Title: Partridge Creek Channel Diversion Project

Waterbody Improved: Partridge Creek (part of AUID number 040201050101-04) is in the Carp Creek watershed in Marquette County, Michigan. Partridge Creek is not on the Clean Water Act section 303(d) list of impaired waters.

GRTS Numbers: 98502312-01 and 98502316-01 (pre and post monitoring support, respectively).

Problem: Partridge Creek is a small coldwater stream that, in 1970, was diverted from the city of Ishpeming's combined sewer system into the Cliffs Shaft iron mine's underground workings via the New York Pit. Removing Partridge Creek from the combined sewer system enabled the City to provide effective primary treatment for their wastewater. Water discharging from the mine workings was low in dissolved oxygen (DO) and high in mercury; macroinvertebrate populations were poor at one location immediately downstream from the mine discharge point; and the existing stream channel was incised with poor access to its floodplain.

Project Highlights: In 2013 the upstream channel was removed from the mine workings and returned to a constructed channel that overflows into the New York Pit at high discharges. The downstream channel was reconfigured and floodplain benches were constructed. The constructed channels are more sinuous, have more riffles and pools, and are better connected to their floodplain than the original channel (Figure 1). DO improved substantially although it does not meet the water quality standard for coldwater streams. Macroinvertebrates did not improve, perhaps due to colonization lag time.

Results:

Moving the channel out of the mine works increased DO concentrations in Partridge Creek, but two of the three sampled stations still do not fully meet the DO water quality standard. Prior to channel reconstruction activities, 100 percent of the DO values at stations 1 and 2 and 49 percent of the values at station 3 were below the coldwater stream criteria of 7 mg/L (Table 1; Figure 2). (Streams where greater than 10 percent of the DO values are below the water quality standard of 7 mg/L are considered "not supporting" the coldwater fishery designated use.) After reconstruction, 100 percent of the DO values at station 1 were above 7 mg/L, while only 54 percent and 60 percent of the values were above 7 mg/L at stations 2 and 3. Nonetheless, DO concentrations are improving at these stations; prior to reconstruction 100 percent of the values at station 2 and 8 percent of the values at station 3 were below 5 mg/L, and after reconstruction this improved to 7 percent and 0.1 percent, respectively (Table 1).

Improving but still relatively low DO concentrations, and/or colonization lag times, may explain the lack of improvement in macroinvertebrate communities at

stations 2 and 3 (Table 2). Daylighting the stream reach at station 1 resulted in an “Acceptable” rating, as expected. Macroinvertebrates at stations 2 and 3, however, did not noticeably improve in terms of total taxa, sensitive taxa, scores or ratings.

Metrics of channel stability improved substantially after the stream was reconstructed. The post-construction channel is more sinuous and less confined than the pre-construction channel (Figures 1 and 3). Floodplain width (defined as valley width at twice the bankfull depth) increased by over a factor of 10 at the upstream reach and by factors of 3 to 6 in the downstream reach (Tables 3 and 4 and Graphs 1 and 2). Floodplain connectivity also improved; channel entrenchment ratio (an expression of floodplain access) increased, and bank height ratio (an expression of channel incision) decreased after construction (Tables 5 and 6). Using EPA’s stream function assessment protocol, entrenchment ratios and bank height ratios were “Not functioning” prior to channel construction, and “Functioning” after construction.

<u>Partners and Funding:</u> Partners in this project were the City of Ishpeming, White Water Associates, the Environmental Protection Agency, and the Michigan Department of Environmental Quality. The Michigan DEQ funded the pre-construction and post-construction monitoring. The total project cost was $9.4 million; $8.7 million in Great Lakes Restoration Initiative funds and $700,000 in local match.

Photographs:

Downstream reach, prior to construction (2012)	Downstream reach, after construction (2014)
	

Figure 1. Aerial photos of the downstream reach. (Courtesy of Google Earth)

Figure 2. Station map.

Upstream reach, after daylighting from the mine works

N. Washington Street culvert

N. Washington Street bridge

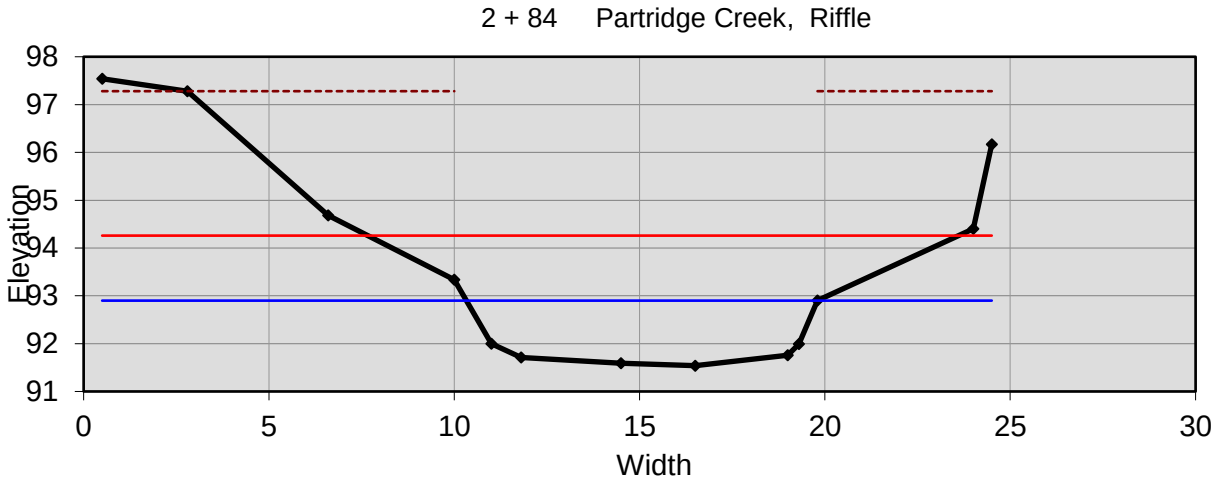
Downstream reach, before construction

Downstream reach, after construction

Figure 3. Pre- and post-construction photographs.

Data table/graph/chart:

Graph 1. Representative pre-restoration channel cross-section.



Graph 2. Representative post-restoration channel cross-section.

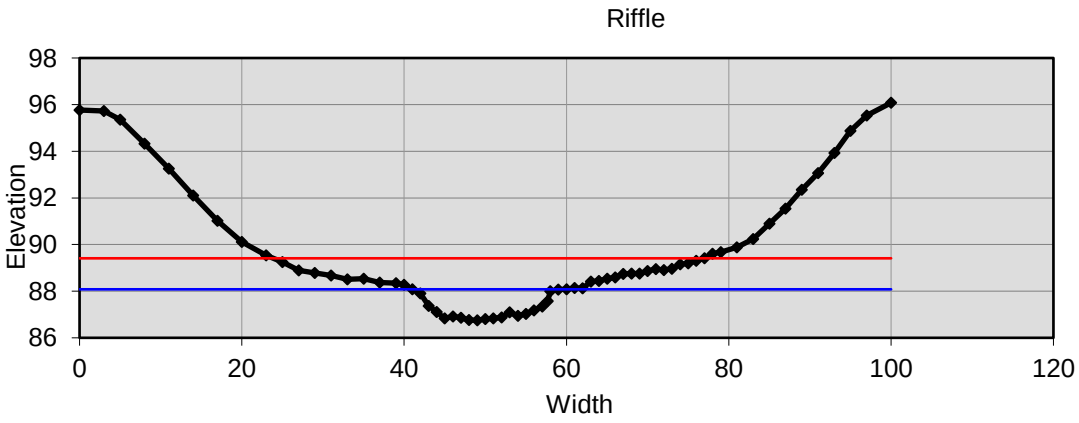


Table 1. Pre- and post-construction dissolved oxygen data; grab sample data at Station 1, continuous-recording sondes at Stations 2 and 3.

Metric	Station 1		Station 2		Station 3	
	Pre (2012; n = 5)	Post (2016; n = 4)	Pre (2012)	Post (2016)	Pre (2012)	Post (2016)
Minimum value (mg/L)	4.03	7.34	0.85	4.43	3.01	4.60
Average value (mg/L)	4.40	7.88	1.13	6.88	6.84	6.68
% of values below 7 mg/L	100	0	100	54	49	60
% of values below 5 mg/L	100	0	100	7	8	0.1

Table 2. Pre- and post-construction macroinvertebrate community data.

Metric	Station 1		Station 2		Station 3	
	Pre (2012; n = 5)	Post (2016; n = 4)	Pre (2012)	Post (2016)	Pre (2012)	Post (2016)
Number of taxa	This stream reach was underground in 2012	16	10	13	15	17
Number of mayfly, stonefly & caddisfly taxa		5	1	1	4	4
Score		-1	-5	-4	+1	-4
Rating		Acceptable	Poor	Acceptable	Acceptable	Acceptable

Table 3. Floodplain widths, prior to construction.

Upstream riffle	Downstream riffle
16.3 ft	15.9 ft

Table 4. Floodplain widths, after construction.

Upstream riffle	Downstream riffle #1	Downstream riffle #2	Downstream riffle #3	Downstream riffle #4
>150 ft	53.1 ft	55.5 ft	46.7 ft	102.5 ft

Table 5. Channel morphology function data, prior to construction (2012).

Stream Function Metric	Upstream riffle	Downstream riffle
Entrenchment ratio	1.3 (Not functioning)	1.7 (Not functioning)
Bank height ratio	4.2 (Not functioning)	3.2 (Not functioning)

Table 6. Channel morphology function data, after construction (2016).

Stream Function Metric	Upstream riffle	Downstream riffle #1	Downstream riffle #2	Downstream riffle #3	Downstream riffle #4
Entrenchment ratio	>2.2 (Functioning)	2.8 (Functioning)	2.0 (Functioning)	2.5 (Functioning)	4.5 (Functioning)
Bank height ratio	1.0 (Functioning)	1.0 (Functioning)	1.0 (Functioning)	1.0 (Functioning)	1.0 (Functioning)

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