Fish Barrier Survey of Twelve Mile Creek (Effingham Branch) Project

Submitted in order to fulfill the requirements of the Field Project course of the Ecosystem Restoration program at Niagara College, 2021-22

Group
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Prepare For: Trout Unlimited Canada – Niagara Chapter

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Executive Summary

This project aimed at identifying and prioritizing barriers to brook trout in the Effingham Branch of Twelve Mile Creek in Pelham, Ontario. Brook trout is a species of freshwater fish that is native to Eastern North America. They belong to the salmon family. Their bodies are very colorful, with pigmentation ranging from olive green to red, yellow, and red spots all over with a pale blue outline. Brook trout travel upstream for spawning and need specific conditions for their survival and spawning. They generally prefer clear cold waters of high purity and a narrow pH range and are sensitive to poor oxygenation, pollution, and changes in pH caused by environmental factors. The optimum temperature range for growth and survival is around 10-19°C, and the optimum temperature for spawning is 6°C (Hokanson, 1973). Below a pH of 5.5, brook trout need to relocate, or they may die (Fost and Ferreri, 2015). Due to these reasons, they are considered a valuable natural indicator as their ongoing presence indicates a healthy aquatic environment. The Twelve-Mile Creek (TMC) is of high importance for the brook trout species as this is the last cold-water stream in Niagara, where brook trout can survive and are found. Our project focused on the Effingham branch of the Upper Twelve Mile Creek (UTMC). The length of the main water body in the Effingham branch is roughly seven kilometers. This area is rural and is primarily used for agricultural purposes and private residences. A physical fish barrier is any object that causes any type of blockage in the waterway, impeding prolonged water flow and/or fish passage (NRC, 2001 and Collins et al., 2007). can be comprised of naturally or unnaturally occurring debris, as well as structures that are man-made. Some examples of common blockages include woody debris, beaver dams, poorly designed weirs, undersized or poor functioning culverts, and other human-made crossings. Many of these barriers may not be an issue now, but in the long term, due to more deposition, these barriers have the potential to be a big issue. They can prevent brook trout from traveling upstream for spawning and even destroying their spawning beds. This project depended on aerial photography to find potential barriers, and these assumptions were confirmed by many site visits and walk-in surveys. Many barriers were found. and all the data collected was ranked by priority. The ranking included minor, intermediate, and major barriers. The results of this study will be shared with to the Niagara Chapter of Trout Unlimited Canada so they can further evaluate the results to see which barriers need to be removed or managed for the betterment of the brook trout species.

Acknowledgements

We would like to express our sincere gratitude towards all individuals who have contributed to this project and supported the work that we have done. Foremost, we would like to thank Brian Green and Trout Unlimited Canada (Niagara Chapter) for providing the opportunity to assist with the great research and survey, including supporting the valuable information for the project. Thank you to Andrea Sinclair for assigning us to this project, and Jocelyn Baker for the continuous support and guidance of the project with her patience, motivation, enthusiasm, and knowledge.

We also would like to thank our fellow Ecosystem Restoration classmates who assisted us with a portion of our study. We are appreciative of Tim Hartwick, the Agape Valley Board of Directors who allowed us to complete the walking survey of the Twelve Mile Creek that belongs to Agape Valley. Thank you to Jen Baker and the Hamilton Naturalists' Club, who allowed us access to the Short Hills Nature Park for the walking survey.

Finally, we would like to thank our team for their best cooperation and knowledge for driving the project until the end.

Table of Contents

1.0 Introduction

The project focuses on identifying and prioritizing barriers to fish passage in the Effingham Branch of Twelve Mile Creek (TMC) in Pelham, Ontario. Specifically, the passage of brook trout.

Brook trout are a species of freshwater fish that belongs to the salmon family. They are native to Eastern North America. They prefer clear, cold waters of high purity and are sensitive to poor oxygenation, pollution, and changes in pH caused by environmental factors. Wild brook trout will start to avoid water when it has a pH of 5.5-6.0 (Fost & Ferreri, 2015). Below a pH of 5.5, brook trout need to relocate, or they may die (Fost & Ferreri, 2015). The optimum temperature range for growth and survival is around 10-19°C, and the optimum temperature for spawning is 6°C (Hokanson, 1973). Due to these reasons, they are considered a valuable natural indicator as their on-going presence indicates a healthy aquatic environment. The Twelve Mile creek is the last remaining cold-water creek in Niagara with a breeding population of brook trout.

This project aims to identify existing physical barriers to the movement of these fish and categorize barriers based on priority (minor, intermediate, or major). All of these barriers will be listed in Appendix III. The importance of this project rises as this creek is the last remaining cold-water creek where brook trout can be found in Niagara. Identifying these physical barriers will allow future projects to enhance the breeding and feeding habitats for brook trout which will in turn help in the species population.

2.0 Goals, Target, and Objectives

2.1 Goals

The main goal of this project is the identification and prioritization of physical barriers to fish passage in the Effingham Branch of Twelve Mile Creek from sources above Metler Road in Pelham up to Short Hills Provincial Park in St. Catharines.

2.2 Targets

To guide and inform the habitat restoration and conservation plan for Niagara's last remaining brook trout population for the Niagara Chapter of Trout Unlimited Canada and to help satisfy implementation actions from the UTMC action plan 2021-2031.

2.3 Objectives

Outlined below are the objectives needed to achieve the goals stated in Section 3.1. above. These objectives are further reflected in a timeline in Section 6.3 of this proposal

1. Determine the fish barrier definition and the criteria for ranking barriers as minor, intermediate, or major.
2. Use aerial imagery to detect and create a map of all possible fish barriers.
3. Provide and update the database of all fish barrier locations and rank the priority of each barrier in the Effingham Branch of Twelve Mile Creek as minor, intermediate, or major

3.0 Background

3.1 Site Description

The TMC watershed is located in the Niagara Region, with the start of it being within the Town of Pelham. This creek sends water from Pelham down through Thorold, to Lincoln and St. Catharines, then emptying out through the Port Dalhousie Pier area into Lake Ontario. Within the TMC, there are 6 sub-watersheds, which are the Upper Twelve Mile Creek (UTMC), Lower Twelve Mile Creek, Richardson Creek, Lake Gibson System, Francis Creek, and Dicks Creek. Also, the UTMC is made up of the Effingham and St. Johns tributaries.

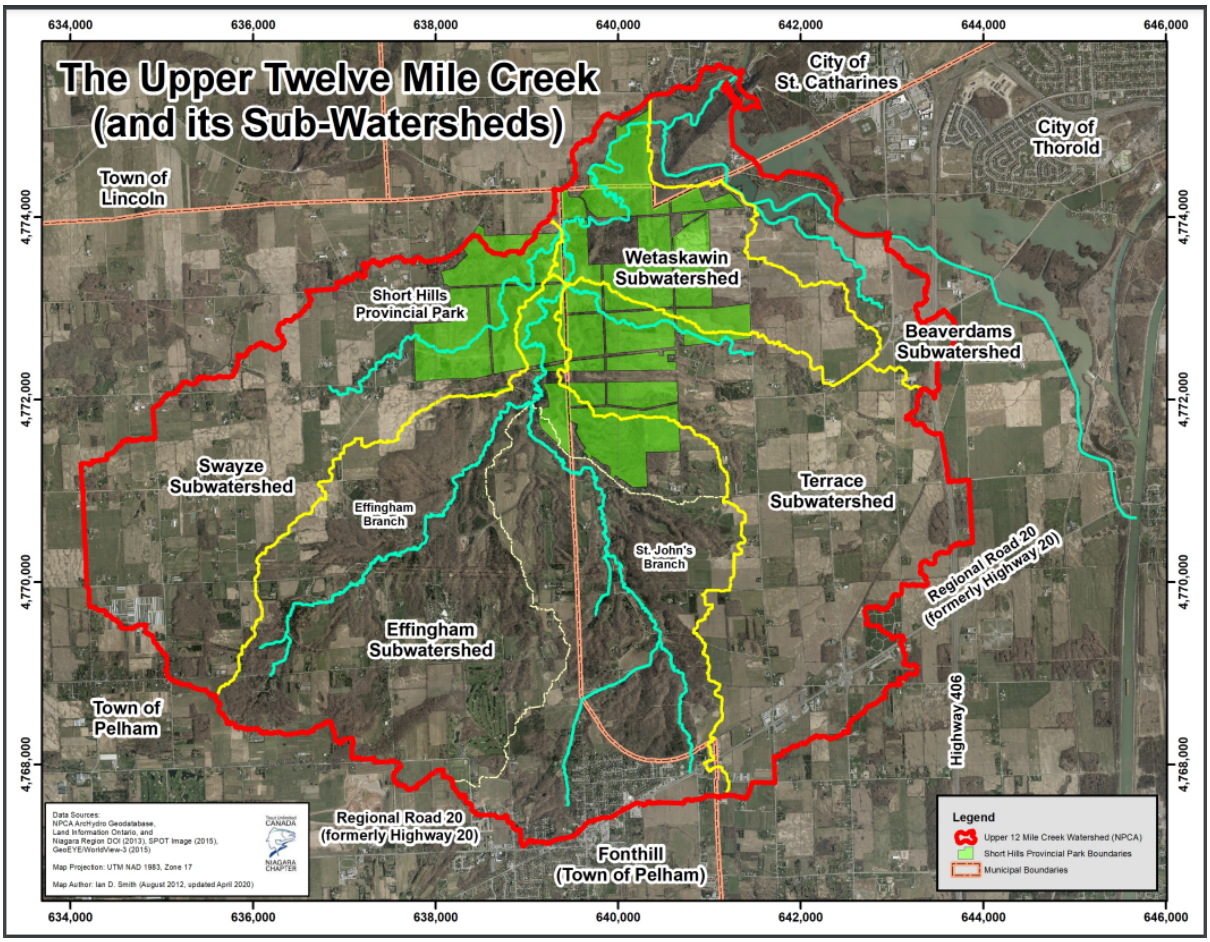

Figure 1. Map of Upper Twelve Mile Creek and its sub-watersheds (Trout Unlimited Canada Niagara Chapter, 2020)

The TMC is a multi-threaded creek, as it starts at multiple locations where groundwater is fed by springs in and around the Fonthill Kame. The springs were created by surface and groundwater mixing, due to the presence of the Fonthill Kame-Delta Complex (Fraser & Jones, 1982). This Kame was created 12.5 thousand years ago by a glacier flowing across the region when it deposited a large amount of gravel, silt and sand in a cylindrical shape and that is now known as the Fonthill Kame (Fraser & Jones, 1982).

The Effingham branch of the Upper Twelve Mile Creek is what this report will be focusing on. The length of the main waterbody in the Effingham branch is roughly seven kilometers, but there are many tributaries along that path that contribute to the overall size. This area is rural and is primarily used for agricultural purposes and private residences. There's also a large campground and resort to the southwest of the site. The roads within the site are all country roads and don't see much traffic.

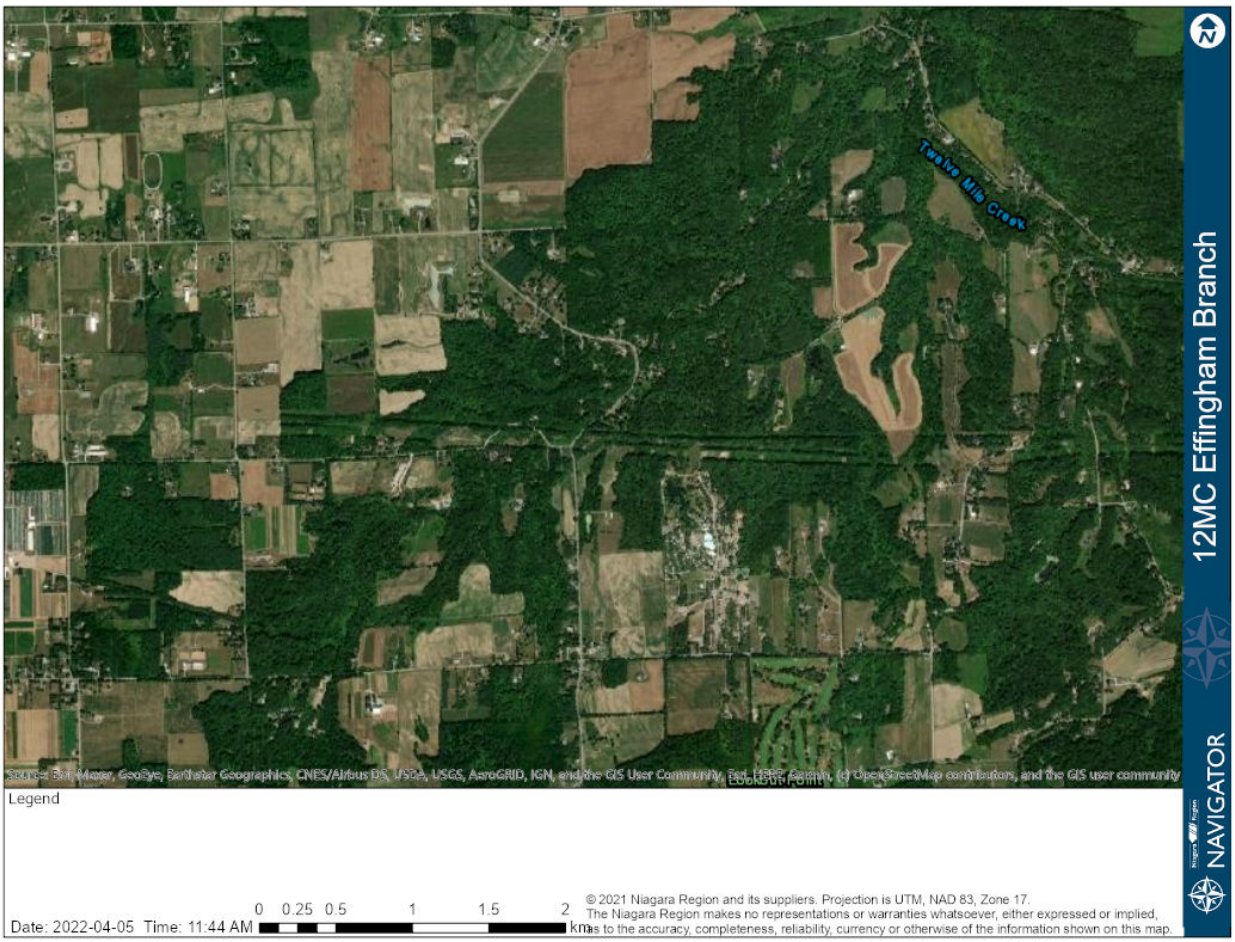

Figure 2. Map of the Pelham area where the Effingham branch of Twelve Mile Creek is located. Map created on Niagara Navigator (Niagara Region, 2021).

3.2 Brook Trout

The brook trout (*Salvelinus fontinalis*) lives in lakes or streams that are fed by aquifers or springs (Lake Ontario Waterkeeper, 2010; Crossman, Van Meter, 1979). Their bodies are very colorful, with pigmentation ranging from olive green to red, yellow and red spots all over with a pale blue outline, black and white streaks on the fins, milky white underside with a tail that is somewhat square (Queen's Printer for Ontario, 2014). Brook trout requires a specific temperature range for their survival and reproduction. A temperature range between 10°C and 16°C is preferred, and they cannot handle water temperatures above 23°C (Hokanson, 1973). For the successful spawning of brook trout, the water temperature during breeding season should not exceed 12°C (Hokanson, 1973). For spawning, brook trout are known to migrate upstream to headwater stream habitats (Hartman, 2006). These headwater habitats usually have a coarse rocky substrate and low temperatures that are essential for reproduction and spawning (Hartman, 2006). Finally, as the species is seen as a good indicator for the health of cold-water

bodies, various conservation groups do work to facilitate population growth within their natural habitat.

3.3 Fish Barriers

A physical fish barrier is any object that causes some type of blockage in the waterway, impeding prolonged water flow and/or fish passage (with an emphasis on adult brook trout) (NRC, 2001 and Collins et al., 2007). Some examples of common blockages include woody debris, beaver dams, poorly designed weirs, undersized or poor functioning culverts, and other human-made crossings. Determining whether water flow and/or fish passage is being obstructed to the point of harmful long-term impacts may need to be determined through consultation with fisheries experts.

Physical fish barriers can be comprised of naturally or unnaturally occurring debris, as well as structures that are human made (Bureau of Reclamation, 2018). Naturally occurring debris would consist of fallen trees, buildup of leaf litter, branches and twigs, rocks, etc. (Niagara Restoration Council, Niagara Peninsula Conservation Authority, 2007). Examples of debris that is unnaturally occurring are concrete, wood, metal, and miscellaneous garbage (Niagara Restoration Council, Niagara Peninsula Conservation Authority, 2007). Human-made structures that could be barriers are dams, weirs, and grates. Because brook trout require a clean creek with gravel and pebbles to create their spawning beds, anything that prevents brook trout from migrating to sections of the creek with these conditions can be considered a barrier. Natural debris such as logs, and artificial debris such as garbage can block the bottom of the creek and prevent brook trout from spawning. Erosion can also create barriers to brook trout. Sediment from erosion can deposit along the bottom of streams in which brook trout normally spawn in, creating a mucky bottom. When brook trout create their spawning beds (also known as redds) in areas with lots of fine sediment, there is generally a lower survival rate of their eggs (Soulsby, 2001). After their eggs are fertilized and buried, fine sediment can infiltrate their redds, reducing permeability and lowering the amount of oxygen available to the eggs (Soulsby, 2001). This results in an increased mortality rate of the eggs. Because of this, sedimentation can be considered a barrier to brook trout and needs to be monitored.

Some of these barriers may be more substantial or have a larger impact on brook trout than the others. Fish barrier project methodology (Niagara Restoration Council, 2001) rated fish barriers based on how much the barriers impacted the stream flow. Fish barriers will be prioritized to one of three levels: minor, intermediate, or major. An example of a high priority barrier would be a perched culvert where the water falls downwards out of the culvert and does

not allow fish to travel back upstream through the culvert (figure 3a). Another example of a high priority barrier is a large fallen log that blocks the entire flow of water for a long time or creates a waterfall which fish cannot pass. An intermediate barrier may be debris or sediment that blocks some, but not all the stream's flow (figure 3b). A minor barrier may be something such as a bridge support which has little effect on the natural flow of water but could become a bigger barrier if debris were to build up on it. The same goes for a culvert.

A)

B)

Figure 3. A) Perched culverts. **B)** Debris restricting the stream. These are examples of fish barriers found in the Niagara River Area of Concern (AOC) - Fish Barrier Project (Niagara Restoration Council, Niagara Peninsula Conservation Authority, 2007)

4.0 Scope of Work

The scope of work for this project focused on prioritizing physical barriers to fish passage in the Twelve Mile Creek watershed, specifically the Effingham branches from source at Metler Road through Short Hills Provincial Park. The Niagara River Area of Concern (AOC) Fish Barrier Project (2007), Evaluating Brook Trout Habitat and Restoration Potential in Short Hills Provincial Park: Effingham Branch report (2013), Twelve Mile Creek Effingham Branch Restoration Project Report (2017), and Upper Twelve Mile Creek Action Plan 2021-2031 (2021) were looked at. This project covered four key areas:

1. Literature review and defining a fish barrier
2. Aerial imagery survey to locate potential fish barriers
3. Confirming potential fish barriers through site visits and scoping out other barriers that cannot be seen through aerial imagery
4. Creating a fish barrier inventory and ranking barriers as minor, intermediate, or major barriers

5.0 Methodology

5.1 Fish Barrier Definition

The definition of fish barrier is determined by Niagara Restoration Council, Niagara Peninsula Conservation Authority as follows "*any object that causes some type of blockage in the waterway, impeding prolonged water flow or fish passage"*.

The definition used in the Fish Barriers Project covers natural structures and other human-made structures such as woody debris, beaver dams, poorly designed weirs, undersized or poor functioning culverts, and other man-made crossings.

For this project barriers were rated as Major, Intermediate, or Minor depending on the severity with which the barrier impacted stream flow and stream habitat.

5.2 Finding/Locating Fish Barriers

Three methods were used to find/locate fish barriers along the upper twelve-mile creek in the Effingham branch. These methods were driving, walking, and aerial imagery using Ontario Flow Assessment Tool.

5.2.1 Aerial Imagery Survey

We looked at aerial imagery on the Ontario Flow Assessment Tool (Ministry of Natural Resources and Forestry, 2020) to find the points where there are bridges over top of the creek

or where the creek crosses under roads through culverts. We recorded all of these points to create a list of potential fish barriers and created a map of them.

5.2.2 Driving Survey

At various times, the creek runs parallel or intersects with the road, so it is easy to inspect it at those points. As this covers a large area, we had to drive to each location. We divided up into groups of two and took half of the locations each. For most of the previously selected sites, we could only look at them from the road as they are on private property. With some, we were able to get closer. If there was a barrier, we took pictures and took the coordinates from Map app on our phones.

5.2.3 Walking Survey

For the portion of the creek that passes through the Short Hills Nature Park, Agape Valley, and other privately-owned land, we decided to walk along some of it and obtained the permission of a couple of the landowners to do so. We also had the help of volunteers for this area. For any barriers found in the creek, the volunteers filled out a form with an identifying code, GPS coordinates, what the barrier is comprised of, the severity of the blockage, whether it will get worse or not, and any other relevant information. They also marked the location on a map with the code, took a picture of the barrier and sent it to a *WhatsApp* group that we invited them to.

5.3 Data Collection

The Barrier Survey of Twelve Mile Creek (Effingham Branch) Project was started in January 2022. The initial three weeks of the project were spent on background research and literature review, organizing available material, and determining the basic features of fish barriers. Then, the second week was spent identifying locations of fish barrier by aerial photography. The proposed plan for the project will be finalized during the third week. The field safety and HASP planning were considered at the end of January.

Site surveying will begin in the first week of February after the proposal plan and HASP plan are completed. Site surveying is divided into two parts: 1. Barrier location, identification, and recording 2. Barrier assessment. The barrier mapping will be created by analyzing aerial photography and field data collection after the field survey is done. During week 4 of March and week 1 of April the fish barrier data will be compiled and organized into the project deliverables, then reported to Trout Unlimited Canada Niagara Chapter.

We estimate the timeline for a barrier survey project of this nature would take approximately 3 months to complete. A timeline detailing all tasks needed for the first, second, and third months of the survey project are outlined below (Appendix V.).

6.0 Result

6.1 Aerial Imagery Survey

Using aerial imagery with the Ontario Flow Assessment Tool (Ministry of Natural Resources and Forestry, 2020) we created a map (Figure 4) and list (Table 1, Appendix II) of potential fish barriers. Most of the potential barriers were found at locations where Twelve Mile Creek crosses underneath roadways. These locations have either culverts that cross under the roads, or bridges that cross over the creek. Ground truthing was used to check if the culverts and bridges were impacting the flow of the creek and acting as fish barriers. The barrier list includes the general location and general description of each potential barrier (Table 1, Appendix II). Although aerial imagery works very well to find culverts and bridges, it was difficult to see many parts of the creek, especially sections with good canopy cover. These sections could have potential barriers that we missed in aerial imagery, which is another reason why we visited these sites in person to inspect them.

Figure 4. Map of potential fish barriers in the Effingham branch of Twelve Mile Creek found using aerial imagery on the Ontario Flow Assessment Tool (Ministry of Natural Resources and Forestry, 2020). The map was created using QGIS version 3.16.11 (QGIS.org, 2022).

6.2 Road Survey

The fish barriers in Effingham Branch that surveyed by driving during March to April 2022 found about twelve barriers. Six barriers that consisted of two natural barriers such as Effingham1, and Kilman1 and four human-made barriers such as Metler1, Metler2, Metler3, Effingham2 have a minor impact on the creek (Figure 4. Orange point). While six barriers that have a major impact on the creek (Figure 4. Red point) are five natural barriers such as Luffman1, Luffman2, SulphurSpring1, Roland2, and Roland3 and one human-made barrier such as Roland1.

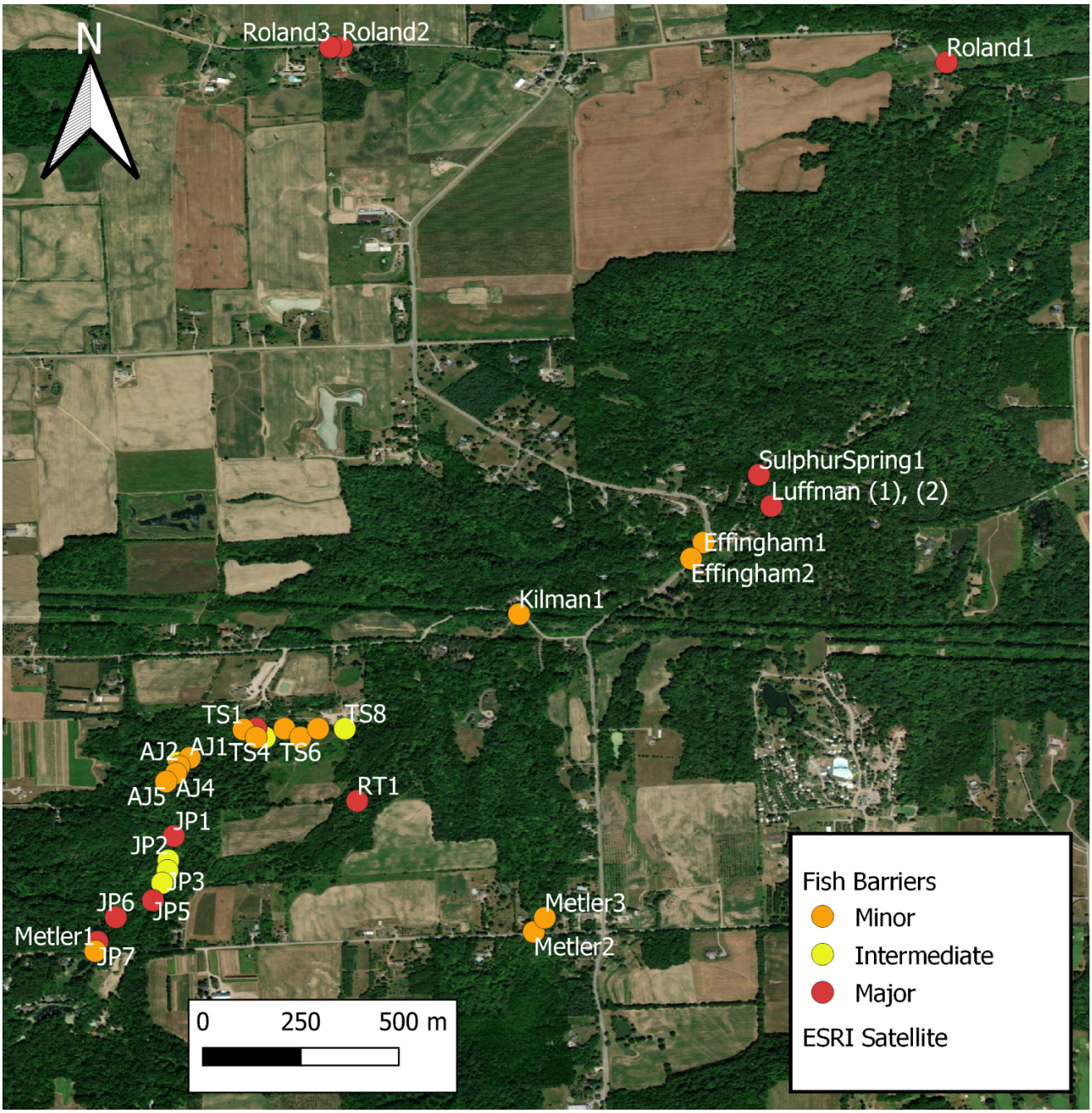

Figure 5. Map of all fish barriers found from the road survey including the barriers found from walking Agape Valley and the Short Hills Nature Sanctuary. The map was created using QGIS version 3.16.11 (QGIS.org, 2022).

6.3 Walking Path Survey

The fish barriers in Short Hills Nature Park and Agape Valley were surveyed by walking the two branches of the creek on the properties. Twenty natural barriers were found located on Creek 1; 1624 m of creek was walked. Five barriers found are a major issue on the creek such as TS2, JP1, JP5, JP6, and JP7. Six barriers are an intermediate problem to the creek such as TS4, TS8, AJ2, JP2, JP3, JP4 and nine barriers are a minor problem to the creek such as TS1, TS3, TS5, TS6, TS7, AJ1, AJ3, AJ4, and AJ5. We were not able to walk most of the second creek, but we did find 1 major barrier, RT1, on the small part we did visit. The map below shows the barrier locations on Creek 1 and Creek 2 (Figure 6).

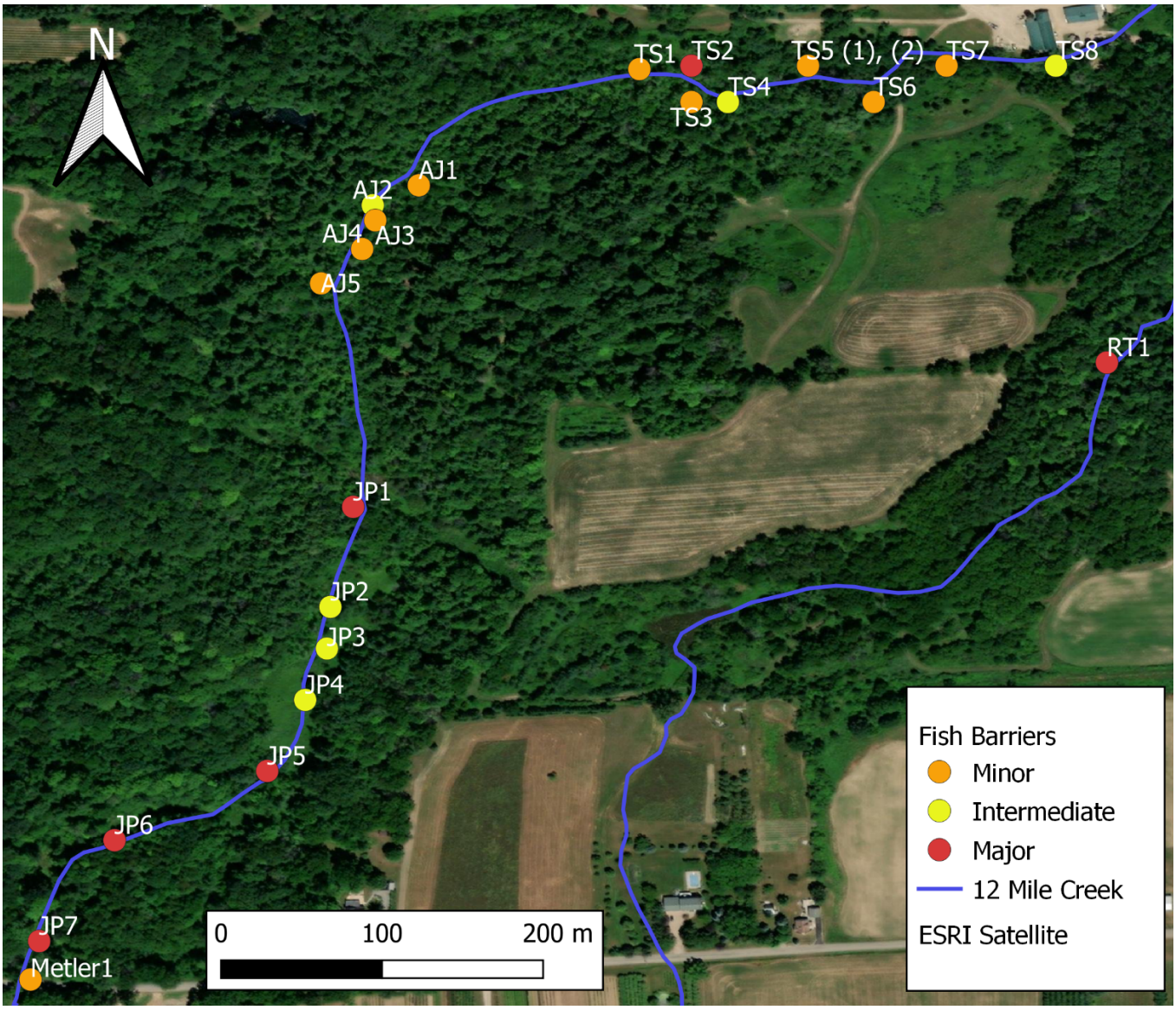

Figure 6. Map of fish barriers found from walking along 12 Mile Creek in the Agape Valley and Short Hills Nature Sanctuary properties. The map was created using QGIS version 3.16.11 (QGIS.org, 2022).

7.0 Discussions and Recommendations

Many of the barriers that were found during this survey are natural and can be removed relatively easily. There were some that would need to be managed though.

For any natural barrier that is comprised of dead vegetation and/or sediment build up, those need to be removed slowly and carefully, so only small amounts of sediment at a time are allowed to carry on downstream. The large waterfall is completely impassable and that will not change. There is an alternate route though. On the opposite side of Luffman Road where the

waterfall is, there is another possible route for the fish, but that also has a barrier in the way. That barrier is natural, and it can be easily removed.

The culverts present more of a complex problem as they are built into the road. They could be re-engineered so that they're slanted downwards, but that would require tearing up the road at various points and it would be prohibitively expensive. Instead, step-pool systems up to the culverts could be constructed with small steps, so the fish could carry on upstream (Wang & Yu, 2007).

8.0 Budget and Schedule

In total, the labour to complete this project was 180 hours, costing $3750. This labour was provided in-kind by Niagara College and Trout Unlimited Canada Niagara Chapter. Our travel costs were approximately $370. The project total cost was $4656. A detailed budget is outlined in Appendix IV. The timeline of the project ranged from January 2022 to April 2022. A detailed timeline is outlined in Appendix V.

9.0 Permits

The project coordinator applied to Trout Unlimited Canada Niagara chapter, and private property (Short Hills Nature Park, Agape Valley, and other privately-owned land) for a site survey permit. Then Trout Unlimited Canada Niagara chapter should apply to Department of Fishery and Ocean Canada (DFO) and the Niagara Peninsula Conservation Area (NPCA) for a review project near the water, fish barrier removal and Twelve Mile creek accessible. The email requests for site survey permits were used for private property access. Before the creek survey, the members of survey team did self-assessment using Hazard assessment (Appendix I). In addition, this project was under the Fisheries and Wildlife Act, Niagara Escarpment Planning and Development Act, Drainage Act, and Lakes and Rivers Improvement Act. All the acts that are mentioned above should be reviewed and ask for permitting before fish barrier removal begins. And other permits may need to be acquired, depending on Trout Unlimited Canada Niagara chapter decides to take.

10.0 Conclusion

The scope of this work included the completion of aerial photography desk-top mapping, ground truthing of results through site surveys to find potential barriers to fish passage. The barriers were then prioritized for removal. The majority of the barriers identified were natural barriers that could easily be cleared. The remaining barriers were human-made and required individual assessment for removal solutions. We anticipate that Trout Unlimited Canada, Niagara Chapter can make use of this data and findings to mitigate these issues so that the brook trout can move freely around the creek.

References

Brook Trout (Salvelinus fontinalis). (2022). Retrieved 22 February 2022, from https://web.archive.org/web/20131214173257/http://www.chebucto.ns.ca/ccn/info/Science/SWCS/WATERSHEDS/FISHERIES/FISHES/TROUT/BROOK_TROUT/brook_trout.html

Bureau of Reclamation. (2018). Fish Barriers. Retrieved from https://www.usbr.gov/lc/phoenix/biology/azfish/fishbarriers.html

Crossman, E.J., Van Meter, H.D. (1979). Annotated List of the Fishes of the Lake Ontario Watershed. *Great Lakes Fishery Commission,* 36, 10. Retrieved from http://www.glfc.org/pubs/TechReports/Tr36.pdf

Fost, B. A., & Ferreri, C. P. (2015). pH preference and avoidance responses of adult brook trout Salvelinus fontinalis and brown trout Salmo trutta. Journal of Fish Biology, 86(3), 952-966.

Fraser, J.Z. & Jones, G. (1982). Ontario Geological Survey: Open File Report 5392. Retrieved from http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/OFR5392/OFR5392.pdf

Hartman, K. J., & Hakala, J. P. (2006). Relationships between fine sediment and brook trout recruitment in forested headwater streams. Journal of Freshwater Ecology, 21(2), 215-230.

Hokanson, KE., McCormick, JH., Jones, BR., & Tucker., JH. (1973). Thermal requirements for maturation, spawning, and embryo survival of the brook trout, *Salvelinus fontinalis*. Journal of the Fisheries Board of Canada, 30 (7), 975-984.

Trout Unlimited Canada – Niagara Chapter (2020). The Upper Twelve Mile (and its Sub-Watersheds).

Lake Ontario Waterkeeper. (2010). Brook Trout (Salvelinus fontinalis). Retrieved from http://www.waterkeeper.ca/blog/19785

Ministry of Natural Resources and Forestry. (2020). *Ontario Flow Assessment Tool [OFAT]*. https://www.gisapplication.lrc.gov.on.ca/OFAT/Index.html?site=OFAT&viewer=OFAT&locale=en-US

Niagara Region. (2021). Niagara Navigator. Retrieved from https://www.niagararegion.ca/exploring/navigator.aspx

Niagara Restoration Council. (2001). Fish Barrier Project Methodology

Niagara Restoration Council, Niagara Peninsula Conservation Authority. (2007). Niagara River Area of Concern (AOC) - Fish Barrier Project - May 2007 - 2006-2007 Final Report.

QGIS.org, 2022. QGIS Geographic Information System. QGIS Association. http://www.qgis.org

Queen's Printer for Ontario. (2014). Brook Trout. Retrieved from https://www.ontario.ca/page/brook-trout

Soulsby, C., Youngson, A. F., Moir, H. J., & Malcolm, I. A. (2001). Fine sediment influence on salmonid spawning habitat in a lowland agricultural stream: a preliminary assessment. Science of the Total Environment, 265(1-3), 295-307.

Wang, Z.Y. & Yu, G.A. (2007). Step-Pool System for Erosion Control and Ecological Restoration. ResearchGate. Retrieved from https://www.researchgate.net/publication/267833472

Appendix

Appendix I: Hazard Assessment of Field Work Activities

Table 1 - Hazard Assessment of Field Work Activities

Field Location: Effingham Rd Sub-watershed	Date: March 2022
Crew: Robert Teodorini, Erik Hohnstein, Rachit Penglee, Sharan Sathya Smitha Wilson Raj	Cell Phone: 905-246-2740
Coordinator/Supervisor: Jocelyn Barker Niagara College 135 Taylor Road, Niagara-on-the-Lake, ON 905-641-2252	Emergency: 911 Ambulance: 905-688-2191 Niagara College Security: ext. 4444
Alternate Contact:	First Aid Kit packed

Activity	Hazards and Conditions	Controls	Personal Protective Equipment
Survey the area by walking	Adverse Weather: Hypothermia	- Dress appropriately and appropriate footwear - work in a group	Winter clothes
	Slipping, Falling	- Wear proper footwear - Be aware of your surroundings - Store equipment safely	Steel toe boots, Waders
	Working Around Water	- Be aware of slipping risk on stream slope - Do not enter water during storms with possible lightning - Carry a change of clothes. - Practice the buddy system; be responsible for each other's safety near water.	Waders. Steel toe boots

Activity	Hazards and Conditions	Controls	Personal Protective Equipment
Survey the area by walking Name:	Working Around Roadways	- Always be aware of your surroundings - Be visible to drivers at all times - Wear high visibility clothing and PPE - Use caution when crossing busy roadways	Hi-Vis Safety Vest
	COVID-19 situation	- Keep distancing of greater than 2 m - Wash your hand after handing equipment	Masks, hand sanitizer
	Thorns	- Watch where you're walking in the forest	Wear long clothing to cover your skin
	Ticks	- Do a tick check after exiting the forest	Long clothing, tick repellent

Appendix II: The fish barriers that were found using aerial imagery

Table 1. List of potential fish barriers in the Effingham branch of Twelve Mile Creek found using aerial imagery on the Ontario Flow Assessment Tool (Ministry of Natural Resources and Forestry, 2020).

Potential Fish Barriers	Latitude (°)	Longitude (°)	General location	Description	Is ground truthing possible (Yes/No/Maybe)
1	43.07179	-79.31378	Kilman Rd	Small bridge crossing over creek at Kilman Rd. Looks like it could be some sort of culvert.	Yes
2	43.06841	-79.32048	LOT 7 CON 5 PELHAM, South of Kilman Rd.	Small bridge crosses the creek.	No
3	43.06967	-79.31416	LOT 6 CON 5 PELHAM	Bridge crosses the creek.	No
4	43.06829	-79.31088	LOT 5 CON 5 PELHAM. East side of Effingham St.	Pond (~2170m^2). Looks like the water travels out to the north underneath of a road. Cannot see if it is a culvert or not from aerial imagery.	Maybe
5	43.07485	-79.3063	Luffman Dr near intersection with Sulphur Spring Dr.	Bridge over top of the creek.	Yes
6	43.07349	-79.30856	Effingham St, South of intersection with Luffman Dr.	Bridge over top of the creek.	Yes

7	43.07454	-79.30807	Effingham St. and Luffman Dr intersection.	Culvert where creek crosses under Effingham St.	Yes
8	43.07462	-79.30727	Sulphur Spring Dr and Luffman Dr intersection	Culvert where creek crosses under Sulphur Spring Rd.	Yes
9	43.07757	-79.30314	Sulphur Spring Dr	Bridge over top of the creek.	Yes
10	43.0801	-79.30238	Sulphur Spring Dr, south of intersection with Orchard Hill Rd	The creek runs right along the side of the road. Possible erosion and debris could form barriers.	Yes
11	43.08054	-79.30187	Sulphur Spring Dr. Just south of intersection with Orchard Hill Rd.	Bridge over top of the creek.	Yes
12	43.081	-79.30099	Orchard Hill Rd. Just east of intersection with Sulphur Spring Dr.	Creek crosses under Orchard Hill Rd (looks like a bridge).	Yes
13	43.08804	-79.29872	Sulphur Spring Dr near Roland Rd.	Creek crosses under Sulphur Spring Dr (possibly a culvert).	Yes
14	43.07529	-79.2976	Luffman Dr (slightly east of the other pond).	Pond (~4300m^2) that flows north underneath Luffman Dr through a culvert.	Yes
15	43.07426	-79.30014	Luffman Dr (slightly west of the other pond).	Pond (~3300m^2) that flows north underneath Luffman Dr. Cannot see any culverts from aerial imagery.	Yes

16	43.08094	-79.29959	Orchard Hill Rd (about halfway between Luffman Dr and Sulphur Spring Dr).	Creek flows underneath Orchard hill rd. Cannot see how it goes under from aerial imagery.	Yes
17	43.0877	-79.29147	Roland Rd	Bridge over top of the creek.	Yes

Appendix III: Fish Barrier Inventory

Walking Survey

Creek 1 Downstream

Name	TS1
Priority level	Minor
Coordinates	43.0683068, -79.32261877
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	Woody debris has built up across the creek, only allowing water to flow across the side of the creek.

Name	TS2
Priority level	Major
Coordinates	43.068333, -79.322222

Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	A large tree has fallen over onto the creek, creating a waterfall that prevents movement of fish upstream

Name	TS3
Priority level	Minor
Coordinates	43.068056, -79.322222
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	A small tree has fallen and stuck with debris on the creek, blocking some of the flow of water.

Name	TS4
Priority level	Intermediate
Coordinates	43.068056, -79.321944
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	The roots of trees go across to the creek and are built up with debris, causing a waterfall in the area.

(1) (2)

Name	TS5 (1), (2)
Priority level	Minor
Coordinates	43.068333, -79.321333
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	Woody debris has built up across the creek. This area has two barriers, and sediment has built up in between them.

Name	TS6
Priority level	Minor
Coordinates	43.068056, -79.320833
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	The creek is blocked by debris.

Name	TS7
Priority level	Minor
Coordinates	43.068333, -79.320278
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	Small trees have fallen on the creek and some debris has stuck on it, blocking a small part of the creek.

Name	TS8
Priority level	Intermediate
Coordinates	43.068333, -79.3194444
Property/Nearest Location	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description	Multiple large rocks in the creek have created a small waterfall.

Creek 1 Upstream

Name:	AJ1
Priority level:	Minor
Coordinates:	43.067539, -79.324510
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen trees, leaf litter build up

Name:	AJ2
Priority level:	Intermediate
Coordinates:	43.067269, -79.3246509
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen branches, leaf litter

Name:	AJ3
Priority level:	Minor
Coordinates:	43.067154, -79.3246318
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen tree, small waterfall

Name:	AJ4
Priority level:	Minor
Coordinates:	43.0669352, -79.3247320
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen tree, leaf litter

Name:	AJ5
Priority level:	Minor
Coordinates:	43.066673, -79.324819
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen tree, leaf litter

Name:	JP1
Priority level:	Major
Coordinates:	43.0649690, -79.3248001
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Split tree trunk, sediment build up and leaf litter

Name:	JP2
Priority level:	Intermediate
Coordinates:	43.064206, -79.324974
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen branches, leaf litter

Name:	JP3
Priority level:	Intermediate
Coordinates:	43.063889, -79.325000
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen logs, branches, leaf litter

Name:	JP4
Priority level:	Intermediate
Coordinates:	43.063497, -79.325166
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Grass and leaf litter build up, elevation change, small waterfall

Name:	JP5
Priority level:	Major
Coordinates:	43.0629550, -79.3254552
Property/Nearest Location:	Short Hills Nature Park Pelham ON
Barrier Description:	Fallen logs, branches

Name:	JP6
Priority level:	Major
Coordinates:	43.062427, -79.326619
Property/Nearest Location:	Short Hills Nature Park Pelham ON
Barrier Description:	Fallen tree, logs

Name:	JP7
Priority level:	Major
Coordinates:	43.0616577, -79.3271936
Property/Nearest Location:	Short Hills Nature Park Pelham ON
Barrier Description:	Fallen log

Creek 2

Name:	RT1
Priority level:	Major
Coordinates:	43.066070, -79.319055
Property/Nearest Location:	Agape Valley, 392 Kilman Rd Pelham ON
Barrier Description:	Fallen logs, branches, leaf litter

Road Survey

Name:	Effingham1
Priority level:	Minor
Coordinates:	43.0741641, -79.3082019
Property/Nearest Location:	2145 Effingham St Pelham ON
Barrier Description:	Blocked by sediment and dense thickets.

Name:	Effingham2
Priority level:	Minor
Coordinates:	43.0736586, -79.3085928
Property/Nearest Location:	2135 Effingham St Pelham ON
Barrier Description:	Thick cable or pipe crosses the creek causing a small waterfall.

Name:	Luffman1
Priority level:	Major
Coordinates:	43.0753066, -79.3060772
Property/Nearest Location:	224 Luffman Dr Pelham ON
Barrier Description:	Large, natural waterfall. North side of road.

Name:	Luffman2
Priority level:	Major
Coordinates:	43.0753066, -79.3060772
Property/Nearest Location:	224 Luffman Dr Pelham ON
Barrier Description:	Debris build up, fallen branches. South side of road.

Name:	SulphurSpring1
Priority level:	Major
Coordinates:	43.0762823, -79.3064685
Property/Nearest Location:	2150 Sulphur Spring Dr Pelham ON
Barrier Description:	Numerous fallen trees

Name:	Roland1
Priority level:	Major
Coordinates:	43.0892011, -79.3005864
Property/Nearest Location:	180 Roland Rd Pelham ON
Barrier Description:	Raised culvert causing a waterfall

Name:	Roland2
Priority level:	Major
Coordinates:	43.089690, -79.319535
Property/Nearest Location:	340 Roland Rd Pelham ON
Barrier Description:	Fallen branches, fallen tree, overgrown grass

Name:	Roland3
Priority level:	Major
Coordinates:	43.0896793, -79.3198946
Property/Nearest Location:	346 Roland Rd Pelham ON
Barrier Description:	Fallen branch, overgrown grass

Name	Metler1
Priority level	Minor
Coordinates	43.0613650, -79.3272597
Property/Nearest Location	480A Metler Rd Pelham ON
Barrier Description	Debris and sand build up inside of the culvert

Name	Metler2
Priority level	Minor
Coordinates	43.061967, -79.313521
Property/Nearest Location	329 Metler Rd (East of Effingham) Pelham ON
Barrier Description	The drain is high from the stream bed, creating a perched culvert

Name	Metler3
Priority level	Minor
Coordinates	43.0624085, -79.3131777
Property/Nearest Location	203-299 Metler Rd Pelham ON
Barrier Description	A small waterfall. However, the water flow only operates in the spring, according to a nearby landowner.

Name	Kilman1
Priority level	Minor
Coordinates	43.071919, -79.313984
Property/Nearest Location	Bridge. Kilman Rd Pelham ON
Barrier Description	A pebble barrier that connects with the bridge.

Appendix IV: Budget

The Fish Barrier Survey of Twelve Mile Creek (Effingham Branch) project required a total budget of $4,656. The estimated cost of labor is $4,840.00, although it will be done in kind. The estimated travel cost for the project is $370.00 (Figure IV-1).

PROPOSAL BUDGET TEMPLATE										
A. DAILY RATES		**Erik**	**Robert**	**Rachit**	**Sharan**	**Jocelyn**	**Brian**		**TOTAL**	**$ 4,656**
		$ 20.00 /h	$ 20.00 /h	$ 20.00 /h	$ 20.00 /h	$ 35.00 /h	$ 35.00 /h			
B. ESTIMATED LABOUR		hours	hours	hours	hours	hours	hours	Task/Item $	Subtotal	
Task 1	Background research and literature review	6	8	5.5	5			$ 490.00		
Task 2	Site survey by aerial imagery	4	2	2	2			$ 200.00		
Task 3	Group Meetings	7	7	7	7	4	4	$ 840.00		
Task 4	Field safety and HASP planning	0.5	0.5	3	3.5			$ 150.00		
Task 5	On Site surveying	9	9	9	9	2		$ 790.00		
Task 6	Barrier mapping using on site data	3	3	3	3			$ 240.00		
Task 7	Create full inventory and prioritize barriers	5	5	5	5			$ 400.00		
Task 8	Final Report	8	8	8	8			$ 640.00		
									$ 3,750	
C. TRAVEL & ACCOMODATION		units	$/unit							
	Mileage	250	$ 0.25					$ 62.50		
	Fuel, $/L	36	$ 1.60					$ 57.60		
	Meals, allow $50 pp/d	5	$ 50.00					$ 250.00		
									$ 370	
								SUBTOTAL BEFORE HST		$ 4,120
								HST (13%)		$ 536
									TOTAL	**$ 4,656**

Figure IV-1. Estimated Budget for Fish Barrier Survey Project.

Appendix V: Project timeline

We estimate the timeline for a barrier survey project of this nature would take approximately 3 months to complete. A timeline detailing all tasks needed for the first, second, and third months of the survey project are outlined below (Figure V-1).

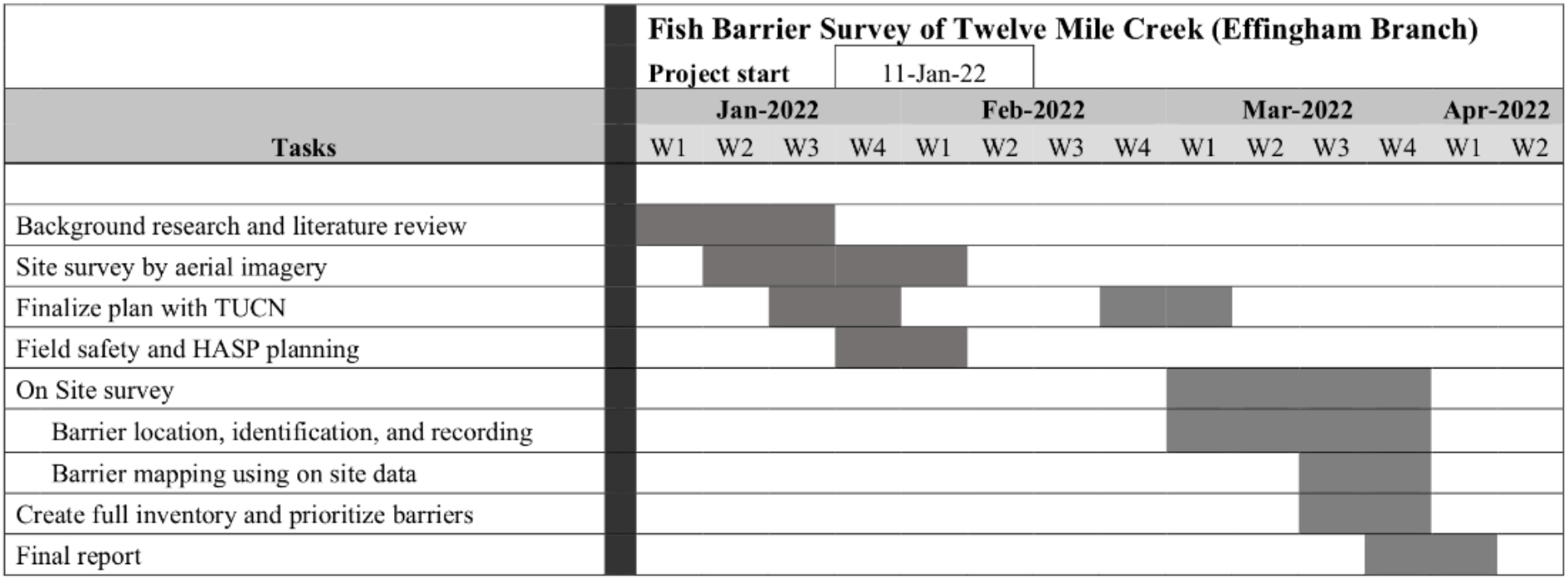

Figure V-1. Project Timeline