TECHNICAL MEMORANDUM

To: Jennifer Kanine and Grant Poole, Pokagon Band of Potawatomi

From: Ben Lee, PE (Inter-Fluve)

Date: December 21, 2018

Re: Dowagiac River Restoration Hydraulic Analysis

Introduction

This hydraulic report was prepared by Ben Lee, P.E., Inter-Fluve (608-441-0342, blee@interfluve.com) and has been reviewed by Maren Hancock, Inter-Fluve (651-243-9700, mhancock@interfluve.com).

The project reach is located on the Dowagiac River in Cass County, Michigan, just south of Peavine Street. The project reach is approximately 6,300 feet long. This hydraulic analysis has been prepared for the Pokagon Band of Potawatomi.

The purpose of this restoration project is to achieve the following objectives on a section of the Dowagiac River that is currently lined by levees on both sides:

- Re-establish historical channel character/aesthetics;
- Increase and enhance habitat available for coldwater fishes;
- Re-establish or maintain tribally significant vegetation within the floodplain
- Maintain recreational boater passage through the channel; and
- Eliminate or minimize flood profile changes that may impact adjacent neighbors.

An assessment phase of the project was completed in 2013 and included an analysis of historical channel and floodplain conditions, hydrology and hydraulic conditions, and recommendations for restoration of a larger reach of the river. Part of this study involved a bathymetric survey that was conducted in 2013 and supplemented in 2016 with additional data. LiDAR data were collected along the river corridor in 2013 to characterize the ground surface of floodplain areas. Sub-surface materials were characterized during an onsite investigation in 2013 to understand the sediment composition of materials that would become exposed after re-meandering took place. The sub-surface data collection involved probing to more resistant materials and digging trenches to verify the materials encountered. Results from the survey suggested that the former channel bed was at an elevation near the existing channel elevation, and the relict bed material was generally coarse sand, similar to the current river bed.

Following the field assessment, the proposed channel alignment was developed based on (1) LiDAR data to identify the pre-channelization sinuosity, and (2) reference reach data in a nearby river with similar physiographic variables. The cross sectional geometry and hydraulic capacity was designed based on flow statistics for similar fluvial systems, regional hydraulic geometry equations, LiDAR data, and hydraulic model results to maintain sediment transport capacity.

The re-meander project will involve channel reconstruction, bank stabilization, and habitat enhancement to achieve the goals listed above.

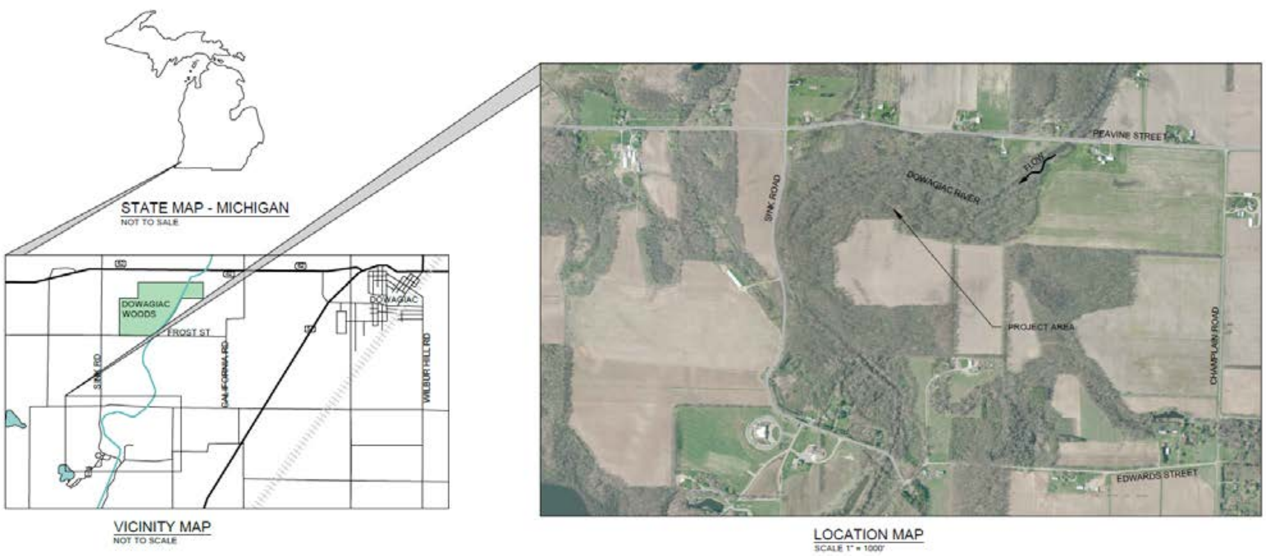

Figure 1. Location of the Dowagiac River and Dowagiac River Restoration Project.

Hydrology

Annual exceedance probability (AEP) flood discharges were obtained from the Michigan Department of Environmental Quality via process number 20170205 for the Dowagiac River 2500 feet downstream of Peavine Street, Section 17, T6S, R16W, Pokagon Township, Cass County (Watershed Basin No. 34 Joseph) (Table 1). This location corresponds to reach station 16022 of the existing conditions model and reach station 19565 of the design conditions model. According to the MDEQ Hydraulic Report Guidelines, the 1% AEP flood (100-yr flood) needs to be analyzed for changes to the energy gradient. The 1% AEP flood on the Dowagiac River in the project reach was estimated to be 1,500 cfs by DEQ.

The flood discharges in the Dowagiac River are relatively muted due to the high infiltration capacity of soils in the watershed that promote infiltration of precipitation (Fongers, 2012). The porous soils are the product of glacial outwash channels and till deposits.

Table 1. Flood quantiles at project site provided by MDEQ.

Recurrence Interval (years)	MDEQ
2	750
5	950
10	1100
25	1200
50	1300
100	1500
200	1600
500	1800

Hydraulics

A one-dimensional, steady-state HEC-RAS model (version 5.0.5; USACE) was developed to understand hydraulic characteristics of the river under existing and designed conditions.

MODEL SETUP

The following sections describe the model setup.

Geometric Data

The existing conditions model cross section geometry was based on survey data collected within the channel in 2013 and 2016. Outside of the channel, LiDAR data were collected for this project reach in 2013. These datasets were integrated in AutoCAD Civil 3D® then exported into HEC-RAS for further model development.

Around the project reach between Peavine Street and Crystal Springs Road, a total of 33 cross sections were created along surveyed sections for an average spacing of 220 feet. This entire reach of channel is bounded by levees that were constructed in the early 20th Century. The direction of flow is relatively straight, resulting in generally one-dimensional flow vectors that are well-represented by a one-dimensional model. In the vertical direction, there is approximately 3.5 feet of head drop through the reach during the 1% AEP. Therefore, there is only about 0.1 feet of head drop between cross sections. Due to the consistent flow direction and relatively low-gradient of the reach, the number of cross sections provided a thorough description of hydraulic form resistance.

Upstream and downstream of the project reach, there was a lower density of cross sections. At least four cross sections were developed around each bridge crossing, in accordance with the HEC (2016) guidance for understanding hydraulic conditions.

The design conditions model geometry required cutting new cross sections through the re-meandered reach. Because the new channel alignment is twice as long as the existing alignment, cross sections had to be re-oriented perpendicular to anticipated flow directions. The direction of flow on the floodplain surfaces was previously investigated through a two-dimensional HEC-RAS model.

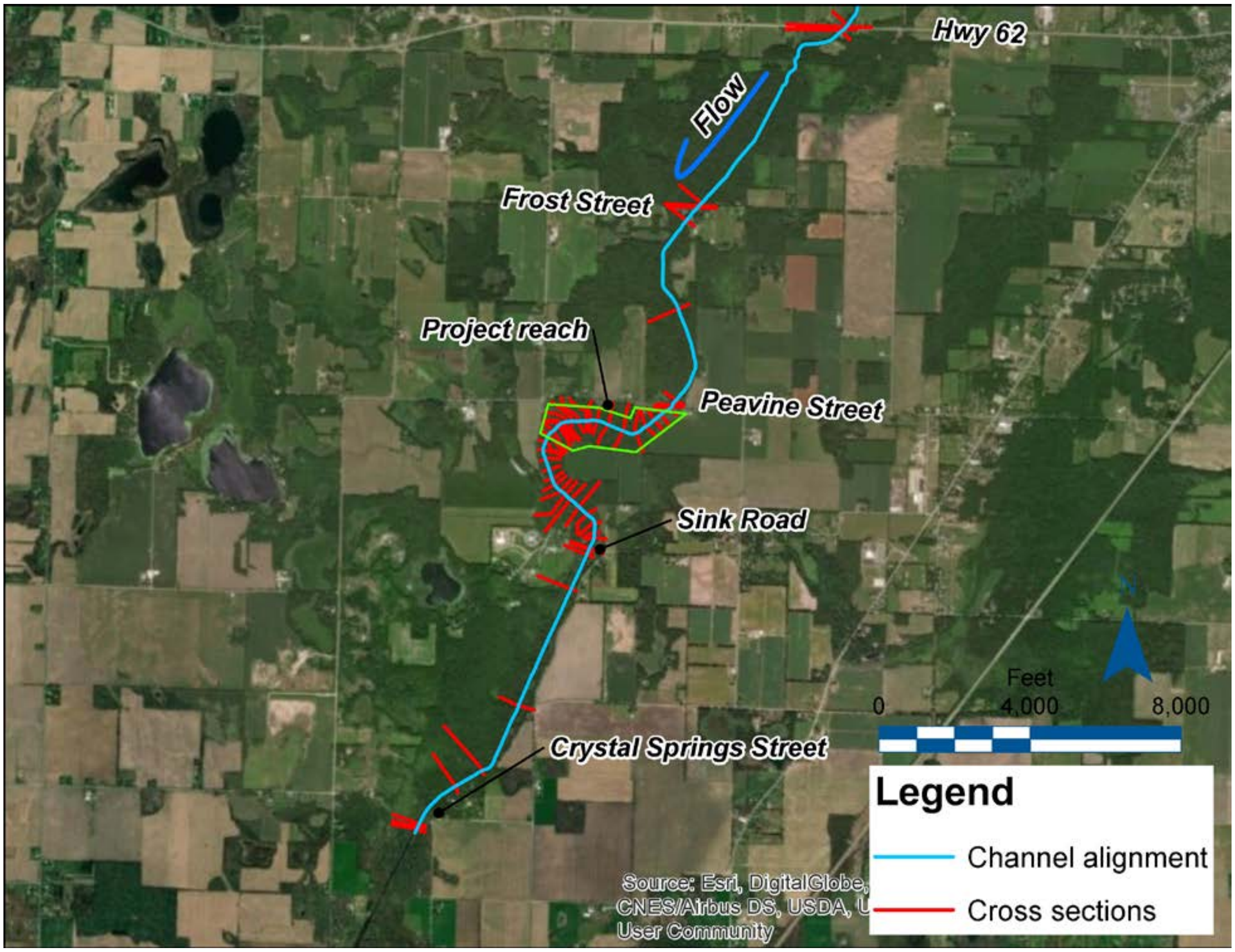

Figure 2. Cross section locations for the existing conditions model. The re-meander project reach is outlined in green.

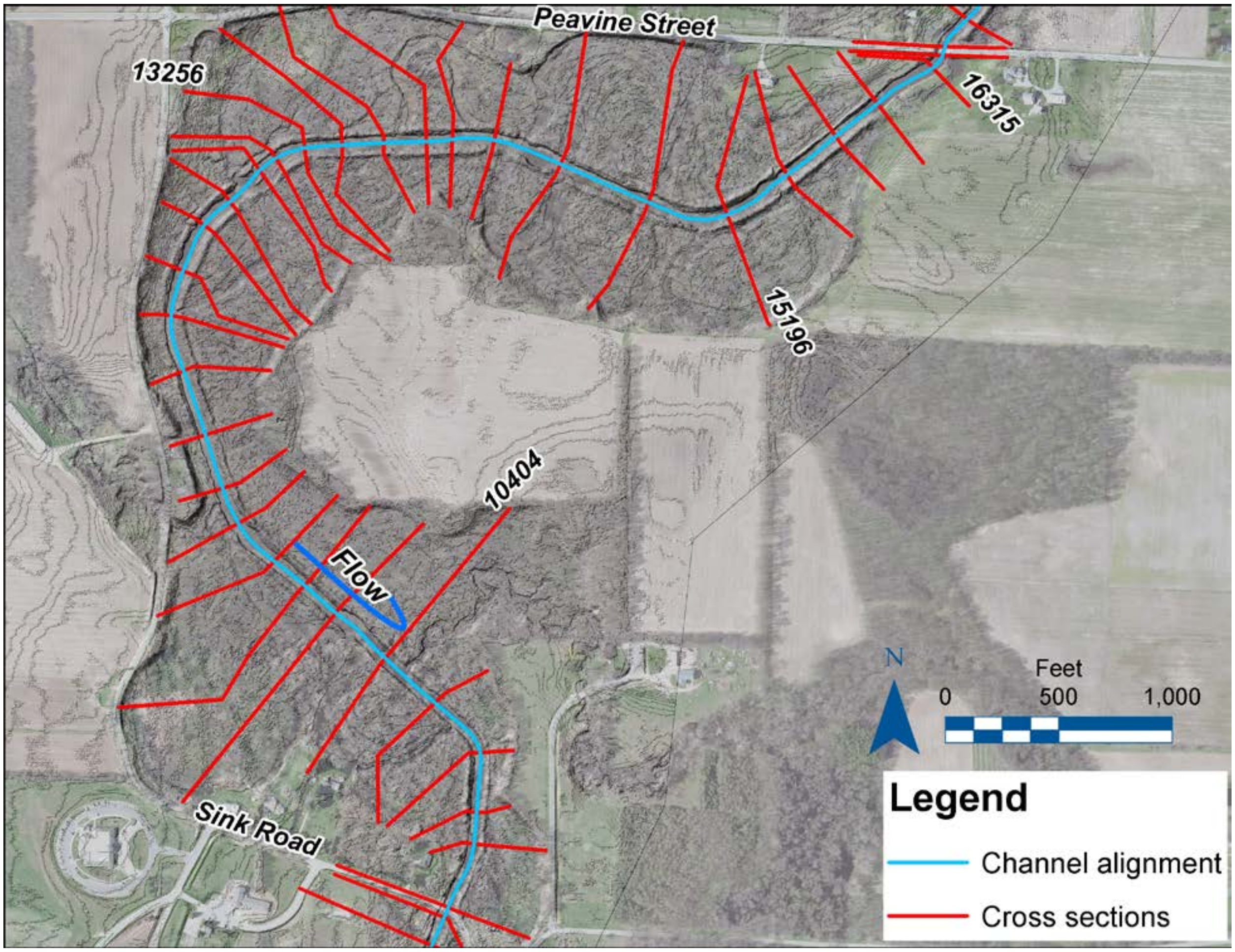

Figure 3. Cross sections and channel alignment for the existing conditions HEC-RAS model.

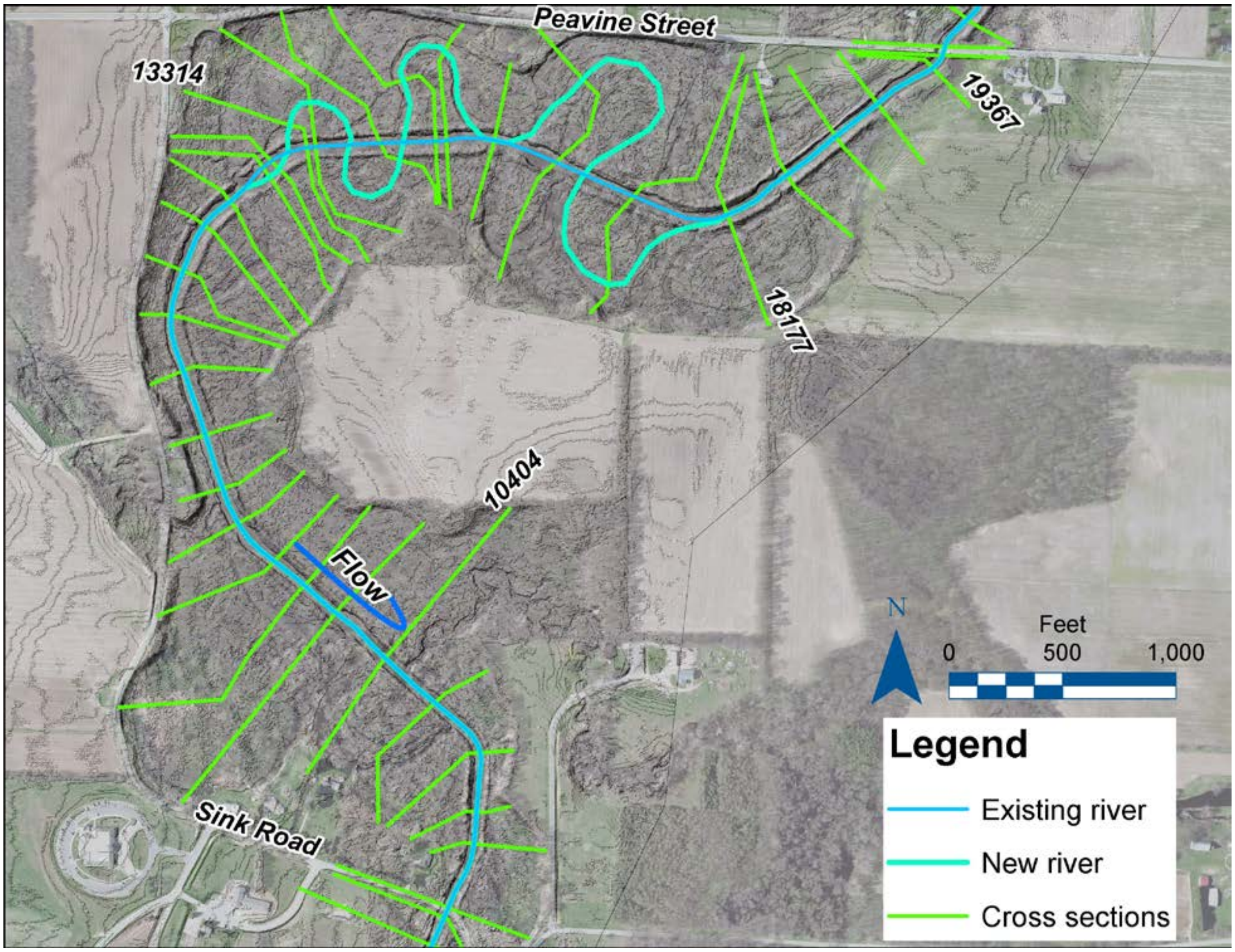

Figure 4. Cross section locations within the project area that represent finish conditions.

Hydraulic Parameters

Roughness values for the existing conditions model were calibrated to match modeled and measured water surface elevations during a 20% AEP flood. The measured water surface elevations were located near the Peavine Street and Sink Road Bridges with one additional measurement 1,200 feet upstream of Sink Road. The resulting channel roughness value was 0.045. For the levee and floodplain areas, we specified a Manning's n value of 0.10 based on interpretation of reference data provided by Arcement and Schneider (1989).

Additional energy losses were specified in the expansion and contraction coefficients. Around bridges, the two adjacent sections included a contraction ratio coefficient of 0.3 and an expansion coefficient of 0.5, as suggested by HEC (2016). For all other areas, a contraction coefficient of 0.1 and an expansion coefficient of 0.3 were used.

Ineffective flow areas were established around bridges and on floodplains outside of levees. The sections adjacent to each bridge included ineffective flow areas defined by a contraction ratio of 1:1 and an expansion ratio of 2:1 as suggested by HEC (2016) for rivers with similar physical characteristics. The floodplain areas outside of the levees were specified as ineffective flow. The water surface elevation that triggers active flow in these areas was defined based on the overtopping of notches in the levee and the ability of flow to move down valley across high points in the floodplain. For most areas, this down valley conveyance was negligible up to the 1% AEP flood.

For the design conditions model, roughness values were retained from the existing conditions. The channel roughness will be similar with a sand bed and some large wood roughness. There are numerous trees currently falling into the river as the channel adjusts to the dredging and straightening project. In the new channel, some large wood bank structures will be installed where the new channel crosses the old to provide stability. These structures will be tucked into the bank and not project more than 20% of the channel width. Floodplain areas will not be graded or altered so that roughness values will remain the same as well.

Boundary Conditions

For the upstream boundary conditions, the 1% AEP flood discharge of 1,500 cfs was defined. The downstream boundary condition was specified as a stage-flow rating curve derived from measurements at the USGS gauging station 04101800 on the Dowagiac River at Sumnerville. Because the gauging station is located 4,700 feet downstream of the last cross section in the HEC-RAS model, we adjusted the stage data by the change in water surface elevation measured with the LiDAR data. Although there is some error associated with this process, the downstream limit of the HEC-RAS model is sufficiently far from the project reach that it does not impact hydraulic results.

MODEL RESULTS

The design conditions model results indicate that water surface elevations during the 1% AEP flood will drop in the project reach. The magnitude of the drop is mostly less than 0.2 feet. Immediately upstream of Peavine Street, the water surface elevation drops 0.08 feet from 711.20 feet to 711.12 feet. The change in lateral inundation extent is relatively small. The primary change is the inundation of the levee footprint following project construction.

Although there is a slight reduction in water surface elevation during the 1% AEP flood, the project will still fulfill performance criteria. During the lower magnitude floods, oxbows and other depressions on the floodplain will actively convey water down valley more frequently. This will reconnect the floodplain to improve sediment and nutrient exchange, provide refuge for native fishes, and promote healthier habitat for tribally important vegetation.

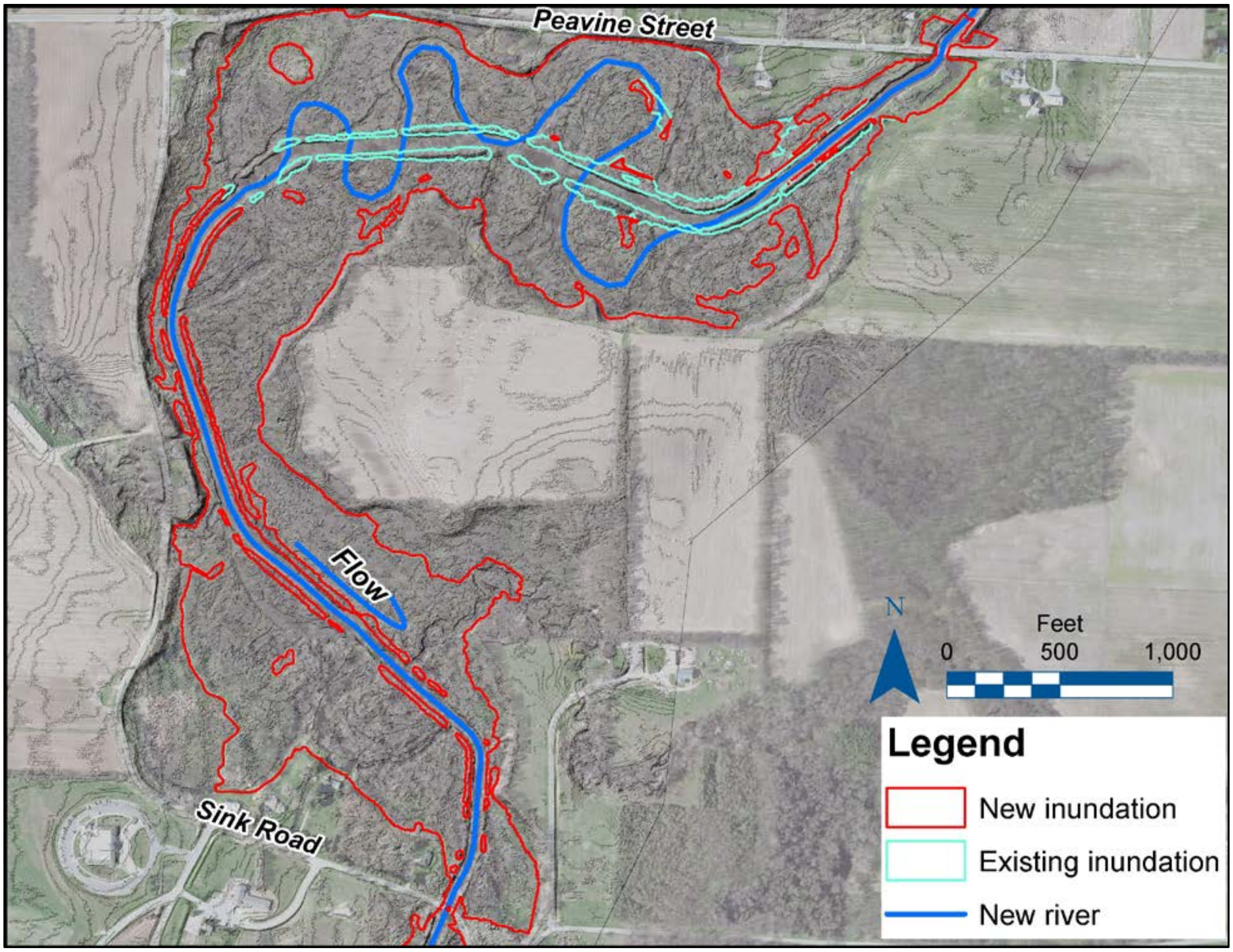

Figure 5. Inundation extent at the 1% AEP flood for existing and design conditions.

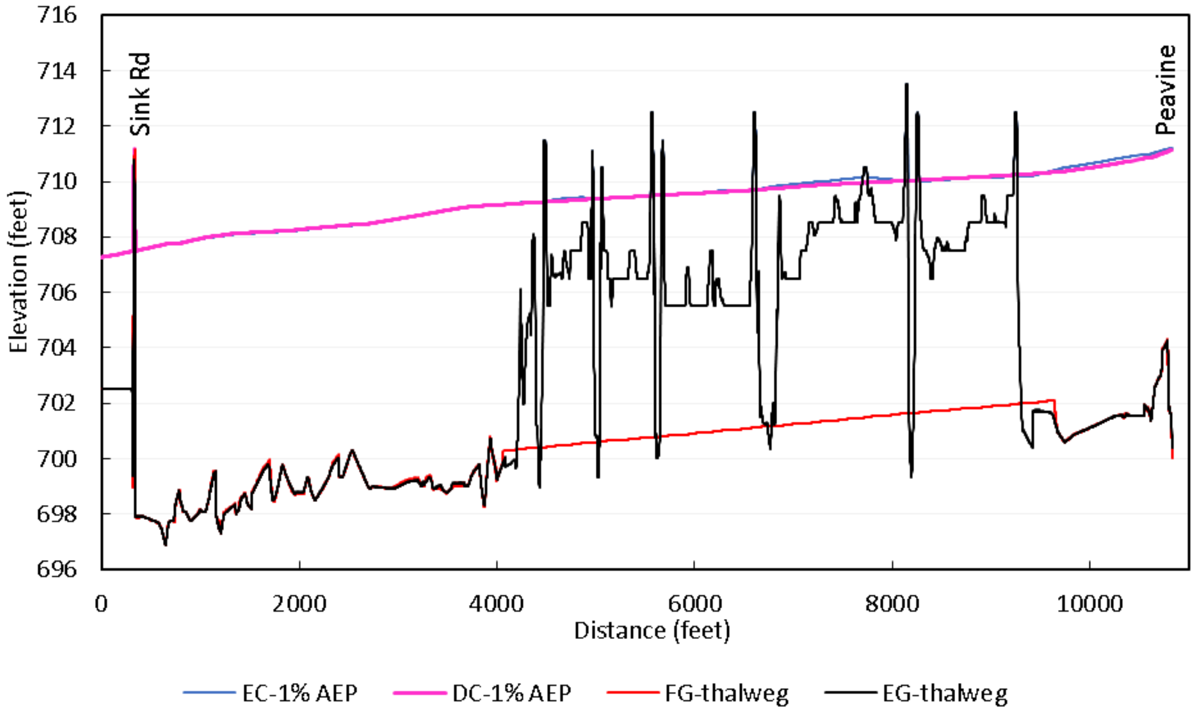

Figure 6. Water surface profile of the 1% AEP flood under existing conditions (EC-1%AEP) and design conditions (DC-1%AEP). Note the slight drop in water surface elevation at Peavine Street. (FG = Finished Grade along the new channel centerline; EG = Existing Grade along the new channel centerline)

References

Arcement, G.J., and V.R. Schneider. 1989. Guide for selecting Manning's roughness coefficients for natural channels and flood plains. USGS Water-Supply Paper 2239.

Fongers, D., R. Day, and J. Rathbun. 2012. Application of the Richards-Baker flashiness index to gaged Michigan rivers and streams. Michigan Department of Environmental Quality, Lansing, Michigan.

U.S. Army Corps of Engineers (USACE). 2016. HEC-RAS River Analysis System, User's Manual. Hydrologic Engineering Center, Davis, California.

Appendix A: HEC-RAS results

Existing conditions model results:

River Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
28981.14	705.66	715.92	708.89	716	0.000422	2.22	419.71	243.14
28901.86	705.65	715.88	709.01	715.97	0.000389	2.32	401.85	44.82
28850	Bridge							
28828.74	707.33	715.82	710.12	715.92	0.000581	2.65	351.35	275.18
28745.58	705.56	715.77	709.56	715.88	0.0005	2.67	398.36	1130.03
22536.49	702.55	713.85	706.06	713.91	0.000217	1.82	525.56	757.31
22430.34	702.73	713.73	707.89	713.86	0.000707	2.87	337.13	503.72
22400	Bridge							
22373.15	702.91	713.7	706.86	713.82	0.000544	2.74	340	402.38
21926.96	703.03	713.42	706.72	713.56	0.000586	2.91	477.58	589.2
19229.14	701.75	712.32		712.35	0.000334	2	1823.21	883.78
16602.19	700.51	711.2		711.31	0.000475	2.83	741.73	246.58
16428.29	701.34	711.04	705.37	711.21	0.000778	3.23	431.43	60.69
16400	Bridge							
16386	701.39	710.99	705.37	711.13	0.000625	2.99	465.03	71.48
16315	701.56	710.98	705.5	711.07	0.000392	2.43	711.89	279.51
16022	701.15	710.81	705.12	710.93	0.000547	2.84	636.57	187.31
15790	701.11	710.65	704.83	710.8	0.000574	3.08	491.46	275.57
15515	700.48	710.51	704.27	710.64	0.000545	2.95	509.7	468.95
15196	701.41	710.21	705.52	710.4	0.001033	3.54	424.47	721.61
14829	697.63	710.14	702.08	710.21	0.000225	2.05	945.16	926.59
14406	699.79	709.97	704.23	710.07	0.000433	2.59	765.85	1024.89
14095	699.87	709.76	704.36	709.9	0.000712	2.99	510.44	552.86
13909	699.69	709.65	704.15	709.78	0.000587	2.85	526.47	714.3
13794	699.89	709.56	703.79	709.7	0.000662	3.02	497.15	921.92
13606	700.13	709.49	703.36	709.59	0.00043	2.62	575.81	862.96
13420	699.19	709.4	703.28	709.51	0.000436	2.69	567.41	1120.99
13256	698.4	709.34	702.94	709.44	0.000393	2.61	585.45	1002.16
13120	699.23	709.21	704.24	709.37	0.000716	3.16	497.84	785.56
13030	699.49	709.25	704.2	709.3	0.00026	1.79	1190.33	892.87
12841	699.1	709.18	703.12	709.24	0.000291	2.13	1296.85	727.63
12685	698.57	709.15	702.77	709.2	0.000255	2	1363.92	705.85
12462	698.94	709.09	702.69	709.14	0.000262	2.05	1435.92	601.22
12256	698.66	708.98	703.06	709.07	0.000453	2.67	1009.21	548.33
12005	699.11	708.8	703.56	708.93	0.000699	3.05	762.91	440.82
11705	698.78	708.62	703.01	708.73	0.000577	2.8	786.45	286.66

River Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
11458	698.94	708.48	702.84	708.6	0.000537	2.82	707.73	300.5
11288	699.21	708.41	703.23	708.51	0.000481	2.62	835.75	586.44
11054	699.19	708.34	702.67	708.4	0.000328	2.21	1274.31	771.14
10885	698.67	708.29	702.13	708.35	0.000296	2.21	1463.59	967.77
10701	698.61	708.21	702.55	708.29	0.00036	2.32	1170.37	1121.05
10404	698.97	708.15	702.49	708.18	0.000211	1.82	2143.37	960.61
10109	697.84	708.1	702.11	708.13	0.000178	1.68	2081.2	723.39
9806	698.02	707.95		708.04	0.000427	2.56	1128.71	537.83
9544	697.93	707.8	702.23	707.91	0.000523	2.94	815.56	341.85
9402	696.9	707.73	701.3	707.84	0.000466	2.85	704.9	341.92
9108.48	697.87	707.49	702.01	707.66	0.000794	3.31	453.24	346.16
9080	Bridge							
9059.96	698.68	707.47	702.17	707.61	0.000623	2.91	515.13	70.25
8925.81	697.84	707.36	702.15	707.51	0.000694	3.21	623.31	271.46
7930.35	696.45	706.79	700.79	706.91	0.000519	2.83	594.98	246.02
4545.18	695.48	705.21	699.38	705.31	0.000432	2.5	598.72	520.25
2511.57	694.16	704.17	698.23	704.31	0.000558	3.02	601.97	777.44
1700.67	695.07	703.55	698.91	703.73	0.000938	3.34	448.14	512.68
279.54	692.5	702.45	696.74	702.6	0.000674	3.1	497.37	331.81
221.81	692.63	702.24	697.84	702.53	0.001476	4.29	351.91	312.48
200	Bridge							
175.75	692.69	702.15	697.9	702.45	0.001623	4.45	338.77	92.4
112.18	693.14	702.15	696.84	702.31	0.000717	3.17	488.56	145.27

Design conditions model results:

River Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
31944	705.66	715.93	708.89	716.01	0.000421	2.22	420.17	243.46
31880	705.65	715.89	709.01	715.97	0.000388	2.31	402.18	44.82
31830	Bridge							
31807	707.33	715.82	710.12	715.93	0.000579	2.65	351.69	276.12
31706	705.56	715.78	709.56	715.89	0.000498	2.66	398.97	1132.51
25498	702.55	713.87	706.06	713.92	0.000215	1.81	527.64	760.15
25407	702.73	713.75	707.89	713.88	0.000703	2.87	337.97	509.6
25380	Bridge							
25350	702.91	713.72	706.86	713.83	0.000541	2.73	340.67	407.98
24891	703.03	713.44	706.72	713.58	0.000583	2.91	478.71	589.47
22217	701.75	712.39		712.42	0.000311	1.94	1885.68	889.97

River Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
19565	700.51	711.12		711.25	0.000673	2.97	722.02	244.49
19406	701.34	710.91	705.54	711.1	0.000962	3.54	423.3	60.49
19400	Bridge							
19367	701.39	710.84	705.52	711.01	0.000775	3.3	455.22	70.94
19296	701.56	710.83	705.66	710.93	0.00051	2.55	688.97	269
19003	701.15	710.63		710.76	0.000604	2.92	604.8	174.28
18771	701.11	710.5		710.63	0.000567	2.91	733.87	302.86
18497	700.48	710.37	704.25	710.47	0.000524	2.7	826.61	480.28
18177	702.03	710.28		710.33	0.000292	2	1373.8	803.12
17542	701.81	710.14		710.17	0.000184	1.65	2269.3	1210.29
15970	701.31	709.86	703.84	709.89	0.000184	1.59	2239.53	1146.52
15460	701.16	709.72		709.78	0.000268	1.98	1129.67	575.24
13882	701	709.61		709.65	0.00023	1.84	1497.98	783.3
13835	700.88	709.55	703.41	709.58	0.000175	1.64	2141.46	1109.57
13591	700.75	709.49	703.29	709.52	0.000204	1.65	1755.91	928.1
13462	700.5	709.3	703	709.35	0.000207	1.77	1571.76	918.52
13314	700.44	709.28	702.98	709.31	0.000192	1.71	1782.95	1053.14
13107	700.38	709.23	702.9	709.28	0.000211	1.79	1445.43	825.7
13050	700.38	709.22	702.9	709.26	0.000192	1.71	1596.79	895.48
12841	700.08	709.17	703.04	709.22	0.000222	1.95	1652.17	742.42
12685	698.57	709.14	702.77	709.18	0.000225	1.88	1700.29	705.61
12462	698.94	709.08	702.68	709.13	0.000256	2.02	1547.9	600.91
12256	698.66	708.97	703.06	709.06	0.000453	2.67	1067.76	547.82
12005	699.11	708.8	703.56	708.92	0.000669	2.98	839.41	440.82
11705	698.78	708.62	703	708.73	0.000578	2.8	785.79	286.59
11458	698.94	708.48	702.84	708.59	0.000538	2.82	706.94	300.29
11288	699.21	708.44	703.24	708.5	0.000367	2.29	1177.36	590.25
11054	699.19	708.36	702.67	708.42	0.000324	2.2	1285.87	773.56
10885	698.67	708.32	702.13	708.37	0.000262	2.08	1805.79	972.43
10701	698.61	708.24	702.55	708.31	0.000341	2.26	1424.66	1127.97
10404	698.97	708.18	702.49	708.21	0.000205	1.8	2172.53	962.05
10109	697.84	708.13	702.11	708.16	0.000173	1.67	2104.09	724.65
9806	698.02	707.99		708.07	0.000416	2.54	1147.7	538.67
9544	697.93	707.76	702.23	707.93	0.000659	3.29	536.44	341.04
9402	696.9	707.74	701.3	707.84	0.000412	2.68	937.92	342.43
9108.48	697.87	707.49	702.01	707.66	0.000794	3.31	453.24	346.16
9080	Bridge							
9059.96	698.68	707.47	702.17	707.61	0.000623	2.91	515.13	70.25
8925.81	697.84	707.36	702.15	707.51	0.000694	3.21	623.31	271.46
7919	696.45	706.79	700.79	706.91	0.000519	2.83	594.98	246.02

River Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
4534	695.48	705.21	699.38	705.31	0.000432	2.5	598.72	520.25
2485	694.16	704.17	698.23	704.31	0.000558	3.02	601.97	777.44
1676	695.07	703.55	698.91	703.73	0.000938	3.34	448.14	512.68
266	692.5	702.45	696.74	702.6	0.000674	3.1	497.37	331.81
218	692.63	702.24	697.84	702.53	0.001476	4.29	351.91	312.48
200	Bridge							
172	692.69	702.15	697.9	702.45	0.001623	4.45	338.77	92.4
100	693.14	702.15	696.84	702.31	0.000717	3.17	488.56	145.27

Appendix B: Site Photos

Figure 7. Typical channel conditions in the project reach.

Figure 8. Typical channel conditions in the project reach.

Figure 9. Typical floodplain conditions in the project reach.

Figure 10. Downstream view of the Dowagiac River from Peavine Street during a 20% AEP flood.

Figure 11. Upstream view of the Dowagiac River from Sink Road during a 20% AEP flood.