 1	10170.00	599.57	604.21	604.21	605.83	0.015863	10.22	995.07	307.44	1.00
Alignment - (PVR	Alignment - (PVR	13969.21	PF 1	10170.00	598.57	603.70	603.70	605.26	0.016051	10.02	1014.58	325.59	1.00
Alignment - (PVR	Alignment - (PVR	13900	PF 1	10170.00	592.48	599.99	599.83	602.09	0.013309	11.62	875.37	194.67	0.97
Alignment - (PVR	Alignment - (PVR	13800	PF 1	10170.00	590.00	599.71		600.89	0.006717	8.71	1167.89	239.41	0.70
Alignment - (PVR	Alignment - (PVR	13774.87	PF 1	10170.00	590.00	599.28		600.68	0.008246	9.49	1071.75	225.24	0.77
Alignment - (PVR	Alignment - (PVR	13700	PF 1	10170.00	589.99	598.78		600.07	0.007321	9.11	1116.62	228.46	0.73
Alignment - (PVR	Alignment - (PVR	13602.97	PF 1	10170.00	589.99	597.84		599.26	0.009186	9.55	1064.99	241.63	0.80
Alignment - (PVR	Alignment - (PVR	13600	PF 1	10170.00	589.99	597.82		599.23	0.009172	9.55	1065.39	241.58	0.80
Alignment - (PVR	Alignment - (PVR	13500	PF 1	10170.00	589.99	597.34		598.31	0.006856	7.88	1290.00	313.96	0.69
Alignment - (PVR	Alignment - (PVR	13400	PF 1	10170.00	589.99	596.66		597.56	0.007844	7.60	1338.92	381.41	0.71
Alignment - (PVR	Alignment - (PVR	13335.69	PF 1	10170.00	589.98	596.25		597.05	0.007042	7.19	1413.93	403.19	0.68
Alignment - (PVR	Alignment - (PVR	13300	PF 1	10170.00	589.98	595.18	595.18	596.62	0.016435	9.65	1053.68	365.01	1.00
Alignment - (PVR	Alignment - (PVR	13200	PF 1	10170.00	589.98	594.53		595.25	0.007605	6.80	1496.05	492.02	0.69
Alignment - (PVR	Alignment - (PVR	13100	PF 1	10170.00	589.96	594.06		594.58	0.004989	5.77	1763.40	541.01	0.56
Alignment - (PVR	Alignment - (PVR	13000	PF 1	11570.00	589.90	593.04		593.83	0.010553	7.12	1624.35	636.90	0.79
Alignment - (PVR	Alignment - (PVR	12997.93	PF 1	11570.00	589.78	593.04		593.80	0.008873	6.98	1657.28	587.91	0.73
Alignment - (PVR	Alignment - (PVR	12944.33	PF 1	11570.00	589.34	592.55		593.28	0.010302	6.84	1691.43	692.12	0.77
Alignment - (PVR	Alignment - (PVR	12900	PF 1	11570.00	588.65	592.19		592.84	0.008465	6.46	1790.09	688.20	0.71

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	12822.92	PF 1	11570.00	587.62	591.50		592.16	0.009327	6.49	1783.54	733.40	0.73
Alignment - (PVR	Alignment - (PVR	12800	PF 1	11570.00	587.30	590.83	590.83	591.83	0.018610	8.02	1443.20	725.21	1.00
Alignment - (PVR	Alignment - (PVR	12726.64	PF 1	11570.00	581.78	589.23		589.61	0.003032	4.95	2338.96	615.65	0.45
Alignment - (PVR	Alignment - (PVR	12700	PF 1	11570.00	581.58	589.18		589.52	0.002417	4.66	2482.33	602.09	0.40
Alignment - (PVR	Alignment - (PVR	12600	PF 1	11570.00	580.80	589.11		589.34	0.001027	3.79	3053.03	529.87	0.28
Alignment - (PVR	Alignment - (PVR	12588.26	PF 1	11570.00	581.60	588.89		589.30	0.002584	5.15	2247.85	494.74	0.43
Alignment - (PVR	Alignment - (PVR	12500	PF 1	11570.00	580.72	588.95		589.12	0.000709	3.28	3522.69	575.83	0.23
Alignment - (PVR	Alignment - (PVR	12496.55	PF 1	11570.00	584.00	587.81	587.81	589.01	0.017496	8.77	1318.63	551.75	1.00
Alignment - (PVR	Alignment - (PVR	12409.91	PF 1	11570.00	580.62	585.06		585.76	0.006279	6.67	1735.23	508.66	0.64
Alignment - (PVR	Alignment - (PVR	12400	PF 1	11570.00	580.12	585.07		585.67	0.005993	6.18	1871.31	593.25	0.61
Alignment - (PVR	Alignment - (PVR	12314.49	PF 1	11570.00	579.95	584.80		585.21	0.003708	5.14	2252.70	657.49	0.49
Alignment - (PVR	Alignment - (PVR	12300	PF 1	11570.00	579.94	584.75		585.16	0.003676	5.11	2264.65	661.90	0.49
Alignment - (PVR	Alignment - (PVR	12200	PF 1	11570.00	579.88	584.30		584.75	0.004377	5.39	2145.29	658.34	0.53
Alignment - (PVR	Alignment - (PVR	12129.32	PF 1	11570.00	579.84	583.70		584.34	0.007339	6.44	1796.59	622.75	0.67
Alignment - (PVR	Alignment - (PVR	12100	PF 1	11570.00	579.75	583.28		584.08	0.009644	7.14	1619.87	589.92	0.76
Alignment - (PVR	Alignment - (PVR	12000	PF 1	11570.00	576.08	582.90		583.37	0.004169	5.54	2086.78	591.24	0.52
Alignment - (PVR	Alignment - (PVR	11974.61	PF 1	11570.00	576.06	582.51		583.21	0.007707	6.73	1718.84	578.49	0.69
Alignment - (PVR	Alignment - (PVR	11900	PF 1	11570.00	573.98	581.80		582.58	0.008981	7.10	1628.84	565.89	0.74
Alignment - (PVR	Alignment - (PVR	11864.42	PF 1	11570.00	573.97	581.43		582.25	0.009922	7.25	1596.34	580.78	0.77
Alignment - (PVR	Alignment - (PVR	11800	PF 1	11570.00	573.91	581.10		581.68	0.006037	6.10	1895.50	615.61	0.61
Alignment - (PVR	Alignment - (PVR	11700.27	PF 1	11570.00	571.97	579.91		580.83	0.011677	7.70	1501.88	563.00	0.83
Alignment - (PVR	Alignment - (PVR	11700	PF 1	11570.00	571.97	579.91		580.83	0.011714	7.71	1500.30	562.87	0.83
Alignment - (PVR	Alignment - (PVR	11600	PF 1	11570.00	571.93	579.01		579.76	0.009015	6.95	1663.66	600.05	0.74
Alignment - (PVR	Alignment - (PVR	11500	PF 1	11570.00	571.88	578.35		578.95	0.006520	6.25	1851.49	615.03	0.63
Alignment - (PVR	Alignment - (PVR	11496.24	PF 1	11570.00	571.88	578.32		578.93	0.006574	6.25	1849.74	617.41	0.64
Alignment - (PVR	Alignment - (PVR	11400	PF 1	11570.00	570.00	577.51		578.23	0.007668	6.80	1700.88	561.81	0.69
Alignment - (PVR	Alignment - (PVR	11300	PF 1	11570.00	569.99	576.75		577.49	0.007160	6.90	1678.02	515.80	0.67
Alignment - (PVR	Alignment - (PVR	11202.87	PF 1	11570.00	569.95	575.96		576.76	0.007939	7.17	1614.36	506.29	0.71
Alignment - (PVR	Alignment - (PVR	11200	PF 1	11570.00	569.95	575.93		576.73	0.008036	7.20	1607.45	505.51	0.71
Alignment - (PVR	Alignment - (PVR	11100	PF 1	11570.00	569.84	575.01		575.88	0.008945	7.48	1546.79	497.40	0.75
Alignment - (PVR	Alignment - (PVR	11028.46	PF 1	11570.00	567.96	574.25		575.19	0.010225	7.77	1488.24	499.45	0.79
Alignment - (PVR	Alignment - (PVR	11000	PF 1	11570.00	567.92	574.20		574.87	0.006923	6.55	1765.24	570.95	0.66
Alignment - (PVR	Alignment - (PVR	10900	PF 1	11597.00	567.74	573.63		574.24	0.005461	6.24	1857.21	540.70	0.59
Alignment - (PVR	Alignment - (PVR	10864.65	PF 1	11597.00	565.98	573.47		574.04	0.005066	6.08	1906.33	545.18	0.57
Alignment - (PVR	Alignment - (PVR	10803.9	PF 1	11597.00	565.84	573.32		573.75	0.003347	5.29	2192.62	566.74	0.47
Alignment - (PVR	Alignment - (PVR	10800	PF 1	11597.00	565.83	573.31		573.74	0.003291	5.26	2206.10	568.27	0.47
Alignment - (PVR	Alignment - (PVR	10700	PF 1	11597.00	565.59	573.05		573.39	0.003233	4.65	2492.90	761.21	0.45
Alignment - (PVR	Alignment - (PVR	10601.68	PF 1	11597.00	563.82	572.88		573.14	0.001711	4.04	2873.88	673.72	0.34
Alignment - (PVR	Alignment - (PVR	10600	PF 1	11597.00	563.82	572.88		573.13	0.001713	4.03	2876.80	676.14	0.34
Alignment - (PVR	Alignment - (PVR	10500	PF 1	11597.00	563.65	572.87		572.99	0.000685	2.86	4056.58	799.92	0.22
Alignment - (PVR	Alignment - (PVR	10400	PF 1	11597.00	562.00	572.86		572.94	0.000266	2.17	5339.15	780.84	0.15
Alignment - (PVR	Alignment - (PVR	10300	PF 1	11597.00	561.99	572.86		572.91	0.000154	1.87	6187.88	747.26	0.11
Alignment - (PVR	Alignment - (PVR	10295.96	PF 1	11597.00	561.99	572.84		572.91	0.000231	2.08	5571.35	780.35	0.14
Alignment - (PVR	Alignment - (PVR	10200	PF 1	11597.00	561.97	572.83		572.89	0.000160	1.94	5968.94	701.50	0.12
Alignment - (PVR	Alignment - (PVR	10154.91	PF 1	11597.00	561.85	572.80		572.88	0.000235	2.23	5210.16	670.15	0.14
Alignment - (PVR	Alignment - (PVR	10100	PF 1	11597.00	560.09	572.80		572.86	0.000175	1.99	5842.08	714.42	0.12
Alignment - (PVR	Alignment - (PVR	10032.9	PF 1	11597.00	559.98	572.80		572.85	0.000140	1.82	6381.13	751.14	0.11

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	10000	PF 1	11597.00	559.96	572.80		572.84	0.000118	1.72	6743.89	759.77	0.10
Alignment - (PVR	Alignment - (PVR	9900	PF 1	11597.00	558.66	572.79		572.83	0.000094	1.58	7358.48	796.10	0.09
Alignment - (PVR	Alignment - (PVR	9800	PF 1	11597.00	557.99	572.78		572.82	0.000087	1.53	7599.31	813.76	0.09
Alignment - (PVR	Alignment - (PVR	9783.68	PF 1	12736.00	557.98	572.77	564.03	572.82	0.000103	1.68	7570.22	796.30	0.10
Alignment - (PVR	Alignment - (PVR	9650		Culvert									
Alignment - (PVR	Alignment - (PVR	9500	PF 1	12736.00	557.88	562.77		563.46	0.006640	6.66	1911.93	585.45	0.65
Alignment - (PVR	Alignment - (PVR	9400	PF 1	12736.00	556.00	561.82		562.66	0.009222	7.35	1733.30	585.78	0.75
Alignment - (PVR	Alignment - (PVR	9300	PF 1	12736.00	553.99	561.15		561.81	0.006941	6.53	1948.97	634.78	0.66
Alignment - (PVR	Alignment - (PVR	9230.43	PF 1	12736.00	553.97	560.77		561.36	0.005548	6.20	2053.47	611.31	0.60
Alignment - (PVR	Alignment - (PVR	9200	PF 1	12736.00	553.96	560.63		561.20	0.004970	6.06	2102.31	597.08	0.57
Alignment - (PVR	Alignment - (PVR	9191.66	PF 1	12736.00	553.96	560.25		561.11	0.008534	7.45	1709.82	534.20	0.73
Alignment - (PVR	Alignment - (PVR	9100	PF 1	12736.00	553.93	559.13		560.18	0.011670	8.22	1550.17	528.76	0.85
Alignment - (PVR	Alignment - (PVR	9000	PF 1	12736.00	551.99	558.06		559.09	0.010116	8.16	1561.17	483.31	0.80
Alignment - (PVR	Alignment - (PVR	8900	PF 1	12736.00	551.03	557.43		558.19	0.006771	6.99	1821.85	525.95	0.66
Alignment - (PVR	Alignment - (PVR	8841.38	PF 1	12736.00	550.00	556.88		557.73	0.008707	7.40	1721.94	551.20	0.74
Alignment - (PVR	Alignment - (PVR	8800	PF 1	12736.00	549.99	556.43		557.34	0.010354	7.62	1671.27	582.53	0.79
Alignment - (PVR	Alignment - (PVR	8700	PF 1	12736.00	549.93	555.61	554.97	556.36	0.008359	6.98	1825.44	619.61	0.72
Alignment - (PVR	Alignment - (PVR	8600	PF 1	12736.00	549.72	553.97	553.97	555.15	0.017593	8.71	1462.38	621.38	1.00
Alignment - (PVR	Alignment - (PVR	8500	PF 1	12736.00	547.97	553.26		553.86	0.006557	6.21	2051.84	691.71	0.64
Alignment - (PVR	Alignment - (PVR	8477.76	PF 1	12736.00	547.99	553.12		553.71	0.006986	6.16	2066.51	738.59	0.65
Alignment - (PVR	Alignment - (PVR	8400	PF 1	12736.00	547.56	552.61		553.17	0.006676	6.01	2119.37	760.03	0.63
Alignment - (PVR	Alignment - (PVR	8300	PF 1	12736.00	545.87	551.25		552.19	0.014018	7.80	1632.37	688.92	0.89
Alignment - (PVR	Alignment - (PVR	8200	PF 1	12736.00	543.93	550.43		551.10	0.007672	6.56	1942.46	677.67	0.68
Alignment - (PVR	Alignment - (PVR	8100	PF 1	12736.00	543.77	549.71		550.33	0.007366	6.29	2025.23	729.71	0.67
Alignment - (PVR	Alignment - (PVR	8000	PF 1	12736.00	541.93	548.91		549.56	0.008021	6.47	1969.96	726.22	0.69
Alignment - (PVR	Alignment - (PVR	7959.66	PF 1	12736.00	541.92	548.57		549.24	0.007621	6.56	1942.94	674.70	0.68
Alignment - (PVR	Alignment - (PVR	7900	PF 1	12736.00	541.85	548.18		548.80	0.006781	6.32	2014.02	676.19	0.65
Alignment - (PVR	Alignment - (PVR	7800	PF 1	12736.00	540.00	547.58		548.13	0.006163	5.95	2141.45	734.77	0.61
Alignment - (PVR	Alignment - (PVR	7700	PF 1	12736.00	541.81	546.67		547.37	0.009195	6.71	1898.90	734.28	0.74
Alignment - (PVR	Alignment - (PVR	7600	PF 1	12736.00	541.87	545.85		546.49	0.008062	6.42	1983.45	742.32	0.69
Alignment - (PVR	Alignment - (PVR	7500	PF 1	12736.00	539.96	545.22		545.76	0.006213	5.94	2145.80	742.93	0.62
Alignment - (PVR	Alignment - (PVR	7400	PF 1	12736.00	539.79	544.81		545.23	0.004014	5.23	2433.11	732.95	0.51
Alignment - (PVR	Alignment - (PVR	7351.97	PF 1	12736.00	539.53	544.62		545.04	0.003895	5.18	2457.18	734.18	0.50
Alignment - (PVR	Alignment - (PVR	7300	PF 1	12736.00	538.00	544.44		544.84	0.003625	5.05	2520.61	741.55	0.48
Alignment - (PVR	Alignment - (PVR	7200	PF 1	12736.00	537.94	544.23		544.53	0.002192	4.43	2876.15	707.57	0.39
Alignment - (PVR	Alignment - (PVR	7100	PF 1	12736.00	537.86	544.10		544.34	0.001478	3.91	3256.97	718.49	0.32
Alignment - (PVR	Alignment - (PVR	7020.1	PF 1	12736.00	537.77	543.93		544.20	0.001826	4.15	3068.47	725.35	0.36
Alignment - (PVR	Alignment - (PVR	7000	PF 1	12736.00	537.76	543.90		544.17	0.001760	4.11	3096.32	721.67	0.35
Alignment - (PVR	Alignment - (PVR	6900	PF 1	12736.00	535.98	543.80		544.01	0.001170	3.61	3528.62	736.66	0.29
Alignment - (PVR	Alignment - (PVR	6838.17	PF 1	12736.00	535.94	543.76		543.93	0.000920	3.27	3898.08	789.04	0.26
Alignment - (PVR	Alignment - (PVR	6800	PF 1	12736.00	535.92	543.75		543.89	0.000731	3.04	4194.29	797.68	0.23
Alignment - (PVR	Alignment - (PVR	6700	PF 1	12736.00	535.85	543.69		543.83	0.000555	2.93	4343.44	707.78	0.21
Alignment - (PVR	Alignment - (PVR	6660.95	PF 1	12736.00	534.93	543.65		543.80	0.000559	3.09	4124.81	625.19	0.21
Alignment - (PVR	Alignment - (PVR	6600	PF 1	12736.00	533.98	543.63		543.77	0.000505	3.01	4226.18	615.21	0.20
Alignment - (PVR	Alignment - (PVR	6500	PF 1	12736.00	533.70	543.51		543.71	0.000665	3.51	3623.67	513.89	0.23
Alignment - (PVR	Alignment - (PVR	6471.95	PF 1	12736.00	532.74	543.50		543.69	0.000527	3.46	3683.61	449.68	0.21
Alignment - (PVR	Alignment - (PVR	6400	PF 1	12736.00	531.98	543.33		543.63	0.000827	4.39	2902.68	346.21	0.27

HEC-RAS Plan: Plan 02 Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (PVR	Alignment - (PVR	6300	PF 1	12736.00	531.94	542.87		543.48	0.001794	6.25	2037.52	255.72	0.39
Alignment - (PVR	Alignment - (PVR	6272.18	PF 1	12736.00	531.92	542.89		543.40	0.001712	5.75	2215.25	301.90	0.37
Alignment - (PVR	Alignment - (PVR	6200	PF 1	12736.00	529.99	542.46		543.24	0.002075	7.07	1801.65	207.54	0.42
Alignment - (PVR	Alignment - (PVR	6108.1	PF 1	12736.00	529.93	542.11		543.03	0.002143	7.72	1649.92	169.12	0.44
Alignment - (PVR	Alignment - (PVR	6100	PF 1	12736.00	529.92	542.09		543.01	0.002097	7.68	1658.01	168.44	0.43
Alignment - (PVR	Alignment - (PVR	6025.13	PF 1	12736.00	529.87	541.44		542.77	0.003471	9.26	1375.67	154.56	0.55
Alignment - (PVR	Alignment - (PVR	6000	PF 1	12736.00	528.51	541.15		542.66	0.004012	9.85	1293.05	147.10	0.59
Alignment - (PVR	Alignment - (PVR	5956.06	PF 1	12736.00	527.99	541.31		542.38	0.002948	8.30	1534.87	180.82	0.50
Alignment - (PVR	Alignment - (PVR	5900	PF 1	12736.00	527.98	540.06		542.06	0.005871	11.35	1122.11	137.76	0.70
Alignment - (PVR	Alignment - (PVR	5842.69	PF 1	12736.00	527.96	537.80	537.80	541.42	0.012702	15.26	834.60	116.91	1.01
Alignment - (PVR	Alignment - (PVR	5800	PF 1	12736.00	527.94	536.92	536.62	539.99	0.011156	14.07	905.50	130.67	0.94
Alignment - (PVR	Alignment - (PVR	5761.38	PF 1	12736.00	527.79	536.86	536.09	539.46	0.009143	12.94	984.20	138.96	0.86
Alignment - (PVR	Alignment - (PVR	5700	PF 1	12736.00	526.73	537.10		538.78	0.004928	10.39	1225.45	150.92	0.64
Alignment - (PVR	Alignment - (PVR	5681.96	PF 1	12736.00	525.98	537.41		538.55	0.003148	8.55	1490.15	176.61	0.52
Alignment - (PVR	Alignment - (PVR	5612.93	PF 1	12736.00	524.67	537.38		538.31	0.002123	7.73	1647.22	167.10	0.43
Alignment - (PVR	Alignment - (PVR	5600	PF 1	12736.00	524.06	537.31		538.28	0.002185	7.91	1610.65	161.09	0.44
Alignment - (PVR	Alignment - (PVR	5500	PF 1	12736.00	523.98	535.48		537.80	0.006023	12.22	1042.01	113.99	0.71
Alignment - (PVR	Alignment - (PVR	5469.94	PF 1	12736.00	523.22	535.27		537.62	0.005869	12.30	1035.70	109.69	0.71
Alignment - (PVR	Alignment - (PVR	5400	PF 1	12736.00	521.64	532.55	532.55	536.85	0.012456	16.63	766.01	89.29	1.00
Alignment - (PVR	Alignment - (PVR	5300	PF 1	12736.00	519.95	531.16	530.52	534.62	0.009919	14.91	854.20	100.71	0.90
Alignment - (PVR	Alignment - (PVR	5258.23	PF 1	12736.00	519.91	530.28	530.28	534.11	0.012614	15.71	810.82	105.82	1.00
Alignment - (PVR	Alignment - (PVR	5200	PF 1	12736.00	519.14	529.06	529.06	532.16	0.014183	14.14	900.88	147.55	1.01
Alignment - (PVR	Alignment - (PVR	5100	PF 1	12736.00	517.77	525.76	525.76	528.45	0.014318	13.15	968.55	181.34	1.00
Alignment - (PVR	Alignment - (PVR	5000	PF 1	12736.00	515.90	522.31	522.31	524.68	0.014839	12.32	1033.40	222.36	1.01

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Nov 7 2016

Crossing ID#J004

Invert Elev Dn (ft)	= 618.00
Pipe Length (ft)	= 178.00
Slope (%)	= 1.50
Invert Elev Up (ft)	= 620.67
Rise (in)	= 144.0
Shape	= Arch
Span (in)	= 288.0
No. Barrels	= 2
n-Value	= 0.012
Culvert Type	= Arch Corrugated Metal
Culvert Entrance	= 90D headwall (A)
Coeff. K,M,c,Y,k	= 0.0083, 2, 0.0379, 0.69, 0.5

Embankment

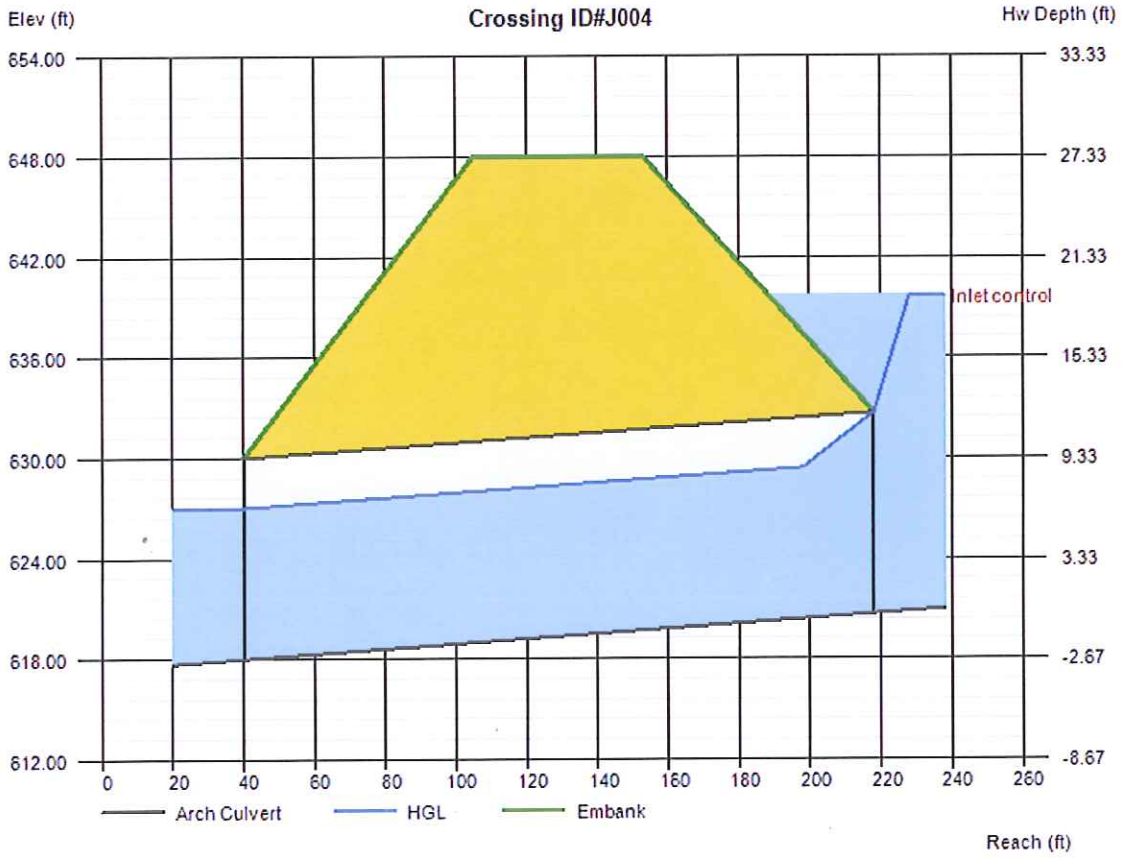
Top Elevation (ft)	= 648.00
Top Width (ft)	= 48.00
Crest Width (ft)	= 300.00

Calculations

Qmin (cfs)	= 7617.00
Qmax (cfs)	= 7700.00
Tailwater Elev (ft)	= Normal

Highlighted

Qtotal (cfs)	= 7617.00
Qpipe (cfs)	= 7617.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 19.65
Veloc Up (ft/s)	= 19.65
HGL Dn (ft)	= 627.02
HGL Up (ft)	= 629.69
Hw Elev (ft)	= 639.60
Hw/D (ft)	= 1.58
Flow Regime	= Inlet Control



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Nov 7 2016

Crossing ID#PRV6b

Circular

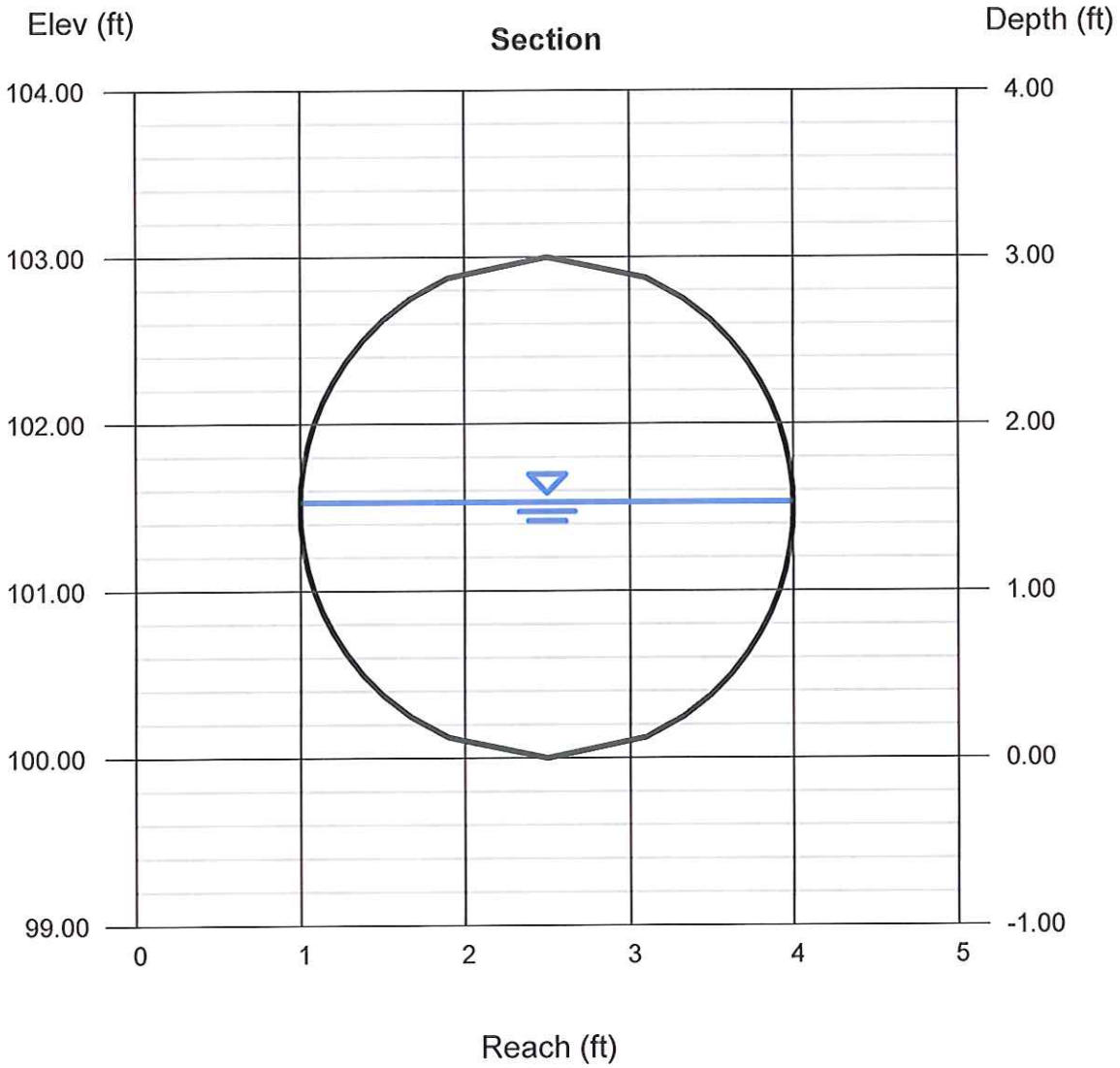
Diameter (ft)	= 3.00
Invert Elev (ft)	= 100.00
Slope (%)	= 8.58
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 101.00

Highlighted

Depth (ft)	= 1.53
Q (cfs)	= 101.00
Area (sqft)	= 3.64
Velocity (ft/s)	= 27.72
Wetted Perim (ft)	= 4.78
Crit Depth, Yc (ft)	= 2.90
Top Width (ft)	= 3.00
EGL (ft)	= 13.48



CHAPTER 7

APPENDIX

CHAPTER 7

7.1. Reference Regarding Sediment Transport Capacity

Sediment Transport Capacity of Overland Flow

P. Y. Julien, D. B. Simons

This article is reprinted from the TRANSACTIONS of the ASAE (Vol. 28, No. 3, pp. 755–762, 1985)
Published by the American Society of Agricultural Engineers, St. Joseph, Michigan

ABSTRACT

OVERLAND flow runoff can be either laminar or turbulent depending on the Reynolds number. The rate of soil erosion may be limited by the sediment transport capacity which depends on the type of flow. Sediment transport equations based on velocity were found to give different results than those based on shear stress. Most of the sediment transport equations developed for turbulent streams should not be applied to soil erosion by overland flow. A general relationship supported by dimensional analysis was derived. The recommended sediment transport capacity relationship can be written as a power function of slope and discharge and the range of exponents was defined from empirical relationships.

INTRODUCTION

Soil erosion by rainfall is one of the major hazards threatening the productivity of farmlands. The physical processes governing the movement of sediments by rainfall are very complex. The rate of soil erosion depends mainly on the detachment of soil particles and on the transporting capacity of overland runoff. Several sediment transport equations and soil loss relationships have been developed both from experimental studies in laboratories under simulated rainfall (Kilinc, 1972) and from statistical and regression analysis using field data (Wischmeier and Smith, 1978). Recently, some researchers have recommended the use of well-known bed-load equations to predict soil erosion losses from overland flow. For example, Komura (1976) used the Kalinske-Brown relationship and obtained fair agreement with observed data though his data set was relatively limited. The Meyer-Peter and Muller equation has also been suggested by Li (1979) for overland flow. Several sediment transport equations have been examined by Alonso, Neibling and Foster (1981) to determine how well they fit observed data on concave slopes.

Fundamental relationships for sediment transport in turbulent stream flows have been used as a basis for the analysis of sediment transport capacity by overland flow. However, since sheet flows are generally classified as laminar a theoretical analysis is required in order to determine if a sediment transport formula derived for turbulent streamflow is also applicable to laminar sheet flow.

Article was submitted for publication in July, 1984; reviewed and approved for publication by the Soil and Water Div. of ASAE in December, 1984.

The contribution of the first author was supported by the Natural Sciences and Engineering Research Council of Canada.

The authors are: P. Y. JULIEN, Fac. Affiliate, Dept. of Civil Engineering, and D. B. SIMONS, Professor, Dept. of Civil Engineering, Colorado State University, Fort Collins.

Therefore, the purpose of this study was to investigate the applicability of several sediment transport equations under various hydraulic conditions, including laminar sheet flow. In the first part of this paper, the hydraulic characteristics relevant to sediment transport are summarized to clearly point out the differences between turbulent and laminar flows. Then several sediment transport formulas valid for turbulent streamflow are examined under laminar sheet flow conditions. These transformed relationships are compared with regression equations obtained from experimental studies of soil erosion.

OVERLAND FLOW CHARACTERISTICS

In natural fields, overland flow occurs when the rainfall intensity is in excess of the infiltration rate of the soil. A very thin film of water covers the soil surface and it is referred to as the laminar sheet flow. As the runoff rate increases downslope, the flow converges into micro-scale channels called rills which gradually develop until they form large-scale channels called gullies. In a recent study, Thorne (1984) also defined ephemeral gullies in arable fields. These gullies are formed by the concentraiton of surface runoff and are obliterated each year by normal tillage.

Gully, rill and sheet runoff have different hydraulic properties depending on the relative magnitude of inertia and viscous forces. The ratio of these two types of forces defines the Reynolds number Re. When the inertia forces largely overcome the viscous forces, such as flows in rivers and gullies, the Reynolds number is large and the flow is turbulent. In the case of thin overland runoff, the viscous forces overcome the inertia forces and the flow is called laminar. In sheet flows, perturbations induced by raindrop impact and surface roughness are greatly attenuated due to the large magnitude of viscous forces at low Reynolds numbers. These forces damp out the velocity fluctuations caused by these disturbances and sheet flows over rough boundaries remain laminar until a critical value of the Reynolds number is exceeded.

Another major difference between stream flow and sheet flow is related to the flow depth. For a given particle size, the transport of sediments by saltation and suspension in overland flow is very limited due to the reduced flow depth. The bed load movement, however, may predominate and the most accurate sediment transport rates might be given by bed-load equations, the validity of this statement being precisely the purpose of this investigation.

The principal variables describing overland flow are shown in Fig. 1. The main geometric variables are slope length L and gradient S. The hydraulic variables are rainfall intensity i, flow depth h, mean velocity $\bar{u}$, unit water discharge q and thickness of the laminar sublayer δ'. The parameter generally associated with the sediment discharge q_s is bed shear stress τ_o; the other properties

  0001-2351/85/2803-0755$02.00

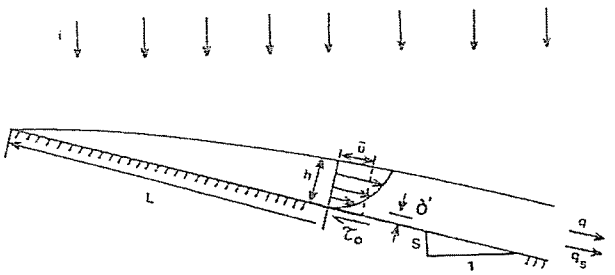


Fig. 1—Overland flow variables.

being gravitational acceleration g, kinematic viscosity ν and specific mass of water ρ.

Fundamental Equations

Two nonlinear partial differential equations derived by de Saint-Venant are generally used to solve the problem of gradually varied unsteady flows. These are the continuity relationship describing the conservation of mass and the momentum equation which is a force equilibrium relationship. In the case of steady overland flow, the continuity equation reduces to:

$$q = \bar{u}\, h \quad \ldots\ldots [1]$$

Considering the principal terms of the momentum equation, the kinematic wave approximation has been recommended by Wooding (1965) and Woolhiser (1975). This approximation states that the slope of the energy line is equal to the soil surface slope, or:

$$S = S_f \quad \ldots\ldots [2]$$

in which S_f is the slope of the energy line or friction slope.

The slope of the energy line can be defined by the Darcy-Weisbach relationship:

$$S_f = \frac{f}{8}\frac{\bar{u}^2}{gh} \quad \ldots\ldots [3]$$

where f is the Darcy-Weisbach friction factor.

The friction factor f is a function of the Reynolds number and the relative roughness for turbulent flows. The Reynolds number is defined as:

$$Re = \frac{\bar{u}\, h}{\nu} \quad \ldots\ldots [4]$$

As the Reynolds number increases, the flow becomes turbulent and the friction factor is then a function of the roughness of the surface. The roughness of the boundary depends on the sediment size d_s and the thickness of the laminar sublayer δ'. Two important variables are associated with the thickness of the boundary sublayer δ'. These are bed shear stress τ_o and shear velocity U_*. These variables are defined as:

$$\tau_o = \rho g h S_f \quad \ldots\ldots [5]$$

$$U_* = \sqrt{\frac{\tau_o}{\rho}} \quad \ldots\ldots [6]$$

$$\delta' = \frac{11.6\,\nu}{U_*} \quad \ldots\ldots [7]$$

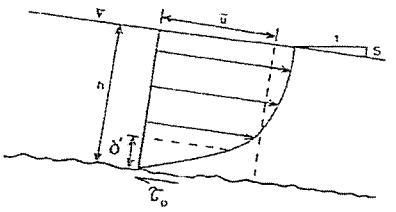


Fig. 2—Turbulent flow over a smooth surface.

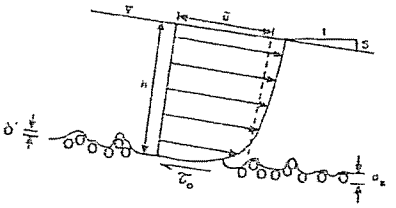


Fig. 3—Turbulent flow over a rough surface.

The ratio of sediment size d_s to the thickness of the laminar sublayer δ' delineates two types of turbulent flow conditions shown in Figs. 2 and 3 for smooth and rough boundaries respectively.

From combining equations [5], [6], and [7], the ratio δ'/d_s is:

$$\frac{\delta'}{d_s} = \frac{11.6\,\nu}{d_s\sqrt{ghS_f}} \quad \ldots\ldots [8]$$

This parameter and the Reynolds number are used to define the type of overland flow.

Overland Flow Types

The four principal types of flow relevant to this investigation on soil erosion by overland flow are: (a) laminar sheet flow; (b) turbulent smooth flow governed by the Blasius equation; (c) turbulent rough flow (Manning equation); and (d) turbulent rough flow with very small relative roughness (Chezy equation). This last flow type is not very likely to occur in overland flow. However, it has been included in this analysis since it represents a limiting case for which the Darcy-Weisbach friction factor remains constant. For steady flow conditions, the principal variables related to soil erosion ($\bar{u}$, h and τ_o) are defined as a function of slope and water discharge.

Laminar Flow

In laminar flows with raindrop impact the Darcy-Weisbach friction factor f is related to: (a) the Reynolds number Re, (b) the surface friction coefficient k_o without raindrop impact, and (c) two empirical coefficients A and b for raindrop impact. The following relationship is generally used:

$$f = \frac{K}{Re} = \frac{k_o + Ai^b}{Re} \quad \ldots\ldots [9]$$

The values of k_o have been tabulated by Woolhiser (1975) for various surface types and the value $k_o = 24$ is representative of the smooth surface condition. Experimental coefficients A and b have been obtained by Izzard (1944), Li (1972), and Fawkes (1972), and these

TABLE 1. RESISTANCE COEFFICIENTS A AND b FOR RAINFALL.

Reference	A†	b
Izzard (1944)	750	1.33
Li (1972)	118	0.4
Fawkes (1972)	393	1.0

†For i in m per hour.

values are indicated in Table 1. The experimental values of the friction coefficient f obtained by Shen and Li (1973) indicate that for a bare smooth surface, the flow is laminar for Re < 900 and the Blasius law is valid for turbulent smooth flows when Re > 2000. Chen's data (1976) show that k_o can be as large as 50,000 for vegetated surfaces and laminar flow conditions were observed for Reynolds numbers as large as 10^5.

At low Reynolds numbers, the friction parameter K for sheet flows is constant, and the Darcy-Weisbach equation is given by:

$$S_f = \left(\frac{K\nu}{\bar{u}\,h}\right)\frac{\bar{u}^2}{8gh} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [10]$$

The variables $\bar{u}$, h, and τ_o for laminar sheet flows derived from equations [1], [2], [5], and [10] are summarized in Table 2 for comparison with similar relationships valid under turbulent conditions.

Turbulent Flow over a Smooth Surface

For bare soil surfaces the flow becomes turbulent when Re > 2000 and the flow is called hydraulically smooth when the thickness of the laminar sublayer given by equation [7] is much in excess of the size of soil particles

TABLE 2. SUMMARY OF FLOW CHARACTERISTICS (VELOCITY, DEPTH, AND SHEAR STRESS).

Velocity $\bar{u} = c\,S^a\,q^d$			
Type of flow	c	a	d
Laminar (K = constant)	$\left(\frac{8g}{K\nu}\right)^{0.333}$	0.333	0.667
Turbulent, smooth boundary	$\left(\frac{8g}{0.316}\right)^{0.333}\nu^{-0.083}$	0.333	0.417
Turbulent (n = constant)	$\left(\frac{1}{n}\right)^{0.6}$	0.3	0.4
Turbulent (f = constant)	$\left(\frac{8g}{f}\right)^{0.333}$	0.333	0.333
Depth $h = c\,S^a\,q^d$			
Type of flow	c	a	d
Laminar (K = constant)	$\left(\frac{K\nu}{8g}\right)^{0.333}$	-0.333	0.333
Turbulent, smooth boundary	$\left(\frac{0.316}{8g}\right)^{0.333}\nu^{0.083}$	-0.333	0.583
Turbulent (n = constant)	$n^{0.6}$	-0.3	0.6
Turbulent (f = constant)	$\left(\frac{f}{8g}\right)^{0.333}$	-0.333	0.667
Shear stress $\tau_o = c\,S^a\,q^d$			
Type of flow	c	a	d
Laminar (K = constant)	$\rho g\left(\frac{K\nu}{8g}\right)^{0.333}$	0.667	0.333
Turbulent, smooth boundary	$\rho g\left(\frac{0.316}{8g}\right)^{0.333}\nu^{0.083}$	0.667	0.583
Turbulent (n = constant)	$\rho g\, n^{0.6}$	0.7	0.6
Turbulent (f = constant)	$\rho g\left(\frac{f}{8g}\right)^{0.333}$	0.667	0.667

($\delta' > 3\,d_s$). In this case, Keulegan (1938) derived an equation similar to the von Karman-Prandtl logarithmic equation. When the Reynolds number is not too large, this equation can be approximated by the Blasius equation for which the Darcy-Weisbach friction factor becomes:

$$f = \frac{0.316}{Re^{0.25}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [11]$$

For turbulent flows over a smooth surface, the variables $\bar{u}$, h and τ_o given in Table 2 are derived from equations [1], [2], [3], [5], and [11]. The exponents of S for these three variables are identical to those obtained for laminar sheet flows.

Turbulent Flow over a Rough Surface

For turbulent flows an increase of the Reynolds number (or water discharge) raises the water level, and decreases the relative roughness and the friction factor. When the thickness of the laminar sublayer is small compared to sediment size ($\delta' < 5\,d_s$), the flow is hydraulically rough and the logarithmic equation given by Keulegan (1938) applies. The friction coefficient is defined as:

$$\sqrt{\frac{8g}{f}} = C = c_1 \log c_2 \frac{h}{d_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots [12]$$

Approximate power relationships such as the Manning equation, however, are frequently used by hydraulic engineers. Since both equations give similar results for open channel flows without bedforms when the relative roughness ranges between 10 and 10000, the Manning equation (SI units) is used in this study. The equivalent Darcy-Weisbach f is then:

$$\sqrt{\frac{8g}{f}} = \frac{h^{1/6}}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [13]$$

in which n is the Manning roughness coefficient. The well-known Manning-Strickler relationship gives the proportionality between the median size of the sediment particles (in mm) at the boundary and the Manning roughness coefficient:

$$n = 0.0132\,d_s^{1/6} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [14]$$

The combination of equations [1], [2], [3], [5], and [13] gives the relationships for $\bar{u}$, h, and τ_o shown in Table 2 for turbulent rough conditions (n = constant).

When the relative roughness becomes extremely small, the Darcy-Weisbach equation is equivalent to the Chézy equation ($f = 8g/C^2$). Both coefficients f and C are constant and after combining equations [1], [2], [3], and [5], the variables $\bar{u}$, h, and τ_o are written as a function of S and q. The resulting expressions are listed in Table 2. The relationship $\tau_o \propto \bar{u}^2$ is valid for the Chézy equation and the exponents are slightly different from those derived for the Manning relationship. The exponents of q and S of the velocity relationship are identical and equal to 0.333.

Discussion

The results of this analysis of the hydraulic characteristics are summarized in Table 2. The velocity, the flow depth, and the bed shear stress are written in

terms of discharge and slope. The exponent of the slope does not vary significantly for different flow conditions ranging from laminar to turbulent. The exponents of the slope for velocity, flow depth, and bed shear stress are respectively 0.33, −0.33, and 0.67. On the other hand, the exponents of the water discharge vary gradually and differ by a factor 2 between the extreme conditions. The exponents of discharge for velocity and shear stress vary in opposite directions. Indeed, for flow conditions changing from laminar to turbulent flows, the exponent of velocity varies gradually from 0.67 to 0.33 while the exponent of shear stress varies from 0.33 to 0.67. This effect is extremely important if we consider the rate of sediment transport.

SEDIMENT TRANSPORT EQUATIONS

The sediment transport capacity of overland flow under rainfall was investigated to obtain a theoretically sound relationship supported by empirical equations. The method of dimensional analysis was applied to the principal variables related to soil erosion.

Variables and Dimensional Analysis

Sheet erosion is the result of the detachment of soil particles by raindrop impact and transport by overland flow. The eroded soil particles are transported downstream by runoff and the unit sediment discharge is a function of the following variables:

$$q_s = f(L, S, i, \bar{u}, h, q, \tau_o, \tau_c, d_s, \rho_s, \rho, \nu, g) \quad \ldots\ldots [15]$$

in which τ_c is critical shear stress and d_s is size of soil particles, and the other variables are as defined previously. Among these variables, the first two (L, S) describe the geometry and the next five (i, $\bar{u}$, h, q, τ_o) are flow characteristics including rainfall intensity. The last six (τ_c, d_s, ρ_s, ρ, ν, g) are associated with soil and water properties and the gravitational acceleration. Shear stress is difficult to measure in the field and is usually computed from other variables. In a river, the variables S, $\bar{u}$, h, and q are used to describe stream flows because the velocity and depth are generally more easily measured than rainfall intensity i and runoff length L. For this reason, Laursen (1956) suggested the reduction of some sediment transport equations to a function of the variables $\bar{u}$ and h. In the case of soil erosion, however, the variables i and L have important physical significance. The slope and unit water discharge may be more easily measured than the velocity and depth. Therefore, the variables S and q may be more convenient than $\bar{u}$ and h as components of a sediment transport relationship for overland flow under steady-state condition; elimination of the variables $\bar{u}$ and h from the Darcy-Weisbach and the continuity equation $q = \bar{u}h$ is possible.

The critical shear stress value τ_c corresponds to the beginning of motion of the sediment particles. Its evaluation remains a complex problem requiring further investigation, but the fundamental relationship defining the incipient motion of sediments indicates that the critical shear stress is a function of the particle size and the specific masses of water and sediment. Therefore, the sediment size can be replaced by the critical shear stress in a sediment transport equation. The specific masses of water and sediment are nearly constant for particle sizes ranging from clays to gravels. In the case of aggregates, equivalent conditions of shear stress can be defined, for example, using an equivalent diameter, while keeping the same specific mass of sediment in the analysis.

Using these relationships and assuming ρ_s constant, equation [15] reduces to:

$$f(q_s, q, i, L, \rho, \nu, \tau_c/\tau_o, S) = 0 \quad \ldots\ldots [16]$$

The following Π-terms are obtained from dimensional analysis after L, ρ, and ν are selected as repeating variables:

$$f\left(\frac{q_s}{\rho\nu}, \frac{q}{\nu}, \frac{iL}{\nu}, \frac{\tau_c}{\tau_o}, S\right) = 0 \quad \ldots\ldots [17]$$

The sediment transport term can be written as a function of the product of the other Π-terms in the form:

$$\left(\frac{q_s}{\rho\nu}\right) = \bar{\alpha}\ S^{\beta}\left(\frac{q}{\nu}\right)^{\gamma}\left(\frac{iL}{\nu}\right)^{\delta}\left(1 - \frac{\tau_c}{\tau_o}\right)^{\epsilon} \quad ; \text{for } \tau_o > \tau_c \quad \ldots\ldots [18]$$

In this equation, $\bar{\alpha}$, β, γ, δ, and ε are experimental coefficients and the sediment equations based on tractive force and stream power concepts are represents by the term $1 - (\tau_c/\tau_o)$.

Under dimensional form, this equation is transformed to:

$$q_s = \alpha\, S^{\beta}\, q^{\gamma}\, i^{\delta}\, \left(1 - \frac{\tau_c}{\tau_o}\right)^{\epsilon} \quad \ldots\ldots [19]$$

in which,

$$\alpha = \frac{\bar{\alpha}\rho L^{\delta}}{\rho^{\gamma+\delta-1}} \quad \ldots\ldots [20]$$

The derivation by Julien (1982) gives a general relationship between the sediment discharge and the dominant geometry and flow variables. The first three factors (S, q, i) represent the potential erosion or transport capacity by overland flow, which is reduced by the last factor reflecting the soil resistance to erosion. When τ_c remains small compared to τ_o, the equation for sediment transport capacity is:

$$q_s = \alpha\, S^{\beta}\, q^{\gamma}\, i^{\delta} \quad \ldots\ldots [21]$$

The sediment transport capacity by turbulent flows in deep channels is not a function of the rainfall intensity, and therefore, $\delta = 0$ in this case.

Empirical Equations

Several empirical equations can be transformed to evaluate the coefficients α, β, γ, δ, and ε. Among the equations analyzed those proposed by Musgrave (1957), Li, Shen and Simons (1973), and Kilinc (1972) include tractive force, stream power, velocity, and discharge relationships. When the variables differ from those of equation [19], the relationships in Table 2 are used for the transformation of $\bar{u}$, h, and τ_o for laminar flows, while the Reynolds number is replaced by $Re = \bar{u}h/\nu$. The results summarized in Table 3 suggest that none of the actual equations is complete since some coefficients are still zero. Consequently, for each particular equation, the number of variables is reduced owing to

TABLE 3. TRANSFORMATION OF EMPIRICAL EROSION EQUATIONS FOR LAMINAR FLOW

$$q_s \sim s^{\beta} q^{\gamma} i^{\delta} \left(1 - \frac{\tau_c}{\tau_o}\right)^{\varepsilon}$$

Eq. No.	Reference	Equation	α†	β	γ	δ	ε
22	Musgrave (1947)	$q_s = \alpha' S^m L^n i^p$	α'	m	n	p-n	0
23	Zingg (1940)	$q_s \sim L^{1.66} S^{1.37}$	--	1.37	1.66	-1.66	--
24	Wischmeier and Smith (1978) (S>5%)	$q_s \sim L^{1.5}$ (.00076S^2 + .0053S + .0076)	--	≅1.7	1.5	-1.5	--
25	Meyer and Monke (1965)	$q_s \sim L^{1.9} S_o^{3.5}$	--	3.5	1.9	-1.9	--
26	Young and Mutchler (1969)	$q_s \sim L^{2.24} S^{0.74}$	--	0.74	2.24	-2.24	--
27	Li et al. (1973)	$q_s = \alpha' \int_o^L \tau_o^2 \, dx$	$3\alpha' \frac{\gamma^2}{5}\left(\frac{K\nu}{8g}\right)^{2/3}$	1.33	1.67	-1	0
28	Komura (1983)	$q_s \sim q^{11/8} i^{1/2} S^{1.5}$	--	1.5	1.38	0.5	0
29	Kilinc (1972)	$q_s = e^{2.05}(\tau_o - \tau_c)^{2.78}$	$e^{2.05} \gamma^{2.78} \left(\frac{K\nu}{8g}\right)^{0.93}$	1.86	0.93	0	2.78
30	Kilinc (1972)	$q_s = e^{0.122}((\tau_o - \tau_c)\bar{u})^{1.67}$	$e^{0.122} \gamma^{1.67}$	1.67	1.67	0	1.67
31	Kilinc (1972)	$q_s = e^{-3.17} \bar{u}^{3.625}$	$e^{-3.17} \left(\frac{8g}{K\nu}\right)^{1.21}$	1.21	2.42	0	0
32	Kilinc (1972)	$q_s = e^{1.24} \bar{u}^{4.67} Re^{-0.878}$	$e^{1.24} \nu^{0.878} \left(\frac{8g}{K\nu}\right)^{1.56}$	1.56	2.24	0	0
33	Kilinc (1972)	$q_s = e^{-11.6} Re^{2.05} S^{1.46}$	$e^{-11.6} \nu^{-2.05}$	1.46	2.05	0	0
34	Kilinc (1972)	$q_s = e^{11.7} q^{2.035} S^{1.66}$	$e^{11.7}$	1.66	2.03	0	0

†Sediment discharge in pounds per ft-s; multiply by 1.64×10^{-3} for q_s in tons/m·s.

these zero values. The most significant parameters pointed out in this analysis are the slope S and the discharge q. The numerical values of the coefficient β vary from 1.2 to 1.9, and γ, varies from 1.4 to 2.4. The variability of these exponents indicates the complexity of the sediment transport processes since only two major parameters are considered in this analysis. These relationships are in most cases particular to a study area or to the laboratory conditions under which the data were collected. Most equations include rill erosion which also influences the rate of soil erosion.

The well-known Universal Soil Loss Equation cannot be transformed directly into the general equation since the slope factor is written in a quadratic form. The equivalent exponent, however, is expected to vary between 1 and 2, and Julien (1982) found an equivalent exponent value near 1.7 while the discharge exponent 1.5 is an approximate value mostly valid when $S > 0.05$. The Kilinc and Richardson equations cannot define the parameters δ and ε since in their experiments, the soil surface was nearly impervious and also the bed tractive force was much in excess of the critical shear stress value. Throughout these transformations, the number of independent parameters remains the same. For example, equations [23], [25], and [26] based on slope and length have only two independent parameters because $\delta = -\gamma$. This remark is also valid for equations having one independent parameter since for equation [29] $\varepsilon = 3\gamma$ and $\beta = 2\gamma$; for equation [30] $\beta = \gamma = \varepsilon$; and for equation [31] $\beta = \gamma/2$.

Further fundamental research is required to better define the exponents δ and ε. The coefficients of the general equation obtained by dimensional analysis are kept variable for the purpose of this study and equation [19] is recommended for watershed modeling. The prediction from each equation will be possible, provided the proper set of coefficients is selected from Table 3. Fair estimates can be obtained from a regression

TABLE 4. TRANSFORMED SEDIMENT TRANSPORT EQUATIONS FOR OVERLAND FLOW

$$q_s \sim s^{\beta} q^{\gamma} \left(1 - \frac{\tau_c}{\tau_o}\right)^{\varepsilon}$$

Eq. No.	Investigator	Equation	Laminar				Turbulent											
							Smooth Boundary				Manning Equation				Chezy Equation			
			β	γ	ε	Index*	β	γ	ε	Index*	β	γ	ε	Index*	β	γ	ε	Index*
36	Du Boys	$q_s \sim \tau_o(\tau_o-\tau_c)$	1.33	0.66	1	1	1.33	1.17	1	1	1.4	1.2	1	1	1.33	1.33	1	1
37	WES	$q_s \sim (\tau_o-\tau_c)^{m=1.5}$	1	0.5	1.5	0	1	0.88	1.5	0	1.05	0.90	1.5	0	1	1	1.5	0
38	Shields	$q_s \sim Sq(\tau_o-\tau_c)$	1.67	1.33	1	1	1.67	1.58	1	2	1.7	1.6	1	2	1.67	1.67	1	2
39	Schoklitsch	$q_s \sim S^{1.5}(q-q_c)$	1.5	1	--	1	1.5	1	--	1	1.5	1	--	1	1.5	1	--	1
40	Kalinske-Brown	$q_s \sim \tau_o^{2.5}$	1.67	0.83	0	1	1.67	1.46	0	2	1.75	1.5	0	2	1.67	1.67	0	2
41	Meyer-Peter et al.	$q_s \sim (\tau_o-\tau_c)^{1.5}$	1	0.5	1.5	0	1	0.88	1.5	0	1.05	0.9	1.5	0	1	1	1.5	0
42	Bagnold	$q_s \sim \tau_o^{0.5}(\tau_o-\tau_c)$	1	0.5	1	0	1	0.88	1	0	1.05	0.9	1	0	1	1	1	0
43	Engelund-Hansen	$q_s \sim \tau_o^{1.5}\bar{u}^2$	1.67	1.83	0	2	1.67	1.71	0	2	1.65	1.7	0	2	1.67	1.67	0	2
44	Inglis-Lacey	$q_s \sim \bar{u}^5 h^{-1}$	2	3	0	0	2	2.5	0	0	1.8	1.4	0	2	2	1	0	0
45	Yalin ($\tau_o \cong \tau_c$)	$q_s \sim \tau_o^{0.5}(\tau_o-\tau_c)^2$	1.67	0.83	2	1	1.67	1.46	2	2	1.75	1.5	2	2	1.67	1.67	2	2
46	Yalin ($\tau_o >> \tau_c$)	$q_s \sim \tau_o^{0.5}(\tau_o-\tau_c)$	1	0.5	1	0	1	0.88	1	0	1.05	0.9	1	0	1	1	1	0
47	Chang et al.	$q_s \sim \tau_o \bar{u}$	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
48	Barekyan	$q_s \sim Sq\bar{u}$	1.33	1.67	0	2	1.33	1.42	0	2	1.3	1.4	0	2	1.33	1.33	0	1
49	Pedroli	$q_s \sim \tau_o^{1.6} h^{0.2}$	1	0.6	0	0	1	1.05	0	0	1.06	1.08	0	0	1	1.2	0	0

*The index represents the number of exponents within the ranges: $1.2 < \beta < 1.9$; and $1.4 < \gamma < 2.4$.

equation such as given by Kilinc (1972). For example, excellent results were obtained by Julien (1982) with the use of the discharge and slope formula (equation 34).

The formation of rills locally increases the unit water discharge q and the resulting erosion rate is expected to be larger than for uniform flow conditions. The rill erosion data collected by Kilinc were analyzed by Julien and Simons (1984) and once the volume of rill erosion was subtracted from the total erosion, the following regression equation was obtained:

$$q_s \sim S^{1.31}\, q^{1.93}\ ;\ (R^2 = 0.96) \quad \ldots\ldots\ldots\ldots\ldots [35]$$

Both exponents for S and q are smaller than those for soil erosion including rills (equation [34]). This equation can be used for comparison with sediments transport equations for laminar sheet flow.

Applicability of Sediment Transport Equations for Turbulent Flows

Most of the well-known sediment transport equations originally derived for turbulent stream flows can be transformed to determine their applicability to natural conditions in overland flows.

This analysis included the transformation of the sediment transport equations suggested by Du Boys (1879), O'Brien-Rindlaub (1934), WES (1935), Shields (1936), Schoklitsch (1934), Kalinske-Brown (1949), Meyer-Peter and Müller (1948), Bagnold (1956), Engelund-Hansen (1967), Inglis-Lacey (1968), Yalin (1977), Chang et al. (1967), Barekyan (1962), and Pedroli (1963). The Einstein bedload equation has not been treated separately since it agreed very well with the Yalin and the Meyer-Peter and Müller equations.

The sediment transport capacity was investigated assuming that sediment size, fluid properties and gravitational acceleration were constant. Particular attention was focused at the values of β and γ which are the exponents of the slope and water discharge in equation 19. For each of the four types of flow described previously, the transformed relationships are summarized in Table 4 as follows: (a) laminar sheet flow; (b) turbulent flow over smooth surface as given by the Blasius equation; (c) turbulent flow described by the Manning equation; and (d) turbulent flow with constant Darcy-Weisbach friction factor f or Che'zy coefficient.

The last column for each type of flow represents an index of fitness of these basic equations with the observed value of exponents. This index is equal to the number of parameters (β, γ) enclosed within the ranges of empirical coefficients as determined in the previous section ($1.2 < \beta < 1.9$ and $1.4 < \gamma < 2.4$). The higher the index, the better this equation should compare with observed data. Conversely, when the index is equal to zero, the given equation is expected to be a poor relationship to predict the sediment transport capacity of overland flow.

The results in this table show that the exponents β of most relationships are within the range of observed values while the exponents γ are usually too small to fall within the range of empirical coefficients. These results were anticipated since it was demonstrated in the analysis of flow characteristics summarized in Table 2 that the exponent of slope remains constant while the exponent of discharge varies for different flow conditions.

CONCLUSIONS

This study points at the relationship existing between the mechanics of overland flow and soil erosion by rainfall. The authors address the problem of estimating the sediment transport capacity for rainfall erosion based on the mechanics of overland flow. The results of this study are of particular interest to:

1. soil scientists concerned with the decrease of productivity of agricultural land caused by rainfall erosion;
2. watershed modelers looking for a better sediment transport capacity relationship for mathematical simulation of erosion processes;
3. sedimentologists interested in the mechanics of sediment transport for both laminar and turbulent flows.

A general sediment transport relationship supported by dimensional analysis ($q_s \sim s^{\beta} q^{\gamma} i^{\delta}\ [1 - \tau_c/\tau_o]^{\epsilon}$) is recommended and the major conclusions of the study are summarized as follows: the analysis of overland flow characteristics encompasses a wide variety of flow conditions varying from laminar sheet flows on uniform soil surfaces to turbulent flows in rills and gullies. When the principal hydraulic variables of flow depth, velocity, and bed shear stress are written in terms of slope and discharge, the exponent of slope remains constant for these various types of flow. For different types of flow the exponents of discharge for the velocity and shear stress were shown to vary in opposite directions. Therefore, for predicting soil erosion the applicability of sediment transport relationships derived for turbulent flows depends on whether the sediment transport capacity is a function of velocity or shear stress.

Most of the sediment transport equations used for turbulent flow in streams should not be applied to rainfall erosion in laminar sheet flows. Among the equations examined, only those proposed by Engelund-Hansen and Barekyan seem relevant for predicting soil erosion losses by overland runoff. The formulas suggested by Shields, Kalinske-Brown and Yalin might also be considered though the exponent of discharge is clearly too small in the case of laminar sheet flow. The other equations generally underestimate the parameters β and γ and are irrelevant to predict rainfall erosion.

The range of values of the exponents of slope β and discharge γ were well-defined in this analysis of empirical relationships. The transformation of several sediment transport equations for overland flow can be summarized as follows: the empirical exponent β varies between 1.2 and 1.9 while the exponent γ ranges from 1.4 to 2.4. The variation of these exponents indicates the complexity of soil erosion processes and the specificity of each relationship for the site-specific conditions under which they were derived. Moreover, these exponents are function of the formation of rills and this study shows that both exponents β and γ of the sediment transport capacity relationship increase when the rills develop.

References

1. Alonso, C.V., W.H. Neibling and G.R. Foster. 1981. Estimating sediment transport capacity in watershed modeling. TRANSACTIONS OF THE ASAE 24(5):1211-1220.
2. Bagnold, R.A. 1956. The flow of cohesionless grains in fluids. Phil. Trans. of the Royal Society of London 249(964):235-297.
3. Barekyan, A.S. 1962. Discharge of channel forming sediments and elements of sand waves. Soviet Hydrol. Selected Papers (Transactions of AGU No. 2), pp. 128-130.
4. Brown, C.B. 1949. Sediment transportation. In: Engineering

hydraulics, (ed.) H. Rouse, chapter XII, pp. 769-857.
5. Chang, F.M., D.B. Simons, and E.V. Richardson. 1967. Total bed-material discharge in alluvial channels. Proceedings of the Twelfth Congress of the IAHR, Fort Collins, CO, pp. 132-140.
6. Chen, C. L. 1976. Flow resistance in borad shallow grassed channels. Journal of the Hydraulics Division, ASCE, 102(HY3):307-322.
7. Du Boys, D. 1879. Le Rhône et les rivieres a lit affouillable. Annales des Ponts et Chaussées, Serie 5, Vol. 18, 1879, pp. 141-195.
8. Engelund, F. and E. Hansen. 1967. A monograph on sediment transport in alluvial streams. Teknisk Forlag, Copenhagen, Denmark, 65 p.
9. Fawkes, P. E. 1972. Roughness in a model of overland flow. M.Sc. Thesis, Colorado State University, 109 p.
10. Inglis, C.C. 1968. Discussion of systematic evaluation of river regime. Journal of Waterways and Harbor Division, ASCE, 94(WW1):109-114.
11. Izzard, C. F. 1944. The surface profile of overland flow. Trans. AGU (6):959-968.
12. Julien, P. 1982. Prédiction d'apport solide pluvial et nival dans les cours d'eau nordiques a partir du ruissellement superficiel, These de doctorat, Universite'Laval, Quebec, 240 p.
13. Julien, P. Y. and D. B. Simons. 1984. Analysis of sediment transport equations for rainfall erosion. Report CER83-84 PYJ-DB552, Civil Eng. Dept. Colorado State University. 46 p.
14. Keulegan, G.H. 1938. Laws of turbulent flow in open channels. Research paper 1151, Journal of Research, U.S. Nat. Bureau of Standards, Vol. 21, pp. 707-741.
15. Kilinc, M.Y. 1972. Mechanics of soil erosion from overland flow generated by simulated rainfall. Ph.D. dissertation, Colorado State University, Fort Collins, 183 p.
16. Komura, S. 1976. Hydraulics of slope erosion by overland flow. Journal of the Hydraulics Division, ASCE 102(HY10):1573-1585.
17. Komura, S. 1983. A method of predicting sediment yields from watersheds. Proceedings of the D. B. Simons Symposium on Erosion and Sedimentation, Section 9, pp. 23-41.
18. Laursen, E.H. 1956. The application of sediment transport mechanics to stable channel design. Journal of the Hydraulics Division, ASCE 82(HY4), 11 p.
19. Li, R. M. 1972. Sheet flow under simulated rainfall. M.Sc. thesis, Department of Civil Engineering, Colorado State University, Fort Collins, 111 p.
20. Li, R.M. 1979. Water and sediment routing from watersheds. In: Modeling of rivers, (ed.) H.W. Shen, J. Wiley & Sons, chapter 9, 88 p.
21. Li, R. M., H. W. Shen and D. B. Simons. 1973. Mechanics of soil erosion by overland flow. Paper presented at 15th Congress IAHR, Istanbul, Turkey. Proc. Paper A-54, pp. 437-446.
22. Meyer, L.D. and E.J. Monke. 1965. Mechanics of soil erosion by rainfall and overland flow. TRANSACTIONS OF THE ASAE 8(4):572-580.
23. Meyer-Peter, E. and R. Müller. Formulas for bed-load transport. Proceedings of the Second Meeting of IAHR, Stockholm, pp. 39-64.
24. Musgrave, G.W. 1947. The qualitative evaluation of factors in water erosion: a first approximation. Journal of Soil and Water Conservation, 2(3):1331-138.
25. O'Brien, M.P. and B.D. Rindlaub. 1934. The transportation of bed-load in streams. Transactions of the AGU:573-603.
26. Pedroli, R. 1963. Transporto di materiale solido in canali a fondo fisso e liscio. Communicazione de'l Ufficio federale dell'economia della acque, No. 63.
27. Schoklitsch, A. 1934. Geschiebetrieb und die geschiebefracht. Wasser Kraft und Wasser Wirtschaft. Jgg. 39, Heft 4.
28. Shen, H. W. and R. M. Li. 1973. Rainfall effect on sheet flow over smooth surface. Journal of the Hydraulics Division, ASCE:771-792.
29. Shields, A. 1936. Anwendung der Ähnlichkeitsmechanik und turbulenz forschung auf die geschiebebewegung. Mitteil Preuss, Versuchsanst Wasser und Schiffsbau, Berlin No. 26. Translated to English by W.P. Ott and J.C. van Uchelen, Calif. Inst. of Tech.
30. Thorne, C. R. 1984. Prediction of soil loss due to ephemeral gullies in arable fields. Report CER 83-84 CRT, Dept. of Civ. Eng., Colorado State University, 79 p.
31. U.S. Waterways Experiment Station. 1935. Studies of river bed materials and their movement with special reference to the lower Mississippi River. USWES, Vicksburg, Paper No. 17.
32. Wischmeier, W.H. and D.D. Smith. 1978. predicting rainfall erosion losses — a guide to conservation planning. USDA Agriculture Handbook No. 537, 58 p.
33. Wooding, R. A. 1965. A hydraulic model for the catchment stream, problem 1 — Kinematic wave theory. Journal of Hydrology, Vol 3.
34. Woolhiser, D. A. 1975. Simulation of unsteady overland flow, Chapter 12 in Unsteady flow in open channels. Edited by K. Mahmood and V. Yevjevich, WRP, pp. 485-508.
35. Yalin, M.S. 1977. Mechanics of sediment transport. Pergamon Press. Second Ed., pp. 112-165.
36. Young, R.A. and C.K. Mutchler. 1969. Soil movement on irregular slopes. Water Resources Research 5(5):1084-1085.
37. Zingg, A.W. 1940. Degree and length of land slope as it affects soil loss by runoff. Agricultural Engineering 21(2):59-64.

LIST OF SYMBOLS

A	coefficient for raindrop impact
a, b, c, d	coefficients
r, r_1, r_2	constants
C	Chezy coefficient
d_s	size of sediment
f	Darcy-Weisbach friction factor
g	gravitational acceleration
h	flow depth
i	rainfall intensity
k_o	surface friction coefficient
K	friction parameter for laminar sheet flow
L	slope length
n	Manning coefficient
q	unit water discharge
q_c	critical unit water discharge
q_s	unit sediment discharge
R^2	coefficient of determination
S	slope
S_f	slope of the energy line
u	velocity at a distance y from the water surface
$\bar{u}$	mean velocity
U_*	shear velocity
$\alpha,\beta,\gamma,\delta,\varepsilon$	coefficients of the sediment transport equation
δ'	thickness of the laminar sublayer
γ	dynamic viscosity
ν	kinematic viscosity
ρ	specific mass of water
ρ_s	specific mass of sediments
τ_o	bed shear stress
τ_c	critical bed shear stress

CHAPTER 7

7.2. Dewatering Calculations Deference Letter

M E M O R A N D U M

Date: January 29, 2018

To: Greg Mattson, AICP, Project Manager
Planning and Development Services, County of San Diego

From: Alisa Vialpando, P.E.

Subject: **Otay Ranch- Village 14 and Planning Areas 16/19: Water Quality Basin- dewatering calculations**

This memo has been prepared to address the County of San Diego plan review comment 6-49 regarding the *SWQMP for Otay Ranch Village 14 and Planning Areas 16/19* which had a submittal date of August 30, 2017. The comment is provided below for quick reference:

The drawdown calculations were not included as part of this submittal. Either include a drawdown calculation on the next submittal OR provide a certified letter from the EOW stating that in their professional opinion deferring this requirement to final engineering will not cause significant design changes on this project.

This letter is provided in response to the comment and is also applicable to the *SWQMP for Otay Ranch Village 14 and Planning Areas 16/19- Land Exchange Alternative* since both projects will utilize similar treatment control BMPs. In particular, both projects propose regional biofiltration basins for most of the developed areas. These basins will concurrently serve as flow control basins to address hydromodification. Due to the nature of these basins being low-flow basins which receive a maximum of the Q10 flowrate, deference of providing dewatering calculations at this phase of the project is acceptable. Although no significant design changes are anticipated, options such as re-allocation of drainage areas, optimization of outlet structures, or preparation of a vector control plans are all alternatives which could be explored to meet or address dewatering concerns and requirements.

Should you have any questions regarding the information contained within this memo, please contact me at (858) 558-4500.

Alisa S. Vialpando

Sincerely,
Alisa S. Vialpando, R.C.E. 47945
Vice President/Principal