Maple River Dam Removal Project

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Introduction

Many dams were used in the 1800s as a power source for saw mills and lumbering. Later, their main use transitioned to the production of hydropower as a renewable energy source. One of the largest impacts of dams is that they disrupt the natural flow of a river and transform the area behind the river into a reservoir lake. This means that dams allow for the formation of habitats not normally found in the river (Michigan DNR, n.d.).

The Maple River Dam in Pellston, Michigan has existed for over 100 years. Like many man made dams, the Maple River dam was first built in 1884 to generate power for the Pellston saw mill. The dam later broke but was rebuilt in 1960 for use as a hydropower plant. The rebuilding of the dam in 1960 caused to water of the Maple River to back up, creating Lake Kathleen (Maple River, n.d.).

In recent years, efforts have been made to start removing dams in rivers to restore ecosystems to their natural states. The Michigan DNR states that dams that are no longer serving a purpose and should be removed for safety, economic, and environmental reasons (Michigan DNR, n.d.).

Because dams have so much influence on the geography of the river, removal of a dam can have large ecological implications that need to be considered. One of the biggest changes, of course, will be that Lake Kathleen will no longer exist as it will be drained when the dam is no longer in place. The creation of a dam and reservoir lake change the natural flow of the water in the river as well as alter the transport of sediments from upstream to downstream (Higgs, 2002). While removing the dam and draining Lake Kathleen will restore the river back to it’s natural state, the change in flow and release of sediments may alter already established ecosystems.

Although the Maple River dam has historical significance, due to poor maintenance and the potential of a dam break, among other factors, plans have been made to remove the dam. Some residents support the return of the Maple River to its natural state, while others are weary of changes that will alter their use of the Maple River.

Despite predictions of physical and ecological changes, there are still many unanswered questions of what removal of the dam will mean for the Maple River. This project aims to develop a comprehensive data set on physical, biology, and chemical aspects of the Maple River and Lake Kathleen before the dam removal. Data collected and presented reflects aspects of the ecosystem that may be impacted upon removal of the dam. Data will be collected in the weeks and years following dam removal to evaluate what changes have actually occurred. As many dams are beginning to be removed from rivers across the country, this report may serve as as model for the potential benefits and consequences of dam removal elsewhere.

Methods

Data was collected for this project at five sites on Lake Kathleen and three sites on the Maple River. The Maple River sites were considered first priority due to their projected sensitivity to flow change and sediment deposition. Sites on Lake Kathleen were chosen based on where the Maple River naturally runs without the presence of the dam. Sites are located on bends of the river or near where the dam resides.

Site	GPS Coordinates
LK 1	(-84.779, 45.533)
LK 2	(-84.774, 45.531)
LK 3	(-84.777, 45.530)
LK 4	(-84.775, 45.530)

LK 5	(-84.774, 45.529)

Table 1. GPS coordinates of Lake Kathleen Sampling Sites

Site	GPS Coordinates
MB 5	(-84.775, 45.531)
MB 11	(-84.776, 45.526)
MB 31	(-84.773, 45.514)

Table 2. GPS coordinates Maple River First Priority Sampling Sites

Maple River

Physical

At each of the three priority sites on the Maple River, we began by measuring the width of the river in meters using a tape measure and dividing the transect into ten equal cells using flags. We measured the depth of each cell. At sixty percent of the cell depth from the bottom, the velocity was taken using a Hach flow meter. The following formula was used to calculate discharge.

$$((Depth_{cell\ 1} \ x\ Velocity_{cell\ 1}) + (Depth_{cell\ 2} \ x\ Velocity_{cell\ 2}) \ldots\ldots + (Depth_{cell\ n} \ x\ Velocity_{cell\ n}))\ x\ 0.001$$

We used a Eureka Hydrolab to obtain measurements for dissolved oxygen, pH, temperature, turbidity, and conductivity in each cell. This data was then recorded in the ArcGIS database.

Chemical

Using a 60 ml syringe and Hawp filter paper, water for chemical analysis was collected in acid wash bottles. One sample was collected at each site. Samples were 100-125 ml in volume. The water was then sent to the lab for analysis of NO_2,NO_3, NH_4, Total N, Total P, PO_4, and SiO_2. The Hawp filter was saved in tinfoil and submitted to the lab for Chlorophyll-a analysis.

Macroinvertebrates

Each river site was sampled for four macroinvertebrate microhabitats: sandy, woody, macrophyte, and rocky. Substrate was kicked into a square foot surber sampler and substrates were placed in an enamel pan. Macroinvertebrates were collected from the pan for a total of 30 minutes. The macroinvertebrates were kept in 70% ethanol in acid wash bottles until identification in the lab. The macroinvertebrates were separated into the five functional feeding groups: shredders, grazers, filtering collectors, gatherers, and predators using the Cummins et al. 2003 macroinvertebrate key. The number of individuals found in each feeding group were compared using ratios to evaluate characteristics of the ecosystem (Table 3). The macroinvertebrate ratios were then recorded in the ArcGIS database.

Ratios	Ecosystem Characteristics
Scrapers/shredders+total collectors	Autotrophic/Heterotrophic
Shredders/total collectors	Coarse POM/Fine POM
filtering collectors/gathering collectors	Suspended FPOM/Benthic FPOM
scrapers + filterers/shredders+gatherers	Channel stability
Predators/total all	Top down predator control

Table 3. Macroinvertebrate Ratios

Substrate

To examine general size of the substrate, we did a pebble count. At each river site, we took two steps and then picked the pebble immediately in front of our left big toe. We then measured the length and width of the pebble using a caliper. This was done for 100 pebbles. Pebbles were categorized using the Wentworth Classification. For every tenth pebble, we recorded the embeddedness based on the amount of the rock embedded in the substrate before it was picked up. The scale begins at 0 indicating it is not imbedded and continues to ¼,⅕,¾, and 1 which indicates fully submerged in the substrate.

Lake Kathleen

Chemical

In order to analyze for NO_2, NO_3, NH_4, TN, TP, PO_4, and SiO_2, a water sample was taken at each of the five sites on Lake Kathleen. A Vandorn Bottle was dropped to 1 meter depth and a messenger was sent down to close the bottle and collect the water sample. After the water sample was obtained, the water was filtered using a 60ml syringe and Hawp filter paper. Water for chemical analysis was collected in acid wash bottles. Water samples were 100-125 ml in volume. The Hawp filter was saved in tinfoil and submitted to the lab for Chlorophyll-a analysis.

Sediments

An Eckman grab was used to obtain a sediment sample at each of the five sites on Lake Kathleen. The Eckman grab was dropped to the bottom of the lake and a messenger was sent down to close the Eckman grab and collect the sample. Sediment samples were placed in Nasco Whirl Packs. In lab, sediments were placed in coffee filters and drained of excess water. Sediments were placed into aluminum foil boats and dried in an oven at 60℃ for 48 hours.

Sediments were then ground up in a soil mill and placed in 20 ml scintillation vials. Samples were sent to lab for analysis of lead and mercury.

Results

Physical

Site	Discharge (L/s)	Temperature (℃)	DO(mg/L)	Conductivity (ohms)	Turbidity (NTU)
MB 5	2714.63	17.596	9.23	311.84	2.749
MB 11	2772.78	18.208	9.136	307.74	1.296
MB 31	2774.17	18.561	9.506	321.23	N/A

Table 4. Calculated discharge as well as average temperature, dissolved oxygen(DO), conductivity, and turbidity at the three priority sites in the Maple River.

Discharge in the Maple River increased from 2714.63 L/second at MB 5 to 2772.78 L/s at MB 11 to 2774.17 L/s at MB 31. Temperature increased from MB 5 to MB 31 going from 17.596 ℃ to 18.561 ℃ at MB 31. Dissolved Oxygen levels and conductivity varied by site. Dissolved oxygen was 9.23 mg/L at MB 5, 9.136 mg/L at MB 11 and 9.506 mg/L at MB 31. Conductivity was 311.84 ohms at MB 5, 307.74 ohms at MB 11, and 321.23 ohms at MB 31. Turbidity was not taken at MB 31 but was found to be 2.749 NTU at MB 5 and 1.296 NTU at MB 11.

Substrate

Particle Size Range	MB 5	MB 11	MB 31
<0.1cm	0	0	0
0.1-0.2 cm	0	0	0
0.2-1.6 cm	13	32	44

1.6-3.2 cm	45	58	45
3.2-6.4 cm	38	20	11
6.4-12.8 cm	4	0	0
12.8-25.6 cm	0	0	0

Table 5. The number of pebbles in each of the respective size categories at each of the three priority sites in the Maple River

The width of all pebbles measured in the pebble count fell between 0.2 cm and 6.4 cm. At MB 13 pebbles fell into the 0.2-16 cm category, 45 fell into the 1.6-3.2cm category, and 38 fell into the 3.2-6.4cm category. At MB 11, 32 pebbles fell into the 0.2-16 cm category, 58 fell into the 1.6-3.2cm category, and 20 fell into the 3.2-6.4cm category. At MB 31, At MB 11, 44 pebbles fell into the 0.2-16 cm category, 45 fell into the 1.6-3.2cm category, and 11 fell into the 3.2-6.4cm category.

Site	Embeddedness Average (%)
MB 5	25
MB 11	50
MB 31	50

Table 6. Average Embeddedness of substrates at each priority site in the Maple River

Chemistry

The average embeddedness of substrate at MB 5 was calculated to be 25%. The average embeddedness was 50% at both MB 11 and MB 31.

Site	Nitrogen (ug N/L)	Phosphorus (ug P/L)

MB 5	480.642	7.929
MB 11	419.33	3.549
MB 31	489.512	5.652
LK 1	688.971	4.383
LK 2	422.528	6.62
LK 3	761.997	8.636
LK 4	953.329	10.805
LK 6	626.868	5.141

Table 7. Total nitrogen and phosphorus at each site on the Maple River and Lake Kathleen

Total nitrogen levels on the Maple River ranged from 419.33 ug N/L to 489.512 ug N/L while phosphorous levels ranged from 3.549 ug P/L to 7.929 ug P/L. Total nitrogen levels at Lake Kathleen ranged from 422.528 ug N/L to 953.329 ug N/L while total phosphorus levels ranged from 4.383 ug P/L to 10.805 ug P/L.

Site	N:P
MB 5	60.6:1
MB 11	118.2:1
MB 31	86.6:1
LK 1	157.2:1
LK 2	63.8:1
LK 3	88.2:1
LK 4	88.2:1

LK 6	121.9:1

Table 8. Ratios of total nitrogen to total phosphorus at each site on the Maple River and Lake Kathleen

All sites on The Maple River and Lake Kathleen showed ratios of nitrogen to phosphorous greater than 60:1. The highest ratio on The Maple River was 118.2:1 while the lowest was 60.6:1. The highest ratio on Lake Kathleen was 157.2:1 while the lowest ratio was 63.8:1.

Site	Chlorophyll-a concentration (ug/L)
MB 5	.4876
MB 11	.4255
MB 31	.2079

Table 9. Chlorophyll-a levels at each of the Maple River sites

Chlorophyll-a concentrations were found to be .4876 ug/L at MB 5, .4255 ug/L at MB 11, and .2079 ug/L at site 31.

Macroinvertebrates

Microhabitat	Autotrophic vs. Heterotrophic	Suspended FPOM Benthic FPOM	Channel Stability
Sandy	0.04	0	0.04
Macrophyte	0	0.5	0.5
Rocky	0.26	6	1.63
Woody	0	0	0

Table 10. *Macroinvertebrate ratios for MB 5.*

All of the microhabitats had autotrophic versus heterotrophic ratios below 0.75. The suspended/benthic fine particulate organic matter ratios were above 0.25 at the macrophyte and rocky microhabitats of this site. The channel stability ratio was at or above 0.5 in the macrophyte and rocky microhabitats for site 5.

Microhabitat	Autotrophic vs. Heterotrophic	Suspended FPOM Benthic FPOM	Channel Stability
Sandy	0	0	0
Macrophyte	0	0	0
Rocky	0	1	0.12
Woody	0	4	1

Table 11. Macroinvertebrate ratios for MB 11.

All of the microhabitats at site 11 were below 0.75 for the autotrophic versus heterotrophic ratio. The suspended/benthic FPOM ratio was below 0.25 in the sandy and macrophyte microhabitat. The channel stability ratio was above .5 in only the woody microhabitat.

Microhabitat	Autotrophic vs. Heterotrophic	Suspended FPOM Benthic FPOM	Channel Stability
Sandy	0.62	0	0.62
Macrophyte	0	9.2	2.55
Rocky	0.08	1.4	1.6
Woody	0.08	21	7.66

Table 12. Macroinvertebrate ratios for MB 31.

The autotrophic versus heterotrophic ratio was above 0.75 at none of the microhabitats at site 31. The suspended/benthic FPOM ratio was above 0.25 at all but the sandy microhabitat. Channel stability was above .5 at all of the microhabitats at site 31.

Discussion

Physical

One of a dam's most notable impact on a river is the change in flow. This disruption could affect the cycles that many aquatic organisms have adapted to (Higgs, 2002). Data on flow was collected at three different sites and showed that discharge increased from upstream to downstream. Discharge increased from 2714.63 L/second at site 5 to 2774.14 L/second at site 31 (table 4.). When dams are placed in rivers, they often make water velocity more constant throughout the river. One possibility that may result from removing the dam is a less constant flow rate (Higgs, 2002). For example, although higher discharge should still be seen downstream after the dam is removed, a larger difference may exist between discharge in sites upstream versus sites downstream. A more diverse flow may lead to more biodiversity as different organisms have adapted to live in different levels of water velocity. If the natural state of the river is more heterogeneous in flow, than biodiversity may become more heterogeneous as well.

Dams have been known to have an impact on the temperature in the river. Depending on whether the dam draws water from the top or bottom of the reservoir lake, the existence of a dam could make the river warmer or colder especially immediately after the dam. The Maple River dam pulls from the top of Lake Kathleen, where the water should be warmer. Temporary fluctuations in temperature may be seen when the dam is first removed however, like flow, temperature should be restored to its natural state (Higgs, 2002). Currently, temperature increases from upstream to downstream, ranging from 17.596 ℃ at site 5 to 18.561℃ at site 31 (table 4.). It is possible changes will be seen in these temperature patterns after dam removal because there are many other factors that go into determining the temperature of the water. Temperature change may be difficult to predict.

Turbidity and conductivity may both increase when the dam is removed as the sediments from Lake Kathleen are released. Current data on turbidity and conductivity can be located in table 4. Like most other changes, however, this will most likely be temporary and the river should return to its natural state after the river is given a chance to settle.

Embeddedness

An embeddedness analysis is an indication of how much erosion will occur when the dam is removed and sediments are released. A larger, more embedded rock would be less likely to be washed down the river and will be less affected by erosion. Our analysis of sediments demonstrated that most substrate at the sites on the river falls into the category of 0.2-1.6 cm or 1.6-3.2 cm . Site 31 showed the smallest average substrate size followed by site 11 and then site 5 with the largest average substrate size (table 5.) Site 31 and site 11 showed a higher level of embeddedness with an average of 50% while site 5 showed an average embeddedness of 25% (table 6.). This may mean that more substrate from site 5 may be washed downstream. The larger substrate size, however, may buffer against this erosion.

In addition, when sediments are washed downstream, they have the potential to destroy spawning areas for fish that prefer rocky substrate. Any area below the dam has the potential to be covered by sediments causing a reduction in spawning area. Like most changes, this flushing of sediments is predicted to be temporary although it is not known though how long the river will take to return to its natural sediment transport conditions. Some rivers have reported to have all sediments washed down in just a few weeks while others have taken centuries (Higgs, 2002).

Chemistry

As previously mentioned, a potential concern of removing the dam may be that certain nutrients that reside in the reservoir will be washed down the river, perhaps changing the ecosystem dynamics. Based on the Redfield ratio, most aquatic organic matter is composed of carbon, nitrogen, and phosphorous in a ratio of 106:16:1 (Townsend et al, 2008). When ratios of total nitrogen to total phosphorous were calculated for the sample sites on the Maple River and Lake Kathleen, they were all greater than 16:1 with the lowest ratio being 60.6:1 (table 8). This would indicate that all sites sampled both in the Maple River and Lake Kathleen are phosphorus limited. Because the river is phosphorus limited, more nitrogen shouldn’t change ecosystem processes significantly. We predict that, because both the lake and river have excess nitrogen, removing the dam should not have significant impacts in respect to these two chemicals.

Benthic sediment samples were obtained from the five sites on Lake Kathleen and analyzed for traces of mercury and lead. If the sediments in the reservoir lake have accumulated significant amounts of toxins, this could potentially damage ecosystems in the river as these toxins would begin to move downstream. Although analysis of these sediments is still being conducted, knowledge of the presence of these elements will be important in evaluating potential effects of removing the dam and perhaps what precautions need to be taken to monitor the potential negative effects of these toxins on organisms and ecosystems in the river (Higgs, 2002).

Data on chlorophyll-a was also included (table 9.). The concentration of chlorophyll-a is often an indication of how much primary productivity is occurring in the ecosystem (Huot. et al, 2007). The concentrations of chlorophyll-a at each site in the river now will be important for comparisons of concentrations after the dam is removed. Comparing before and after concentrations of chlorophyll-a will allow for analysis of how all the other aforementioned factors, such as temperature and chemical changes, are coming together and impacting the ecosystem as a whole.

Macroinvertebrates

Returning the flow of the Maple River to its natural state creates a continuous environment for organisms to inhabit. Macroinvertebrates will be able to move between the main, East, and West branch freely. While is beneficial, it is possible that the removal of the dam may originally remove habitat for macroinvertebrates when sediments move downstream and flow of the river changes.

Currently, the macroinvertebrate ratio for channel stability indicates a wide range of stable attachments at site 31 (table 12.). At site 11, the ratios are all below .5 indicating an unstable environment for macroinvertebrates (table 11.). Site 11 is located on a bend in the river with higher flow and is deeper. Conditions like these might become more common if flow increases after the dam is removed. This would mean fewer suitable habitats for macroinvertebrates.

It is predicted that sediments from Lake Kathleen will flow into the Maple River following the removal of the dam. If this occurs, the substrate of the river will generally become sandier. The suspended organic matter ratios are high at all sites except in the sandy microhabitats. Suspended organic matter is important for filtering macroinvertebrates that collect their food from the water as it flows by. These unproductive sandy habitats may become more common after the dam is removed and sediments move downstream.

At site 5, 11, and 31, the autotrophic versus heterotrophic ratio indicates that the sites are mainly autotrophic (tables 10-12.). This is expected for most rivers. We do not predict that this will change because the surface area to riparian zone ratio should not change significantly.

Although ecological changes after dam removal are inevitable, exactly what changes will occur is still largely unknown. This report outlines a number of possible outcomes of removing the Maple River Dam. Whether these outcomes will be beneficial, both in the short and long term, is yet to be seen. The data presented in this paper can serve as a comparison to post dam removal data. These comparisons may serve as a resource for other dam projects to consider when making a choices about removal or replacement of aging dams.

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