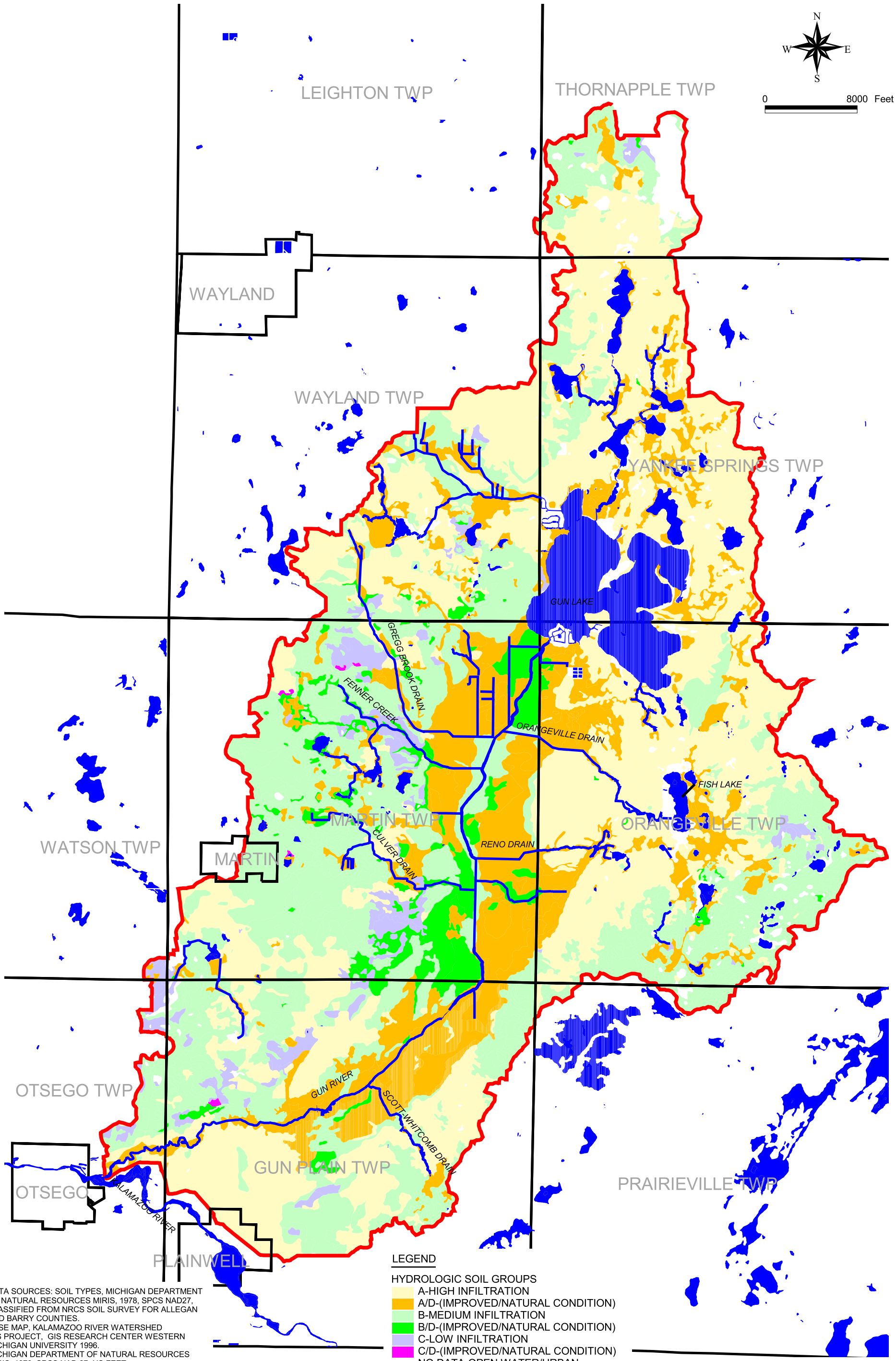
D:\WORK\01339\PROJECT\GUN_EXHIBITS.APR\HHFIG1A SOILS DATE: 10-6-2003 USER: CDA



DATA SOURCES: SOIL TYPES, MICHIGAN DEPARTMENT OF NATURAL RESOURCES MIRIS, 1978, SPCS NAD27, CLASSIFIED FROM NRCS SOIL SURVEY FOR ALLEGAN AND BARRY COUNTIES.
BASE MAP, KALAMAZOO RIVER WATERSHED GIS PROJECT, GIS RESEARCH CENTER WESTERN MICHIGAN UNIVERSITY 1996.
MICHIGAN DEPARTMENT OF NATURAL RESOURCES MIRIS, 1978, SPCS NAD 27, US FEET.
WATERSHED DELINEATION, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY GIS, DIGITAL SHEDS, 2001.

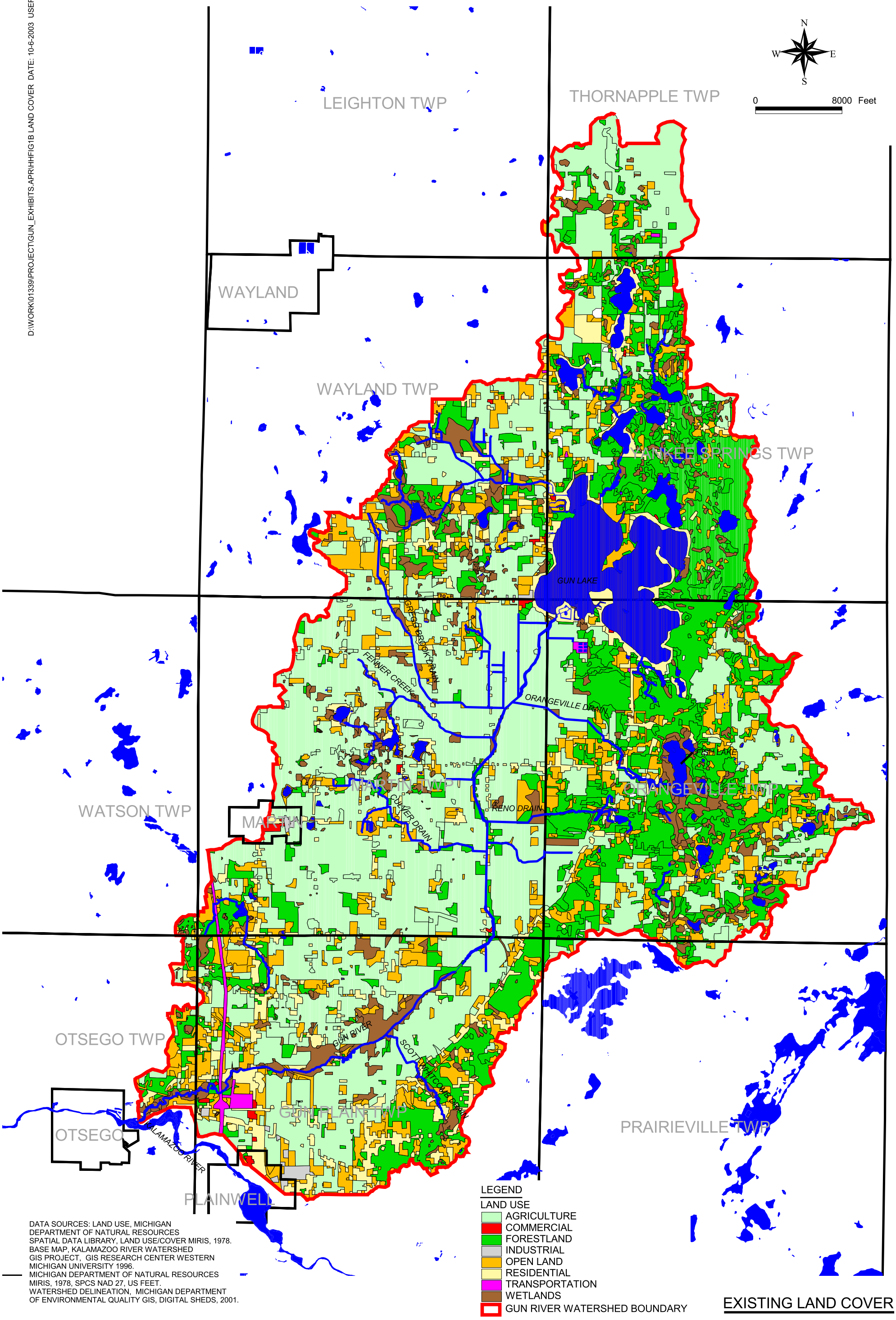
LEGEND

HYDROLOGIC SOIL GROUPS
- A-HIGH INFILTRATION
- A/D-(IMPROVED/NATURAL CONDITION)
- B-MEDIUM INFILTRATION
- B/D-(IMPROVED/NATURAL CONDITION)
- C-LOW INFILTRATION
- C/D-(IMPROVED/NATURAL CONDITION)
- NO DATA-OPEN WATER/URBAN
- GUN RIVER WATERSHED BOUNDARY

HYDROLOGIC SOIL GROUPS

PROJECT NO. G01339	Allegan Conservation District Allegan County, Michigan	Fishbeck, Thompson, Carr & Huber Engineers • Scientists • Architects Grand Rapids, Michigan
FIGURE NO. 1A	Hydrologic and Hydraulic Analysis of Gun River	

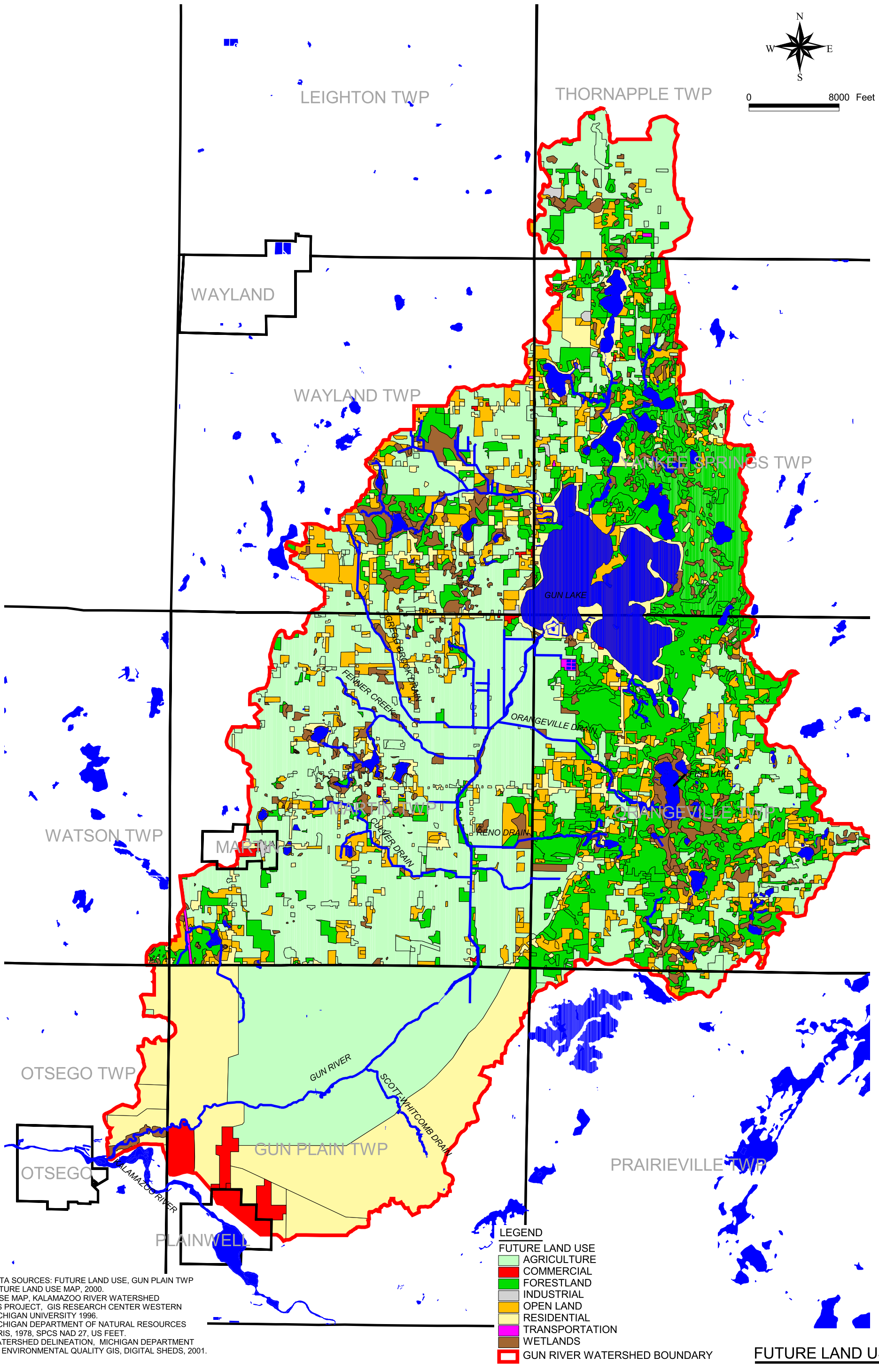
D:\WORK\01339\PROJECT\GUN_EXHIBITS.APR\HHFIG1B LAND COVER DATE: 10-6-2003 USER: CDA



EXISTING LAND COVER

PROJECT NO. G01339	Allegan Conservation District Allegan County, Michigan	Fishbeck, Thompson, Carr & Huber Engineers • Scientists • Architects Grand Rapids, Michigan
FIGURE NO. 1B	Hydrologic and Hydraulic Analysis of Gun River	

D:\WORK\01339\PROJECT\GUN_EXHIBITS.APR\HHFIG1C FLU DATE: 10-6-2003 USER: CDA

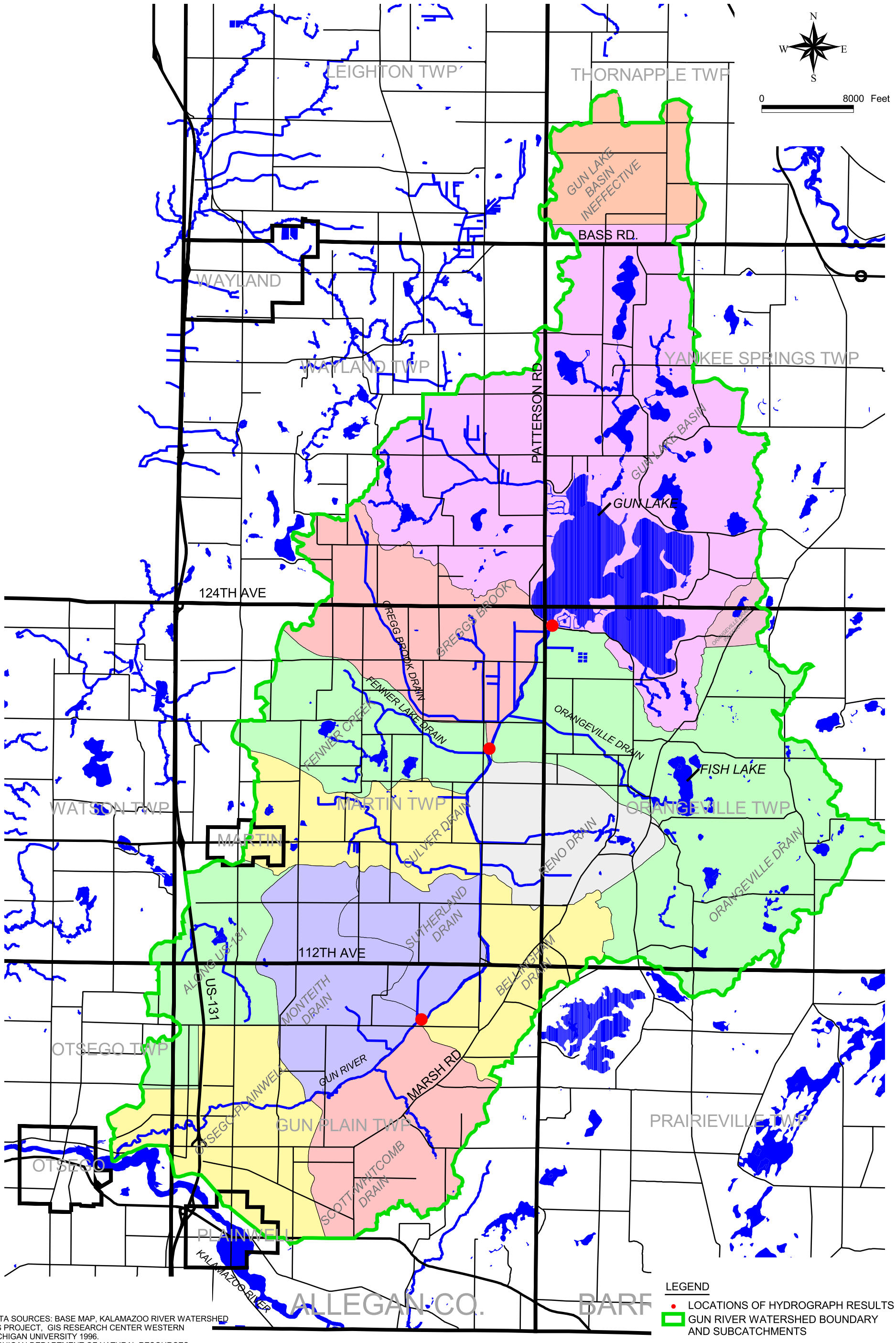


DATA SOURCES: FUTURE LAND USE, GUN PLAIN TWP FUTURE LAND USE MAP, 2000.
BASE MAP, KALAMAZOO RIVER WATERSHED GIS PROJECT, GIS RESEARCH CENTER WESTERN MICHIGAN UNIVERSITY 1996.
MICHIGAN DEPARTMENT OF NATURAL RESOURCES MIRIS, 1978, SPCS NAD 27, US FEET.
WATERSHED DELINEATION, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY GIS, DIGITAL SHEDS, 2001.

FUTURE LAND USE

PROJECT NO. G01339	Allegan Conservation District Allegan County, Michigan	Fishbeck, Thompson, Carr & Huber Engineers • Scientists • Architects Grand Rapids, Michigan
FIGURE NO. 1C	Hydrologic and Hydraulic Analysis of Gun River	

D:\WORK\01339\PROJECT\GUN_EXHIBITS.APR\HHFIG1D HYDROGRAPH DATE: 10-6-2003 USER: CDA



DATA SOURCES: BASE MAP, KALAMAZOO RIVER WATERSHED GIS PROJECT, GIS RESEARCH CENTER WESTERN MICHIGAN UNIVERSITY 1996.
MICHIGAN DEPARTMENT OF NATURAL RESOURCES MIRIS, 1978, SPCS NAD 27, US FEET.
WATERSHED DELINEATION, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY GIS, DIGITAL SHEDS, 2001.

HYDROLOGIC SUBBASIN MAP

PROJECT NO. G01339	Allegan Conservation District Allegan County, Michigan	Fishbeck, Thompson, Carr & Huber Engineers • Scientists • Architects Grand Rapids, Michigan
FIGURE NO. 1D	Gun River Watershed Management Plan	

Appendix 2

Calibration Data and Photographs

Location: 114th Street
River Station: 363+12
Water Surface Elevation: 729.1 ft

Location: 2nd Avenue (middle)
River Station: 333+29
Water Surface Elevation: 727.9 ft

Location: 2nd Avenue (south)
River Station: 298+00
Water Surface Elevation: 725.9 ft

Location: 7th Street
River Station: 120+58
Water Surface Elevation: 717.4 ft

Location: 9th Street
River Station: 73+61
Water Surface Elevation: 715.7 ft

Location: 10th Street
River Station: 34+29
Water Surface Elevation: 713.3 ft

Appendix 3 – HEC-RAS Summary Table

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
638+21		100 Year	187.96	745.52	1.73	108.75	68.49	0.038
638+21		50 Year	142.85	745.01	1.54	92.95	65.29	0.038
638+21		25 Year	108.25	744.59	1.36	79.87	62.65	0.038
638+21		10 Year	77.37	744.18	1.16	66.96	59.48	0.038
638+21		5 Year	63.91	743.97	1.05	60.70	57.19	0.038
638+21		2 Year	51.75	743.78	0.95	54.58	54.89	0.038
638+04		100 Year	187.96	745.52	1.73	108.56	68.45	0.038
638+04		50 Year	142.86	745.01	1.54	92.75	65.25	0.038
638+04		25 Year	108.25	744.59	1.36	79.69	62.61	0.038
638+04		10 Year	77.37	744.17	1.16	66.79	59.42	0.038
638+04		5 Year	63.91	743.97	1.06	60.54	57.13	0.038
638+04		2 Year	51.75	743.77	0.95	54.43	54.83	0.038
Marsh Road Culvert								
637+46		100 Year	187.96	743.32	4.65	40.40	49.55	0.038
637+46		50 Year	142.86	743.05	4.48	31.91	46.00	0.038
637+46		25 Year	108.25	742.79	4.51	24.00	41.36	0.038
637+46		10 Year	77.37	742.54	4.76	16.25	36.81	0.038
637+46		5 Year	63.91	742.43	4.99	12.80	34.79	0.038
637+46		2 Year	51.75	742.33	5.29	9.78	33.02	0.038
637+18		100 Year	187.99	743.38	1.23	152.88	50.31	0.038
637+18		50 Year	142.88	743.05	1.05	136.68	46.69	0.038
637+18		25 Year	108.27	742.76	0.88	123.63	44.99	0.038
637+18		10 Year	77.40	742.48	0.70	111.22	43.30	0.038
637+18		5 Year	63.94	742.35	0.61	105.42	42.49	0.038
637+18		2 Year	51.77	742.22	0.52	100.03	41.73	0.038
635+00	AZ	100 Year	188.17	743.33	1.25	150.23	49.69	0.038
635+00	AZ	50 Year	143.05	743.01	1.06	134.81	46.45	0.038
635+00	AZ	25 Year	108.44	742.73	0.89	122.27	44.80	0.038
635+00	AZ	10 Year	77.57	742.46	0.70	110.31	43.18	0.038
635+00	AZ	5 Year	64.10	742.33	0.61	104.71	42.39	0.038
635+00	AZ	2 Year	51.95	742.21	0.52	99.51	41.65	0.038
625+50		100 Year	188.94	742.75	2.16	87.54	45.38	0.038
625+50		50 Year	143.81	742.55	1.82	78.83	43.93	0.038
625+50		25 Year	109.20	742.39	1.53	71.59	42.69	0.038
625+50		10 Year	78.31	742.22	1.21	64.50	41.44	0.038
625+50		5 Year	64.86	742.14	1.06	61.14	40.83	0.038
625+50		2 Year	52.70	742.06	0.91	57.92	40.24	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
625+20		100 Year	188.97	742.76	1.49	126.72	46.45	0.038
625+20		50 Year	143.83	742.56	1.22	117.60	45.54	0.038
625+20		25 Year	109.22	742.39	0.99	109.94	44.77	0.038
625+20		10 Year	78.34	742.22	0.77	102.36	43.99	0.038
625+20		5 Year	64.88	742.14	0.66	98.75	43.61	0.038
625+20		2 Year	52.72	742.06	0.55	95.27	43.25	0.038
Patterson Avenue Weir								
625+15		100 Year	116.54	742.54	1.10	106.12	1612.08	0.038
625+15		50 Year	69.09	741.63	0.81	85.29	42.86	0.038
625+15		25 Year	109.22	740.24	2.05	53.37	38.21	0.038
625+15		10 Year	78.34	739.86	1.75	44.65	36.99	0.038
625+15		5 Year	64.88	739.67	1.61	40.30	36.39	0.038
625+15		2 Year	52.72	739.49	1.46	36.05	35.79	0.038
625+14		100 Year	116.54	742.54	1.10	106.12	1654.71	0.038
625+14		50 Year	69.10	741.63	0.81	85.28	42.86	0.038
625+14		25 Year	109.22	740.24	2.05	53.35	38.21	0.038
625+14		10 Year	78.34	739.86	1.76	44.63	36.99	0.038
625+14		5 Year	64.88	739.67	1.61	40.28	36.38	0.038
625+14		2 Year	52.73	739.49	1.46	36.04	35.79	0.038
Patterson Avenue Culvert								
624+62		100 Year	94.83	741.93	0.88	107.94	44.70	0.038
624+62		50 Year	67.86	741.19	0.75	91.04	42.64	0.038
624+62		25 Year	56.02	739.83	0.94	59.68	38.81	0.038
624+62		10 Year	48.05	738.53	1.60	29.94	34.78	0.038
624+62		5 Year	64.89	738.27	2.72	23.83	33.81	0.038
624+62		2 Year	52.72	738.10	2.66	19.83	33.18	0.038
623+18		100 Year	96.38	741.93	0.42	230.44	45.28	0.038
623+18		50 Year	69.52	741.19	0.35	197.73	43.58	0.038
623+18		25 Year	57.55	739.82	0.41	140.27	40.40	0.038
623+18		10 Year	48.93	738.47	0.56	87.83	37.18	0.038
623+18		5 Year	65.00	738.02	0.91	71.43	36.06	0.038
623+18		2 Year	52.84	737.77	0.85	62.37	35.42	0.038
615+00	AY	100 Year	104.88	741.91	0.47	223.25	35.98	0.038
615+00	AY	50 Year	78.95	741.18	0.40	198.01	33.56	0.038
615+00	AY	25 Year	66.26	739.81	0.43	153.88	30.76	0.038
615+00	AY	10 Year	53.93	738.44	0.48	113.24	28.67	0.038
615+00	AY	5 Year	65.64	737.94	0.66	98.98	27.87	0.038
615+00	AY	2 Year	53.48	737.69	0.58	92.19	27.38	0.038
598+88		100 Year	122.17	741.87	0.68	178.88	34.90	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
598+88		50 Year	97.16	741.14	0.63	154.26	32.92	0.038
598+88		25 Year	83.44	739.73	0.76	110.34	29.69	0.038
598+88		10 Year	63.80	738.31	0.91	70.26	26.39	0.038
598+88		5 Year	55.31	737.74	0.99	55.78	25.09	0.038
598+88		2 Year	54.76	737.43	1.14	48.05	24.37	0.038
598+78		100 Year	122.28	741.86	0.89	137.69	35.04	0.038
598+78		50 Year	97.27	741.13	0.80	121.71	32.89	0.038
598+78		25 Year	83.54	739.73	0.92	90.81	29.55	0.038
598+78		10 Year	63.86	738.30	1.08	59.32	26.15	0.038
598+78		5 Year	55.35	737.73	1.18	46.90	24.81	0.038
598+78		2 Year	54.77	737.42	1.37	39.93	24.06	0.038
122nd Avenue Culvert								
598+26		100 Year	122.05	741.64	0.86	142.49	34.15	0.038
598+26		50 Year	97.27	741.00	0.78	124.87	32.55	0.038
598+26		25 Year	83.54	739.69	0.93	90.21	29.34	0.038
598+26		10 Year	63.86	738.28	1.15	55.42	25.91	0.038
598+26		5 Year	55.35	737.71	1.32	42.08	24.52	0.038
598+26		2 Year	54.77	737.38	1.58	34.61	23.73	0.038
597+86		100 Year	122.50	741.65	0.69	176.85	34.16	0.038
597+86		50 Year	97.72	741.01	0.63	155.48	32.64	0.038
597+86		25 Year	83.97	739.69	0.73	114.49	29.67	0.038
597+86		10 Year	64.10	738.28	0.86	74.85	26.48	0.038
597+86		5 Year	55.52	737.71	0.92	60.11	25.19	0.038
597+86		2 Year	54.80	737.38	1.06	51.94	24.45	0.038
595+00	AX	100 Year	125.74	741.64	0.63	199.83	34.15	0.038
595+00	AX	50 Year	100.94	741.00	0.57	178.43	32.85	0.038
595+00	AX	25 Year	87.02	739.68	0.64	136.67	30.34	0.038
595+00	AX	10 Year	65.85	738.25	0.69	95.42	27.63	0.038
595+00	AX	5 Year	56.71	737.67	0.71	79.72	26.52	0.038
595+00	AX	2 Year	55.02	737.33	0.78	70.69	25.86	0.038
579+88		100 Year	141.69	741.61	0.04	10027.53	6713.94	0.043
579+88		50 Year	117.93	740.97	0.46	256.40	43.54	0.038
579+88		25 Year	103.12	739.63	0.51	200.81	39.47	0.038
579+88		10 Year	75.11	738.18	0.52	145.55	36.79	0.038
579+88		5 Year	63.03	737.58	0.51	123.93	35.69	0.038
579+88		2 Year	51.87	737.22	0.47	111.38	35.03	0.038
Weir								
579+77		100 Year	142.63	741.61	0.04	10013.82	6713.88	0.043
579+77		50 Year	117.93	740.96	0.71	166.94	43.69	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
579+77		25 Year	103.12	739.61	0.77	134.75	39.44	0.038
579+77		10 Year	75.11	738.17	0.75	99.98	36.63	0.038
579+77		5 Year	63.03	737.57	0.74	85.67	35.47	0.038
579+77		2 Year	51.87	737.22	0.67	77.18	34.79	0.038
579+76		100 Year	142.64	741.61	0.04	10013.82	6713.88	0.043
579+76		50 Year	117.94	740.96	0.71	166.94	43.69	0.038
579+76		25 Year	103.13	739.61	0.77	134.74	39.44	0.038
579+76		10 Year	75.12	738.17	0.75	99.98	36.63	0.038
579+76		5 Year	63.03	737.57	0.74	85.67	35.47	0.038
579+76		2 Year	51.87	737.22	0.67	77.18	34.79	0.038
Farm Lane Culvert								
579+44		100 Year	141.10	741.58	0.12	3125.47	2546.99	0.042
579+44		50 Year	117.94	740.85	0.87	135.57	42.94	0.038
579+44		25 Year	103.13	739.55	0.99	104.44	39.31	0.038
579+44		10 Year	75.12	738.13	1.07	70.32	36.56	0.038
579+44		5 Year	63.03	737.53	1.13	55.88	35.39	0.038
579+44		2 Year	51.87	737.18	1.09	47.45	34.71	0.038
578+96		100 Year	141.41	741.58	0.11	3126.13	2548.27	0.042
578+96		50 Year	118.48	740.85	0.73	161.33	43.00	0.038
578+96		25 Year	103.65	739.55	0.96	108.51	38.25	0.038
578+96		10 Year	75.41	738.10	1.34	56.32	33.95	0.038
578+96		5 Year	63.23	737.45	1.78	35.44	30.17	0.038
578+96		2 Year	51.98	737.01	2.28	22.82	27.08	0.038
575+00	AW	100 Year	145.07	741.58	0.22	1686.62	1601.60	0.041
575+00	AW	50 Year	121.99	740.84	0.47	256.89	1020.44	0.038
575+00	AW	25 Year	107.86	739.52	0.53	202.68	39.25	0.038
575+00	AW	10 Year	77.83	737.99	0.54	144.99	36.29	0.038
575+00	AW	5 Year	64.88	737.14	0.57	114.72	34.64	0.038
575+00	AW	2 Year	52.92	736.19	0.64	82.94	32.27	0.038
560+00	AV	100 Year	162.11	741.57	0.08	5688.83	4530.83	0.042
560+00	AV	50 Year	138.36	740.82	0.18	2512.59	3851.83	0.041
560+00	AV	25 Year	123.82	739.48	0.54	227.31	45.19	0.038
560+00	AV	10 Year	87.02	737.94	0.54	160.69	41.28	0.038
560+00	AV	5 Year	71.12	737.07	0.56	126.02	38.11	0.038
560+00	AV	2 Year	56.44	736.07	0.63	89.98	34.28	0.038
540+00	AU	100 Year	181.95	741.57	0.16	2840.37	1901.65	0.041
540+00	AU	50 Year	156.21	740.81	0.27	1487.49	1632.67	0.040
540+00	AU	25 Year	145.07	739.42	0.61	239.04	50.65	0.038
540+00	AU	10 Year	99.26	737.86	0.58	169.85	40.71	0.038
540+00	AU	5 Year	79.44	736.97	0.59	134.96	37.32	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
540+00	AU	2 Year	61.14	735.91	0.63	97.53	33.32	0.038
534+93		100 Year	516.85	741.55	1.15	705.87	1994.15	0.039
534+93		50 Year	402.78	740.77	1.15	450.30	1425.14	0.038
534+93		25 Year	280.51	739.35	1.09	257.64	48.51	0.038
534+93		10 Year	175.26	737.80	0.93	189.18	41.07	0.038
534+93		5 Year	133.36	736.91	0.87	153.59	38.53	0.038
534+93		2 Year	95.99	735.84	0.84	114.01	35.49	0.038
534+83		100 Year	513.83	741.54	1.40	370.76	396.61	0.038
534+83		50 Year	402.89	740.77	1.23	330.73	257.41	0.038
534+83		25 Year	280.62	739.35	1.09	257.59	48.50	0.038
534+83		10 Year	175.32	737.80	0.93	189.15	41.07	0.038
534+83		5 Year	133.40	736.91	0.87	153.56	38.53	0.038
534+83		2 Year	96.02	735.84	0.84	113.97	35.49	0.038
120th Avenue Culvert								
534+61		100 Year	480.19	741.40	1.33	363.47	371.26	0.038
534+61		50 Year	396.20	740.68	1.22	326.05	241.12	0.038
534+61		25 Year	280.62	739.30	1.10	255.31	48.16	0.038
534+61		10 Year	175.32	737.78	0.93	188.14	41.00	0.038
534+61		5 Year	133.40	736.89	0.87	152.90	38.48	0.038
534+61		2 Year	96.02	735.83	0.85	113.57	35.46	0.038
534+21		100 Year	488.29	741.41	1.14	649.38	372.52	0.039
534+21		50 Year	397.00	740.68	1.16	426.45	241.14	0.038
534+21		25 Year	281.37	739.30	1.10	255.11	48.13	0.038
534+21		10 Year	175.75	737.77	0.93	187.99	40.99	0.038
534+21		5 Year	133.70	736.89	0.88	152.76	38.47	0.038
534+21		2 Year	96.18	735.82	0.85	113.41	35.44	0.038
520+00	AT	100 Year	467.41	741.28	1.20	390.05	49.75	0.038
520+00	AT	50 Year	413.32	740.55	1.17	354.36	48.43	0.038
520+00	AT	25 Year	305.65	739.17	1.06	289.39	45.92	0.038
520+00	AT	10 Year	191.17	737.66	0.86	222.20	43.18	0.038
520+00	AT	5 Year	143.09	736.77	0.78	184.48	41.56	0.038
520+00	AT	2 Year	101.58	735.68	0.72	140.18	39.57	0.038
500+00	AS	100 Year	807.29	741.03	0.93	3265.04	2670.97	0.056
500+00	AS	50 Year	684.73	740.30	1.12	1478.72	2222.37	0.042
500+00	AS	25 Year	555.60	738.81	1.27	567.36	205.78	0.038
500+00	AS	10 Year	338.96	737.31	1.19	308.47	138.10	0.036
500+00	AS	5 Year	246.09	736.37	1.24	199.16	96.15	0.035
500+00	AS	2 Year	160.74	735.17	1.44	111.42	50.90	0.035
485+82		100 Year	1072.29	740.94	1.41	2790.38	978.53	0.069

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
485+82		50 Year	898.56	740.15	1.51	2058.08	884.82	0.063
485+82		25 Year	740.54	738.45	2.11	838.46	530.64	0.047
485+82		10 Year	453.50	736.81	2.04	260.19	177.57	0.036
485+82		5 Year	327.15	735.68	1.93	169.57	41.12	0.035
485+82		2 Year	209.23	734.44	1.69	124.02	33.81	0.035
485+64		100 Year	1072.76	740.81	6.30	170.19	1953.82	0.035
485+64		50 Year	898.93	740.03	5.70	157.70	911.01	0.035
485+64		25 Year	736.56	738.25	5.70	129.25	42.72	0.035
485+64		10 Year	453.70	736.62	4.40	103.21	39.48	0.035
485+64		5 Year	327.28	735.52	3.83	85.56	37.29	0.035
485+64		2 Year	209.30	734.33	3.14	66.62	34.77	0.035
2nd Street Bridge (north)								
485+32		100 Year	1072.76	740.17	6.61	162.18	46.54	0.035
485+32		50 Year	889.74	739.16	6.09	146.09	44.53	0.035
485+32		25 Year	736.56	738.22	5.62	131.06	42.66	0.035
485+32		10 Year	453.70	736.59	4.32	105.05	39.43	0.035
485+32		5 Year	327.28	735.49	3.74	87.40	37.23	0.035
485+32		2 Year	209.30	734.31	3.06	68.46	34.69	0.035
484+60		100 Year	1074.73	740.58	2.85	376.89	2140.32	0.035
484+60		50 Year	897.47	739.50	2.74	327.19	45.22	0.035
484+60		25 Year	742.21	738.50	2.62	282.94	43.23	0.035
484+60		10 Year	454.48	736.74	2.16	210.02	39.73	0.035
484+60		5 Year	327.81	735.59	1.98	165.54	37.43	0.035
484+60		2 Year	209.60	734.36	1.73	120.91	34.84	0.035
480+00	AR	100 Year	1087.28	740.40	2.96	367.10	2682.22	0.035
480+00	AR	50 Year	903.60	739.32	2.85	317.50	1611.81	0.035
480+00	AR	25 Year	746.25	738.31	2.73	273.31	1382.19	0.035
480+00	AR	10 Year	459.45	736.57	2.27	202.05	39.39	0.035
480+00	AR	5 Year	331.03	735.41	2.10	157.63	37.07	0.035
480+00	AR	2 Year	211.51	734.17	1.87	113.18	34.29	0.035
475+89		100 Year	1098.47	740.23	2.98	369.17	3221.09	0.035
475+89		50 Year	907.84	739.15	2.84	319.77	2129.55	0.035
475+89		25 Year	753.72	738.13	2.73	275.60	1672.53	0.035
475+89		10 Year	463.00	736.42	2.25	205.80	39.09	0.035
475+89		5 Year	334.06	735.25	2.07	161.43	36.76	0.035
475+89		2 Year	213.21	734.00	1.82	117.18	33.80	0.035
475+69		100 Year	1099.02	740.14	3.76	292.51	2919.17	0.035
475+69		50 Year	904.60	739.08	3.49	259.42	2096.78	0.035
475+69		25 Year	749.09	738.07	3.28	228.29	1644.81	0.035
475+69		10 Year	463.21	736.39	2.63	176.02	39.01	0.035

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
475+69		5 Year	334.21	735.22	2.39	139.94	36.70	0.035
475+69		2 Year	213.30	733.98	2.10	101.61	33.72	0.035
118th Avenue Culvert								
474+67		100 Year	1052.91	739.29	3.89	270.97	44.80	0.035
474+67		50 Year	884.76	738.56	3.56	248.24	43.34	0.035
474+67		25 Year	737.24	737.70	3.33	221.70	41.64	0.035
474+67		10 Year	463.21	736.19	2.65	174.73	38.62	0.035
474+67		5 Year	334.21	735.07	2.38	140.17	36.40	0.035
474+67		2 Year	213.30	733.85	2.08	102.67	33.35	0.035
473+85		100 Year	1054.28	739.31	3.35	314.76	44.83	0.035
473+85		50 Year	882.17	738.56	3.13	281.80	43.34	0.035
473+85		25 Year	738.65	737.69	3.02	244.83	41.61	0.035
473+85		10 Year	464.10	736.16	2.53	183.47	38.56	0.035
473+85		5 Year	334.81	735.03	2.37	141.26	36.32	0.035
473+85		2 Year	213.64	733.80	2.18	98.18	33.19	0.035
460+00	AQ	100 Year	1072.42	739.20	1.17	4131.38	2176.51	0.074
460+00	AQ	50 Year	895.03	738.28	1.50	2197.84	2010.25	0.061
460+00	AQ	25 Year	731.95	737.26	1.75	1096.90	632.24	0.051
460+00	AQ	10 Year	478.73	735.69	1.80	399.12	271.53	0.038
460+00	AQ	5 Year	344.98	734.50	1.72	201.11	60.30	0.035
460+00	AQ	2 Year	219.28	733.17	1.51	145.16	39.60	0.035
440+00	AP	100 Year	1103.28	739.15	0.78	7833.02	2729.47	0.086
440+00	AP	50 Year	920.07	738.17	0.97	5295.20	2483.63	0.079
440+00	AP	25 Year	746.90	737.04	1.41	2644.47	2179.89	0.062
440+00	AP	10 Year	499.58	735.34	1.69	447.41	118.60	0.042
440+00	AP	5 Year	359.56	734.10	1.55	313.43	97.25	0.039
440+00	AP	2 Year	227.58	732.71	1.36	195.35	73.45	0.037
420+00	AO	100 Year	1134.80	739.11	0.83	7612.63	3039.16	0.086
420+00	AO	50 Year	947.94	738.11	1.11	4702.11	2773.71	0.077
420+00	AO	25 Year	774.37	736.86	1.66	2032.02	1871.29	0.058
420+00	AO	10 Year	520.60	735.03	1.87	456.01	145.49	0.043
420+00	AO	5 Year	374.13	733.74	1.78	291.31	110.00	0.039
420+00	AO	2 Year	235.68	732.27	1.64	159.82	69.72	0.036
416+02		100 Year	1141.30	739.10	0.83	8126.59	3351.16	0.087
416+02		50 Year	953.53	738.10	1.04	5172.94	2510.35	0.079
416+02		25 Year	779.72	736.83	1.59	1395.36	1880.94	0.061
416+02		10 Year	524.74	734.98	1.66	732.65	295.20	0.051
416+02		5 Year	377.02	733.66	1.70	403.63	206.34	0.044
416+02		2 Year	237.29	732.16	1.69	169.77	104.41	0.036

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
415+82		100 Year	1141.33	739.07	3.90	292.66	3116.46	0.035
415+82		50 Year	953.81	738.05	3.57	267.25	2042.37	0.035
415+82		25 Year	780.00	736.76	3.32	234.85	1496.39	0.035
415+82		10 Year	524.95	734.92	2.78	188.91	47.55	0.035
415+82		5 Year	377.17	733.62	2.41	156.44	44.37	0.035
415+82		2 Year	237.38	732.14	1.99	119.29	40.72	0.035
116th Avenue Culvert								
414+90		100 Year	1120.95	737.18	4.48	250.22	53.09	0.035
414+90		50 Year	941.53	736.68	3.96	237.75	51.87	0.035
414+90		25 Year	775.83	735.80	3.60	215.60	49.70	0.035
414+90		10 Year	524.95	734.28	2.95	177.71	45.98	0.035
414+90		5 Year	377.17	733.10	2.54	148.22	43.09	0.035
414+90		2 Year	237.38	731.70	2.10	113.18	39.65	0.035
414+10		100 Year	1128.93	737.28	1.85	1611.70	451.10	0.056
414+10		50 Year	945.50	736.76	1.74	1387.30	416.04	0.054
414+10		25 Year	777.09	735.86	1.76	1041.16	355.26	0.051
414+10		10 Year	525.80	734.32	1.77	574.53	251.01	0.044
414+10		5 Year	377.76	733.12	1.78	322.21	169.79	0.039
414+10		2 Year	237.71	731.70	1.69	148.91	73.19	0.035
400+00	AN	100 Year	1098.16	736.96	2.77	396.56	48.17	0.035
400+00	AN	50 Year	935.68	736.44	2.52	371.85	46.58	0.035
400+00	AN	25 Year	773.82	735.51	2.35	329.41	44.65	0.035
400+00	AN	10 Year	524.04	733.95	2.00	262.42	41.69	0.035
400+00	AN	5 Year	376.77	732.75	1.77	213.35	39.59	0.035
400+00	AN	2 Year	237.06	731.30	1.50	157.79	37.08	0.035
380+00	AM	100 Year	1267.69	736.10	2.28	1286.19	907.62	0.038
380+00	AM	50 Year	1070.67	735.50	3.41	314.38	38.03	0.035
380+00	AM	25 Year	901.56	734.59	3.21	281.10	35.33	0.035
380+00	AM	10 Year	620.43	733.19	2.67	232.51	33.95	0.035
380+00	AM	5 Year	447.48	732.07	2.29	195.17	32.84	0.035
380+00	AM	2 Year	280.96	730.71	1.86	151.38	31.50	0.035
363+55		100 Year	1284.59	735.96	0.60	4746.50	2108.45	0.040
363+55		50 Year	1084.38	735.36	0.72	3474.47	2083.63	0.039
363+55		25 Year	918.13	734.36	1.26	1416.04	2042.80	0.037
363+55		10 Year	635.21	732.91	1.34	502.07	153.55	0.035
363+55		5 Year	458.86	731.76	1.33	346.49	116.94	0.035
363+55		2 Year	288.49	730.38	1.35	213.27	76.87	0.035
363+35	AL	100 Year	1277.38	735.90	5.04	253.53	3125.91	0.035
363+35	AL	50 Year	1084.55	735.28	4.54	238.73	2921.87	0.035
363+35	AL	25 Year	918.33	734.24	4.30	213.74	2577.22	0.035

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
363+35	AL	10 Year	635.39	732.78	3.56	178.64	149.42	0.035
363+35	AL	5 Year	459.00	731.66	3.02	151.81	114.02	0.035
363+35	AL	2 Year	288.58	730.31	2.41	119.54	75.29	0.035
114th Avenue Bridge								
362+89		100 Year	1277.38	735.44	5.27	242.47	2115.72	0.035
362+89		50 Year	1083.60	735.00	4.67	231.92	2091.59	0.035
362+89		25 Year	918.33	734.20	4.31	212.88	2048.04	0.035
362+89		10 Year	635.39	732.75	3.57	177.93	141.46	0.035
362+89		5 Year	459.00	731.63	3.04	151.15	101.02	0.035
362+89		2 Year	288.58	730.29	2.43	118.91	66.90	0.035
362+09		100 Year	1278.12	735.50	0.83	3762.41	2119.17	0.041
362+09		50 Year	1084.32	735.06	0.95	2838.74	2095.11	0.040
362+09		25 Year	919.12	734.29	1.47	1240.73	2052.82	0.037
362+09		10 Year	636.11	732.85	1.51	456.29	145.08	0.035
362+09		5 Year	459.56	731.70	1.48	313.44	103.26	0.035
362+09		2 Year	288.95	730.32	1.46	198.26	67.35	0.035
360+00	AK	100 Year	1278.79	735.48	4.13	309.82	39.53	0.035
360+00	AK	50 Year	1085.11	734.91	3.76	288.26	37.12	0.035
360+00	AK	25 Year	921.19	734.12	3.55	259.39	35.93	0.035
360+00	AK	10 Year	637.99	732.67	3.05	208.97	33.77	0.035
360+00	AK	5 Year	461.00	731.54	2.69	171.45	32.59	0.035
360+00	AK	2 Year	289.91	730.18	2.26	128.11	31.16	0.035
340+00	AJ	100 Year	1322.02	734.07	4.37	337.95	601.64	0.035
340+00	AJ	50 Year	1100.06	733.34	4.01	274.18	36.60	0.035
340+00	AJ	25 Year	940.27	732.60	3.80	247.40	35.25	0.035
340+00	AJ	10 Year	656.13	731.37	3.20	205.09	33.74	0.035
340+00	AJ	5 Year	474.93	730.36	2.77	171.49	32.77	0.035
340+00	AJ	2 Year	299.14	729.09	2.29	130.69	31.54	0.035
333+67		100 Year	1328.89	733.45	4.38	303.39	37.10	0.035
333+67		50 Year	1106.58	732.81	3.95	280.01	36.30	0.035
333+67		25 Year	946.06	732.07	3.73	253.48	35.87	0.035
333+67		10 Year	661.88	730.94	3.11	213.02	35.21	0.035
333+67		5 Year	479.09	729.97	2.67	179.42	34.65	0.035
333+67		2 Year	301.90	728.74	2.20	137.00	33.93	0.035
333+44	AI	100 Year	1329.13	733.42	4.40	302.38	37.07	0.035
333+44	AI	50 Year	1106.85	732.79	3.96	279.24	36.29	0.035
333+44	AI	25 Year	947.45	732.05	3.75	252.74	35.86	0.035
333+44	AI	10 Year	662.09	730.92	3.12	212.44	35.20	0.035
333+44	AI	5 Year	479.26	729.96	2.68	178.92	34.64	0.035
333+44	AI	2 Year	302.01	728.72	2.21	136.57	33.92	0.035

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
2nd Street Bridge (middle)								
333+14		100 Year	1329.00	733.14	4.51	294.88	36.62	0.035
333+14		50 Year	1102.76	732.56	4.03	273.93	36.15	0.035
333+14		25 Year	947.45	732.03	3.72	255.02	35.85	0.035
333+14		10 Year	662.09	730.90	3.08	214.73	35.19	0.035
333+14		5 Year	479.26	729.94	2.64	181.25	34.63	0.035
333+14		2 Year	302.01	728.71	2.17	138.98	33.91	0.035
332+22		100 Year	1329.97	732.99	4.82	276.14	35.84	0.035
332+22		50 Year	1104.02	732.44	4.30	256.57	35.01	0.035
332+22		25 Year	948.46	731.92	3.97	238.85	34.29	0.035
332+22		10 Year	662.92	730.81	3.29	201.39	33.26	0.035
332+22		5 Year	479.92	729.87	2.82	170.40	32.38	0.035
332+22		2 Year	302.45	728.65	2.30	131.58	31.25	0.035
320+00	AH	100 Year	1342.41	732.32	1.75	1456.72	620.84	0.041
320+00	AH	50 Year	1111.55	731.77	1.65	1182.84	404.24	0.041
320+00	AH	25 Year	961.23	731.25	1.69	982.66	364.37	0.041
320+00	AH	10 Year	674.03	730.16	1.73	632.81	281.42	0.040
320+00	AH	5 Year	488.61	729.25	1.79	407.12	211.28	0.039
320+00	AH	2 Year	308.23	728.07	1.80	211.60	121.25	0.038
310+49		100 Year	1352.31	731.75	3.18	425.70	75.01	0.038
310+49		50 Year	1121.86	731.25	2.89	388.38	72.10	0.038
310+49		25 Year	971.06	730.72	2.76	351.22	69.09	0.038
310+49		10 Year	682.67	729.66	2.43	280.88	62.98	0.038
310+49		5 Year	495.37	728.76	2.19	226.52	57.83	0.038
310+49		2 Year	312.73	727.58	1.92	162.71	51.12	0.038
310+19	AG	100 Year	1352.62	731.67	3.80	356.41	74.51	0.038
310+19	AG	50 Year	1122.47	731.18	3.37	333.12	71.73	0.038
310+19	AG	25 Year	971.42	730.67	3.15	308.42	68.78	0.038
310+19	AG	10 Year	682.95	729.62	2.64	258.26	62.80	0.038
310+19	AG	5 Year	495.59	728.73	2.30	215.52	57.70	0.038
310+19	AG	2 Year	312.87	727.57	1.96	159.87	51.02	0.038
112th Avenue Bridge								
309+84		100 Year	1352.67	731.64	3.81	355.09	74.35	0.038
309+84		50 Year	1122.47	731.16	3.38	331.91	71.59	0.038
309+84		25 Year	971.42	730.64	3.16	307.23	68.64	0.038
309+84		10 Year	682.95	729.60	2.65	257.24	62.67	0.038
309+84		5 Year	495.59	728.71	2.31	214.54	57.58	0.038
309+84		2 Year	312.87	727.54	1.97	158.45	50.84	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
308+64	AF	100 Year	1353.91	731.68	2.71	499.34	65.95	0.038
308+64	AF	50 Year	1124.95	731.19	2.41	466.88	64.70	0.038
308+64	AF	25 Year	972.84	730.67	2.24	433.46	63.39	0.038
308+64	AF	10 Year	684.04	729.61	1.86	368.01	60.72	0.038
308+64	AF	5 Year	496.45	728.71	1.58	314.53	58.46	0.038
308+64	AF	2 Year	313.44	727.53	1.27	247.07	55.47	0.038
300+00	AE	100 Year	1362.86	731.19	2.34	1008.76	367.17	0.040
300+00	AE	50 Year	1142.82	730.76	2.24	858.96	333.27	0.040
300+00	AE	25 Year	983.08	730.26	2.27	701.34	293.39	0.040
300+00	AE	10 Year	691.90	729.25	2.23	446.41	213.68	0.039
300+00	AE	5 Year	502.61	728.38	2.12	290.44	144.66	0.038
300+00	AE	2 Year	317.54	727.23	1.82	176.46	54.45	0.038
298+28		100 Year	1364.34	730.98	3.85	366.95	56.59	0.038
298+28		50 Year	1146.38	730.59	3.43	345.06	55.79	0.038
298+28		25 Year	984.11	730.10	3.17	318.32	54.81	0.038
298+28		10 Year	693.46	729.14	2.65	266.46	52.84	0.038
298+28		5 Year	503.83	728.30	2.28	222.51	51.12	0.038
298+28		2 Year	318.36	727.15	1.93	165.52	48.79	0.038
298+19	AD	100 Year	1364.72	730.97	3.85	366.55	56.57	0.038
298+19	AD	50 Year	1146.57	730.58	3.43	344.72	55.78	0.038
298+19	AD	25 Year	984.22	730.10	3.18	318.02	54.80	0.038
298+19	AD	10 Year	693.54	729.14	2.65	266.21	52.83	0.038
298+19	AD	5 Year	503.90	728.29	2.29	222.28	51.11	0.038
298+19	AD	2 Year	318.40	727.15	1.93	165.29	48.78	0.038
2nd Street Bridge (south)								
297+82		100 Year	1364.44	730.94	3.87	365.06	56.52	0.038
297+82		50 Year	1146.50	730.56	3.44	343.34	55.73	0.038
297+82		25 Year	984.22	730.07	3.19	316.68	54.75	0.038
297+82		10 Year	693.54	729.11	2.66	264.83	52.78	0.038
297+82		5 Year	503.90	728.26	2.30	220.93	51.06	0.038
297+82		2 Year	318.40	727.13	1.94	164.09	48.73	0.038
297+43		100 Year	1364.84	731.04	2.85	755.89	263.93	0.040
297+43		50 Year	1147.33	730.63	2.69	651.11	239.56	0.039
297+43		25 Year	984.70	730.12	2.66	537.60	209.99	0.039
297+43		10 Year	693.90	729.12	2.49	356.55	151.31	0.039
297+43		5 Year	504.17	728.25	2.27	247.55	100.65	0.038
297+43		2 Year	318.59	727.11	1.87	170.14	41.40	0.038
280+00	AC	100 Year	1382.12	730.37	2.88	1358.83	579.85	0.060
280+00	AC	50 Year	1183.95	729.99	2.59	1150.63	369.56	0.060
280+00	AC	25 Year	1005.16	729.46	2.48	963.47	334.98	0.057

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
280+00	AC	10 Year	709.66	728.48	2.23	664.83	270.80	0.052
280+00	AC	5 Year	516.22	727.63	2.02	459.23	215.79	0.047
280+00	AC	2 Year	326.86	726.51	1.76	257.82	142.63	0.042
260+00	AB	100 Year	1370.59	729.69	2.99	1254.40	495.53	0.059
260+00	AB	50 Year	1226.03	729.29	2.97	1063.92	450.92	0.057
260+00	AB	25 Year	1030.00	728.74	2.89	835.42	390.74	0.053
260+00	AB	10 Year	727.54	727.74	2.69	498.44	279.25	0.046
260+00	AB	5 Year	530.12	726.87	2.48	297.95	183.14	0.041
260+00	AB	2 Year	336.35	725.73	2.10	161.22	56.84	0.038
235+00	AA	100 Year	1451.06	728.64	2.45	1353.61	976.84	0.040
235+00	AA	50 Year	1277.85	728.21	2.82	931.88	966.25	0.039
235+00	AA	25 Year	1063.31	727.69	2.37	666.56	208.27	0.039
235+00	AA	10 Year	750.02	726.71	2.14	482.61	167.85	0.039
235+00	AA	5 Year	547.46	725.86	1.95	354.50	132.60	0.039
235+00	AA	2 Year	348.25	724.76	1.64	234.40	87.49	0.038
220+77		100 Year	1493.89	727.49	4.12	362.36	79.17	0.038
220+77		50 Year	1307.28	726.93	4.10	319.23	73.76	0.038
220+77		25 Year	1082.49	726.45	3.80	284.66	69.12	0.038
220+77		10 Year	762.12	725.48	3.43	222.25	59.83	0.038
220+77		5 Year	556.58	724.68	3.06	181.67	40.35	0.038
220+77		2 Year	355.00	723.62	2.51	141.33	34.73	0.038
220+68	Z	100 Year	1493.89	727.48	4.14	360.72	79.00	0.038
220+68	Z	50 Year	1307.27	726.91	4.11	317.88	73.58	0.038
220+68	Z	25 Year	1082.49	726.43	3.82	283.51	68.96	0.038
220+68	Z	10 Year	762.12	725.46	3.44	221.31	59.68	0.038
220+68	Z	5 Year	556.58	724.67	3.07	181.22	40.32	0.038
220+68	Z	2 Year	355.00	723.62	2.52	141.07	34.67	0.038
110th Avenue Bridge								
220+33		100 Year	1492.76	727.21	4.39	339.95	76.40	0.038
220+33		50 Year	1307.27	726.87	4.15	314.72	73.17	0.038
220+33		25 Year	1082.49	726.38	3.86	280.45	68.53	0.038
220+33		10 Year	762.12	725.42	3.49	218.61	59.25	0.038
220+33		5 Year	556.58	724.64	3.09	179.85	40.22	0.038
220+33		2 Year	354.59	723.59	2.53	140.12	34.48	0.038
219+94		100 Year	1493.88	727.26	3.64	830.70	255.61	0.051
219+94		50 Year	1307.27	726.92	3.41	745.17	239.51	0.050
219+94		25 Year	1082.49	726.42	3.11	632.96	216.57	0.048
219+94		10 Year	762.12	725.45	2.69	443.71	171.06	0.044
219+94		5 Year	556.58	724.67	2.33	324.09	134.57	0.041
219+94		2 Year	355.00	723.61	1.89	207.77	85.24	0.039

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
215+00	Y	100 Year	1509.09	726.95	3.93	1064.16	883.04	0.050
215+00	Y	50 Year	1317.77	726.59	3.84	781.18	708.55	0.046
215+00	Y	25 Year	1089.92	726.09	3.64	489.91	464.97	0.041
215+00	Y	10 Year	766.78	725.19	2.93	345.77	115.05	0.041
215+00	Y	5 Year	559.81	724.45	2.49	268.20	93.34	0.040
215+00	Y	2 Year	356.60	723.43	1.99	187.97	63.49	0.038
200+00	X	100 Year	1557.34	726.08	3.12	1990.43	1373.36	0.066
200+00	X	50 Year	1353.11	725.76	2.64	1712.75	701.68	0.069
200+00	X	25 Year	1114.07	725.31	2.50	1411.79	628.86	0.066
200+00	X	10 Year	779.74	724.47	2.32	938.21	492.96	0.060
200+00	X	5 Year	568.49	723.80	2.13	645.84	390.14	0.054
200+00	X	2 Year	362.60	722.83	1.93	333.29	253.90	0.045
180+00	W	100 Year	1623.17	724.81	3.99	1261.04	706.57	0.059
180+00	W	50 Year	1401.44	724.53	3.84	1064.84	678.70	0.056
180+00	W	25 Year	1146.69	724.17	3.63	829.17	643.63	0.051
180+00	W	10 Year	797.61	723.50	2.81	578.79	261.06	0.051
180+00	W	5 Year	580.42	722.96	2.38	447.75	222.76	0.048
180+00	W	2 Year	369.81	722.02	2.00	270.64	156.77	0.043
160+00	V	100 Year	1631.62	723.38	3.11	1778.51	775.48	0.076
160+00	V	50 Year	1434.32	723.02	3.19	1502.19	743.49	0.073
160+00	V	25 Year	1172.79	722.79	2.89	1337.72	723.78	0.070
160+00	V	10 Year	803.02	722.21	2.68	929.63	672.38	0.063
160+00	V	5 Year	583.17	721.72	3.33	177.47	48.33	0.038
160+00	V	2 Year	377.45	720.83	2.67	141.24	36.99	0.038
140+00	U	100 Year	1683.60	722.97	1.04	7529.51	2670.26	0.095
140+00	U	50 Year	1465.84	722.46	1.12	6196.15	2524.93	0.092
140+00	U	25 Year	1195.58	722.17	1.04	5477.97	2443.08	0.091
140+00	U	10 Year	788.88	721.50	0.97	3664.62	1816.31	0.086
140+00	U	5 Year	565.77	720.92	0.91	2704.11	1518.18	0.081
140+00	U	2 Year	382.75	719.81	1.93	212.00	62.34	0.038
120+94		100 Year	1737.96	722.87	0.99	6950.99	2817.37	0.091
120+94		50 Year	1506.39	722.32	1.07	5499.05	2537.41	0.089
120+94		25 Year	1224.38	722.05	0.98	4818.38	2394.92	0.088
120+94		10 Year	800.76	721.24	2.64	303.76	72.93	0.038
120+94		5 Year	575.52	720.38	2.35	244.65	64.85	0.038
120+94		2 Year	390.43	718.91	2.45	159.21	50.97	0.038
120+75		100 Year	1738.51	722.79	5.01	347.05	2775.46	0.038
120+75		50 Year	1493.22	722.24	4.67	319.99	2496.01	0.038
120+75		25 Year	1224.68	721.99	3.99	307.07	2272.29	0.038
120+75		10 Year	800.93	721.18	3.00	266.75	72.00	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
120+75		5 Year	575.64	720.35	2.55	225.53	64.60	0.038
120+75		2 Year	390.51	718.89	2.54	153.73	50.73	0.038
7th Street Bridge								
120+42	T	100 Year	1736.79	722.32	5.15	337.00	2555.71	0.038
120+42	T	50 Year	1486.43	721.96	4.66	319.04	2387.11	0.038
120+42	T	25 Year	1205.28	721.47	4.09	294.49	2049.63	0.038
120+42	T	10 Year	793.90	720.73	3.08	257.81	1492.79	0.038
120+42	T	5 Year	575.64	719.98	2.62	220.08	927.25	0.038
120+42	T	2 Year	390.51	718.87	2.37	164.43	473.10	0.038
120+00		100 Year	1738.42	722.37	1.33	5711.28	2576.23	0.085
120+00		50 Year	1487.38	722.00	1.34	4803.46	2409.07	0.083
120+00		25 Year	1205.92	721.51	1.36	3675.14	2136.75	0.078
120+00		10 Year	794.28	720.77	2.41	330.06	59.60	0.038
120+00		5 Year	575.92	720.00	2.01	286.11	55.65	0.038
120+00		2 Year	390.53	718.88	1.73	226.05	52.50	0.038
119+63		100 Year	1739.46	722.36	1.24	5471.56	2574.44	0.083
119+63		50 Year	1488.23	722.00	1.31	4010.87	1843.88	0.079
119+63		25 Year	1206.47	721.50	1.31	3149.89	1624.61	0.076
119+63		10 Year	794.62	720.76	2.21	363.17	102.71	0.038
119+63		5 Year	576.16	719.99	1.95	296.16	77.27	0.038
119+63		2 Year	390.68	718.87	1.80	216.82	64.81	0.038
100+00	S	100 Year	1794.16	722.06	2.09	4261.60	2321.64	0.082
100+00	S	50 Year	1530.28	721.65	2.72	2313.07	1736.59	0.070
100+00	S	25 Year	1231.43	721.03	2.98	1558.88	1652.08	0.060
100+00	S	10 Year	806.75	719.98	3.18	348.83	177.41	0.041
100+00	S	5 Year	588.84	719.12	2.74	241.28	84.44	0.039
100+00	S	2 Year	398.84	718.02	2.30	174.14	37.94	0.038
80+00	R	100 Year	1793.78	720.97	4.45	880.84	311.49	0.052
80+00	R	50 Year	1529.78	720.55	4.15	754.85	283.19	0.050
80+00	R	25 Year	1229.63	719.85	3.88	572.16	236.21	0.046
80+00	R	10 Year	806.14	718.71	3.26	347.49	160.58	0.041
80+00	R	5 Year	588.44	717.93	2.82	242.28	108.32	0.039
80+00	R	2 Year	398.82	716.91	2.40	166.63	40.51	0.038
73+93		100 Year	1805.87	720.64	3.01	1201.08	1146.01	0.043
73+93		50 Year	1538.68	720.24	2.89	759.35	1080.90	0.039
73+93		25 Year	1235.55	719.55	2.64	467.96	79.90	0.038
73+93		10 Year	809.20	718.49	2.10	385.17	76.05	0.038
73+93		5 Year	590.49	717.74	1.79	329.09	73.32	0.038
73+93		2 Year	399.81	716.73	1.56	256.60	69.64	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
73+78	Q	100 Year	1806.17	720.56	4.02	697.25	1133.26	0.040
73+78	Q	50 Year	1538.66	720.16	3.72	413.93	1067.32	0.038
73+78	Q	25 Year	1235.69	719.49	3.26	379.34	79.68	0.038
73+78	Q	10 Year	809.28	718.46	2.48	325.72	75.93	0.038
73+78	Q	5 Year	590.54	717.72	2.06	287.32	73.25	0.038
73+78	Q	2 Year	399.84	716.72	1.70	235.04	69.60	0.038
9th Street Bridge								
73+44		100 Year	1806.17	720.52	4.05	656.84	1123.56	0.039
73+44		50 Year	1538.66	720.04	3.74	411.57	1044.61	0.038
73+44		25 Year	1235.69	719.46	3.24	381.39	69.62	0.038
73+44		10 Year	809.28	718.44	2.46	328.42	66.32	0.038
73+44		5 Year	590.54	717.70	2.04	289.81	63.91	0.038
73+44		2 Year	399.84	716.70	1.68	237.69	60.66	0.038
72+84		100 Year	1807.35	720.53	3.36	1040.09	1125.10	0.042
72+84		50 Year	1539.55	720.06	3.26	533.58	1047.61	0.038
72+84		25 Year	1236.28	719.47	2.88	429.75	69.63	0.038
72+84		10 Year	809.71	718.44	2.25	359.84	66.29	0.038
72+84		5 Year	590.74	717.69	1.90	311.32	63.88	0.038
72+84		2 Year	399.94	716.69	1.61	248.75	60.62	0.038
66+31		100 Year	1820.36	719.82	4.08	446.08	500.18	0.038
66+31		50 Year	1549.21	719.42	3.75	413.49	467.02	0.038
66+31		25 Year	1242.66	718.91	3.34	372.32	424.14	0.038
66+31		10 Year	813.09	718.01	2.68	303.46	345.45	0.038
66+31		5 Year	592.94	717.34	2.30	257.56	62.37	0.038
66+31		2 Year	401.00	716.37	1.94	206.41	45.03	0.038
66+21	P	100 Year	1820.46	719.80	4.09	444.92	499.00	0.038
66+21	P	50 Year	1549.36	719.41	3.76	412.48	465.98	0.038
66+21	P	25 Year	1242.75	718.90	3.35	371.47	423.24	0.038
66+21	P	10 Year	813.15	718.01	2.68	302.91	344.75	0.038
66+21	P	5 Year	592.98	717.33	2.31	257.20	62.25	0.038
66+21	P	2 Year	401.02	716.37	1.94	206.24	45.02	0.038
RR Bridge								
66+05		100 Year	1820.56	719.78	4.11	442.76	83.16	0.038
66+05		50 Year	1549.36	719.39	3.77	410.84	81.52	0.038
66+05		25 Year	1242.75	718.87	3.37	369.16	79.34	0.038
66+05		10 Year	813.15	717.99	2.70	301.61	72.04	0.038
66+05		5 Year	592.98	717.32	2.32	256.12	61.89	0.038
66+05		2 Year	400.88	716.35	1.95	205.49	44.96	0.038
65+65		100 Year	1821.36	719.72	4.16	437.97	82.92	0.038

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
65+65		50 Year	1549.95	719.34	3.81	406.63	81.31	0.038
65+65		25 Year	1243.14	718.83	3.40	365.62	79.15	0.038
65+65		10 Year	813.36	717.96	2.72	299.32	71.68	0.038
65+65		5 Year	593.11	717.29	2.33	254.69	61.41	0.038
65+65		2 Year	401.08	716.33	1.96	204.81	44.91	0.038
60+00	O	100 Year	1832.57	718.67	3.23	1562.17	883.06	0.053
60+00	O	50 Year	1557.48	718.39	3.23	1313.39	864.84	0.052
60+00	O	25 Year	1248.60	718.02	3.42	865.74	709.58	0.047
60+00	O	10 Year	816.36	717.35	3.02	497.17	384.86	0.043
60+00	O	5 Year	594.75	716.79	2.72	321.64	256.20	0.040
60+00	O	2 Year	401.91	715.88	2.37	172.45	71.51	0.038
46+38		100 Year	1859.83	717.63	3.01	1235.57	631.06	0.042
46+38		50 Year	1574.23	717.31	2.95	1039.21	574.54	0.041
46+38		25 Year	1261.23	716.90	2.86	820.95	504.34	0.041
46+38		10 Year	823.20	716.20	2.63	511.51	383.39	0.039
46+38		5 Year	599.32	715.69	2.42	340.23	266.86	0.039
46+38		2 Year	404.20	714.78	2.25	179.28	47.22	0.038
46+28	N	100 Year	1860.03	717.44	5.03	425.78	598.03	0.039
46+28	N	50 Year	1574.37	717.16	4.52	401.17	548.40	0.039
46+28	N	25 Year	1261.33	716.79	3.93	370.08	485.68	0.039
46+28	N	10 Year	823.26	716.16	3.00	315.50	375.55	0.039
46+28	N	5 Year	599.35	715.67	2.49	273.36	262.56	0.038
46+28	N	2 Year	404.22	714.78	2.21	197.00	85.93	0.038
Abandoned RR Bridge								
46+06		100 Year	1860.03	717.41	5.06	423.36	592.81	0.039
46+06		50 Year	1574.37	717.13	4.55	398.94	543.55	0.039
46+06		25 Year	1261.33	716.77	3.95	368.24	481.60	0.039
46+06		10 Year	823.26	716.13	3.02	313.37	370.92	0.039
46+06		5 Year	599.35	715.65	2.51	271.73	259.25	0.038
46+06		2 Year	404.22	714.76	2.23	195.21	89.84	0.038
45+26		100 Year	1861.63	717.46	4.23	930.95	600.84	0.042
45+26		50 Year	1575.50	717.11	4.31	733.77	540.91	0.041
45+26		25 Year	1262.09	716.69	4.35	518.73	466.87	0.040
45+26		10 Year	823.68	715.99	3.86	238.66	128.93	0.038
45+26		5 Year	599.62	715.54	3.11	195.28	61.13	0.038
45+26		2 Year	404.35	714.68	2.52	160.69	36.52	0.038
40+00	M	100 Year	1872.16	717.18	2.35	1689.47	698.47	0.047
40+00	M	50 Year	1580.93	716.80	2.42	1421.37	685.88	0.046
40+00	M	25 Year	1266.08	716.30	2.61	1086.46	669.83	0.045
40+00	M	10 Year	825.70	715.46	3.70	366.28	539.02	0.042

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
40+00	M	5 Year	601.06	714.90	3.49	172.44	347.23	0.038
40+00	M	2 Year	405.01	714.16	2.78	145.87	90.28	0.038
34+65		100 Year	1882.87	717.11	1.15	3035.88	974.63	0.044
34+65		50 Year	1588.43	716.71	1.12	2655.12	944.27	0.044
34+65		25 Year	1271.12	716.20	1.09	2183.54	905.26	0.043
34+65		10 Year	828.56	715.32	1.12	1405.32	868.19	0.041
34+65		5 Year	602.86	714.74	1.18	934.67	757.21	0.040
34+65		2 Year	405.88	714.00	1.33	430.48	611.91	0.038
34+51	L	100 Year	1882.99	716.99	3.92	481.36	966.06	0.038
34+51	L	50 Year	1588.62	716.62	3.48	456.43	937.15	0.038
34+51	L	25 Year	1271.25	716.13	3.00	424.03	899.60	0.038
34+51	L	10 Year	828.64	715.27	2.26	367.71	862.12	0.038
34+51	L	5 Year	602.91	714.71	1.83	330.58	751.13	0.038
34+51	L	2 Year	405.91	713.99	1.43	283.14	601.64	0.038
10th Street Bridge								
34+06		100 Year	1883.15	716.96	3.94	478.80	963.08	0.038
34+06		50 Year	1588.62	716.59	3.50	454.58	935.01	0.038
34+06		25 Year	1271.25	716.10	3.01	422.40	897.71	0.038
34+06		10 Year	828.64	715.25	2.27	366.13	857.39	0.038
34+06		5 Year	602.91	714.69	1.83	328.97	746.31	0.038
34+06		2 Year	405.91	713.97	1.44	282.02	584.13	0.038
33+51		100 Year	1884.25	717.04	1.20	3015.35	969.65	0.047
33+51		50 Year	1589.39	716.66	1.17	2650.04	940.39	0.046
33+51		25 Year	1271.76	716.16	1.17	2186.16	901.86	0.046
33+51		10 Year	828.92	715.28	1.28	1413.73	866.92	0.045
33+51		5 Year	603.08	714.70	1.51	916.49	848.37	0.044
33+51		2 Year	405.99	713.94	2.21	287.07	698.25	0.039
20+00	K	100 Year	1911.23	716.45	2.79	1312.95	440.36	0.056
20+00	K	50 Year	1606.42	716.07	2.64	1148.97	417.02	0.055
20+00	K	25 Year	1284.44	715.51	2.60	923.61	401.70	0.054
20+00	K	10 Year	835.89	714.51	2.64	533.65	378.46	0.050
20+00	K	5 Year	607.21	713.89	2.50	317.67	210.85	0.048
20+00	K	2 Year	408.03	712.99	2.22	200.22	78.87	0.048
3+41		100 Year	1944.33	715.48	2.12	1388.04	629.61	0.050
3+41		50 Year	1627.82	715.09	2.01	1243.01	621.75	0.050
3+41		25 Year	1299.28	714.01	2.41	845.37	339.33	0.050
3+41		10 Year	776.46	713.18	1.95	591.51	273.97	0.049
3+41		5 Year	612.58	712.69	1.86	466.76	235.56	0.049
3+41		2 Year	410.67	711.74	1.86	277.07	159.97	0.048

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
3+27		100 Year	1944.62	715.23	5.09	390.73	624.56	0.048
3+27		50 Year	1628.02	714.89	4.48	371.37	617.77	0.048
3+27		25 Year	1298.56	713.83	4.27	310.90	579.49	0.048
3+27		10 Year	776.43	713.10	2.94	269.28	492.63	0.048
3+27		5 Year	612.62	712.63	2.56	242.80	455.02	0.048
3+27		2 Year	410.69	711.70	2.17	190.91	389.14	0.048
107th Avenue Bridge								
2+93	J	100 Year	1944.79	714.70	5.72	348.41	614.02	0.048
2+93	J	50 Year	1628.02	714.26	5.16	323.27	605.20	0.048
2+93	J	25 Year	1298.56	713.72	4.55	292.21	566.83	0.048
2+93	J	10 Year	776.43	713.03	3.13	253.30	487.36	0.048
2+93	J	5 Year	612.62	712.57	2.74	227.36	454.16	0.048
2+93	J	2 Year	410.69	711.65	2.34	176.70	390.12	0.048
2+37		100 Year	1945.91	714.83	1.20	2327.00	616.68	0.049
2+37		50 Year	1628.79	714.37	1.17	2041.65	607.36	0.049
2+37		25 Year	1299.09	713.84	3.50	497.29	586.04	0.050
2+37		10 Year	776.23	713.03	2.63	373.54	515.39	0.049
2+37		5 Year	612.78	712.56	2.39	312.10	474.12	0.049
2+37		2 Year	410.79	711.61	2.17	212.19	394.93	0.048
0+25	I	100 Year	1950.24	714.81	1.26	2592.77	587.88	0.064
0+25	I	50 Year	1631.82	714.34	1.20	2319.44	584.31	0.064
0+25	I	25 Year	1301.15	713.80	1.13	2003.51	580.16	0.064
0+25	I	10 Year	845.24	712.81	1.08	1433.64	572.60	0.063
0+25	I	5 Year	613.46	712.14	3.59	170.92	498.95	0.048
0+25	I	2 Year	411.17	711.27	2.97	138.38	457.94	0.048
0+00		100 Year	1950.76	714.80	1.24	2758.63	651.88	0.064
0+00		50 Year	1632.18	714.34	1.18	2459.37	631.15	0.064
0+00		25 Year	1301.40	713.80	1.10	2123.30	607.02	0.063
0+00		10 Year	845.38	712.81	1.03	1545.45	563.12	0.062
0+00		5 Year	613.55	712.17	2.85	215.25	535.52	0.048
0+00		2 Year	411.22	711.29	2.30	179.15	499.49	0.048
-13+22		100 Year	1977.59	714.37	1.42	3558.43	1072.69	0.079
-13+22		50 Year	1650.86	713.85	2.06	1335.92	1017.60	0.062
-13+22		25 Year	1314.03	713.26	1.86	1137.70	966.79	0.060
-13+22		10 Year	852.45	712.21	1.55	819.54	877.71	0.057
-13+22		5 Year	616.43	711.47	1.39	613.78	616.57	0.053
-13+22		2 Year	413.55	710.71	1.21	411.86	468.06	0.050
-13+38	H	100 Year	1977.90	714.25	4.65	451.12	1058.19	0.049
-13+38	H	50 Year	1651.08	713.74	4.14	421.22	1007.85	0.049
-13+38	H	25 Year	1314.18	713.14	3.58	386.12	957.52	0.049

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
-13+38	H	10 Year	852.53	712.15	2.71	327.30	873.15	0.049
-13+38	H	5 Year	616.43	711.43	2.22	284.88	609.32	0.048
-13+38	H	2 Year	413.58	710.69	1.72	241.59	394.97	0.048
US-131 Bridge								
-14+38		100 Year	1977.95	714.02	4.78	438.73	1031.97	0.049
-14+38		50 Year	1651.08	713.54	4.25	410.86	991.50	0.049
-14+38		25 Year	1314.18	712.99	3.65	378.26	944.78	0.049
-14+38		10 Year	852.53	712.03	2.76	321.44	863.35	0.049
-14+38		5 Year	616.43	711.34	2.26	280.49	591.51	0.048
-14+38		2 Year	413.58	710.63	1.74	238.66	453.58	0.048
-15+02		100 Year	1979.17	714.06	0.88	5335.63	1124.46	0.094
-15+02		50 Year	1651.96	713.57	0.81	4803.60	1085.95	0.094
-15+02		25 Year	1314.76	713.01	0.73	4206.68	1041.05	0.094
-15+02		10 Year	852.85	712.04	0.61	3231.12	963.17	0.092
-15+02		5 Year	616.58	711.34	0.56	2577.59	907.27	0.091
-15+02		2 Year	413.67	710.63	0.50	1951.45	850.26	0.089
-16+85	G	100 Year	1982.81	713.97	2.81	1540.10	332.54	0.083
-16+85	G	50 Year	1654.48	713.49	2.62	1382.87	329.37	0.082
-16+85	G	25 Year	1316.46	712.94	2.41	1201.14	325.67	0.080
-16+85	G	10 Year	853.78	711.97	2.12	888.95	319.21	0.076
-16+85	G	5 Year	617.02	711.27	2.03	666.04	314.52	0.072
-16+85	G	2 Year	413.96	710.47	2.71	152.69	263.29	0.048
-35+47		100 Year	2019.89	710.18	3.01	1805.56	667.22	0.084
-35+47		50 Year	1680.20	709.74	2.96	1521.40	639.13	0.082
-35+47		25 Year	1333.60	709.30	2.85	1245.01	610.57	0.078
-35+47		10 Year	863.57	708.59	2.66	831.22	565.12	0.071
-35+47		5 Year	550.76	708.56	1.73	812.49	562.97	0.071
-35+47		2 Year	417.14	707.88	2.02	447.13	485.88	0.060
-35+59	F	100 Year	2020.13	709.79	7.65	289.94	650.18	0.051
-35+59	F	50 Year	1680.36	709.41	6.85	268.55	627.32	0.050
-35+59	F	25 Year	1333.71	709.04	5.88	247.45	604.77	0.050
-35+59	F	10 Year	563.67	708.46	2.85	214.13	569.17	0.050
-35+59	F	5 Year	547.71	708.50	2.74	216.60	571.81	0.050
-35+59	F	2 Year	417.16	707.84	2.50	178.79	492.51	0.049
11th Street Bridge								
-35+91		100 Year	2020.14	709.50	8.08	274.03	635.16	0.050
-35+91		50 Year	1680.03	709.22	7.13	257.75	618.02	0.050
-35+91		25 Year	1333.71	708.91	6.05	240.32	599.68	0.050
-35+91		10 Year	563.67	708.37	2.91	209.49	567.23	0.050

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
-35+91		5 Year	547.71	708.39	2.82	210.59	568.38	0.050
-35+91		2 Year	417.16	707.80	2.52	177.15	486.37	0.049
-36+39		100 Year	2021.09	709.68	3.65	1483.21	635.26	0.081
-36+39		50 Year	1680.69	709.35	3.51	1274.08	613.63	0.079
-36+39		25 Year	1334.16	708.99	3.31	1057.76	590.43	0.076
-36+39		10 Year	863.88	708.38	3.03	711.84	551.31	0.068
-36+39		5 Year	539.92	708.40	1.87	721.94	552.49	0.069
-36+39		2 Year	417.24	707.78	2.14	400.31	451.18	0.058
-37+85	G	100 Year	2023.88	709.58	1.45	4400.23	1736.49	0.098
-37+85	G	50 Year	1682.68	709.25	1.42	3818.26	1724.50	0.097
-37+85	G	25 Year	1335.49	708.89	1.37	3195.39	1711.57	0.096
-37+85	G	10 Year	864.62	708.28	1.31	2170.99	1690.09	0.092
-37+85	G	5 Year	526.18	708.09	0.92	1841.99	1683.13	0.090
-37+85	G	2 Year	417.50	707.55	2.84	146.85	922.63	0.048
-56+85	F	100 Year	2061.39	708.20	3.43	1877.49	707.39	0.087
-56+85	F	50 Year	1708.58	707.84	3.31	1628.44	696.51	0.085
-56+85	F	25 Year	1352.55	707.47	3.14	1369.15	685.00	0.082
-56+85	F	10 Year	874.09	706.80	2.98	918.40	664.51	0.073
-56+85	F	5 Year	654.90	706.45	2.83	685.44	653.67	0.067
-56+85	F	2 Year	420.12	705.81	2.78	287.24	494.93	0.053
-76+85	E	100 Year	2097.62	705.68	2.90	2687.80	1335.15	0.092
-76+85	E	50 Year	1735.40	705.37	2.91	2283.56	1330.60	0.089
-76+85	E	25 Year	1370.39	705.05	2.91	1858.04	1325.80	0.085
-76+85	E	10 Year	884.11	704.51	3.04	1145.29	1317.71	0.075
-76+85	E	5 Year	650.17	704.24	3.00	780.89	1313.56	0.066
-76+85	E	2 Year	423.52	703.65	3.09	168.57	429.90	0.048
-90+75		100 Year	2116.56	704.74	2.38	2864.65	1204.83	0.089
-90+75		50 Year	1751.62	704.34	2.40	2392.67	1181.78	0.086
-90+75		25 Year	1381.72	703.93	2.38	1917.98	1143.52	0.083
-90+75		10 Year	890.94	703.36	2.16	1303.74	989.30	0.076
-90+75		5 Year	653.54	702.92	2.11	899.94	860.66	0.069
-90+75		2 Year	425.61	702.44	1.89	531.64	649.77	0.060
-115+43	D	100 Year	2154.50	703.78	2.01	4033.76	1931.51	0.091
-115+43	D	50 Year	1779.35	703.07	2.35	2771.73	1594.29	0.087
-115+43	D	25 Year	1400.64	702.49	2.54	1930.21	1322.49	0.081
-115+43	D	10 Year	902.52	701.56	2.90	902.76	883.76	0.069
-115+43	D	5 Year	661.50	701.06	2.93	520.99	649.13	0.060
-115+43	D	2 Year	429.45	700.26	2.93	146.55	183.90	0.048
-125+21		100 Year	2171.48	703.54	1.59	4947.11	1864.47	0.089
-125+21		50 Year	1791.06	702.70	1.78	3502.43	1550.81	0.085

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
-125+21		25 Year	1408.19	702.01	1.83	2528.38	1297.22	0.080
-125+21		10 Year	906.91	700.77	2.00	1200.93	835.75	0.069
-125+21		5 Year	664.71	700.06	1.99	704.55	574.83	0.062
-125+21		2 Year	431.19	699.16	1.80	350.30	209.13	0.056
-125+29	C	100 Year	2171.61	703.44	4.82	534.46	1826.95	0.052
-125+29	C	50 Year	1791.15	702.59	4.49	465.87	1513.00	0.051
-125+29	C	25 Year	1408.26	701.92	3.93	411.55	1264.36	0.050
-125+29	C	10 Year	906.95	700.70	3.17	312.26	809.91	0.049
-125+29	C	5 Year	664.74	700.01	2.68	256.68	555.50	0.048
-125+29	C	2 Year	431.25	699.13	2.12	203.22	197.49	0.048
RR Bridge								
-125+57		100 Year	2171.56	702.88	5.22	488.67	1617.39	0.051
-125+57		50 Year	1791.15	702.29	4.71	441.13	1399.77	0.051
-125+57		25 Year	1408.26	701.76	4.04	398.60	1205.10	0.050
-125+57		10 Year	906.95	700.67	3.18	310.28	800.86	0.049
-125+57		5 Year	664.74	699.98	2.70	254.05	543.49	0.048
-125+57		2 Year	431.21	699.10	2.14	201.76	186.07	0.048
-125+89		100 Year	2172.17	702.97	2.04	3603.20	1437.37	0.086
-125+89		50 Year	1791.54	702.37	2.10	2796.44	1257.72	0.082
-125+89		25 Year	1408.53	701.83	2.05	2156.63	1094.48	0.079
-125+89		10 Year	907.12	700.71	2.15	1121.06	759.21	0.068
-125+89		5 Year	664.85	699.99	2.21	654.11	544.21	0.060
-125+89		2 Year	431.27	699.08	2.15	279.98	277.94	0.051
-132+80	B	100 Year	2184.23	702.60	3.27	1692.14	628.67	0.071
-132+80	B	50 Year	1800.01	701.95	3.23	1314.26	544.36	0.067
-132+80	B	25 Year	1414.40	701.42	2.96	1041.28	474.21	0.064
-132+80	B	10 Year	910.70	700.20	2.76	560.25	314.61	0.055
-132+80	B	5 Year	667.29	699.42	2.56	354.47	216.89	0.051
-132+80	B	2 Year	432.61	698.51	2.14	206.97	103.42	0.048
-132+98		100 Year	2184.48	702.36	5.59	476.30	580.38	0.049
-132+98		50 Year	1800.24	701.73	5.20	348.79	451.06	0.048
-132+98		25 Year	1414.55	701.25	4.49	316.83	378.65	0.048
-132+98		10 Year	910.79	700.07	3.81	239.14	202.69	0.048
-132+98		5 Year	667.36	699.31	3.51	190.35	78.73	0.048
-132+98		2 Year	432.64	698.41	3.02	143.14	47.42	0.048
106th Avenue Bridge								
-133+33		100 Year	2184.54	702.09	5.64	408.66	504.06	0.048
-133+33		50 Year	1800.24	701.72	4.96	365.74	449.39	0.048
-133+33		25 Year	1414.55	701.25	4.25	334.69	379.38	0.048

River Station	Surveyed Cross Section	Plan	Peak Flow rate [cfs]	Water Surface Elevation [ft]	Channel Velocity [ft/s]	Flow Area [ft^2]	Top Width [ft]	Manning's "n"
-133+33		10 Year	910.79	700.07	3.54	257.62	200.02	0.048
-133+33		5 Year	667.36	699.31	3.17	210.22	76.96	0.048
-133+33		2 Year	432.64	698.42	2.70	160.45	51.83	0.048
-133+99	A	100 Year	2185.70	702.14	3.75	863.57	468.83	0.054
-133+99	A	50 Year	1801.07	701.73	3.53	686.27	398.45	0.051
-133+99	A	25 Year	1415.13	701.21	3.35	422.09	295.47	0.048
-133+99	A	10 Year	911.13	699.99	3.04	299.57	90.10	0.048
-133+99	A	5 Year	667.59	699.21	2.85	234.41	77.14	0.048
-133+99	A	2 Year	432.77	698.31	2.55	169.72	66.18	0.048

Appendix 4 - Gun River Crossings

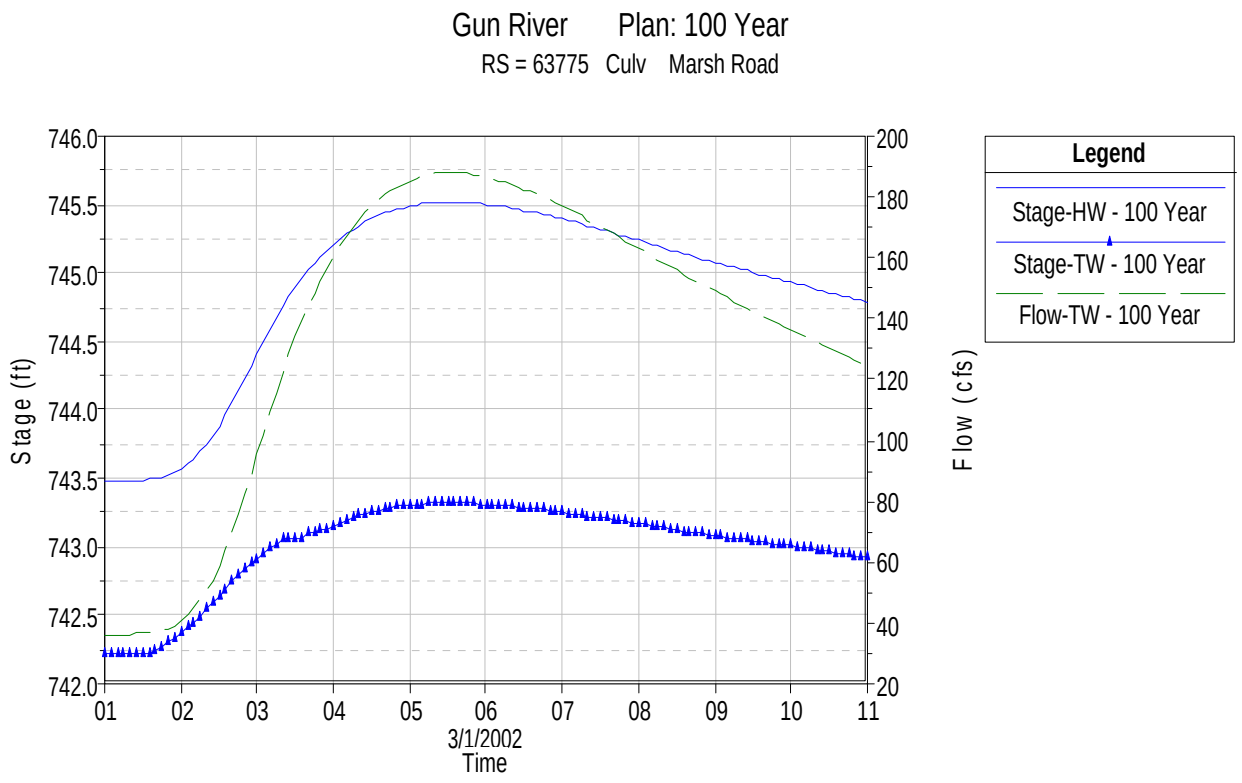
Summary Table

County	Twp	Street	Type	Description	River Station	Authority	Opening Size [ft^2]	Min Deck Elev [ft]	Min Road Elev [ft]	Max Water Surf [ft]	100-yr Flow [cfs]
Barry	Orangeville	Marsh Rd	Culvert	4 - 48" CMP	637+75	BCRC	50	749.0	749.0	745.5	188
Barry	Orangeville	Patterson Rd	Culvert	4 - 48" CMP	624+88	BCRC	50	744.4	744.2	742.7	129
Allegan	Martin	122nd Ave	Culvert	3 - 72" CMP	598+52	ACRC	85	742.8	742.7	742.0	123
Allegan	Martin	Farm Lane	Culvert	3 - 72" CMP	579+60		85	741.6	741.2	741.8	142
Allegan	Martin	120th Ave	Culvert	2 – 15’ x 9’ CMPA	534+72	ACRC	105	742.0	742.0	741.6	728
Allegan	Martin	2nd St (N)	Bridge		485+49	ACRC	152	744.7	742.0	740.6	1028
Allegan	Martin	118th Ave	Culvert	2 - 9'1" x 14'10" CMPA	475+18	ACRC	105	740.7	740.7	740.0	1050
Allegan	Martin	116th Ave	Culvert	2 – 10’ CMP	415+36	ACRC	157	739.5	739.5	739.0	1114
Allegan	Martin	114th Ave	Bridge	Clear Span	363+12	ACRC	233	736.7	735.0	735.9	1257
Allegan	Martin	2nd St (M)	Bridge	Clear Span	333+29	ACRC	273	736.4	736.0	733.3	1284
Allegan	Martin	112th Ave	Bridge	Clear Span	310+00	ACRC	443	735.5	735.3	731.6	1306
Allegan	Gun Plain	2nd St (S)	Bridge	Clear Span	298+00	ACRC	448	735.5	733.8	730.9	1240
Allegan	Gun Plain	110th Ave	Bridge	Clear Span	220+50	ACRC	363	731.1	728.1	727.5	1489
Allegan	Gun Plain	7th St	Bridge	Clear Span	120+58	ACRC	297	724.3	723.9	722.8	1725
Allegan	Gun Plain	9th St	Bridge	Clear Span	73+61	ACRC	384	722.0	720.3	720.5	1794
Allegan	Gun Plain	CSX RR	Bridge	Clear Span	66+13		578	728.3	728.4	719.8	1809
Allegan	Gun Plain	RR	Bridge	Clear Span	46+17		613	721.2	719.9	717.4	1850
Allegan	Gun Plain	10th St	Bridge	Middle Pier	34+29	ACRC	467	719.9	719.9	717.0	1873
Allegan	Gun Plain	107th Ave	Bridge	Clear Span	3+10	ACRC	342	717.0	716.7	715.2	1936
Allegan	Gun Plain	U.S. 131	Bridge	Clear Span	-13+65	MDOT	561	720.0	719.7	714.2	1969
Allegan	Gun Plain	11th St	Bridge	Clear Span	-35+75	ACRC	351	716.2	715.7	709.8	2012
Allegan	Otsego	CSX RR	Bridge	Middle Pier	-12+543		368	704.8	704.6	703.4	2163
Allegan	Otsego	106th Ave	Bridge	Clear Span	-13+314	ACRC	393	704.2	702.0	702.4	2175

Marsh Road

HEC-RAS Crossing Data and Hydrograph – Marsh Rd

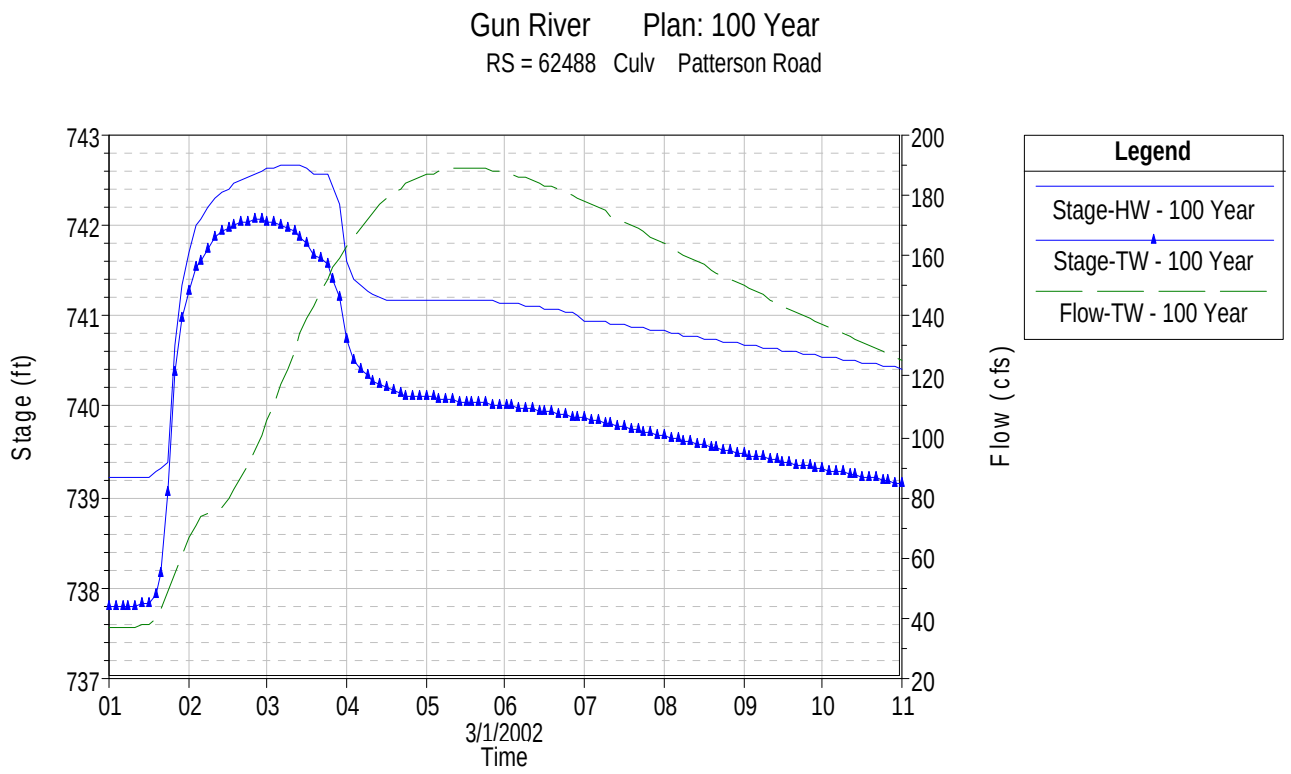
RS: 63+775			
Culv Q (cfs)	187.96	Culv Ful Lngh (ft)	
# Barrels	4	Culv Vel US (ft/s)	4.89
Q Barrel (cfs)	46.99	Culv Vel DS (ft/s)	7.23
E.G. US. (ft)	745.56	Culv Inv El Up (ft)	742.00
W.S. US. (ft)	745.52	Culv Inv El Dn (ft)	742.00
E.G. DS (ft)	743.65	Culv Frctn Ls (ft)	0.36
W.S. DS (ft)	743.32	Culv Ext Lss (ft)	1.21
Delta EG (ft)	1.91	Culv Ent Lss (ft)	0.33
Delta WS (ft)	2.20	Q Weir (cfs)	
E.G. IC (ft)	745.21	Weir Sta Lft (ft)	
E.G. OC (ft)	745.56	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	744.86	Weir Max Depth (ft)	
Culv WS Outlet (ft)	744.05	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Wr Flw Area (sq ft)	
Culv Crt Depth (ft)	2.05	Min El Weir Flow (ft)	749.01


Gun River Plan: 100 Year
RS = 63775 Culv Marsh Road
Stage (ft)
Flow (cfs)
746.0
745.5
745.0
744.5
744.0
743.5
743.0
742.5
742.0
200
180
160
140
120
100
80
60
40
20
01
02
03
04
05
06
07
08
09
10
11
3/1/2002
Time
Legend
Stage-HW - 100 Year
Stage-TW - 100 Year
Flow-TW - 100 Year

Patterson Road	

HEC-RAS Crossing Data and Hydrograph – Patterson Rd

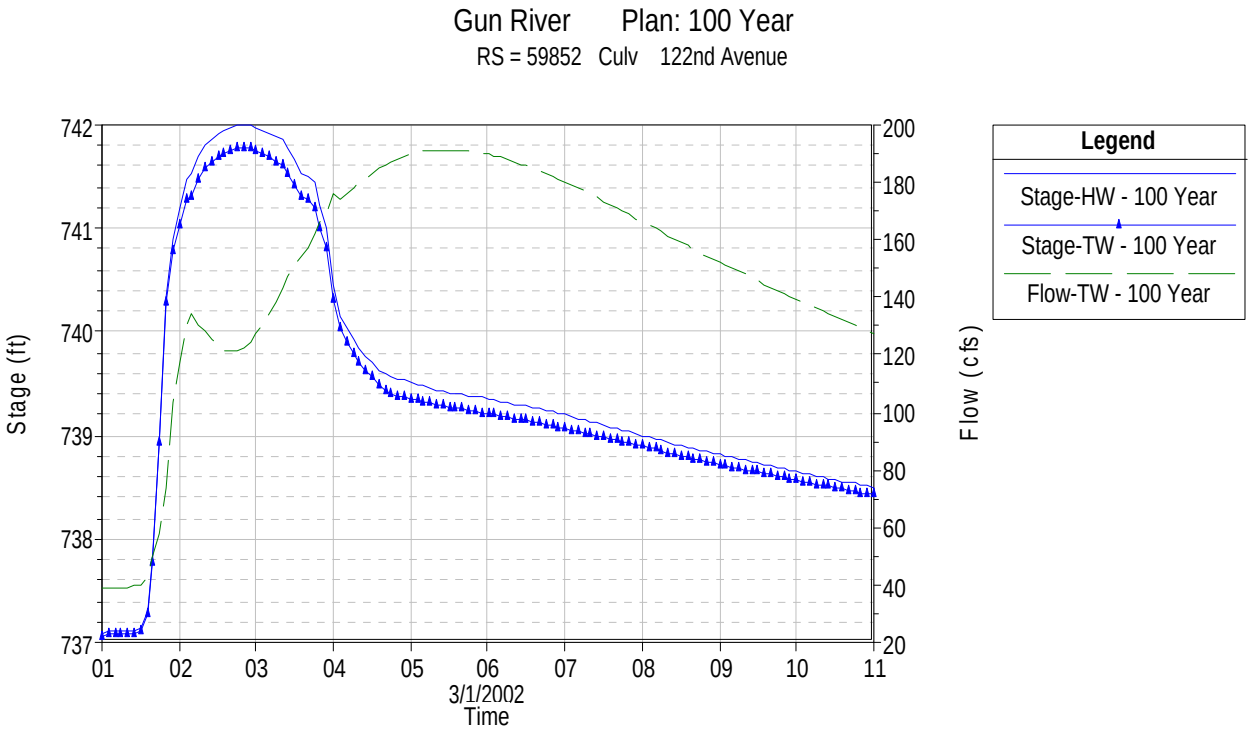
RS: 62488			
Culv Q (cfs)	129.30	Culv Ful Lngh (ft)	50.00
# Barrels	4	Culv Vel US (ft/s)	2.57
Q Barrel (cfs)	32.33	Culv Vel DS (ft/s)	2.57
E.G. US. (ft)	742.30	Culv Inv El Up (ft)	737.90
W.S. US. (ft)	742.68	Culv Inv El Dn (ft)	737.00
E.G. DS (ft)	742.07	Culv Frctn Ls (ft)	0.09
W.S. DS (ft)	742.06	Culv Ext Lss (ft)	0.09
Delta EG (ft)	0.23	Culv Ent Lss (ft)	0.05
Delta WS (ft)	0.62	Q Weir (cfs)	
E.G. IC (ft)	740.39	Weir Sta Lft (ft)	
E.G. OC (ft)	742.30	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	741.90	Weir Max Depth (ft)	
Culv WS Outlet (ft)	741.00	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Wr Flw Area (sq ft)	
Culv Crt Depth (ft)	1.69	Min El Weir Flow (ft)	744.15


Gun River Plan: 100 Year
RS = 62488 Culv Patterson Road
Stage (ft)
Flow (cfs)
743
742
741
740
739
738
737
200
180
160
140
120
100
80
60
40
20
01
02
03
04
05
06
07
08
09
10
11
3/1/2002
Time
Legend
Stage-HW - 100 Year
Stage-TW - 100 Year
Flow-TW - 100 Year

122nd Avenue	

HEC-RAS Crossing Data and Hydrograph - 122nd Avenue

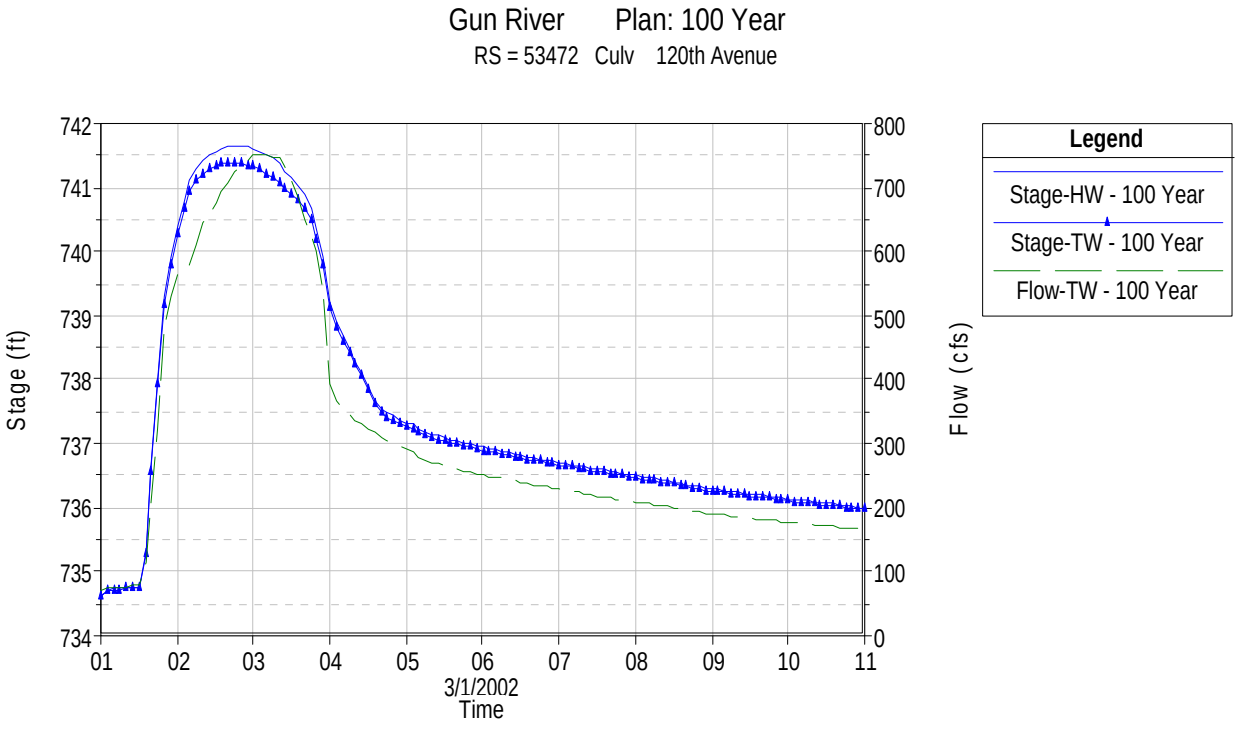
RS: 59852			
Q (cfs)	122.63	Culv Ful Lngh (ft)	50.00
# Barrels	3	Culv Vel US (ft/s)	1.45
Q Barrel (cfs)	40.88	Culv Vel DS (ft/s)	1.45
E.G. US. (ft)	741.86	Culv Inv El Up (ft)	733.00
W.S. US. (ft)	742.00	Culv Inv El Dn (ft)	733.50
E.G. DS (ft)	741.79	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	741.78	Culv Ext Lss (ft)	0.02
Delta EG (ft)	0.07	Culv Ent Lss (ft)	0.03
Delta WS (ft)	0.22	Q Weir (cfs)	
E.G. IC (ft)	735.42	Weir Sta Lft (ft)	
E.G. OC (ft)	741.86	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	739.00	Weir Max Depth (ft)	
Culv WS Outlet (ft)	739.50	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Wr Flw Area (sq ft)	
Culv Crt Depth (ft)	1.69	Min El Weir Flow (ft)	742.71



120th Ave.	

HEC-RAS Crossing Data and Hydrograph - 120th Ave.

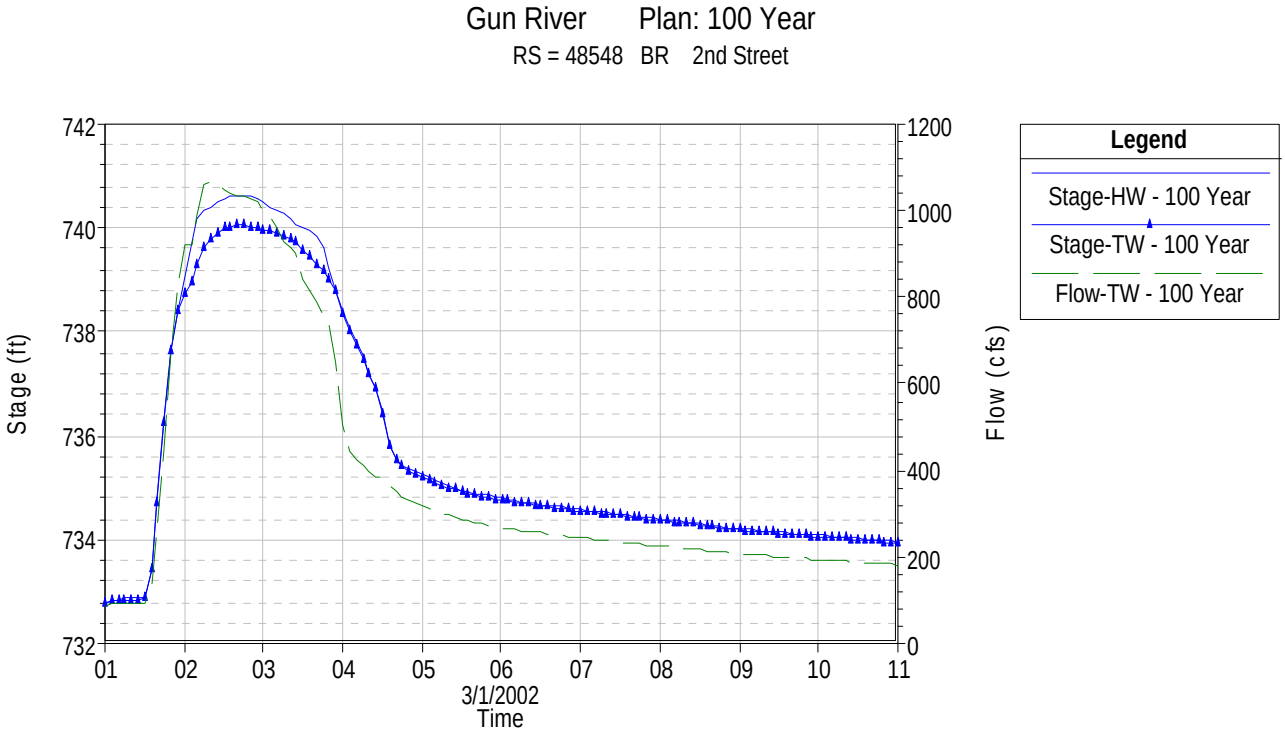
RS: 53472			
Culv Q (cfs)	727.69	Culv Ful Lngh (ft)	20.00
# Barrels	2	Culv Vel US (ft/s)	3.43
Q Barrel (cfs)	363.85	Culv Vel DS (ft/s)	3.43
E.G. US. (ft)	741.70	Culv Inv El Up (ft)	732.00
W.S. US. (ft)	741.64	Culv Inv El Dn (ft)	732.00
E.G. DS (ft)	741.46	Culv Frctn Ls (ft)	0.03
W.S. DS (ft)	741.39	Culv Ext Lss (ft)	0.12
Delta EG (ft)	0.24	Culv Ent Lss (ft)	0.09
Delta WS (ft)	0.25	Q Weir (cfs)	
E.G. IC (ft)	736.09	Weir Sta Lft (ft)	
E.G. OC (ft)	741.70	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	741.00	Weir Max Depth (ft)	
Culv WS Outlet (ft)	741.00	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Wr Flw Area (sq ft)	
Culv Crt Depth (ft)	2.63	Min El Weir Flow (ft)	742.01



2nd Street (North crossing)	

HEC-RAS Crossing Data and Hydrograph - 2nd Street (North crossing)

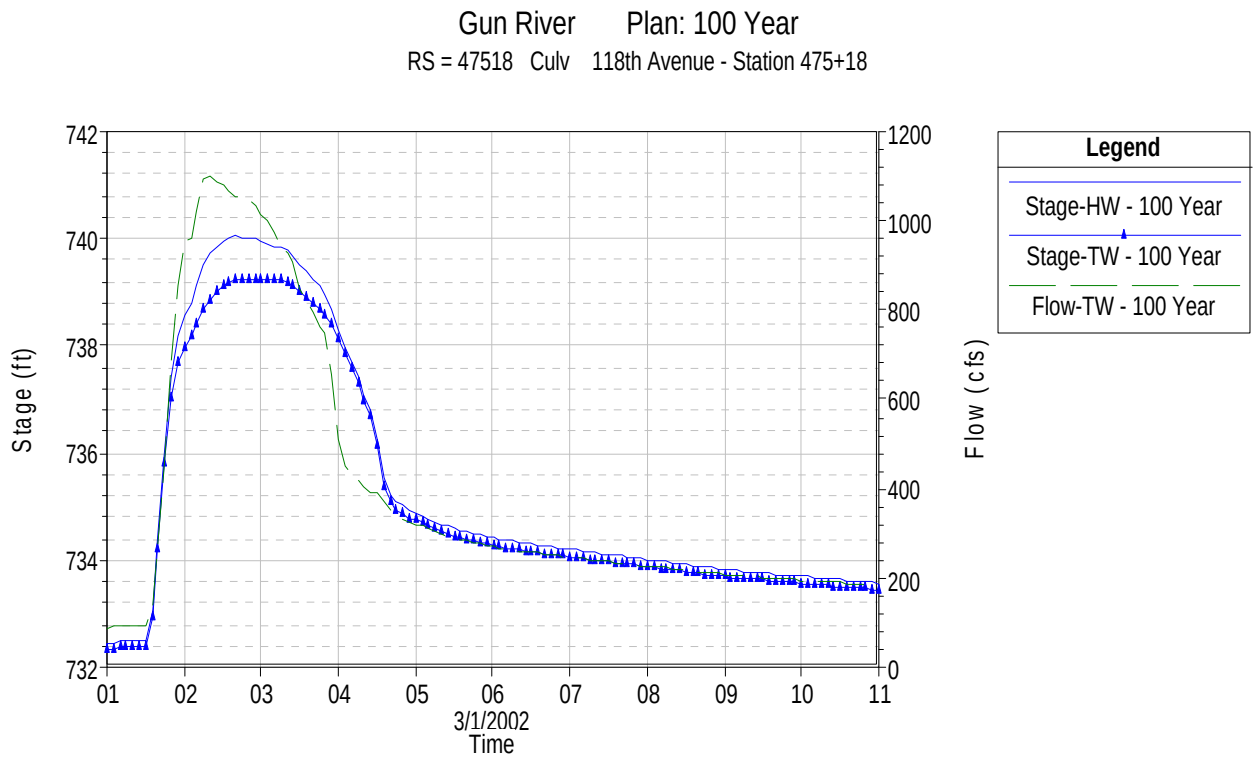
RS: 48548				
E.G. US. (ft)	741.22	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	740.64	E.G. Elev (ft)	741.18	740.71
Q Total (cfs)	1028.35	W.S. Elev (ft)	739.70	739.70
Q Bridge (cfs)	1028.35	Crit W.S. (ft)	735.21	735.05
Q Weir (cfs)		Max Chl Dpth (ft)	9.70	9.90
Weir Sta Lft (ft)		Vel Total (ft/s)	6.74	6.65
Weir Sta Rgt (ft)		Flow Area (sq ft)	152.47	154.73
Weir Submerg		Froude # Chl	0.04	0.04
Weir Max Depth (ft)		Specif Force (cu ft)	942.07	960.80
Min El Weir Flow (ft)	742.01	Hydr Depth (ft)	152552.90	154817.00
Min El Prs (ft)	739.70	W.P. Total (ft)	50.46	50.62
Delta EG (ft)	0.47	Conv. Total (cfs)	18940.4	19370.9
Delta WS (ft)	0.51	Top Width (ft)		
BR Open Area (sq ft)	152.47	Frctn Loss (ft)		
BR Open Vel (ft/s)	6.74	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.56	0.54
Br Sel Method	Press Only	Power Total (lb/ft s)	3.75	3.57



118th Avenue	

HEC-RAS Crossing Data and Hydrograph - 118th Avenue

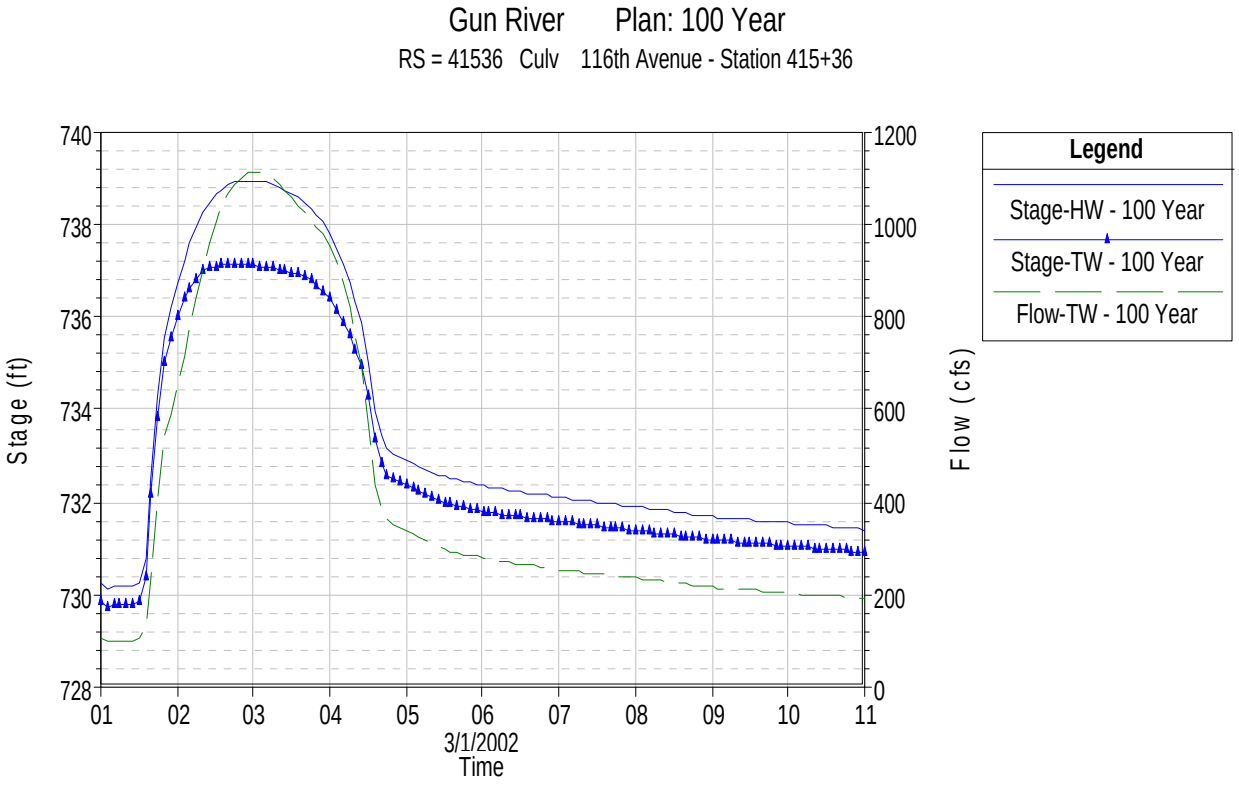
RS: 47518			
Culv Q (cfs)	1050.06	Culv Ful Lngh (ft)	100.00
# Barrels	2	Culv Vel US (ft/s)	5.17
Q Barrel (cfs)	525.03	Culv Vel DS (ft/s)	5.17
E.G. US. (ft)	740.21	Culv Inv El Up (ft)	730.40
W.S. US. (ft)	740.05	Culv Inv El Dn (ft)	730.00
E.G. DS (ft)	739.51	Culv Frctn Ls (ft)	0.32
W.S. DS (ft)	739.27	Culv Ext Lss (ft)	0.18
Delta EG (ft)	0.71	Culv Ent Lss (ft)	0.21
Delta WS (ft)	0.78	Q Weir (cfs)	
E.G. IC (ft)	736.50	Weir Sta Lft (ft)	
E.G. OC (ft)	740.21	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	739.40	Weir Max Depth (ft)	
Culv WS Outlet (ft)	739.00	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Wr Flw Area (sq ft)	
Culv Crt Depth (ft)	3.90	Min El Weir Flow (ft)	740.71



116th Avenue	

HEC-RAS Crossing Data and Hydrograph - 116th Avenue

RS: 41536			
Culv Q (cfs)	1113.87	Culv Ful Lngh (ft)	90.00
# Barrels	2	Culv Vel US (ft/s)	7.09
Q Barrel (cfs)	556.94	Culv Vel DS (ft/s)	7.09
E.G. US. (ft)	739.20	Culv Inv El Up (ft)	727.20
W.S. US. (ft)	738.97	Culv Inv El Dn (ft)	727.00
E.G. DS (ft)	737.44	Culv Frctn Ls (ft)	0.58
W.S. DS (ft)	737.14	Culv Ext Lss (ft)	0.48
Delta EG (ft)	1.77	Culv Ent Lss (ft)	0.70
Delta WS (ft)	1.83	Q Weir (cfs)	
E.G. IC (ft)	736.28	Weir Sta Lft (ft)	
E.G. OC (ft)	739.20	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	737.20	Weir Max Depth (ft)	
Culv WS Outlet (ft)	737.00	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Wr Flw Area (sq ft)	
Culv Crt Depth (ft)	5.65	Min El Weir Flow (ft)	739.51



114th Avenue	

Handheld GPS Location: N 42-31-24 W 85-33-47

Benchmark: Paint spot on SW corner of West end, North headwall of bridge
Elevation: 735.87

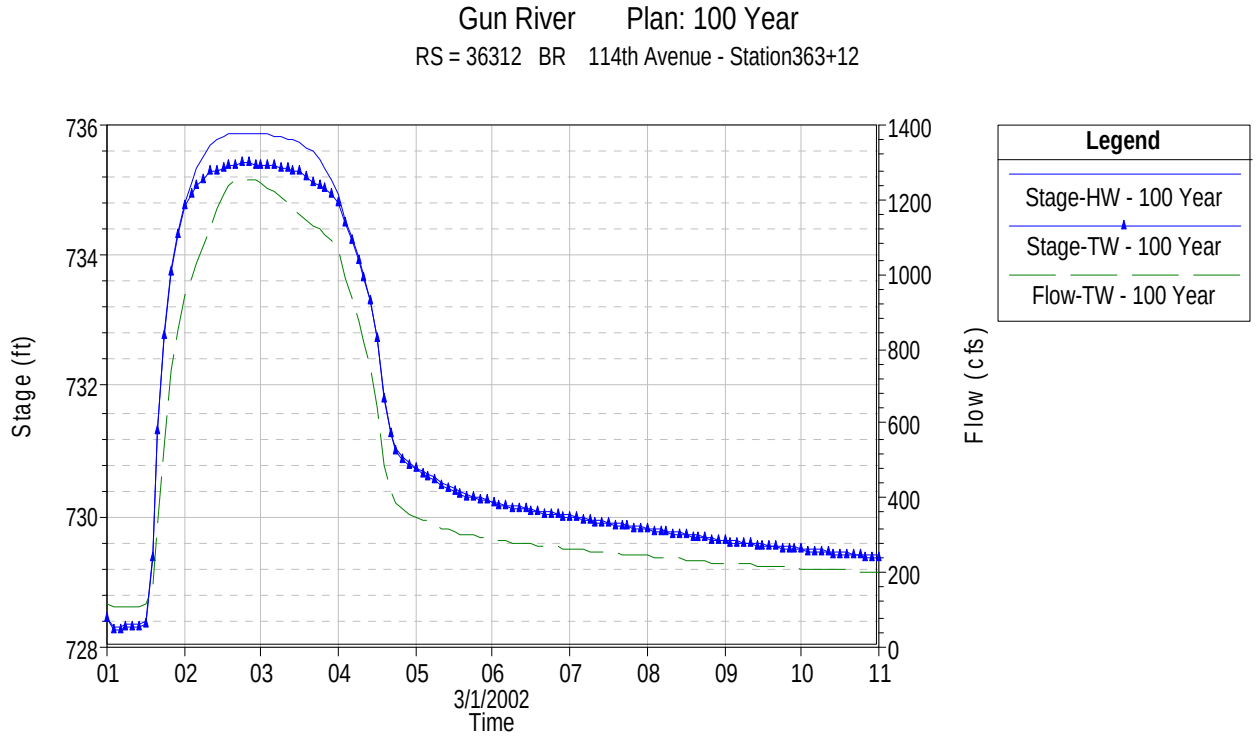
Control Points:

1018: PK nail in East edge of bit of 2nd Street, 70 feet South of South end of bridge, 15 feet North of centerline of gravel drive
N 42-30-55 W 85-33-46
N: 372,324.9727 E: 12,800,904.5531 Z: 735.57

1019: PK nail in SW quadrant of 2nd Street and 114th Avenue, 25 feet South of centerline of 114th Avenue, 20 feet West of centerline of 2nd Street
N 42-31-24 W 85-33-46
N: 375,233.8894 E: 12,800,933.5899 Z: 737.27

HEC-RAS Crossing Data and Hydrograph - 114th Avenue

RS: 36312				
E.G. US. (ft)	736.26	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	735.88	E.G. Elev (ft)	736.10	735.83
Q Total (cfs)	1256.97	W.S. Elev (ft)	735.25	735.25
Q Bridge (cfs)	1256.97	Crit W.S. (ft)	729.72	729.72
Q Weir (cfs)		Max Chl Dpth (ft)	11.28	11.28
Weir Sta Lft (ft)		Vel Total (ft/s)	5.39	5.39
Weir Sta Rgt (ft)		Flow Area (sq ft)	233.32	233.32
Weir Submerg		Froude # Chl	0.04	0.04
Weir Max Depth (ft)		Specif Force (cu ft)	1392.89	1392.89
Min El Weir Flow (ft)	737.26	Hydr Depth (ft)	116613.50	116613.50
Min El Prs (ft)	735.25	W.P. Total (ft)	48.31	48.31
Delta EG (ft)	0.28	Conv. Total (cfs)	39624.8	39624.8
Delta WS (ft)	0.30	Top Width (ft)		
BR Open Area (sq ft)	233.32	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.39	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.30	0.30
Br Sel Method	Press Only	Power Total (lb/ft s)	1.63	1.63



2nd Street (Middle)	

Handheld GPS Location: N 42-30-57 W 85-33-46

Benchmark: Paint spot on SW abutment of bridge
Elevation: 732.71

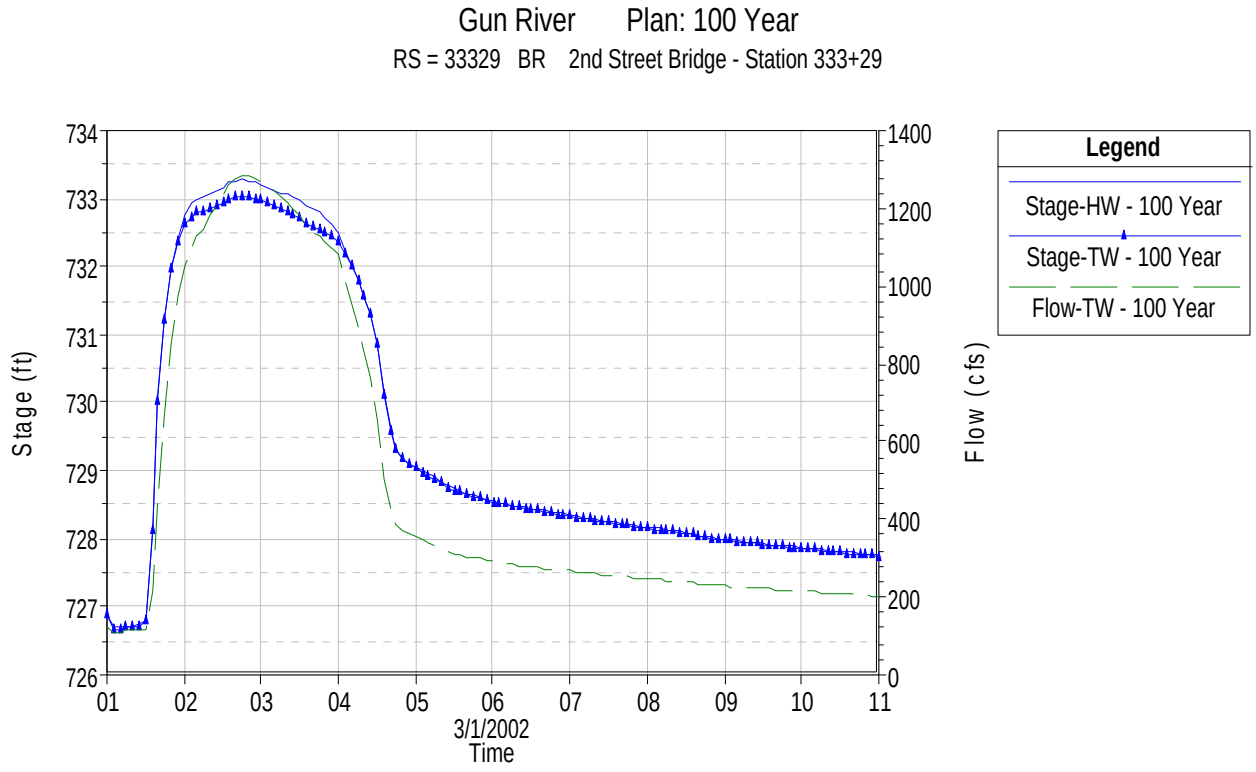
Control Points:

1018: PK nail in East edge of bit of 2nd Street, 70 feet South of South end of bridge, 15 feet North of centerline of gravel drive
N 42-30-55 W 85-33-46
N: 372,324.9727 E: 12,800,904.5531 Z: 735.57

1017: 8 inch nail, SW quadrant 2nd Street and 112th Street
N 42-30-37 W 85-33-47
N: 370,496.1839 E: 12,800,837.8524 Z: 736.67

HEC-RAS Crossing Data and Hydrograph - 2nd Street (Middle)

RS: 33329				
E.G. US. (ft)	733.57	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	733.28	E.G. Elev (ft)	733.55	733.33
Q Total (cfs)	1284.40	W.S. Elev (ft)	732.62	732.62
Q Bridge (cfs)	1284.40	Crit W.S. (ft)	728.23	728.12
Q Weir (cfs)		Max Chl Dpth (ft)	9.23	9.23
Weir Sta Lft (ft)		Vel Total (ft/s)	4.70	4.65
Weir Sta Rgt (ft)		Flow Area (sq ft)	273.14	276.15
Weir Submerg		Froude # Chl	0.30	0.30
Weir Max Depth (ft)		Specif Force (cu ft)	1276.88	1301.71
Min El Weir Flow (ft)	736.21	Hydr Depth (ft)	7.55	7.63
Min El Prs (ft)	732.62	W.P. Total (ft)	48.38	48.43
Delta EG (ft)	0.23	Conv. Total (cfs)	51474.4	52389.0
Delta WS (ft)	0.24	Top Width (ft)	36.19	36.19
BR Open Area (sq ft)	273.14	Frctn Loss (ft)		
BR Open Vel (ft/s)	4.70	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.22	0.21
Br Sel Method	Press Only	Power Total (lb/ft s)	1.03	1.00



112th Avenue	

Handheld GPS Location: N 42-30-34 W 85-33-37

Benchmark: No benchmark set

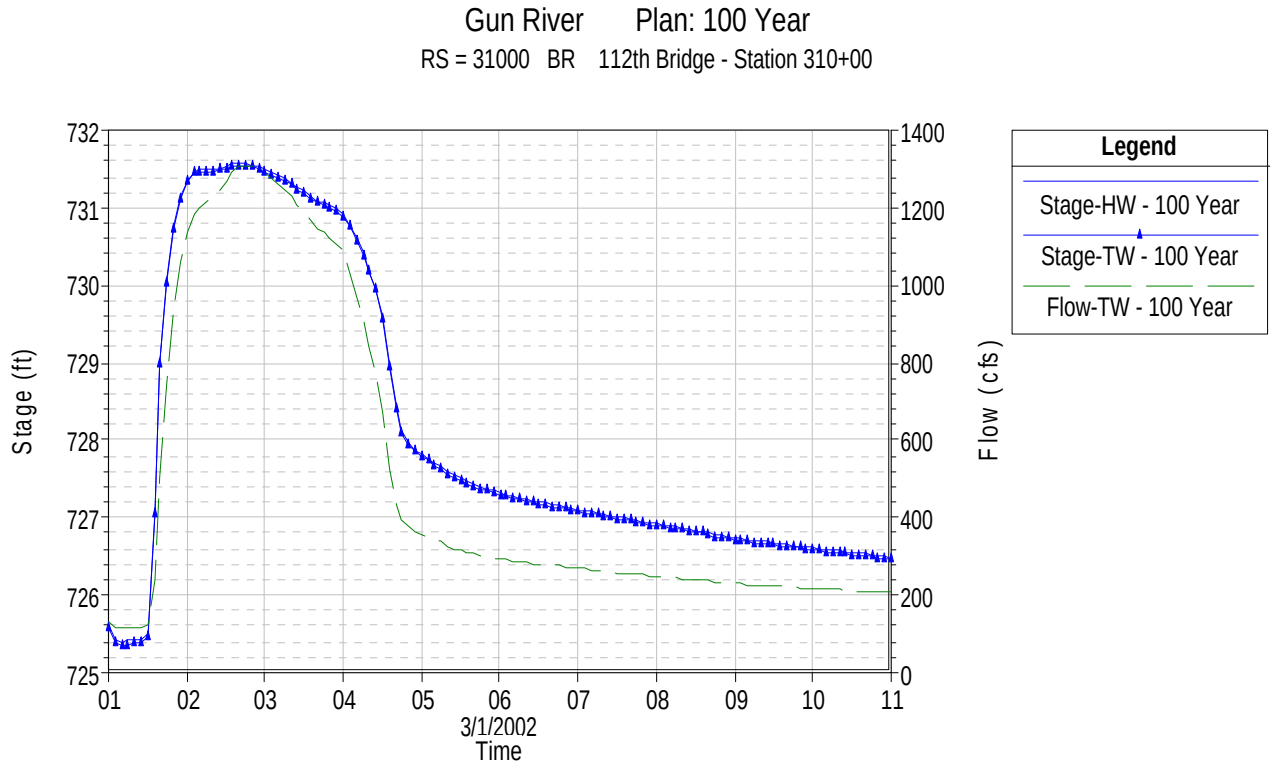
Control Points:

1016: PK nail, South side of 112th on West end of bridge
N 42-30-34 W 85-33-37
N 370,181.8950 E: 12,801,567.7353 Z: 735.41

1017: 8 inch nail, SW quadrant 2nd Street and 112th Street
N 42-30-37 W 85-33-47
N: 370,496.1839 E: 12,800,837.8524 Z: 736.67

HEC-RAS Crossing Data and Hydrograph - 112th Avenue

RS: 31000				
E.G. US. (ft)	731.78	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	731.57	E.G. Elev (ft)	731.77	731.76
Q Total (cfs)	1305.87	W.S. Elev (ft)	731.55	731.55
Q Bridge (cfs)	1305.87	Crit W.S. (ft)	727.03	727.03
Q Weir (cfs)		Max Chl Dpth (ft)	8.29	8.29
Weir Sta Lft (ft)		Vel Total (ft/s)	3.72	3.72
Weir Sta Rgt (ft)		Flow Area (sq ft)	350.98	350.74
Weir Submerg		Froude # Chl	0.02	0.02
Weir Max Depth (ft)		Specif Force (cu ft)	1466.86	1465.19
Min El Weir Flow (ft)	735.31	Hydr Depth (ft)	7.31	7.31
Min El Prs (ft)	733.47	W.P. Total (ft)	58.31	58.30
Delta EG (ft)	0.01	Conv. Total (cfs)	69026.6	68954.9
Delta WS (ft)	0.02	Top Width (ft)	48.00	48.00
BR Open Area (sq ft)	442.95	Frctn Loss (ft)	0.01	0.00
BR Open Vel (ft/s)	3.72	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.13	0.13
Br Sel Method	Energy only	Power Total (lb/ft s)	0.50	0.50



2nd Street (South)	

Handheld GPS Location: N 42-30-25 W 85-33-46

Benchmark: Paint spot on SE corner of top step to SE abutment of bridge
N: 369,270.1553 E: 12,800,864.4770 Z: 735.20
Elevation: 735.20

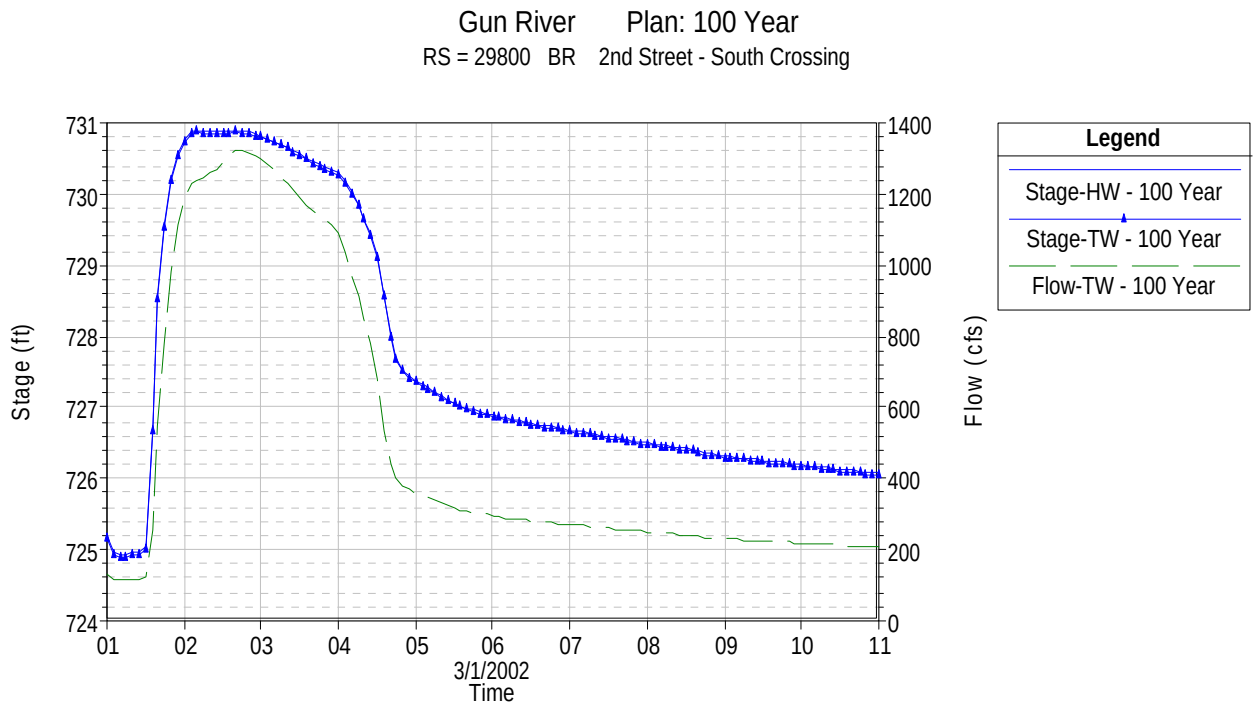
Control Points:

1015: Nail, East of 2nd Street, 2.5 feet South of South end of guardrail
N 42-30-25 W 85-33-46
N: 369,205.9782 E: 12,800,863.2582 Z: 734.69

1017: 8-inch nail in SW quadrant of 2nd Street and 112th Street, 0.5 feet SW of bit, opposite sign “Michigan Career and Tech Institute”
N 42-30-37 W 85-33-47
N: 370,496.1839 E: 12,800,837.8524 Z: 736.67

HEC-RAS Crossing Data and Hydrograph - 2nd Street (South)

RS: 29800				
E.G. US. (ft)	731.09	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	730.90	E.G. Elev (ft)	731.07	731.07
Q Total (cfs)	1240.07	W.S. Elev (ft)	730.87	730.87
Q Bridge (cfs)	1240.07	Crit W.S. (ft)	726.36	726.36
Q Weir (cfs)		Max Chl Dpth (ft)	8.43	8.43
Weir Sta Lft (ft)		Vel Total (ft/s)	3.49	3.49
Weir Sta Rgt (ft)		Flow Area (sq ft)	355.54	355.47
Weir Submerg		Froude # Chl	0.02	0.02
Weir Max Depth (ft)		Specif Force (cu ft)	1423.76	1423.27
Min El Weir Flow (ft)	733.60	Hydr Depth (ft)	6.84	6.84
Min El Prs (ft)	732.65	W.P. Total (ft)	59.76	59.76
Delta EG (ft)	0.01	Conv. Total (cfs)	74856.4	74830.7
Delta WS (ft)	0.01	Top Width (ft)	52.00	52.00
BR Open Area (sq ft)	447.91	Frctn Loss (ft)	0.01	0.00
BR Open Vel (ft/s)	3.49	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.10	0.10
Br Sel Method	Energy only	Power Total (lb/ft s)	0.36	0.36



110th Avenue	

Handheld GPS Location: N42-29-38 W 85-35-04

Benchmark: Paint spot on top of NE corner of abutment, NW corner of bridge
Elevation: 730.95

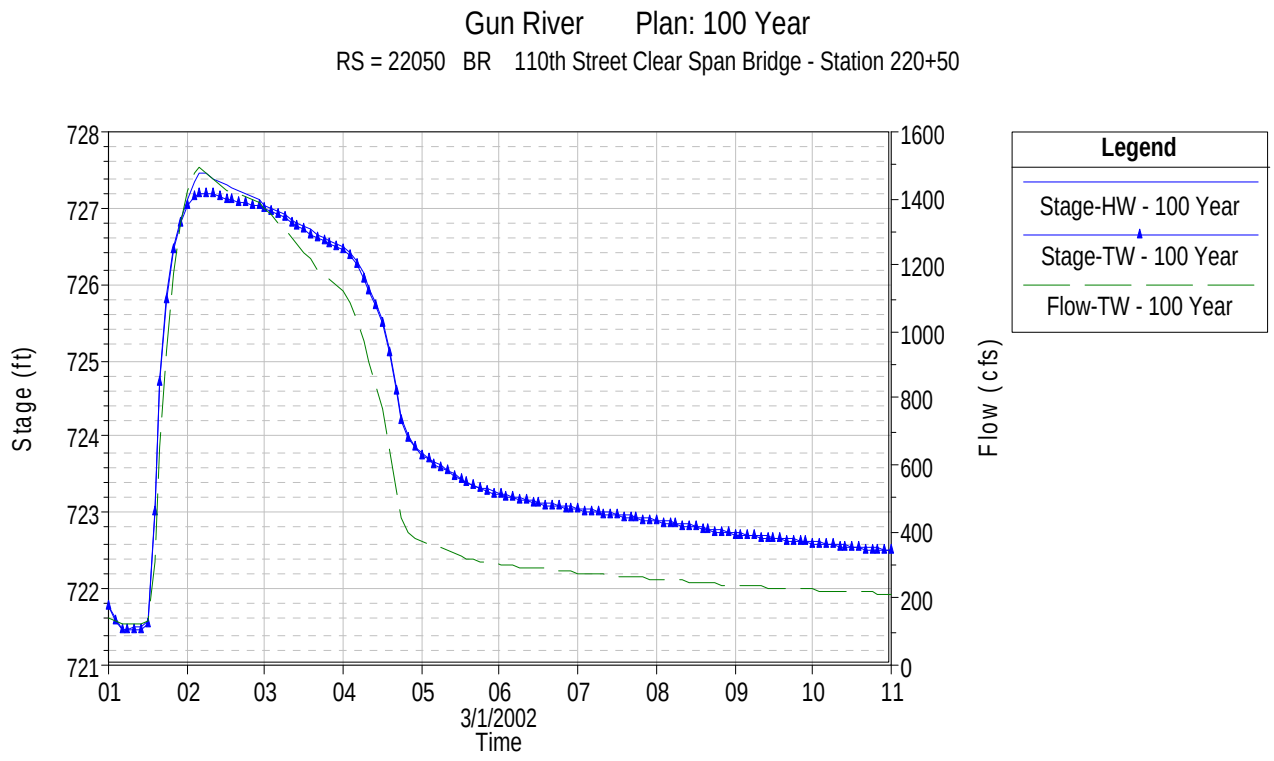
Control Points:

1012: Nail in South side of 110th Street, 4.5 feet West of West end of guardrail
N 42-29-38 W 85-35-04
N: 364,581.0113 E: 12,794,957.5410 Z: 731.13

1013: Nail in North edge of gravel of 110th Street, 10.5 feet East of East end of guardrail
N 42-29-38 W 85-35-02
N: 364,609.3419 E: 12,795,062.5620 Z: 730.85

HEC-RAS Crossing Data and Hydrograph - 110th Avenue

RS: 22050				
E.G. US. (ft)	727.72	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	727.46	E.G. Elev (ft)	728.01	727.50
Q Total (cfs)	1488.57	W.S. Elev (ft)	727.50	727.20
Q Bridge (cfs)	1488.57	Crit W.S. (ft)	723.30	723.30
Q Weir (cfs)		Max Chl Dpth (ft)	9.21	8.91
Weir Sta Lft (ft)		Vel Total (ft/s)	4.11	4.39
Weir Sta Rgt (ft)		Flow Area (sq ft)	362.58	339.32
Weir Submerg		Froude # Chl	0.33	0.37
Weir Max Depth (ft)		Specif Force (cu ft)	1433.58	1340.40
Min El Weir Flow (ft)	730.95	Hydr Depth (ft)	4.68	4.45
Min El Prs (ft)	727.50	W.P. Total (ft)	85.96	84.88
Delta EG (ft)	0.52	Conv. Total (cfs)	56259.2	50802.8
Delta WS (ft)	0.58	Top Width (ft)	79.23	76.32
BR Open Area (sq ft)	362.58	Frctn Loss (ft)		
BR Open Vel (ft/s)	4.11	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.18	0.21
Br Sel Method	Press Only	Power Total (lb/ft s)	0.76	0.94



7th Street	

Handheld GPS Location: N 42-29-38 W 85-35-04

Benchmark: Paint spot on top SE corner step on SE abutment of 7th Street bridge
Elevation: 723.91

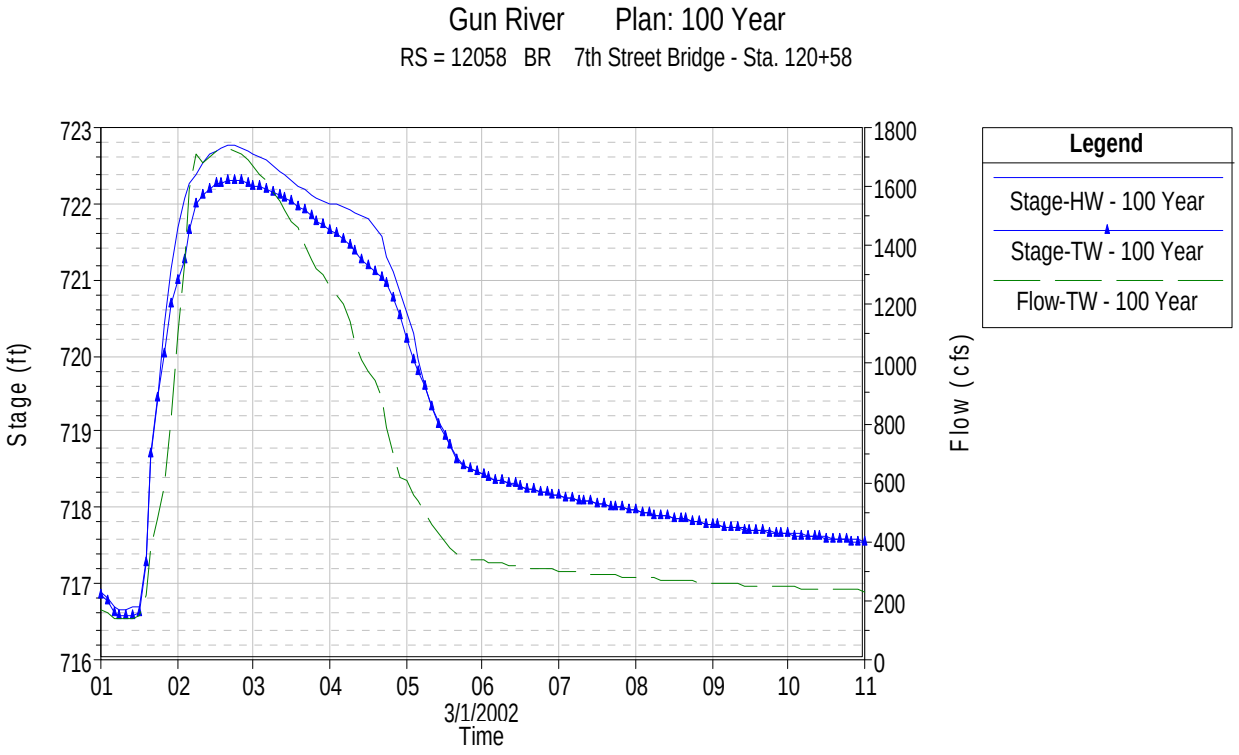
Control Points:

G-4: PK nail, 2 feet West of East edge of bit, on 7th Street bridge over Gun River
N 42-28-40 W 85-36-44
N: 358,812.5767 E: 12,787,339.7254 Z: 724.18

1011: Nail in East edge of gravel, East side of 7th Street, 243 feet North of centerline of bridge, 30 feet North of South drive to House #786
N 42-28-42 W 85-36-44
N: 359,055.4629 E: 12,787,348.3526 Z: 724.31

HEC-RAS Crossing Data and Hydrograph - 7th Street

RS: 12058				
E.G. US. (ft)	723.14	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	722.76	E.G. Elev (ft)	723.12	722.71
Q Total (cfs)	1725.22	W.S. Elev (ft)	721.79	721.79
Q Bridge (cfs)	1725.22	Crit W.S. (ft)	719.07	718.91
Q Weir (cfs)		Max Chl Dpth (ft)	7.15	6.53
Weir Sta Lft (ft)		Vel Total (ft/s)	5.80	5.55
Weir Sta Rgt (ft)		Flow Area (sq ft)	297.28	310.62
Weir Submerg		Froude # Chl	0.04	0.04
Weir Max Depth (ft)		Specif Force (cu ft)	1247.40	1273.41
Min El Weir Flow (ft)	724.35	Hydr Depth (ft)	297444.20	310788.60
Min El Prs (ft)	721.79	W.P. Total (ft)	108.45	110.03
Delta EG (ft)	0.41	Conv. Total (cfs)	34608.3	36877.1
Delta WS (ft)	0.43	Top Width (ft)		
BR Open Area (sq ft)	297.28	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.80	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.43	0.39
Br Sel Method	Press Only	Power Total (lb/ft s)	2.47	2.14



9th Street	

Handheld GPS Location: N 42-28-28 W 85-37-40

Benchmark: Paint spot on top SE corner step to abutment, SE corner of bridge
Elevation: 721.84

Control Points:

G-5: PK nail in centerline of Northbound 9th Street, at South edge of bridge over Gun River

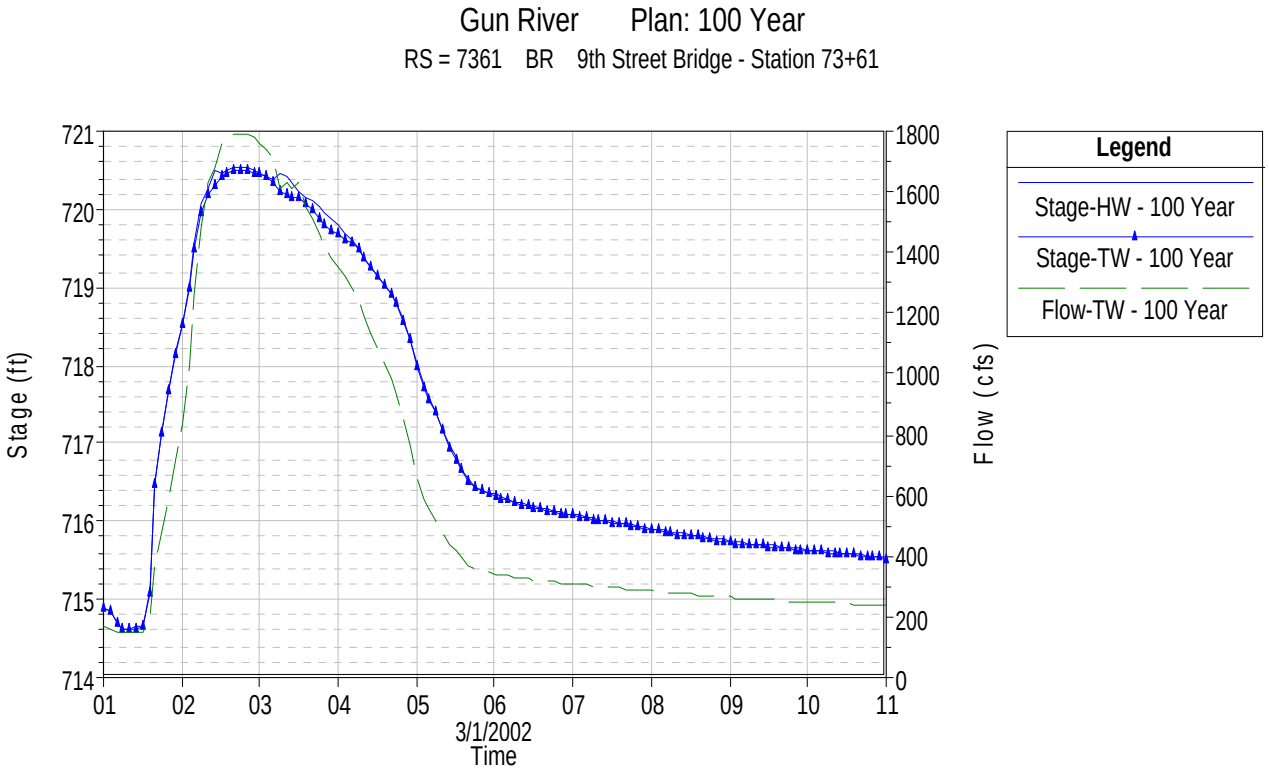
N 42-28-28 W 85-37-40
N: 357,623.6627 E: 12,783,164.9069 Z: 721.94

1009: Nail, 4 feet East of East edge of bit of 9th Street, 420 feet North of bridge, opposite gravel drive on South edge of cultivated field

N 42-28-32 W 85-37-39
N: 358,072.0499 E: 12,783,235.9763 Z: 722.73

HEC-RAS Crossing Data and Hydrograph - 9th Street

RS: 7361				
E.G. US. (ft)	720.78	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	720.53	E.G. Elev (ft)	720.81	720.77
Q Total (cfs)	1794.61	W.S. Elev (ft)	720.49	720.45
Q Bridge (cfs)	1767.08	Crit W.S. (ft)	715.53	715.46
Q Weir (cfs)		Max Chl Dpth (ft)	9.13	8.73
Weir Sta Lft (ft)		Vel Total (ft/s)	3.26	3.45
Weir Sta Rgt (ft)		Flow Area (sq ft)	550.12	520.12
Weir Submerg		Froude # Chl	0.02	0.02
Weir Max Depth (ft)		Specif Force (cu ft)	2060.20	2050.84
Min El Weir Flow (ft)	720.31	Hydr Depth (ft)	0.60	0.58
Min El Prs (ft)	719.58	W.P. Total (ft)	1024.51	1015.68
Delta EG (ft)	0.08	Conv. Total (cfs)	51809.6	51757.2
Delta WS (ft)	0.18	Top Width (ft)	909.60	898.76
BR Open Area (sq ft)	383.99	Frctn Loss (ft)	0.04	0.00
BR Open Vel (ft/s)	4.60	C & E Loss (ft)	0.00	0.02
Coef of Q		Shear Total (lb/sq ft)	0.04	0.04
Br Sel Method	Energy only	Power Total (lb/ft s)	0.13	0.13



CSX Railroad	

Handheld GPS Location: N 42-28-42 W 85-36-44

Benchmark: Paint spot on SW abutment of bridge
Elevation: 727.55

Control Points:

1010: Nail, 5.5 feet East of East edge of wood timber railroad crossing for farm drive, South side of drive, 400 feet North of railroad bridge

N 42-28-32 W 85-37-49

N: 358,047.1218 E: 12,782,502.5609 Z: 728.97

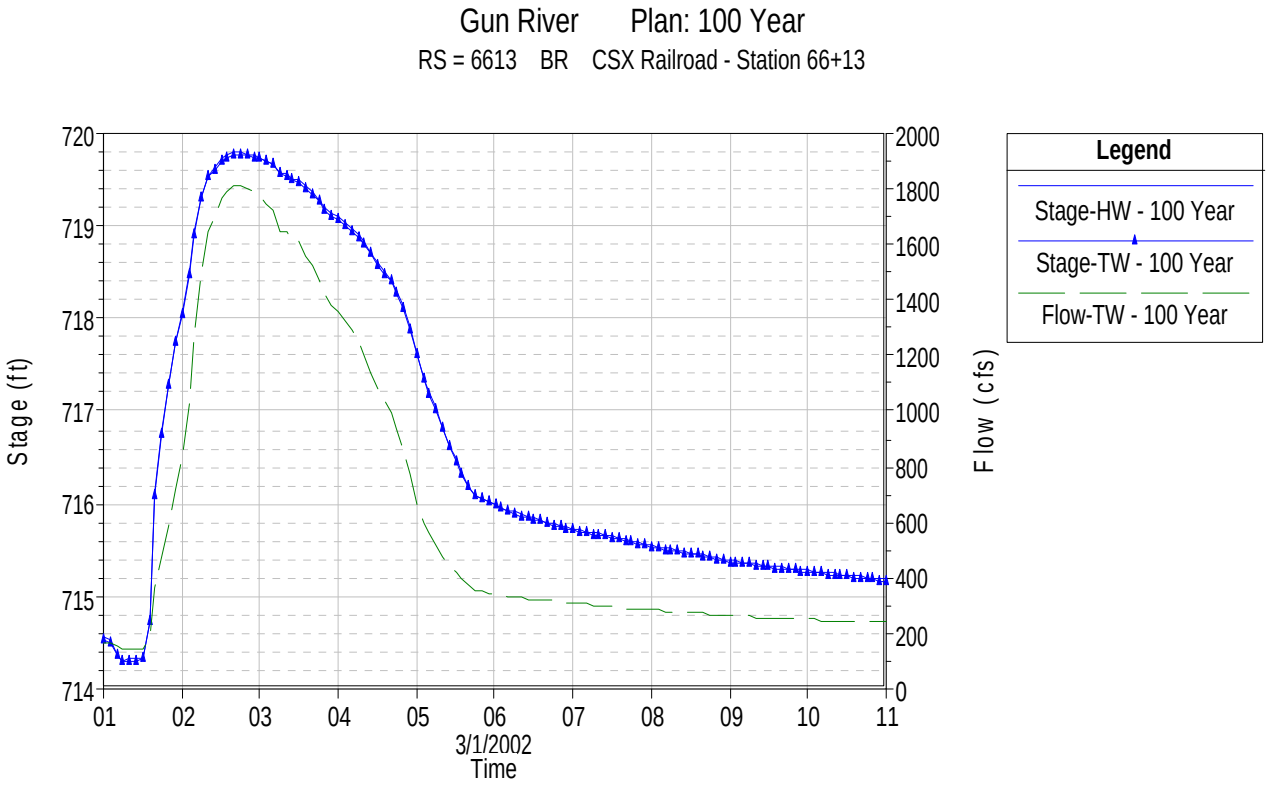
1009: Nail, 4 feet East of East edge of bit of 9th Street, 420 feet North of 9th Street bridge over Gun River, opposite gravel drive, South side of cultivated field

N 42-28-32 W 85-37-39

N: 358,072.0499 E: 12,783,235.9763 Z: 722.73

HEC-RAS Crossing Data and Hydrograph - CSX Railroad

RS: 6613				
E.G. US. (ft)	720.05	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	719.79	E.G. Elev (ft)	720.03	720.03
Q Total (cfs)	1809.24	W.S. Elev (ft)	719.77	719.76
Q Bridge (cfs)	1809.24	Crit W.S. (ft)	715.32	715.32
Q Weir (cfs)		Max Chl Dpth (ft)	9.66	9.65
Weir Sta Lft (ft)		Vel Total (ft/s)	4.10	4.10
Weir Sta Rgt (ft)		Flow Area (sq ft)	441.75	441.70
Weir Submerg		Froude # Chl	0.31	0.31
Weir Max Depth (ft)		Specif Force (cu ft)	1841.26	1841.00
Min El Weir Flow (ft)	728.36	Hydr Depth (ft)	5.32	5.31
Min El Prs (ft)	721.40	W.P. Total (ft)	87.36	87.36
Delta EG (ft)	0.00	Conv. Total (cfs)	77354.0	77339.6
Delta WS (ft)	0.00	Top Width (ft)	83.11	83.10
BR Open Area (sq ft)	578.94	Frctn Loss (ft)	0.01	0.00
BR Open Vel (ft/s)	4.10	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.17	0.17
Br Sel Method	Energy only	Power Total (lb/ft s)	0.71	0.71



Abandoned RR	

Handheld GPS Location: N 42-28-30 W 85-38-15

Benchmark: Paint spot on SW abutment of bridge
Elevation: 721.87

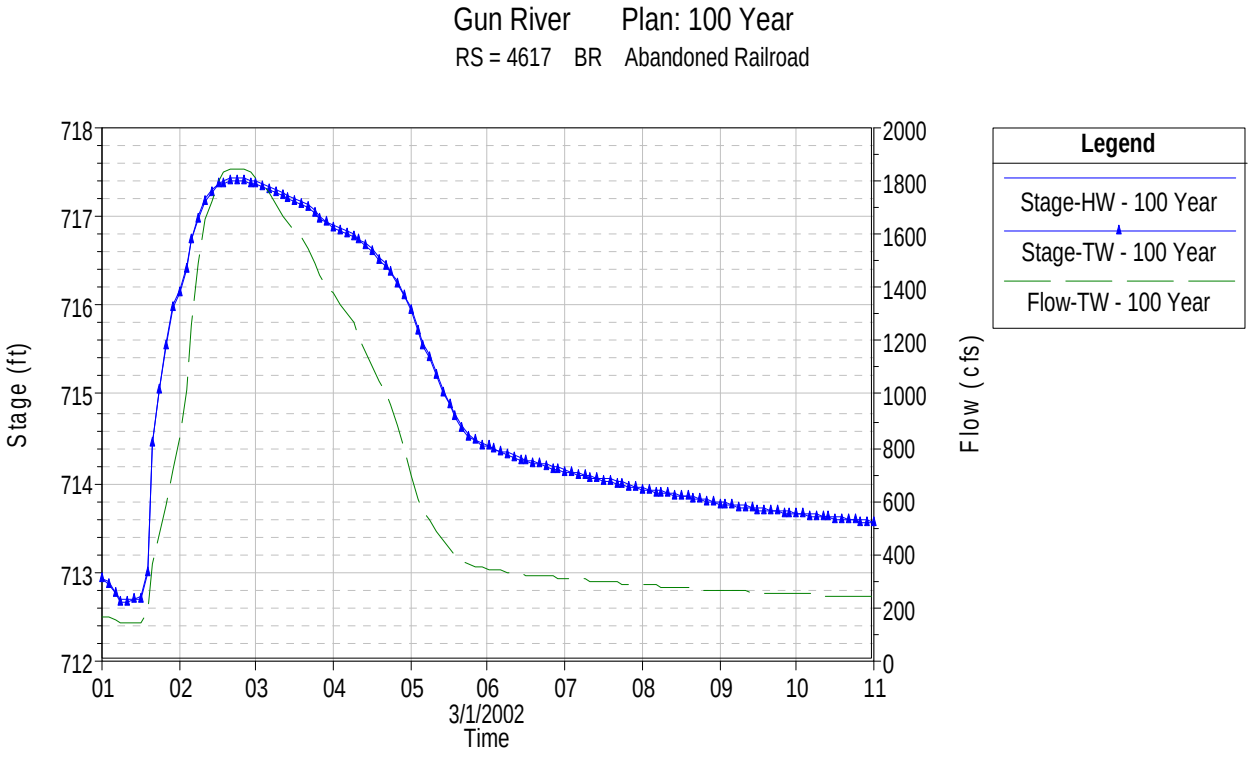
Control Points:

1021: Nail in East edge of gravel trail, 16 feet North of North end of railroad bridge
N 42-28-31 W 85-38-15
N: 357,963.0639 E: 12,780,543.5221 Z: 719.71

1022: Nail in East edge of gravel trail, 8 feet South of South end of railroad bridge
N 42-28-29 W 85-38-15
N: 357,847.7508 E: 12,780,543.5108 Z: 720.86

HEC-RAS Crossing Data and Hydrograph - Abandoned RR

RS: 4617				
E.G. US. (ft)	717.77	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	717.43	E.G. Elev (ft)	717.78	717.76
Q Total (cfs)	1849.50	W.S. Elev (ft)	717.39	717.37
Q Bridge (cfs)	1849.50	Crit W.S. (ft)	714.85	714.84
Q Weir (cfs)		Max Chl Dpth (ft)	7.83	7.81
Weir Sta Lft (ft)		Vel Total (ft/s)	4.55	4.57
Weir Sta Rgt (ft)		Flow Area (sq ft)	406.39	404.86
Weir Submerg		Froude # Chl	0.03	0.03
Weir Max Depth (ft)		Specif Force (cu ft)	1456.52	1449.87
Min El Weir Flow (ft)	721.21	Hydr Depth (ft)	4.96	4.94
Min El Prs (ft)	719.91	W.P. Total (ft)	97.85	98.04
Delta EG (ft)	0.04	Conv. Total (cfs)	61047.3	60646.7
Delta WS (ft)	0.05	Top Width (ft)	82.00	82.00
BR Open Area (sq ft)	613.37	Frctn Loss (ft)	0.02	0.00
BR Open Vel (ft/s)	4.57	C & E Loss (ft)	0.00	0.02
Coef of Q		Shear Total (lb/sq ft)	0.24	0.24
Br Sel Method	Energy only	Power Total (lb/ft s)	1.08	1.10



10th Street	

Handheld GPS Location: N 42-28-29 W 85-38-31

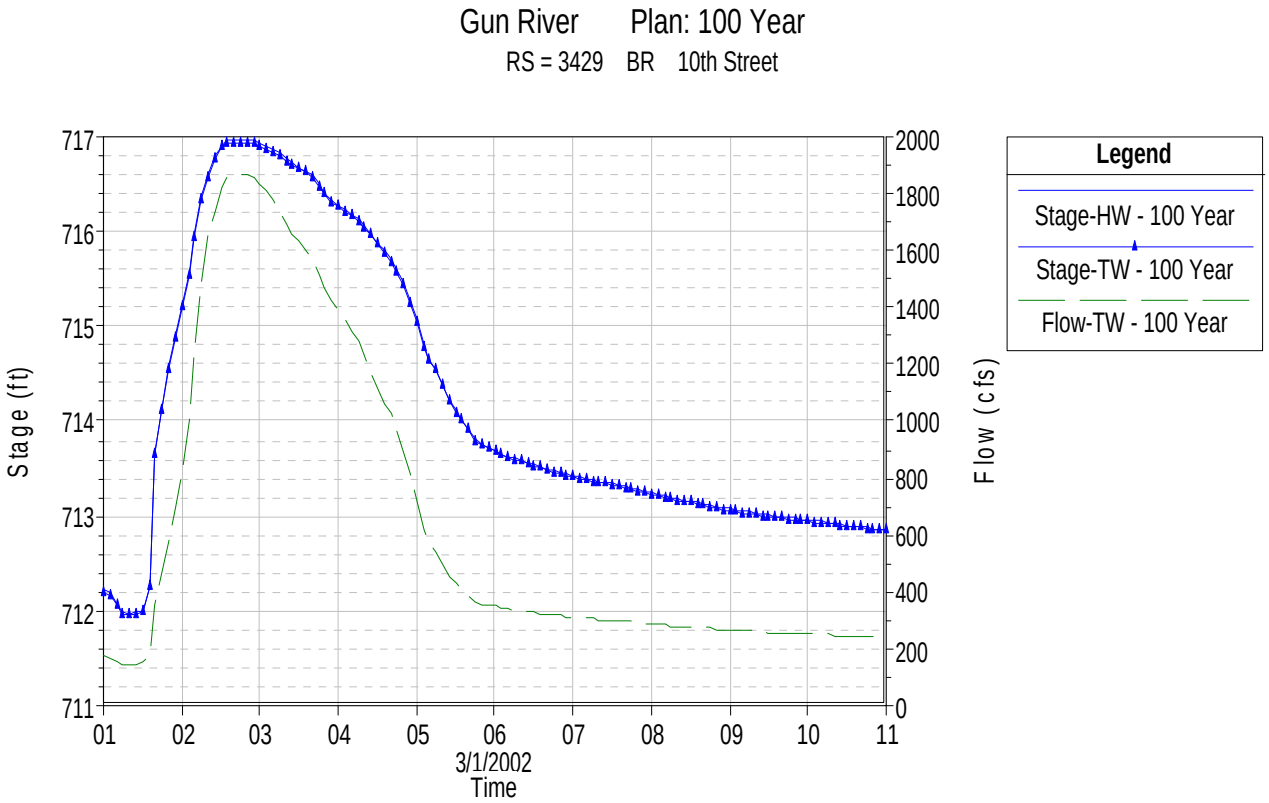
Benchmark: Paint mark on top of SW corner wing wall, SW corner of bridge
N 42-28-29 W 85-38-31
N: 357,771.0098 E: 12,779,341.8748 Z: 719.34
Elevation: 719.34

Control Points:

1006: Nail, East of 10th Street between edge of bit and guardrail, South of bridge at South end of guardrail
N 42-28-28 W 85-38-30
N: 357,709.6736 E: 12,779,380.8138 Z: 719.54

HEC-RAS Crossing Data and Hydrograph - 10th Street

RS: 3429				
E.G. US. (ft)	717.22	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	716.98	E.G. Elev (ft)	717.22	717.20
Q Total (cfs)	1872.97	W.S. Elev (ft)	716.94	716.91
Q Bridge (cfs)	1872.97	Crit W.S. (ft)	712.60	712.60
Q Weir (cfs)		Max Chl Dpth (ft)	9.27	9.24
Weir Sta Lft (ft)		Vel Total (ft/s)	4.26	4.27
Weir Sta Rgt (ft)		Flow Area (sq ft)	440.16	438.49
Weir Submerg		Froude # Chl	0.03	0.03
Weir Max Depth (ft)		Specif Force (cu ft)	1922.92	1912.04
Min El Weir Flow (ft)	719.84	Hydr Depth (ft)	7.10	7.07
Min El Prs (ft)	717.39	W.P. Total (ft)	89.03	88.93
Delta EG (ft)	0.04	Conv. Total (cfs)	77852.2	77410.9
Delta WS (ft)	0.05	Top Width (ft)	62.00	62.00
BR Open Area (sq ft)	467.99	Frctn Loss (ft)	0.03	0.00
BR Open Vel (ft/s)	4.27	C & E Loss (ft)	0.00	0.01
Coef of Q		Shear Total (lb/sq ft)	0.18	0.18
Br Sel Method	Energy only	Power Total (lb/ft s)	0.76	0.77



107th Avenue	

Handheld GPS Location: N 42-28-18 W 85-39-03

Benchmark: Paint mark on top of NW corner of NW wingwall of bridge over Gun River
Elevation: 716.56

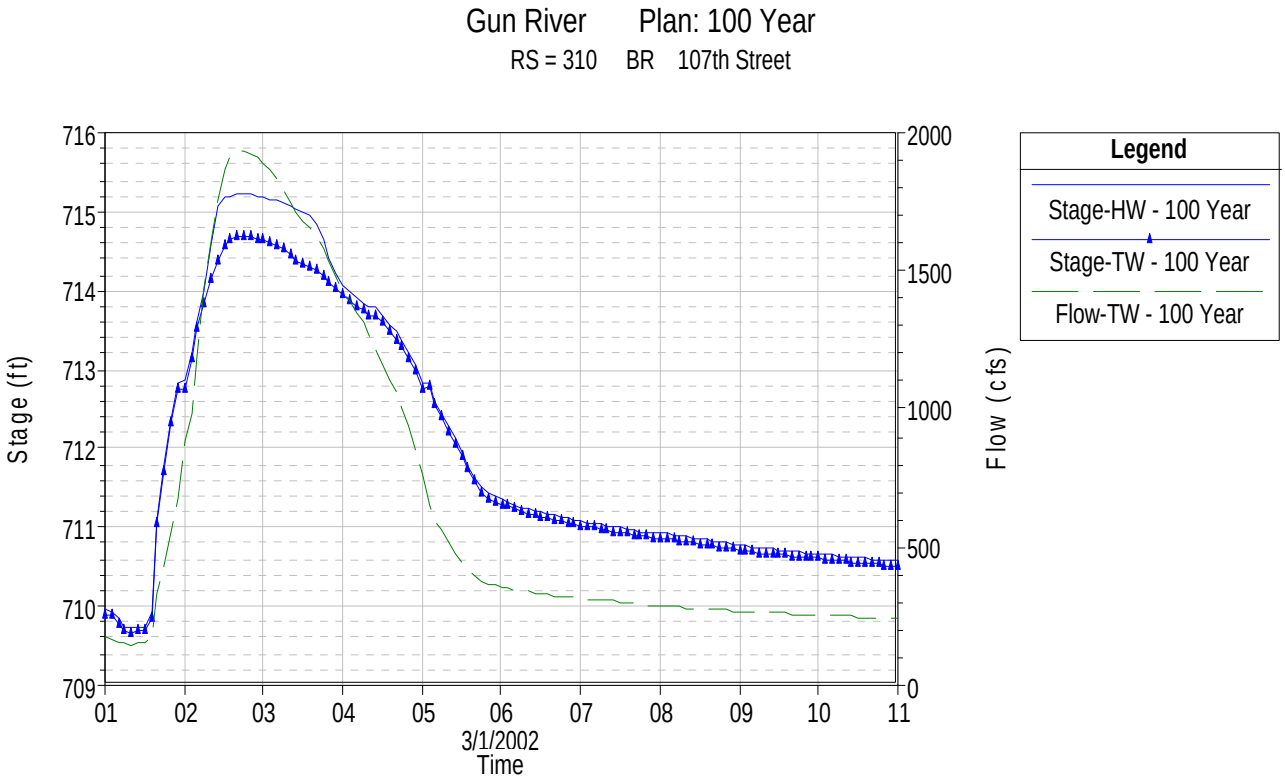
Control Points:

G-3: PK nail and tag in centerline of 107th Street on West edge of bridge
N 42-28-18 W 85-39-03
N: 356,751.8498 E: 12,776,903.2787 Z: 716.94

1004: PK nail and tag in North edge of bit of 107th Street, 50 feet West of centerline of West Gun River
N 42-28-19 W 85-38-55
N: 356,756.8273 E: 12,777,551.3743 Z: 718.82

HEC-RAS Crossing Data and Hydrograph - 107th Avenue

RS: 310				
E.G. US. (ft)	715.61	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	715.22	E.G. Elev (ft)	715.47	715.18
Q Total (cfs)	1935.53	W.S. Elev (ft)	714.58	714.58
Q Bridge (cfs)	1935.53	Crit W.S. (ft)	711.58	711.76
Q Weir (cfs)		Max Chl Dpth (ft)	7.41	7.12
Weir Sta Lft (ft)		Vel Total (ft/s)	5.47	5.67
Weir Sta Rgt (ft)		Flow Area (sq ft)	353.79	341.52
Weir Submerg		Froude # Chl	0.04	0.04
Weir Max Depth (ft)		Specif Force (cu ft)	1485.49	1426.92
Min El Weir Flow (ft)	716.99	Hydr Depth (ft)	353986.00	341704.60
Min El Prs (ft)	714.58	W.P. Total (ft)	121.36	122.86
Delta EG (ft)	0.29	Conv. Total (cfs)	36661.4	34305.9
Delta WS (ft)	0.37	Top Width (ft)		
BR Open Area (sq ft)	341.52	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.67	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.51	0.55
Br Sel Method	Press Only	Power Total (lb/ft s)	2.78	3.13



US-131

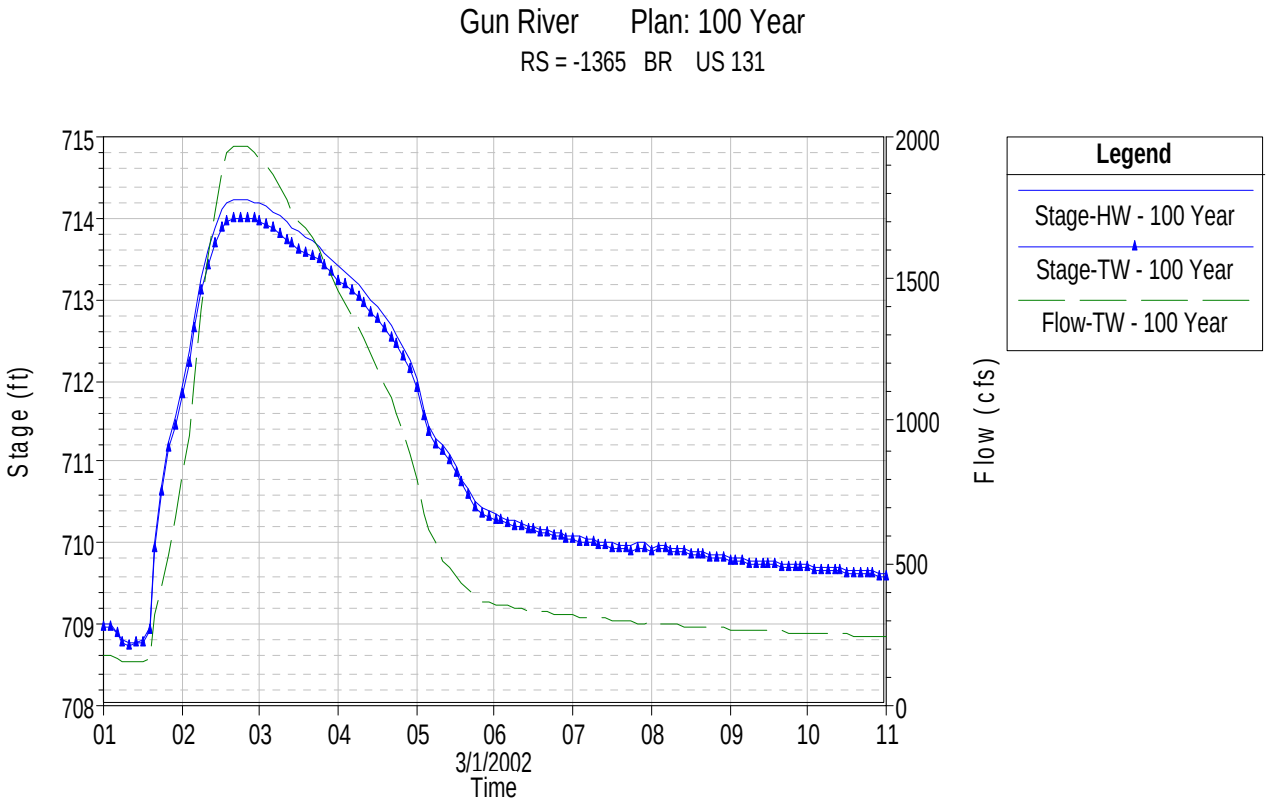
Handheld GPS Location: N 42-28-08 W 85-39-12

Benchmark: Paint mark on top of concrete headwall, South side of Gun River, centerline of median of US-131
N 42-28-06 W 85-39-11
N: 355,495.3789 E: 12,776,338.1390 Z: 720.60
Elevation: 720.60

Control Points:
1007: Nail 9 feet West of West edge of concrete of Southbound US-131, 150 feet North of North end of bridge at North end of guardrail
N 42-28-08 W 85-39-12
N: 355,733.3952 E: 12,776,260.3478 Z: 718.89

HEC-RAS Crossing Data and Hydrograph – US 131

RS: -1365				
E.G. US. (ft)	714.56	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	714.23	E.G. Elev (ft)	714.53	714.35
Q Total (cfs)	1969.01	W.S. Elev (ft)	714.20	714.01
Q Bridge (cfs)	1969.01	Crit W.S. (ft)	709.45	709.45
Q Weir (cfs)		Max Chl Dpth (ft)	10.38	10.19
Weir Sta Lft (ft)		Vel Total (ft/s)	4.39	4.50
Weir Sta Rgt (ft)		Flow Area (sq ft)	448.41	438.02
Weir Submerg		Froude # Chl	0.03	0.03
Weir Max Depth (ft)		Specif Force (cu ft)	2129.46	2053.83
Min El Weir Flow (ft)	719.71	Hydr Depth (ft)	7.60	7.42
Min El Prs (ft)	716.10	W.P. Total (ft)	72.89	72.92
Delta EG (ft)	0.18	Conv. Total (cfs)	47287.0	45558.4
Delta WS (ft)	0.20	Top Width (ft)	59.00	59.00
BR Open Area (sq ft)	560.56	Frctn Loss (ft)	0.18	0.00
BR Open Vel (ft/s)	4.50	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.67	0.70
Br Sel Method	Energy only	Power Total (lb/ft s)	2.92	3.15



11th Street	

Handheld GPS Location: N 42-28-13 W 85-39-24

Benchmark: Paint mark on SW corner of top headwall, SW corner of bridge
Elevation: 716.67

Control Points:

1002: Nail, 3 feet East of East edge of bit of 11th Street, South of bridge at South end of guardrail

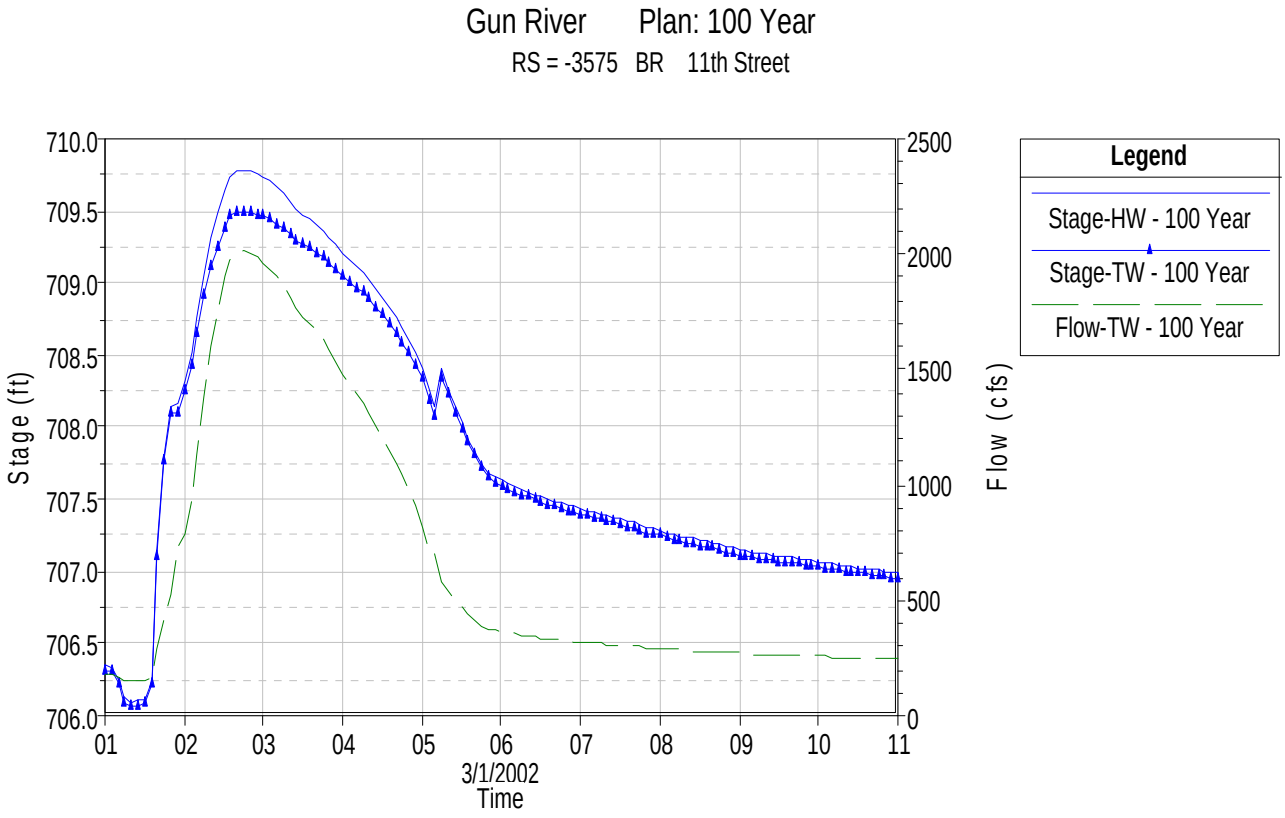
N 42-28-13 W 85-39-24
N: 356,260.2880 E: 12,775,359.5536 Z: 715.59

1003: Nail, 3 feet East of East edge of bit of 11th Street, North of bridge at North end of guardrail

N 42-28-15 W 85-39-24
N: 356,460.6014 E: 12,775,372.2506 Z: 716.44

HEC-RAS Crossing Data and Hydrograph - 11th Street

RS: -3575				
E.G. US. (ft)	710.65	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	709.78	E.G. Elev (ft)	710.59	710.50
Q Total (cfs)	2011.77	W.S. Elev (ft)	709.61	709.45
Q Bridge (cfs)	2011.77	Crit W.S. (ft)	708.17	708.17
Q Weir (cfs)		Max Chl Dpth (ft)	6.64	6.48
Weir Sta Lft (ft)		Vel Total (ft/s)	7.19	7.42
Weir Sta Rgt (ft)		Flow Area (sq ft)	279.96	271.29
Weir Submerg		Froude # Chl	0.05	0.05
Weir Max Depth (ft)		Specif Force (cu ft)	1246.47	1219.60
Min El Weir Flow (ft)	716.19	Hydr Depth (ft)	4.91	4.76
Min El Prs (ft)	710.85	W.P. Total (ft)	68.58	68.52
Delta EG (ft)	0.14	Conv. Total (cfs)	36357.4	34585.2
Delta WS (ft)	0.22	Top Width (ft)	57.00	57.00
BR Open Area (sq ft)	350.58	Frctn Loss (ft)	0.09	0.01
BR Open Vel (ft/s)	7.42	C & E Loss (ft)	0.01	0.02
Coef of Q		Shear Total (lb/sq ft)	0.78	0.84
Br Sel Method	Energy only	Power Total (lb/ft s)	5.61	6.20



CSX RR	

Handheld GPS Location: N 42-27-51 W 85-40-41

Benchmark: Top of painted bolt on NW corner of railroad bridge
N42-27-51 W 85-40-41
N: 354,130.1525 E: 12,769,572.9863 Z: 704.30

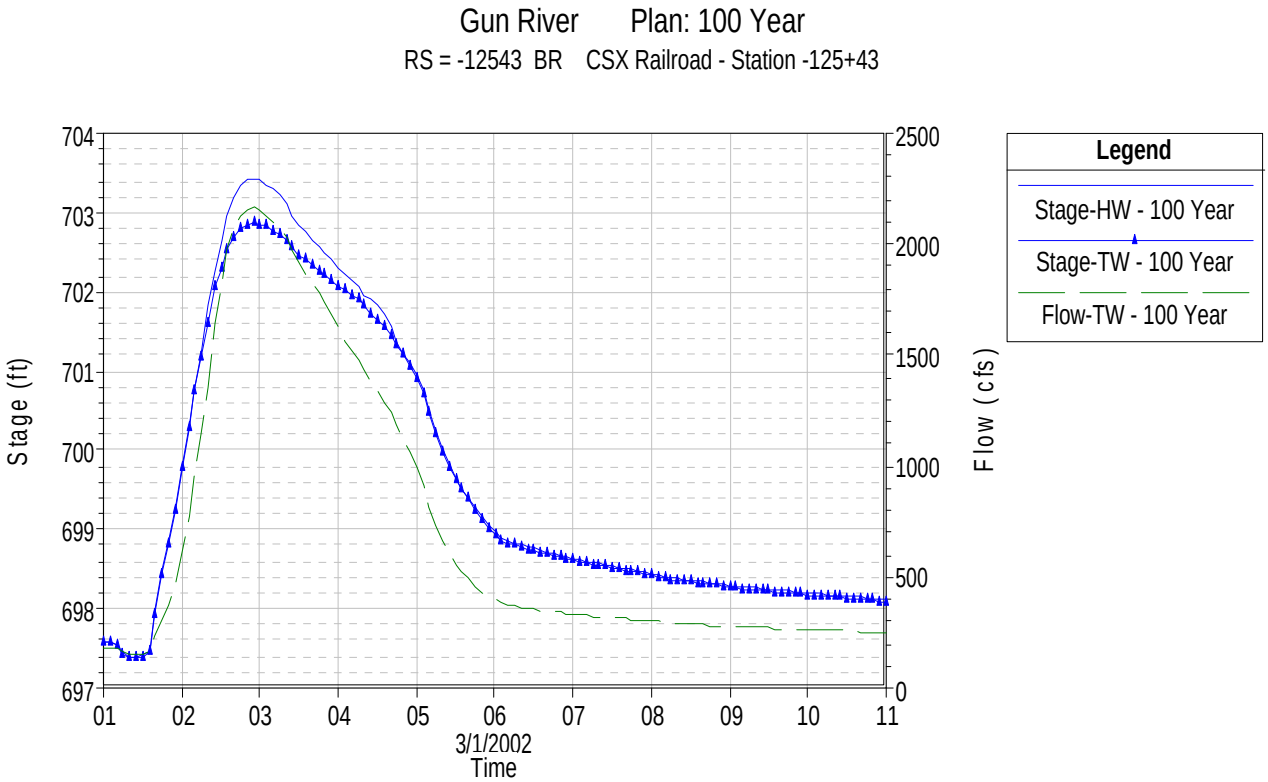
Elevation: 704.30

Control Points:

G-6: Nail and washer set in RR tie, centerline of railroad, 25 feet West of West end of RR bridge
N 42-27-51 W 85-40-41
N: 354,126.4984 E: 12,769,547.0693 Z: 704.26

HEC-RAS Crossing Data and Hydrograph - CSX RR

RS: -12543				
E.G. US. (ft)	703.76	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	703.42	E.G. Elev (ft)	703.70	703.26
Q Total (cfs)	2162.72	W.S. Elev (ft)	701.60	701.60
Q Bridge (cfs)	2162.72	Crit W.S. (ft)	699.06	699.06
Q Weir (cfs)		Max Chl Dpth (ft)	6.97	6.97
Weir Sta Lft (ft)		Vel Total (ft/s)	5.88	5.88
Weir Sta Rgt (ft)		Flow Area (sq ft)	367.82	367.82
Weir Submerg		Froude # Chl	0.04	0.04
Weir Max Depth (ft)		Specif Force (cu ft)	1527.86	1527.86
Min El Weir Flow (ft)	704.65	Hydr Depth (ft)	122673.00	122673.00
Min El Prs (ft)	701.60	W.P. Total (ft)	181.33	181.33
Delta EG (ft)	0.44	Conv. Total (cfs)	30494.4	30494.4
Delta WS (ft)	0.50	Top Width (ft)		
BR Open Area (sq ft)	367.82	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.88	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.64	0.64
Br Sel Method	Press Only	Power Total (lb/ft s)	3.75	3.75



106th Avenue	

Handheld GPS Location: N 42-27-45 W 85-40-44

Benchmark: Top of most Southwest corner of the Southwest Abutment, Paint mark, Approx 1.0 foot below bridge deck.

Elevation: 703.95

Control Points:

G-1: PK nail 0.5 feet South of the North edge of Bit., North side of 106th, 80 feet West of mailbox to house #1350, 700 feet ? East of the Gun River bridge.

N 42-27-46 W 85-40-32

N: 353,567.2940 E: 12,770,186.6502 Z: 705.68

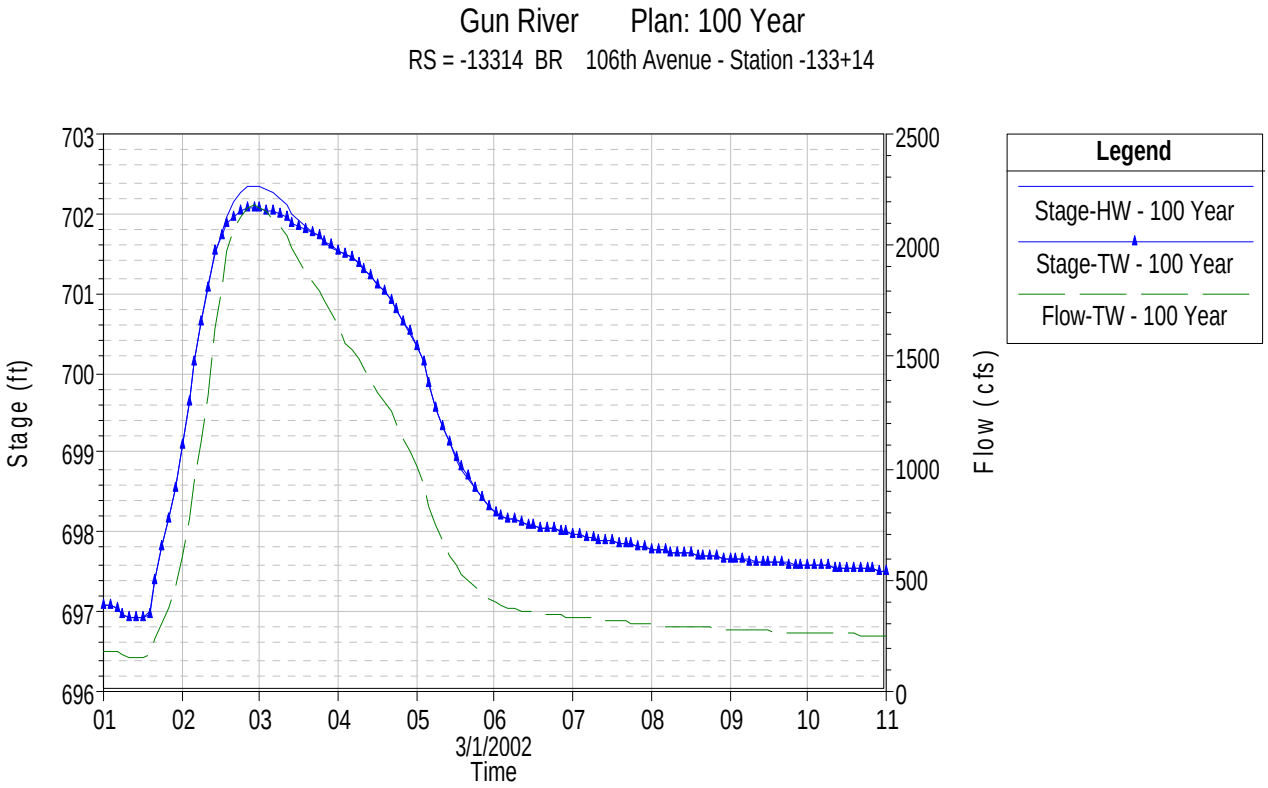
G-2: 12 inch nail and washer, 4 feet South of the South Edge of Bit, 15 feet East of West End of the guard rail, 100 feet West of the bridge.

N 42-47-45 W 85-40-45

N: 353,478.2864 E: 12,769,205.1890 Z: 704.85

HEC-RAS Crossing Data and Hydrograph - 106th Avenue

RS: -13314				
E.G. US. (ft)	702.83	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	702.35	E.G. Elev (ft)	702.67	702.59
Q Total (cfs)	2175.75	W.S. Elev (ft)	702.09	702.06
Q Bridge (cfs)	2173.40	Crit W.S. (ft)	699.77	699.36
Q Weir (cfs)		Max Chl Dpth (ft)	9.22	8.33
Weir Sta Lft (ft)		Vel Total (ft/s)	5.73	5.62
Weir Sta Rgt (ft)		Flow Area (sq ft)	379.48	386.81
Weir Submerg		Froude # Chl	0.04	0.04
Weir Max Depth (ft)		Specif Force (cu ft)	1568.74	1638.23
Min El Weir Flow (ft)	702.01	Hydr Depth (ft)	1.14	1.19
Min El Prs (ft)	702.61	W.P. Total (ft)	357.31	347.40
Delta EG (ft)	0.15	Conv. Total (cfs)	46334.1	51082.7
Delta WS (ft)	0.47	Top Width (ft)	333.98	325.28
BR Open Area (sq ft)	393.29	Frctn Loss (ft)	0.07	0.00
BR Open Vel (ft/s)	6.04	C & E Loss (ft)	0.01	0.01
Coef of Q		Shear Total (lb/sq ft)	0.15	0.13
Br Sel Method	Energy only	Power Total (lb/ft s)	0.84	0.71



APPENDIX 6

Determining Required Stream Protection Volumes and Release Rates for Detention Basins

Background

Recently Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) developed subdivision drainage rules and storm water design criteria for Van Buren, Newaygo, and Montcalm Counties and the City of Portage, Kalamazoo County (counties). These rules include, among other things, provisions for protecting streambanks from erosive velocities during 1 to 2 year rainfall events. The intent was to find a simple set of rules based on easily determined site parameters that, when followed, would provide this streambank protection. The result is that detention basins that are to be designed for streambank protection must have at least 5,000 ft3 of storage per impervious acre of development and that the peak release rate from the basin shall be less than or equal to 0.05 cfs per impervious acre during a 1.5-year rainfall event. Note that additional criteria exist for flood protection, spill protection, etc.

The basis for these rules comes from the Uniform Storm Water Sizing Criteria established for the State of Maryland (Maryland). Their criteria for channel protection are given in the document "Method for Computing the Channel Protection Storage Volume (CPV)" (Appendix D.11 of the Unified Storm Water Sizing Criteria). The Maryland sizing criteria is based on obtaining a 24-hour extended detention time for the 1-year rainfall event. The detention time is defined as the lag time between the centroids of the inflow and outflow detention pond hydrographs. The implementation procedures in Maryland are more involved than the rules developed by FTC&H. The following analysis provides a direct comparison with the Maryland approach.

Basis

Streambank erosion occurs when velocities associated with channel-forming flows are given time to cause damage. Storm water detention policies that are based on maintaining predevelopment flow rates for a 2-year (channel-forming) event can often lead to increased erosion since erosive velocities are present for a longer period of time because of the increased volume associated with development. The Maryland stream protection sizing criteria is based on over-managing the more frequent (1-year) events by extended detention. By doing this, the peak discharges from the 2-year event are reduced to approximately predevelopment levels but, more importantly, these discharges occur over the same amount of time as would under pre-development conditions since they pass through the extended detention controls.

The county stream protection rules developed by FTC&H require extended detention for the 1.5-year event. This means that, on average, any drop of water entering the basin will be held for a 24-hour period. The specific criterion is that the centroid of the outflow hydrograph is delayed from the centroid of the inflow hydrograph by 24 hours.

Methodology

The major problem that has to be solved is that of finding a simple rule based on easily identified site specific parameters that, when followed, has a high likelihood of meeting the 24 hour detention time goal. The approach that was followed involves extensive sampling. Many runs were made using hydrologic modeling software (HydroCad) each with a different set of parameters. The results of these runs were used to establish a set of relationships which could then be used to establish the appropriate rules. The major challenge with this approach is to reduce the number of parameters that need to be varied to keep the task manageable and to make the derived relationships presentable. The hydrologic model (in HydroCad) is simple - a single subbasin providing flow into a single detention pond. The possible parameters that could be varied are the following:

- Drainage area, A
- Curve Number, CN
- Time of concentration, tc
- Rainfall depth, P
- Type of unit hydrograph
- Type and duration of storm
- Shape of the detention pond
- Size of the detention pond
- Side slopes of the detention pond
- Peak depth of the detention pond
- Outlet diameter of the detention pond

There are two ways to reduce the number of parameters that need to be sampled. First, a set of reasonable assumptions can be made about several of the parameters. Second, some of the parameters can be combined into groups allowing variation of a smaller number of parameters.

The following assumptions have been made to reduce the number of parameters:

- Use a 24-hour soil conservation service (SCS) type II rainfall distribution.

- Use a unit hydrograph that corresponds to observed stream behavior in Michigan. A SCS triangular unit hydrograph with 28.5% of the volume under the rising limb was used for this purpose. This is the same unit hydrograph used to generate the results published in the document “Computing Flood Discharges For Small Ungaged Watersheds”.

- Use a rectangular detention basin with 4:1 side slopes and peak depth (for the 1.5-year storm) of approximately 5 feet.

The parameterization follows the approach in Appendix D.11 of Maryland’s Unified Storm Water Sizing Criteria. In this approach a relationship is first developed between the Unit peak discharge, qU (in cfs per mi2 per inch of runoff), and 2 parameters - the time of concentration and the ratio of initial abstraction, Ia to the precipitation depth, P. This unit peak discharge is the same as QP given in equation 9.1 in “Computing Flood Discharges For Small Ungaged Watersheds”. (Equation 9.1 does not include the second parameter (Ia/P) because it is based on a fixed CN value of 75). To show that the unit peak discharge can be expressed as a function of only Ia/P and tC consider the 2 cases given in the table below:

Parameter	Case I	Case II
A [acre]	100	25
CN	80	66.7
P [in]	2	4
tc [hr]	1	1
Ia [in] = .2(1000/CN-10)	0.5	1.0
Ia/P	0.25	0.25
Peak discharge [cfs]	20.14	10.31
Runoff depth [in]	0.56	1.14
Unit Peak discharge, qU [cfs/mi2/in]	230	231

In this example A, CN, and P are different for both cases but they produce the same Ia/P value and the same resulting unit peak discharge. No new information was therefore derived from the running of the second sample. If the unit peak discharge can be used as a key parameter in the detention basin model, then the selected sample values of A, CN, and P need only generate a complete range of Ia/P values. This greatly reduces the number of sample cases to be run.

The second relationship that is developed is that between the unit peak discharge and the ratio of peak outflow to peak inflow, qo/qi, for a 24-hour detention time. This simple relationship is possible since the shape of the inflow hydrograph is influenced more by the SCS rainfall distribution than the time of

concentration of the drainage area. All of the inflow hydrographs will have a shape, which is quite independent of the drainage area parameters. The table below shows the results of running 3 examples to show that this relationship is valid. All cases use the same detention basin side slope (4:1). In each case, the detention basin base area and outlet diameter are manually adjusted to get a 24-hour detention time with a maximum depth of about 5 feet. All 3 runs use the same precipitation depth of 2.0 inches.

Parameter	Case A	Case B	Case C
A [acre]	640	1,280	640
CN	84	84	71
tC [min]	30	30	15
Runoff depth [in]	0.74	0.74	0.27
Peak drainage area discharge or peak detention basin inflow, qi [cfs]	312.5	624.9	115.1
Unit Peak Discharge, qu [cfs/mi2/in]	422	422	426
Detention pond base area [ac]	4	8	1.4
Outlet diameter [in]	14.5	21	8.4
Peak Detention basin outflow, qo [cfs]	11.27	22.84	3.99
Detention outflow/inflow ratio, qo/qi	.036	.036	.035

In this example each case has the same unit peak discharge and results in the same detention outflow/inflow ratio.

The results of detailed sampling are shown in the data table provided as Table 1 at the end of this appendix. The detailed sampling procedure used was as follows:

- The rainfall depth was fixed at 2.06 inches. This is arbitrary as long as a range of Ia/P values are used.

- Basin side slopes were set to 4:1.

- CN values were selected to give Ia/P range from 0.05 to 0.40 (columns 2 and 3).

- tC values were selected in the range from 15 to 480 minutes (column 4).

- The runoff depth, peak discharge, and unit peak discharge were computed from the HydroCad computer model (columns 5, 6, and 7).

- With the detention basin base area set to 1 acre the drainage area (column 1) and outlet diameter (column 8) were adjusted to provide a 24-hour detention time (column 9) with a 5-foot peak pond elevation (column 10). This was easier than setting a particular, arbitrary drainage area and then adjusting the basin base area and outlet diameter.

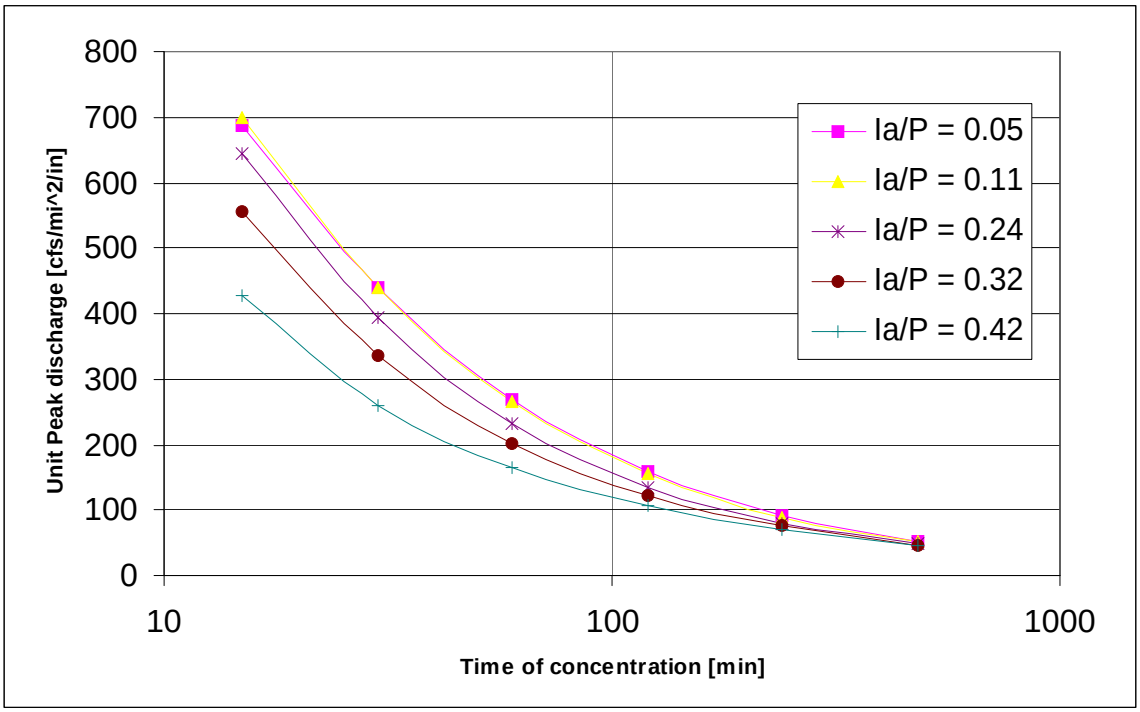
- From these results the peak release rate (column 11) and outflow/inflow ratio (column 13) can be computed.

- The detention storage volume (column 12) and the ratio of storage volume to inflow volume (column 13) are also computed.

Results

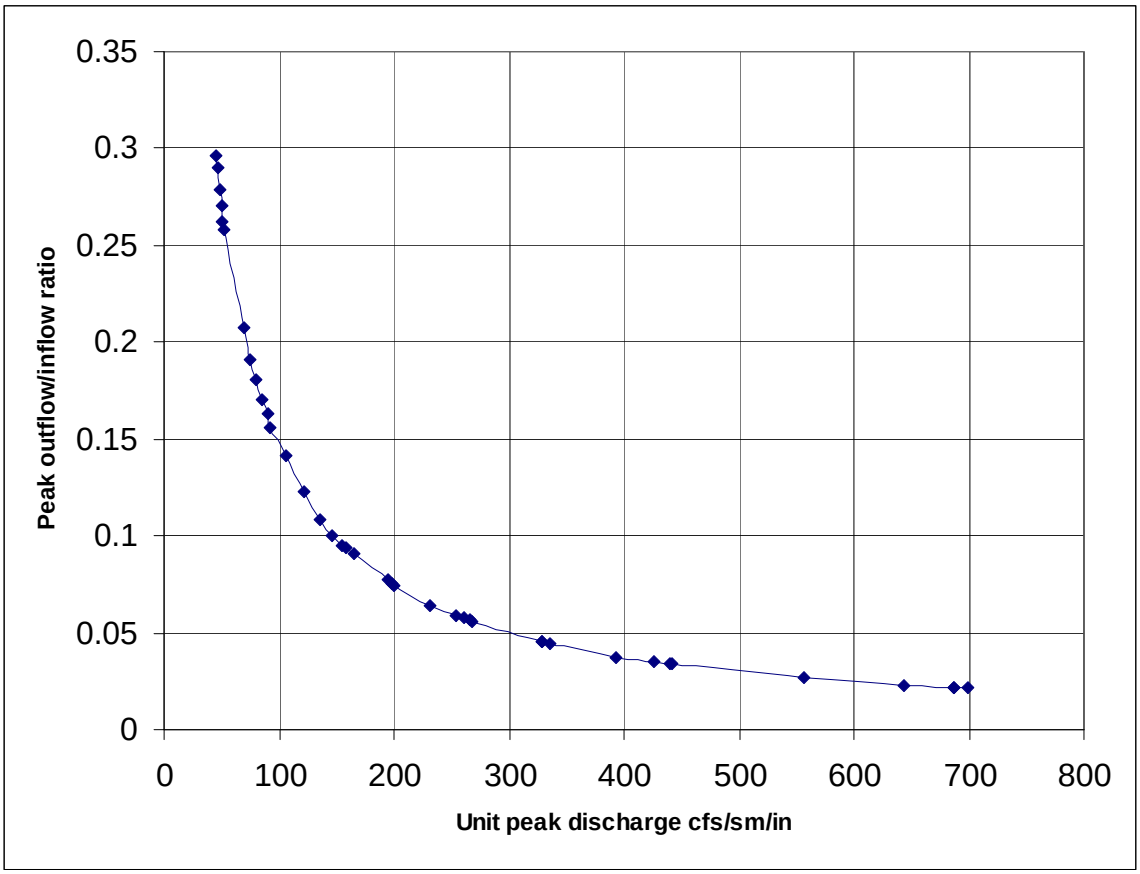
The two relationships described above are the primary results of this analysis. The first is the unit peak discharge (column 7) given as a function of time of concentration (column 4) and Ia/P (column 3). This is shown graphically in Figure 1.

Figure 1 - Unit Peak Discharge Related to Ia/P and Time of Concentration



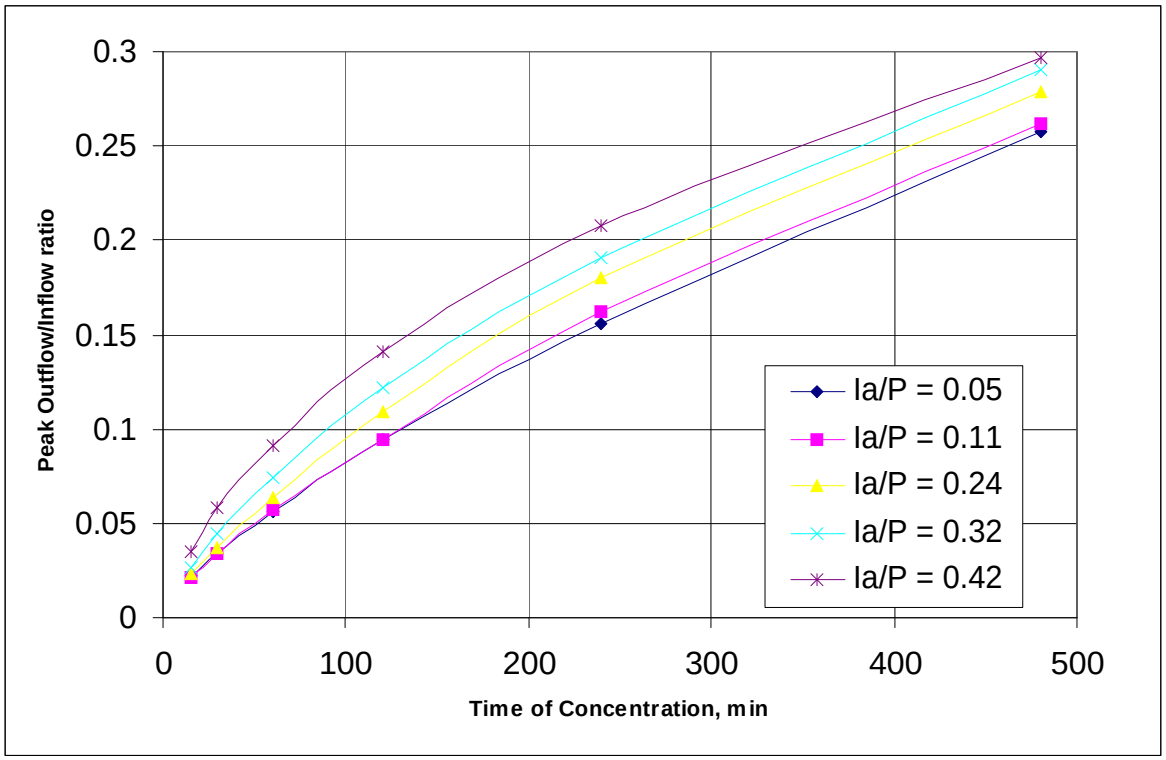
The second relationship is that between Unit Peak Discharge (column 7) and the detention basin outflow/inflow ratio needed to obtain a 24-hour detention time (column 13). This is shown in figure 2.

Figure 2 - Peak Outflow/Inflow as a Function of Unit Peak Discharge



These two relationships can also be combined as shown in Figure 3.

Figure 3 - Peak Inflow/Outflow as a Function of Ia/P and Time of Concentration



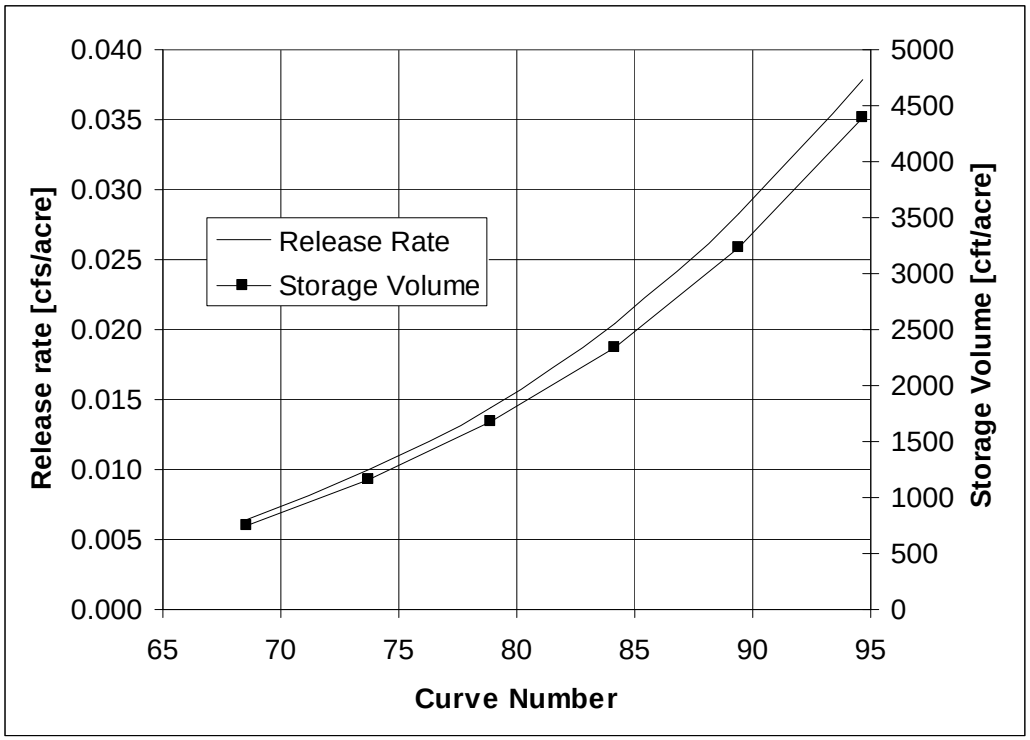
Results applied to Allegan County

Figures 1 and 2 could easily be used together to size a detention basin outlet for streambank protection. The procedures that would be followed are outlined in Appendix D.11 of the Maryland Uniform Storm Water Sizing Criteria. A simpler method was desired for the county storm water design criteria that used a simple discharge release rate restriction.

Table 2 shows the results of the release rate analysis applied to Allegan County. Columns 1 through 5 are the results of the sampling described above. They are the tabular version of Figures 1 and 2. This data can be considered generic for Michigan since they are based on a typical Michigan unit hydrograph. Column 6 (column 1 times 2.2 inches) is the initial abstraction associated with the 1.5-year rainfall event in Allegan County. Column 7 is the CN associated with that initial abstraction value (Ia=0.2*[1000/CN-10]). Column 8 is the runoff depth associated with the CN in column 7 and the 2.2 inches of rainfall. Column 9 is the peak discharge (per acre) from the drainage area. This is also the peak inflow rate into the detention basin. It is computed by multiplying the Unit Peak Discharge (column 3) by the runoff depth (column 8) times 1/640 (1 acre in mi2). Column 10 is the release rate in cfs/acre. It is column 9 times column 4. Column 11 gives the required detention storage in ft3/acre. It is computed as the runoff depth in feet (column 8 divided by 12) times 43560 ft2 times the storage volume to runoff volume ratio (column 5).

It can be seen that using a 24-hour detention of the 1.5-year event as the basis for stream protection results in a very wide range of values in columns 10 and 11. For the range of Ia/P and tC values used in this analysis this release rate varies over 6.5 orders of magnitude from 0.006 to 0.039 cfs per acre. Selecting a single value would be difficult to do. To be able to select a release criterion that has less variability requires incorporating more parameters. One approach would be to simply use the developed curve number as an additional parameter. The values in column 10 and 11 vary only a small amount for any particular CN value. Averaging the release rates and storage volumes for each curve number value results in the relationships shown in Figure 4.

Figure 4 - Release Rate as a Function of Curve Number



Another, somewhat simpler, approach does not require the developer to compute the curve number. It is based on the hydrologic soil group and the imperviousness of the drainage area. Additional columns are now needed in Table 2. Columns 12 through 15 are the impervious fraction for development for the 4 different hydrologic soil groups. This assumes that the curve number in column 7 is a weighted average of 98 for the impervious part and the value associated with open space in good condition. So, if the soil is in hydrologic soil group B the impervious fraction needs 0.91 to get an average curve number of 95 (row 1). By dividing column 10 by the impervious fractions in columns 12 through 15 the release rate is recomputed in terms of cfs per impervious acres (columns 16 through 19). The values in each of these columns vary less than those in column 10. This same process was done for the detention storage volume, resulting in the values in columns 20 through 23 which are now in ft3/impervious acre for each soil type.

A recommended value can now be determined for each hydrologic soil group using an average from each column. The results are as follows:

- HSG A: Release 0.026 cfs/impervious acre, Volume 3,000 ft3/impervious acre
- HSG B: Release 0.034 cfs/impervious acre, Volume 4,000 ft3/impervious acre
- HSG C: Release 0.051 cfs/impervious acre, Volume 5,800 ft3/impervious acre
- HSG D: Release 0.059 cfs/impervious acre, Volume 5,800 ft3/impervious acre

If it is assumed that infiltration will be used for type A and B soils then a reasonable value for C and D soils is 0.05 cfs per impervious acre and 5800 ft3/impervious acre.

Table 1 - Sampling Data and Calculations

Drainage Area Inputs				Drainage Area Output			Reservoir Input	Reservoir Output				Calculations	
Area [acre] (1)	CN (2)	Ia/P (3)	Time of Concentration tc [min] (4)	Runoff Depth [in] (5)	Peak Discharge qi [cfs] (6)	Unit peak Discharge, qu [cfs/mi2/in] (7)	Orifice Diameter [in] (8)	Detention Time [min] (9)	Maximum Depth [ft] (10)	Peak Release, qo [cfs] (11)	Storage Volume, Vs [ac-ft] (12)	Peak Outflow to Inflow Ratio qo/qi (13)	Storage Volume to Runoff Volume Ratio, Vs/Vr (14)
80	95	0.051	15	1.54	132.18	687	7.1	1,455	5.05	2.89	7.65	0.022	0.745
80	95	0.051	30	1.54	84.55	439	7.1	1,454	5.05	2.89	7.65	0.034	0.745
80	95	0.051	45	1.54	63.42	329	7.1	1,453	5.04	2.88	7.64	0.045	0.744
80	95	0.051	60	1.54	51.53	268	7.1	1,451	5.04	2.88	7.63	0.056	0.743
80	95	0.051	90	1.54	38.17	198	7.1	1,447	5.03	2.88	7.62	0.075	0.742
80	95	0.051	120	1.54	30.57	159	7.1	1,443	5.01	2.88	7.59	0.094	0.739
80	95	0.051	240	1.54	17.83	93	7	1,462	4.97	2.78	7.52	0.156	0.732
80	95	0.051	480	1.54	10.19	53	6.9	1,454	4.71	2.63	7.14	0.258	0.695
110	90	0.108	15	1.15	138.11	699	7.2	1,435	5.11	2.99	7.74	0.022	0.734
110	90	0.108	30	1.15	87.16	441	7.2	1,433	5.11	2.98	7.74	0.034	0.734
110	90	0.108	45	1.15	65.08	329	7.2	1,431	5.1	2.98	7.73	0.046	0.733
110	90	0.108	60	1.15	52.51	266	7.2	1,429	5.09	2.98	7.72	0.057	0.732
110	90	0.108	90	1.15	38.48	195	7.2	1,425	5.08	2.98	7.69	0.077	0.729
110	90	0.108	120	1.15	30.68	155	7.1	1,457	5.09	2.9	7.71	0.095	0.731
110	90	0.108	240	1.15	17.71	90	7.1	1,436	5.02	2.88	7.6	0.163	0.721
110	90	0.108	480	1.15	10.14	51	6.9	1,467	4.83	2.66	7.31	0.262	0.693
150	85	0.171	15	0.84	135.08	686	7.2	1,431	5.06	2.97	7.74	0.022	0.737
150	85	0.171	60	0.84	50.15	255	7.2	1,425	5.04	2.96	7.64	0.059	0.728
150	85	0.171	120	0.84	28.93	147	7.1	1,453	5.05	2.89	7.65	0.100	0.729
150	85	0.171	240	0.84	16.86	86	7.1	1,432	4.99	2.87	7.56	0.170	0.720
150	85	0.171	480	0.84	9.84	50	6.9	1,464	4.81	2.66	7.28	0.270	0.693
210	80	0.243	15	0.6	126.75	644	7.1	1,462	5.1	2.9	7.72	0.023	0.735
210	80	0.243	30	0.6	77.43	393	7.1	1,461		2.9	7.71	0.037	0.734
210	80	0.243	60	0.6	45.66	232	7.1	1,457		2.9	7.7	0.064	0.733
210	80	0.243	120	0.6	26.58	135	7.1	1,448		2.89	7.65	0.109	0.729
210	80	0.243	240	0.6	15.85	81	7.1	1,428	4.97	2.86	7.54	0.180	0.718
210	80	0.243	480	0.6	9.5	48	6.9	1,462	4.78	2.65	7.25	0.279	0.690

Drainage Area Inputs				Drainage Area Output			Reservoir Input	Reservoir Output				Calculations	
Area [acre] (1)	CN (2)	Ia/P (3)	Time of Concentration tc [min] (4)	Runoff Depth [in] (5)	Peak Discharge qi [cfs] (6)	Unit peak Discharge, qu [cfs/mi2/in] (7)	Orifice Diameter [in] (8)	Detention Time [min] (9)	Maximum Depth [ft] (10)	Peak Release, qo [cfs] (11)	Storage Volume, Vs [ac-ft] (12)	Peak Outflow to Inflow Ratio qo/qi (13)	Storage Volume to Runoff Volume Ratio, Vs/Vr (14)
300	75	0.324	15	0.41	107.09	557	7.1	1,442	5.02	2.88	7.6	0.027	0.741
300	75	0.324	30	0.41	64.6	336	7.1	1,440	5.01	2.87	7.59	0.044	0.740
300	75	0.324	60	0.41	38.58	201	7.1	1,437	4.99	2.87	7.59	0.074	0.740
300	75	0.324	120	0.41	23.28	121	7.1	1,429	4.95	2.85	7.49	0.122	0.731
300	75	0.324	240	0.41	14.44	75	7	1,449	4.89	2.76	7.41	0.191	0.723
300	75	0.324	480	0.41	9	47	6.9	1,445		2.61	7.04	0.290	0.687
450	70	0.416	15	0.26	77.99	427	7	1,448	4.9	2.76	7.42	0.035	0.761
450	70	0.416	30	0.26	47.66	261	7	1,447	4.89	2.76	7.4	0.058	0.759
450	70	0.416	60	0.26	30.29	166	7	1,444	4.86	2.75	7.37	0.091	0.756
450	70	0.416	120	0.26	19.35	106	7	1,437	4.81	2.73	7.28	0.141	0.747
450	70	0.416	240	0.26	12.72	70	6.9	1,459	4.73	2.64	7.17	0.208	0.735
450	70	0.416	480	0.26	8.37	46	6.8	1,457	4.47	2.48	6.77	0.296	0.694

Table 2 - Allegan County Data

Results from Sampling (see Table 1)					Values Based on Allegan County 1.5-Year Rainfall: P=2.2 in						Impervious Fraction				Release Rate [cfs/imp acre]				Storage Volume [ft3/imp acre]			
Ia/P (1)	Time of Concentration tc [min] (2)	Unit Peak Discharge, qu [cfs/mi2/in] (3)	Peak Outflow to Inflow Ratio qo/qi (4)	Storage Volume to Runoff Volume Ratio, Vs/Vr (5)	Initial Abstraction, Ia [in] (6)	CN (7)	Runoff Depth, [in] (8)	Peak Detention Basin Inflow, qi [cfs/acre] (9)	Peak Detention Basin Outflow, qo [cfs/acre] (10)	Detention Storage [ft3/acre (11)	HSG A Open CN=39 (12)	HSG B Open CN=61 (13)	HSG C Open CN=74 (14)	HSG D Open, CN=80 (15)	HSG A (16)	HSG B (17)	HSG C (18)	HSG D (19)	HSG A (20)	HSG B (21)	HSG C (22)	HSG D (23)
0.051	15	686.6	0.022	0.745	0.112	95	1.64	1.76	0.039	4,449	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4,714	4,887	5,163	5,455
0.051	30	439.2	0.034	0.745	0.112	95	1.64	1.13	0.039	4,449	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4,714	4,887	5,163	5,455
0.051	45	329.5	0.045	0.744	0.112	95	1.64	0.85	0.038	4,443	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4,708	4,881	5,157	5,448
0.051	60	267.7	0.056	0.743	0.112	95	1.64	0.69	0.038	4,437	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4,702	4,875	5,150	5,441
0.051	90	198.3	0.075	0.742	0.112	95	1.64	0.51	0.038	4,431	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4,696	4,868	5,143	5,434
0.051	120	158.8	0.094	0.739	0.112	95	1.64	0.41	0.038	4,414	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4,677	4,849	5,123	5,413
0.051	240	92.6	0.156	0.732	0.112	95	1.64	0.24	0.037	4,373	0.94	0.91	0.86	0.82	0.039	0.041	0.043	0.046	4,634	4,804	5,076	5,363
0.051	480	52.9	0.258	0.695	0.112	95	1.64	0.14	0.035	4,152	0.94	0.91	0.86	0.82	0.037	0.039	0.041	0.043	4,400	4,562	4,819	5,092
0.108	15	698.7	0.022	0.734	0.237	89	1.22	1.34	0.029	3,260	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3,817	4,248	5,083	6,248
0.108	30	441.0	0.034	0.734	0.237	89	1.22	0.84	0.029	3,260	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3,817	4,248	5,083	6,248
0.108	45	329.3	0.046	0.733	0.237	89	1.22	0.63	0.029	3,256	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3,812	4,243	5,076	6,240
0.108	60	265.7	0.057	0.732	0.237	89	1.22	0.51	0.029	3,252	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3,807	4,237	5,070	6,231
0.108	90	194.7	0.077	0.729	0.237	89	1.22	0.37	0.029	3,239	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3,792	4,221	5,050	6,207
0.108	120	155.2	0.095	0.731	0.237	89	1.22	0.30	0.028	3,247	0.85	0.77	0.64	0.52	0.033	0.037	0.044	0.054	3,802	4,232	5,063	6,223
0.108	240	89.6	0.163	0.721	0.237	89	1.22	0.17	0.028	3,201	0.85	0.77	0.64	0.52	0.033	0.036	0.043	0.053	3,748	4,172	4,991	6,135
0.108	480	51.3	0.262	0.693	0.237	89	1.22	0.10	0.026	3,079	0.85	0.77	0.64	0.52	0.030	0.034	0.040	0.049	3,605	4,012	4,801	5,901
0.171	15	686.1	0.022	0.737	0.377	84	0.90	0.96	0.021	2,399	0.77	0.63	0.42	0.23	0.028	0.034	0.050	0.092	3,135	3,835	5,676	
0.171	60	254.7	0.059	0.728	0.377	84	0.90	0.36	0.021	2,368	0.77	0.63	0.42	0.23	0.028	0.034	0.050	0.092	3,094	3,785	5,603	
0.171	120	146.9	0.100	0.729	0.377	84	0.90	0.21	0.021	2,371	0.77	0.63	0.42	0.23	0.027	0.033	0.049	0.089	3,098	3,790	5,610	
0.171	240	85.6	0.170	0.720	0.377	84	0.90	0.12	0.020	2,343	0.77	0.63	0.42	0.23	0.027	0.033	0.048	0.089	3,062	3,746	5,544	
0.171	480	50.0	0.270	0.693	0.377	84	0.90	0.07	0.019	2,256	0.77	0.63	0.42	0.23	0.025	0.030	0.045	0.082	2,949	3,607	5,339	
0.243	15	643.8	0.023	0.735	0.534	79	0.64	0.64	0.015	1,708	0.68	0.48	0.21		0.022	0.030	0.072		2,525	3,526	8,322	
0.243	30	393.3	0.037	0.734	0.534	79	0.64	0.39	0.015	1,706	0.68	0.48	0.21		0.022	0.030	0.072		2,521	3,522	8,311	
0.243	60	231.9	0.064	0.733	0.534	79	0.64	0.23	0.015	1,704	0.68	0.48	0.21		0.022	0.030	0.072		2,518	3,517	8,300	
0.243	120	135.0	0.109	0.729	0.534	79	0.64	0.14	0.015	1,693	0.68	0.48	0.21		0.022	0.030	0.072		2,502	3,494	8,246	
0.243	240	80.5	0.180	0.718	0.534	79	0.64	0.08	0.015	1,669	0.68	0.48	0.21		0.021	0.030	0.071		2,466	3,444	8,128	
0.243	480	48.3	0.279	0.690	0.534	79	0.64	0.05	0.013	1,604	0.68	0.48	0.21		0.020	0.028	0.066		2,371	3,311	7,815	
0.324	15	557.2	0.027	0.741	0.712	74	0.44	0.38	0.010	1,181	0.59	0.34			0.017	0.030			2,005	3,427		
0.324	30	336.1	0.044	0.740	0.712	74	0.44	0.23	0.010	1,179	0.59	0.34			0.017	0.030			2,002	3,422		
0.324	60	200.7	0.074	0.740	0.712	74	0.44	0.14	0.010	1,179	0.59	0.34			0.017	0.030			2,002	3,422		
0.324	120	121.1	0.122	0.731	0.712	74	0.44	0.08	0.010	1,164	0.59	0.34			0.017	0.030			1,976	3,377		
0.324	240	75.1	0.191	0.723	0.712	74	0.44	0.05	0.010	1,151	0.59	0.34			0.017	0.029			1,955	3,341		
0.324	480	46.8	0.290	0.687	0.712	74	0.44	0.03	0.009	1,094	0.59	0.34			0.016	0.027			1,857	3,174		
0.416	15	426.6	0.035	0.761	0.915	69	0.28	0.19	0.007	778	0.50	0.21			0.013	0.032			1,550	3,786		
0.416	30	260.7	0.058	0.759	0.915	69	0.28	0.11	0.007	776	0.50	0.21			0.013	0.032			1,546	3,775		
0.416	60	165.7	0.091	0.756	0.915	69	0.28	0.07	0.007	772	0.50	0.21			0.013	0.032			1,540	3,760		
0.416	120	105.8	0.141	0.747	0.915	69	0.28	0.05	0.007	763	0.50	0.21			0.013	0.032			1,521	3,714		
0.416	240	69.6	0.208	0.735	0.915	69	0.28	0.03	0.006	752	0.50	0.21			0.013	0.031			1,498	3,658		
0.416	480	45.8	0.296	0.694	0.915	69	0.28	0.02	0.006	710	0.50	0.21			0.012	0.029			1,414	3,454		