HALIFAX

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Item No. 12.1.2
Environment & Sustainability Standing Committee
July 7, 2022

TO: Chair and Members of the Environment & Sustainability Standing Committee

SUBMITTED BY: [redacted] **(Original Signed)**

Jacques Dubé, Chief Administrative Officer

DATE: June 27, 2022

SUBJECT: Yellow Floating Heart Control - Little Albro Lake 2022

ORIGIN

July 30, 2019 Halifax Regional Council motion (Item 15.1.6):

MOVED by Councillor Sam Austin, seconded by Deputy Mayor Tony Mancini

THAT Halifax Regional Council direct the Chief Administrative Officer to pilot the use of benthic mats to control the Yellow Floating Heart infestation at Little Albro Lake, contingent on regulatory approval from the Province of Nova Scotia and Government of Canada.

MOTION PUT AND PASSED

LEGISLATIVE AUTHORITY

Halifax Regional Municipality Charter, Section 7A The purposes of the Municipality are to (a) provide good government; (b) provide services, facilities and other things that, in the opinion of the Council, are necessary or desirable for all or part of the Municipality; and (c) develop and maintain safe and viable communities.

Halifax Regional Municipality Charter, Section 79A (1) Subject to subsections (2) to (4), the Municipality may only spend money for municipal purposes if (a) the expenditure is included in the Municipality's operating budget or capital budget or is otherwise authorized by the Municipality…

RECOMMENDATIONS ON PAGE 2

RECOMMENDATION

It is recommended that the Environment & Sustainability Standing Committee recommend that Halifax Regional Council direct the Chief Administrative Officer to:

1. End the usage of benthic mats to control the yellow floating heart in Little Albro Lake, based on the results of the testing completed in the 2021 pilot study; and

2. Prepare and submit an application for special approval from Health Canada to use ProcellaCOR^{TM}, a selective herbicide, for a pilot study to control invasive yellow floating heart in Little Albro Lake, contingent on regulatory approval by Nova Scotia Environment & Climate Change, and Environment & Climate Change Canada, discussion with all relevant government agencies, and consultation with concerned stakeholders.

BACKGROUND

Little Albro Lake ("the lake") is a shallow, roughly 3-hectare lake located in Dartmouth. Inflow comes into the lake from Albro Lake, and outflow enters the municipal storm sewer system, eventually discharging into Halifax Harbour via the Dartmouth Wastewater Treatment facility. The lake is in a residential neighbourhood, and use is predominately recreational.

Yellow Floating Heart (YFH), a freshwater ornamental floating plant native to Eurasia, was unintentionally introduced to Little Albro Lake, Dartmouth in 2006. YFH is not listed in the Canadian Aquatic Invasive Species Regulations but is listed as invasive with the Nova Scotia Invasive Species Council. YFH is the dominant aquatic plant species in Little Albro Lake, covering the majority of the lake's shallow surface area. It reproduces vigorously from seed, fragments and running roots, allowing it to quickly colonize new water bodies once introduced.

Constituents[1] have voiced repeated concerns to members of Regional Council about the extent of YFH in Little Albro Lake, and the future viability of the lake's use for recreational purposes.

DISCUSSION

In 2021, a research team from the Centre for Water Resource Studies at Dalhousie University (CWRS) undertook a pilot program testing the use of benthic mats to eradicate YFH in Little Albro Lake. The full report from this study can be found in Attachment A. Two types of barriers, permeable (to water flow) and impermeable, were installed in test plots between May 3-5, 2021, and monitored against adjacent control sites in both shallow (roughly 1 metre (m) in depth) and deep (roughly 3m in depth) areas of the lake. Plots were installed by Dominion Diving, with oversight by McCallum Environmental Ltd.

The pilot study considered physical and chemical effects of benthic mats on YFH population and sediment and water quality. YFH coverage was measured by regular photo sampling of plots and analyzed to determine the percent of plot surface area covered by YFH. CWRS took in situ measurements for pH, dissolved oxygen, temperature and conductivity at the centre of each study area at the same frequency as photo sampling. Water samples were taken from the lake surface and ~0.5m above the lakebed, and analyzed for total nitrogen, total phosphorus, and soluble reactive phosphorus at the CWRS lab. Before and after the pilot study period, water samples were taken at the surface at the deepest part of the lake and sent to AGAT Laboratories for full water quality analysis. Sediment samples were collected before and after the study period to assess the effect of mats on the benthic environment. Composite samples from each

[1] Report available at: [Floating Yellow Heart – Little Albro Lake - July 30/19 Regional Council | Halifax.ca]

treatment method (i.e. permeable vs. impermeable barrier material) were analyzed for physical, chemical, and biological properties.

During the 2021 pilot study period, YFH covered a maximum of 55% of the surface of Little Albro Lake. All barriers were removed in late September 2021.

Both impermeable and permeable barriers successfully obstructed the growth of YFH in the study plots. YFH coverage was nearly complete in the shallow zone. Photo sampling (*Figure 1*) shows barrier mats controlled the growth of YFH in the shallow plots, with clearly defined, straight edges to YFH foliage at the surface. YFH generally covered a far lower percentage of the surface in the deep zone, but in areas where coverage was greater, the mats still clearly obstructed YFH growth. Over the course of the pilot study, YFH growth on barriered plots was roughly half of that in control plots.

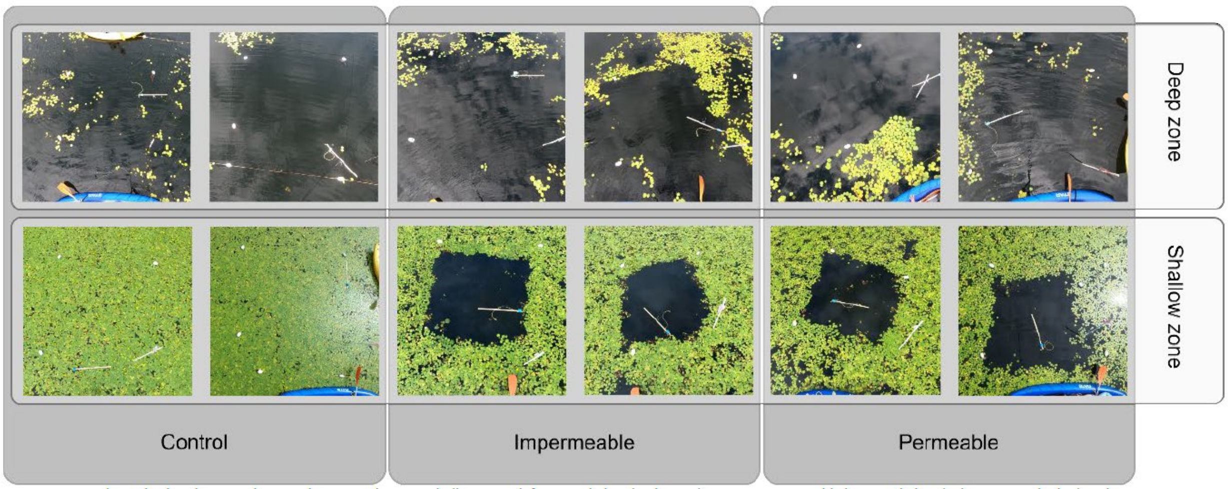

Figure 1: Photo sampling of study plots demonstrating the success of benthic mats at controlling YFH in shallow and deep study zones. CWRS photo, 2021

Negative effects of benthic barriers to water chemistry and aquatic organisms in Little Albro Lake include:

- Decreased oxidation-reduction potential (ORP) in sediment beneath mats installed in deep plots, increasing the risk of arsenic release from the sediment

- Slight decrease in macroinvertebrate populations

Both permeable and impermeable benthic barriers required regular maintenance during the pilot study. Gases trapped between the barrier and the lakebed had to be manually released by divers regularly during inspections, particularly in the case of impermeable mats in deep water plots. Trapped gases accumulated in the shallow zone for both barrier types. There was significant sediment accumulation on top of the mats during the study period, and YFH rooted into this sediment and grew on top of the mats. This sediment had to be physically removed by divers during inspections. These problems would persist in a full-scale application of benthic mats for YFH removal and may be more pronounced in the case of trapped gases, where wide coverage with benthic mats would, by design, obstruct the flow of more water and gases from the lakebed upwards.

When benthic mats were removed at the end of the study period, it became apparent that YFH roots had grown through the permeable barrier material, allowing the plants to establish themselves and rendering this type of mat ineffective. The impermeable barrier material did effectively prevent roots from establishing themselves on the lakebed beneath it. The ability of YFH to establish itself in sediment on top of the mats would require regular maintenance and removal to ensure YFH does not re-establish itself in uncovered areas of the lakebed and through potential gaps between mat sections.

The cost of a full deployment of impermeable benthic mats to control YFH in the lake is prohibitive. Assuming mats would provide 55% lakebed coverage (based on estimates of lake surface coverage by YFH as stated above) plus an additional 10% for overlap and waste, 19,500m^2 of barrier is required. At roughly \$14/m^2, the cost of barrier material alone is approximately \$270,000. Further costs estimated by the CRWS include labour, additional materials, maintenance, seasonal barrier removal, laboratory fees, consulting fees and end of project barrier disposal. These costs were not estimated by CWRS.

In addition to the high cost of implementation, the CWRS pilot study does not guarantee benthic mats will successfully eradicate YFH from Little Albro Lake. Project permits require barriers be removed seasonally, preventing the year-round complete coverage required for full eradication. YFH has a long dormant stage in lakebed sediment, with seeds remaining viable for years. The entire root system must be removed from the lake to prevent YFH from rebounding from fragments. To successfully kill YFH's robust root systems, barrier installation would be required over multiple years, further increasing the program's cost.

Despite the unsuccessful result of the benthic mat pilot study, it is recommended that the Municipality does take further action to remove YFH from Little Albro Lake. While YFH is currently contained to Little Albro Lake, if the invasive plant spreads to other water bodies, the risk of it establishing itself therein is high. As outlined in the Background section of this report, YFH can quickly establish itself in new environments from root fragments. Once established, as seen from the results of the CWRS pilot study, YFH is very difficult to eradicate. It is imperative that YFH be contained to Little Albro Lake, where control and removal remains manageable for the Municipality. Doing nothing to remove YFH will eventually lead to the spread of YFH to other lakes in the region, an outcome that should be prevented.

ProcellaCor™

The CWRS report proposes investigating the use of ProcellaCor™, a selective herbicide[2], to control YFH. ProcellaCor™ was approved by the USEPA in 2018. In a peer-reviewed study conducted in a drinking water reservoir in Oklahoma, ProcellaCor™ was shown to successfully reduce YFH surface coverage from 55.5 acres to 3 acres after one application.[3] Analysis of key water quality parameters (dissolved oxygen, biological oxygen demand) showed no net negative effects in the reservoir within 20 days of the application of ProcellaCor™. The active ingredient in ProcellaCor™, florpyrauxifen-benzyl, is currently pending approval by Health Canada.

A review of literature did not find successful alternate removal methods, with most resources noting the difficulty of mechanical treatment. In some cases, YFH became more widespread after mechanical removal. While pesticide use is currently banned in HRM, a motion to repeal the Municipality's pesticide by-law has currently passed first reading at Regional Council. In the event this by-law is not repealed, Regional Council could consider amending the accompanying Administrative Order to include permitting the use of ProcellaCor™ in the lake. Even if the bylaw is repealed, HRM would still require the necessary approval to use ProcellaCor™ under the province of Nova Scotia's pesticide regulations.

HRM's Integrated Pest Management Strategy, pending Council approval, will further guide how to manage invasive species, including when pesticides should be deployed. This plan encourages the use of herbicides only after non-chemical means have been tested and ruled out. In the case of YFH, benthic mats are the least disruptive mechanical removal method, as compared to surface covers or dredging. With the cost of benthic mats being prohibitive in this case, the use of herbicide is a reasonable option to consider.

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[2] Further information on ProcellaCor™ can be found on the manufacturer's website: https://www.sepro.com/aquatics/procellacor-product
[3] Study available at: Monitoring and water quality impacts of an herbicide treatment on an aquatic invasive plant in a drinking water reservoir - ScienceDirect

ProcellaCor™ can only be applied by specialists certified by the manufacturer, SePRO. There are currently no certified specialists in Canada, as the product is not approved. If ProcellaCor™ is approved for a pilot study, a partnership with SePRO should be investigated. Offering SePRO the opportunity to engage a new market could reduce costs incurred by HRM and offer ready access to expertise and certified applicators.

Engagement with Nova Scotia Environment and Climate Change, Department of Fisheries and Oceans, and Health Canada will be necessary to approve a pilot study into using ProcellaCor™ in Little Albro Lake. HRM's ability to conduct a pilot study of ProcellaCor™ in Little Albro Lake depends on the cooperation of these agencies and requires relevant permit approvals. As originally stated in the July 24, 2007 report to Council[4], all lakes in Nova Scotia are provincial property, and any program undertaken in the lake would require provincial approval.

Expected potential avenues for approving the use of ProcellaCor™ in Little Albro Lake are emergency use approval by Health Canada, which can be used for the control of invasive species or waiting for the general approval of the active ingredient in ProcellaCor™ by Health Canada.

Emergency use approval may be sought through Health Canada for a one-year period, in cases where a pest infestation is deemed to be seriously detrimental to public health, domestic animals, ecosystems, and/or natural resources. Applications must be sponsored by either the federal agency or provincial ministry supporting the management of the pest problem. An initial inquiry with invasive species experts and the Fisheries & Oceans Canada, and at Nova Scotia Environment & Climate Change indicated there was some appetite to pursue this option for YFH removal, pending the initial approval by Regional Council. The full procedure for the emergency use application process can be found in Attachment B.

FINANCIAL IMPLICATIONS

The costs associated with this recommendation can be accommodated with existing budget for Environment & Climate Change.

Further costs related to the control of YFH recommended through the development of this pilot study are unknown at this time and would be considered as part of future capital and/or operating budgets and as such, would be returned to Council for approval.

The financial burden of proceeding with benthic mats as a means of eradicating YFH should be considered excessive. As stated above, materials alone will be roughly $270,000. The mats will need to be deployed for multiple years to ensure effective YFH removal, further raising the projected costs.

Expected costs of investigating the use of ProcellaCor™ pertain to community and aboriginal consultation and permit and regulatory approvals.

RISK CONSIDERATION

As ProcellaCor™ is still awaiting approval for use in Canada by Health Canada, there is a medium risk that the use of this herbicide for a pilot study in Little Albro Lake will not be approved by the necessary regulatory bodies. If the Municipality cannot secure the necessary approvals to use ProcellaCor™, alternative control measures will be revisited.

The proposed actions respond to current impacts to recreational opportunities and biological diversity. The staff recommendation poses a minor environmental risk to the existing lake ecology and any resident fish

[4] Report available at: Invasive Plant Species - Little Albro Lake - Regional Council July 31 2007 - HRM (halifax.ca)

populations. That risk is mitigated by strict provincial and federal regulations and policies designed to identify, assess, and approve only those activities that impose acceptably low risks.

COMMUNITY ENGAGEMENT

Notification was given to residents before the study was conducted, notice of the study was posted on the HRM website, and signage was placed at the park entrance while the study was underway.

Community consultation regarding the use of ProcellaCorTM in Little Albro Lake will be required. Application of a new or pre-approved chemical in a residential lake may pose a concern for residents and other stakeholders. However, the stated desire of many residents to eradicate YFH from Little Albro Lake, the risk of YFH spreading to and overtaking other nearby water bodies, and the success of ProcellaCorTM elsewhere may help to overcome any concerns.

ENVIRONMENTAL IMPLICATIONS

The proposed actions respond to current impacts to recreational opportunities and biological diversity. The staff recommendation poses a minor environmental risk to the existing lake ecology and any resident fish populations. That risk is mitigated by strict provincial and federal regulations and policies designed to identify, assess, and approve only those activities that impose acceptably low risks.

This recommendation balances the risk of invasive YFH spreading to other water bodies in HRM, and the risks posed by recommending a chemical still pending approval with Health Canada. ProcellaCor™ has been shown to be effective with a single application, with minimal disruption to the aquatic ecosystem. In contrast, YFH spreads vigorously, and as shown through this pilot project, is difficult to remove once established. The negative environmental effects of allowing YFH to spread to other water bodies are estimated to be far more detrimental than the limited use of ProcellaCor™.

ALTERNATIVES

The Environment & Sustainability Standing Committee could:

1. refuse to recommend that Halifax Regional Council take further action to control Yellow Floating Heart in Little Albro Lake. Taking this approach may lead to the spread of invasive Yellow Floating Heart to other municipal lakes and is not recommended.

2. recommend that Halifax Regional Council direct the Chief Administrative Officer to return with a report to Halifax Regional Council at a time where Health Canada has made a decision on the approval of the use of the selective herbicide ProcellaCor™ in Canada.

ATTACHMENTS

Attachment A. Little Albro Lake Restoration Pilot Study: Assessment of Benthic Barriers
Attachment B. Registration of Pesticides for Emergency Use: Revised Procedures

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A copy of this report can be obtained online at halifax.ca or by contacting the Office of the Municipal Clerk at 902.490.4210.

Report Prepared by: Elizabeth Montgomery, Water Resource Specialist, Environment & Climate Change, 902.943.1954

Little Albro Lake Restoration Pilot Study:
Assessment of Benthic Barriers

February 3, 2022

Prepared by:

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List of Abbreviations

%	Percent
°C	Degree Celsius
ANOVA	Analysis of Variance
C	Control
CCME	Canadian Council of Ministers of the Environment
cm	Centimeter
CWRS	Centre for Water Resources Studies
FBI	Family Biotic Index
ha	Hectare
HRM	Halifax Regional Municipality
I	Impermeable
ISQG	Interim Sediment Quality Guidelines
kg	Kilogram
L	Liter
m	meter
mm	Millimeter
mg	Milligram
mV	Millivolts
NE	Northeast
NTU	Nephelometric Turbidity Units
ORP	Oxidation – reduction potential
P	Permeable
PEL	Probable Effect Level
PVC	Polyvinyl chloride
SRP	Soluble Reactive Phosphorous
µg	Micrograms
µmho	Micromhos
TCU	True colour units
YFH	Yellow Floating Heart
YSI	Yellow Springs Instrument Company

Executive Summary

Halifax is investigating options to control the growth of Yellow Floating Heart (YFH) in Little Albro Lake, which is a small (3 ha), shallow (< 5 m deep) lake in Dartmouth, Nova Scotia. A pilot study was conducted during the 2021 growing season to assess the feasibility of using benthic barriers to prevent YFH growth. Two types of commercially available benthic barriers (permeable and impermeable) were tested in shallow (1 m water depth) and deep (3 m water depth) areas of the lake. A total of 18 test plots (9 permeable, 9 impermeable, 6 control), each measuring 3 m x 3 m, were established in early May 2021, and monitored throughout the growing season. The barriers were removed from the lake in late September 2021.

Both types of barriers were effective in reducing YFH growth, with barriered plots possessing significantly less YFH coverage than control plots. Inspection of the permeable barriers after their removal from the lake, however, revealed that YFH had been able to grow through this barrier material. This indicates that the impermeable barrier (Lake Bottom Blanket) would be a more durable, and effective, product for YFH control. Several maintenance issues were noted during regular inspections conducted by diving technicians. Most notable was (i) gas build-up under the barriers, which caused billowing, and (ii) an accumulation of sediment on top of the barriers, and growth of YFH through these sediment layers. Both issues would need to be managed during a full-scale benthic barrier application program.

An environmental monitoring program was also undertaken to understand the lake ecosystem and impacts of the barrier on the chemical and biological properties on the lakebed. The barriers had measurable impacts on the lakebed and generated lower oxidation reduction potential (ORP) in sediments, as compared to control plots with no barriers. Reduced ORP in lake sediments could facilitate the mobilization of redox-sensitive metals, such as arsenic. Benthic macroinvertebrates were also sampled and enumerated to assess impacts of the barriers on the sediment biota. There were only minor differences between barriered and control plots. However, based on the small numbers of organisms recovered from sediment samples, and ecological quality metrics that were evaluated, it was concluded that the lake has poor water quality and is an unfavourable environment for macroinvertebrates. Water quality results indicated that the lake is meso-eutrophic (elevated nutrients) and possesses chloride and iron concentrations that exceed Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Aquatic Life.

At the peak of the 2021 growing season YFH covered 55% of the lake surface area. If this area of the lake was to be covered with the Lake Bottom Blanket, it would cost approximately $270,000 for the barrier materials. This does not include the other costs that would be incurred within a full-scale restoration program, which would include labour for installation, maintenance, removal of the barriers, consulting fees for planning, permitting, and monitoring, other materials (e.g., rebar), and disposal of the barriers once the project is completed. The barriers would also need to be repeatedly installed and removed for several years to eradicate YFH. Before initiating a full-scale application of benthic barriers, it is recommended that this approach be carefully compared to other potential control options.

1 Introduction

1.1 Project Context

Little Albro Lake is a small urban lake (~ 3 ha) located in a residential neighborhood in Dartmouth, Nova Scotia (Figure 1). The lake is shallow, with a mean and maximum depth of 2 and 4 m, respectively. Little Albro Lake drains a highly developed watershed of approximately 100 ha, mainly consisting of low density residential, commercial, and parkland land uses. The lake outlet discharges to a stormwater pipe at the southwest end, which conveys water to the Jamieson St. pumping station and eventually to the Dartmouth Wastewater Treatment Plant. Effluent from the treatment plant is discharged to the Halifax Harbour.

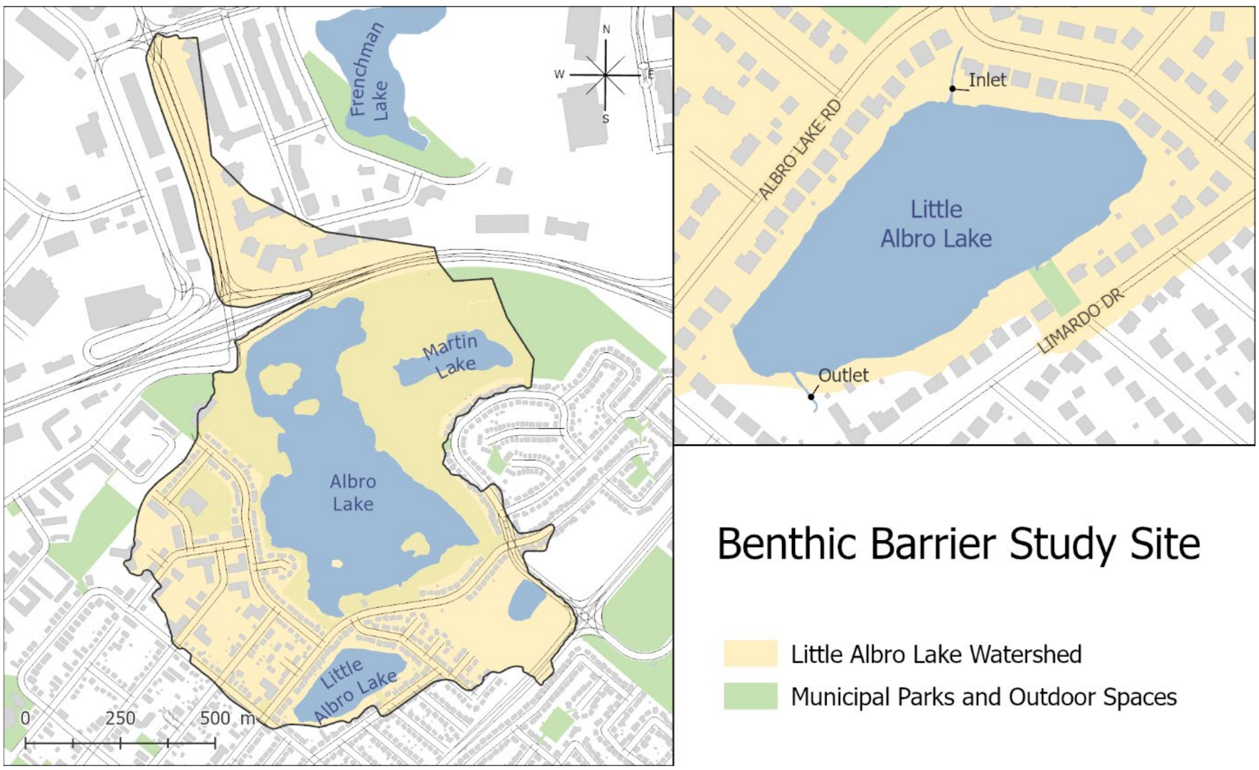

Figure 1. Little Albro Lake Watershed in Dartmouth, NS.

Historically, the lake has suffered water quality issues; the Dartmouth Lakes Advisory Board proposed sediment dredging in 1985. Yellow Floating Heart (YFH) was first identified by researchers at Saint Mary's University in 2006 but is thought to have been present since 2002/2003. The ornamental plant is believed to have been introduced to the lake from a backyard pond. Since then, this nuisance plant has taken over a large portion of the lake, restricting recreational use by residents, and outcompeting native vegetation.

Halifax Regional Council was first presented with a staff report on YFH in Little Albro Lake in July 2007. Between 2010 and 2018, staff did not record any complaints concerning YFH, but residents living on the lake indicated to their councilor in 2019 that the plant now covers the lake surface during the growing season. A staff report in July 2019 reviewed four potential methods for control of YFH: mechanical, cultural, biological, and chemical. The report recommended a pilot project on the use of benthic mats (categorized as mechanical) for the control of the YFH infestation at Little Albro Lake. HRM engaged researchers in the CWRS at Dalhousie University and McCallum Environmental Ltd. to implement and monitor the pilot project.

1.2 Yellow Floating Heart

Yellow Floating Heart (*Nymphoides peltata*) is a rooted aquatic plant that occurs in freshwater lakes and ponds, with leaves and flowering structures that float on the surface of the water. Long stems attach these floating parts to the root system embedded in the sediment. It is also commonly known as fringed water lily, fringed buckbean, and marshflower. YFH is native to Europe and parts of Asia, with established nuisance populations in Canada and the United States (Darbyshire & Francis, 2008; United States Geological Survey, 2021). As a perennial herbaceous plant, the leaves and shoots die back each fall and regrow the following spring from established rhizomes, which overwinter in the sediment. This species is quite robust and can tolerate cold weather, fresh to slightly brackish water, and a range of water pH. The plants thrive in slow moving or still waters with relatively high nutrient levels. While they prefer water that is 1 – 2 m deep they have been observed to grow on intermittently inundated shorelines and in water up to 4 m deep (Darbyshire & Francis, 2008).

Yellow Floating Heart can spread by stolon (runner) growth, fragmentation, and seed production, making it capable of colonizing areas quickly. While spread within an area is mainly thought to be achieved by producing clone plants through stolon growth, seed production in established populations is vigorous (Brock et al., 1983). In mid-June, the plants begin to produce small yellow flowers that extend above the water surface. These flowers are insect pollinated and produce a fruit capsule that contains many seeds, which eventually breaks off from the plant and floats when mature. Dense colonies of YFH can produce up to 1000 seeds/m^2. These seeds are flat and edged with small fibers that allow them to float more easily and to cling to things that move through the water surface, like birds, mammals, and boats. The viability of seeds produced by Canadian YFH populations is unknown, however seeds of European populations are viable for extended time periods, even when desiccated, producing a seed bank that remains present in the lake sediment for many years (Darbyshire & Francis, 2008).

The plant can pose issues in infested waterways. The leaves of the plant form a dense canopy that nearly covers the water surface in colonized areas, and the large mass of stems that attach floating leaves and flowers to the root system dominate the water column. This tangle of plant material can make recreational swimming, boating, and fishing in YFH areas very difficult. The dense floating canopy can restrict light from reaching native submerged plants and phytoplankton species while limiting exchange between the atmosphere and water, as stomata occur only on the upper surface of the leaves. The species can also serve as a nutrient pump, which over its lifespan, removes nutrients from the water during growth and transfers them to the sediments upon decay, later increasing sediment levels in areas with established populations (Kelly & Maguire, 2009; Darbyshire & Francis, 2008). These sediment nutrients can later be released back into the water column where they become available to future YFH plants, or other photosynthetic organisms, retaining excess nutrients in the lake longer than they would otherwise be available.

Though Yellow Floating Heart is not listed in the Canadian Aquatic Invasive Species Regulations, persistent populations in Ontario and the United States have proved difficult to eradicate (Darbyshire & Francis, 2008; Government of Canada, Legislative Services Branch, 2021; United States Geological Survey, 2021).

1.3 Objectives

The primary objective of this study was to assess the applicability of benthic barriers as a method to control the growth of Yellow Floating Heart in Little Albro Lake, Dartmouth, NS. Specific objectives of the study were to:

- Document the effectiveness of two commercial benthic barrier products in controlling YFH growth in different areas of the lake,
- Investigate any effects the barriers might have on the lake ecosystem.

2 Study Design

During the 2021 growing season (May - September) two types of benthic barriers were installed in two areas of the lake. These barriered plots were installed alongside control plots of similar size. The following sections explain the study design and installation process.

2.1 Benthic Barriers

Benthic barriers are sheets of material that are designed to prohibit plant growth by covering the lakebed to prevent rooted plants from growing up through the water column. Some barriers also block sunlight, inhibiting photosynthesis in any plants rooted below them. Two types of barriers were chosen for study, one that is permeable to water and gasses, and one that is impermeable.

2.1.1 Impermeable Barriers

Lake Bottom Blanket is a sheet of material that does not allow passage of liquids or gasses directly through it (Figure 2). This product is designed to be installed with some slack between parallel lengths of rebar slotted into sleeves in the fabric, creating tented channels that allow for some gas and water exchange in the surrounding environment. Plots barriered with this material were considered impermeable plots. This barrier material works primarily by blocking sunlight from reaching any plants beneath the barrier, preventing photosynthesis, and causing the plants to die back.

2.1.2 Permeable Barriers

Aquascreen is a mesh fabric that is designed to allow liquids and gasses to pass freely across the barrier while prohibiting plants from growing up to the water surface (Figure 2). Plots barriered with this material were considered permeable plots. This barrier material does not prevent light from reaching the plants underneath them but retains the plants near the bottom of the lake.

Figure 2. Barrier types used in Little Albro Lake Pilot Study. Top: Lake Bottom Blanket impermeable barrier, bottom: Aquascreen permeable barrier.

2.2 Plot Design

Plots were designed to approximate barrier effectiveness and conditions at a larger scale. Each study plot was 3 m x 3 m. The corners of each plot were marked at the water surface to allow for growth monitoring. The NE corner of each plot was marked by a vertical piece of rebar, 3 m in length with 1 m driven into the lakebed and PVC that extended 1 m above the water surface. This rigidly marked corner was used to create a consistent location that would not change with fluctuating lake water levels over the course of the growing season. The three remaining corners of each plot were marked by buoys attached to small concrete blocks (APPENDIX A). At barriered plots, these concrete blocks helped to secure the corners of the barrier material to the lakebed, while the control plots were simply marked with buoys as there was no material to anchor. Barriers were also secured with horizontal pieces of rebar at the lakebed to ensure the edges were anchored to the sediment.

2.2.1 Study Area Locations

The two study locations were chosen in early 2021 based on a bathymetric survey conducted in October 2020. As the lake is up to 4 m deep in places, it was important to observe barrier performance at a range of depths. The target depths of 1 m and 3 m were chosen to study the barriers at the full growing range of YFH in Little Albro Lake. The area with an average depth of approximately 1 m, the shallow zone, was positioned in the SW end of the lake near the Albro Lake Road access park where the water was between 0.5 and 1 m deep. The deep zone, with an average depth of 3 m, was positioned along the SE edge of the lake approximately 25 m from the shore (Figure 3). Both the shallow and deep study areas contained a total of nine plots: three permeable plots, three impermeable plots, and three control plots.

2.2.2 Plot Locations

Within the study areas, plots were placed 3 metres apart in a grid pattern to allow a small boat/kayak to pass between plots. A grid pattern was chosen to minimize differences in plot locations, and accompanying differences in slope, depth, and sediment composition, over the entire study area. The locations of the plot types (control, impermeable, permeable) within the grid were randomly assigned. Plots were given unique names, containing a number and letter. The number indicates the plot's location within the grid (numbers 1 – 9 are in the deep zone, and numbers 10 – 18 are in the shallow zone), and the letter indicates the plot type or barrier material (P = permeable, I = impermeable, C = control).

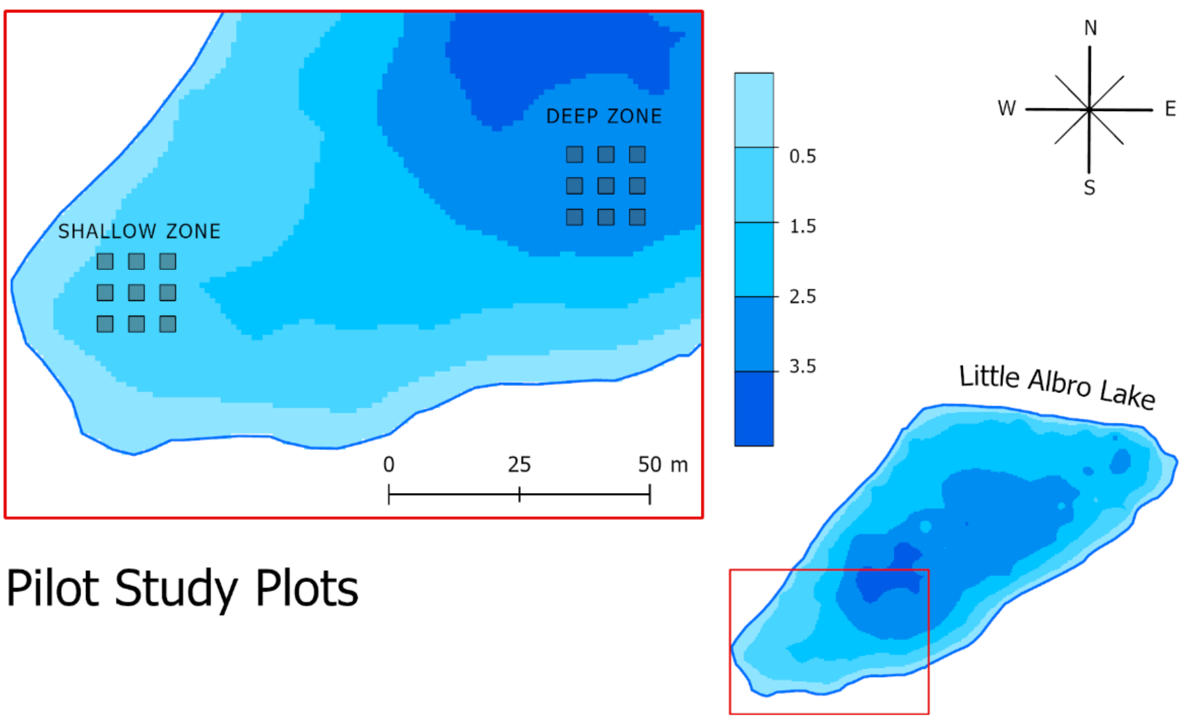

Figure 3. Shallow and deep study plots in Little Albro Lake.

2.3 Installation Process

All installation was performed by *Dominion Diving* with onshore assistance and direction by *McCallum Environmental Ltd*. Shallow zone plots were installed on May 3rd, 2021, and the installation of deep zone plots was completed on May 5th, 2021. As outlined in the plot design, rebar was used to mark the NE corner of each plot. It was driven approximately 1 m into the sediment where possible. When this could not be achieved due to large, buried rocks, the vertical rebar was supported with extra concrete blocks. A length of PVC was fitted over this rebar so that it extended about 1 m above the water surface, this was tagged with the plot type.

Divers installed the control plots using a 3 m length of PVC as a guide to mark the plot corners with concrete blocks and buoys. The two types of barriers were installed differently. This was done to best approximate how each barrier type would perform at a larger scale. For barriered plots, the horizontal rebar was attached or fitted to barrier materials onshore and brought to the study areas on a boat. For permeable plots, all four edges of the material were anchored with a length of rebar to ensure the edges sat as flat against the lakebed as possible (Figure 4). Impermeable barriers were installed as specified by the manufacturer, with rebar fitted into sleeves in the material at two parallel edges, and through the middle in the same direction, to create two channels in each plot. Plots in the shallow zone could be installed with only one diver intermittently underwater to check the placement of the plot and condition of the barrier. The plots in the deep zone required more divers in under the water and took significantly longer to install.

Figure 4. Overhead photo of a shallow permeable plot on May 28, 2021. Concrete blocks, horizontal rebar, and vertical marker visible under water.

3 Monitoring Approach

To measure barrier efficacy and assess the potential effects of the barriers on the lakebed, vegetation growth and sediment conditions were monitored during the study. Additionally, to characterize and better understand the lake ecosystem, water quality was monitored throughout the study. Monitoring frequency varied depending on the parameter, with some monitored throughout the study period, some before and after the study, and some sampled only after the barriers were removed from the lake.

3.1 Vegetation

Yellow Floating Heart growth in each study plot was quantified throughout the 2021 growing season (May – October) by analyzing images that were taken from a camera suspended over the centre of the plot. Photo-sampling occurred 1 – 2 times a month and was carried out from a kayak anchored parallel to the edge of each plot. Images were always taken from the same edge of the plot to ensure consistency. All photo-sampling was completed by CWRS research engineers and/or assistants.

Images were analyzed using *FIJI* software to obtain the percent of the plot area water surface that was covered with YFH plant matter. Mean YFH coverage for treatment types at the peak of the growing season were compared using one-way ANOVAs, with Tukey's comparisons, using *Minitab* software.

3.2 Water Quality

To characterize the lake chemistry, water quality parameters were monitored during the study. Growing season measurements began in August 2021 and occurred 1 to 2 times per month. In situ measurements of temperature, pH, dissolved oxygen, and conductivity were measured using a multiparameter YSI handheld sonde. Vertical profiles were recorded with measurements taken every 0.5 – 1 m, depending on depth of sampling location.

Water samples were collected and analyzed for nutrients at the CWRS lab. Samples were collected from the water surface and ~0.5 m above the lakebed using a Kemmerer vertical bottle sampler. All samples and measurements were taken from a kayak near the centre of each study area. Water samples were analysed for total nitrogen using HACH persulfate digestion test kits. Total phosphorous (persulfate digestion) and soluble reactive phosphorus (SRP) were analysed using the ascorbic acid method.

In addition, water samples were taken 0.5 m below the water surface at the deepest area of the lake before and after the study, during well-mixed conditions, and were analyzed by *AGAT Laboratories Ltd.* for a full suite of water quality parameters.

3.3 Lakebed Monitoring

To characterize the lakebed and observe any effects the barriers might have on the benthic environment, sediment samples were collected before and after the study period and analyzed for physical, chemical, and biological properties. Samples were collected using a Petite Ponar dredge sampler or Dutch auger depending on the conditions at the sampling site. Pre-installation samples were taken from each study area and post-barrier-removal samples were collected from each study plot. Treatment group composite samples were used for analysis.

3.4 Physical and Chemical Monitoring

Pre-study sediment samples were collected from within the deep and shallow study zones (2 samples total). Samples were analyzed by *AGAT Laboratories Ltd.* for total available metals and the Nova Scotia Department of Agriculture and Fisheries Analytical Services Laboratory Department for other parameters, including organic matter and nutrients. Post-study analyses of these parameters were performed at the same laboratories on treatment group composite samples (6 samples total). Composite post-study samples were also used for particle size analysis at a CWRS laboratory. The oxidation-reduction potential (ORP) of sediment samples from each study plot were also measured in the field using a YSI 600 multiparameter sonde immediately after collection.

3.5 Biological Monitoring

Benthic macroinvertebrates were measured to assess the condition of the benthic habitat under the different study situations. After barriers were removed, sediment samples were collected from each plot, and preserved with isopropyl alcohol. Two samples from each treatment group were selected for analysis, for a total of 12 analysed samples. Benthic invertebrate identification and enumeration was completed by *Envirosphere Consultants Ltd*. A Family Biotic Index (FBI) was calculated for each analyzed sample. While this index was originally designed for stream environments it is regularly used to assess lakes (EPA, 1998; Mandaville, 2002). In addition to the FBI, macroinvertebrate abundance and taxa richness were compared between treatments.

3.6 Barrier Monitoring

Barriers were inspected monthly by *Dominion Diving* technicians. The state of the barrier material, buoys and anchors, vertical rebar, and mat position were assessed. The technicians also made note of any presence of plants growing on top of the material, sediment on top of the barrier, and/or gas trapped under the barrier material. Any repairs, including gas release, were completed during the inspection. Each plot was inspected individually by divers at the mat surface.

4 Study Findings

4.1 Benthic Mats – Vegetation Exclusion

Barriers of both types were able to impede YFH growth in both study zones over the course of the growing season. Figure 5 illustrates the difference in growth between the shallow and deep zones with respect to the different treatments. Throughout the study period, YFH growth was more intense in the shallow zone, covering most of the water surface. Growth was patchier in the deep zone, where most of the water surface remained open. In the shallow zone, both permeable and impermeable barriers succeeded at keeping some water surface free of YFH. Barriers were also able to prevent some growth of YFH in the deep zone. This can be seen in the patches of YFH growing in the laneways that are intercepted by a barriered plot. These growth patches have straight edges along the edge of the barrier, indicating that the barrier has stopped the growth of the plant within the plot (Figure 5). Compiled data from all sampling events is available in APPENDIX B.

In the deep zone, where YFH growth was relatively sparse, the average coverage of barriered plots was not significantly different than control plots ($p = 0.56$). Neither barrier type performed better than control plots in the deep area, which is likely due to the sparse growth of YFH in the deep area. In areas with more YFH coverage, both barrier types performed well in terms of reducing the coverage by YFH at the water surface. Impermeable and permeable barriers had significantly less YFH coverage than control plots ($p = 0.017$). Though growth did infringe on the edges of the barriered plot at the surface, the YFH coverage of barriered plots was about half that of control plots throughout the project (Figure 5 & Figure 6). In general, the quantified effect of the barriers is less obvious in the deep study zone (Figure 6). In areas where coverage of the plant is already sparse, like the deep zone, placing barriers did not have a significant impact on the amount of YFH covering the surface. Overall, the permeable and impermeable barriers performed equally well, with neither type showing significantly less YFH growth than the other, as determined by Tukey's pairwise comparisons (APPENDIX B).

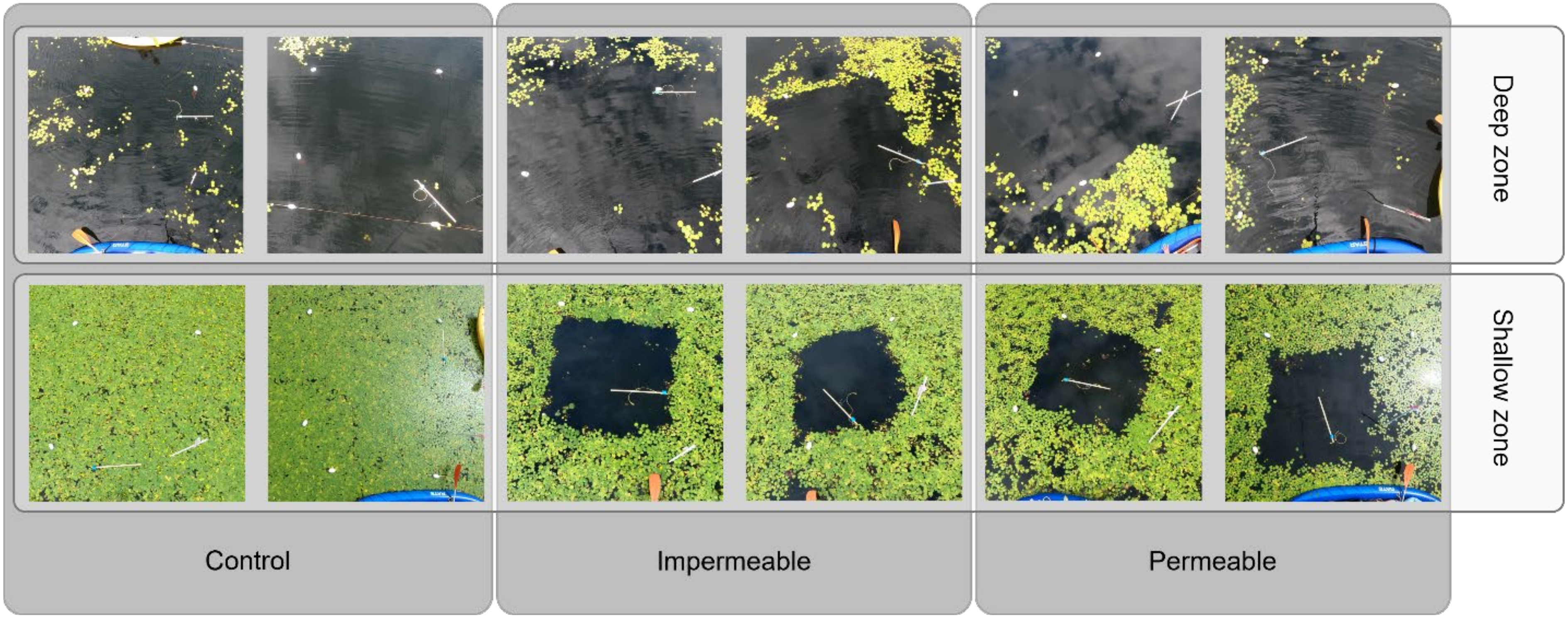

Figure 5. Example study plot photographs, top: deep zone, bottom: shallow zone, left: control plots (no barrier), centre: impermeable barriered plots (Lake Bottom Blanket), right: permeable barriered plots (Aquascreen).

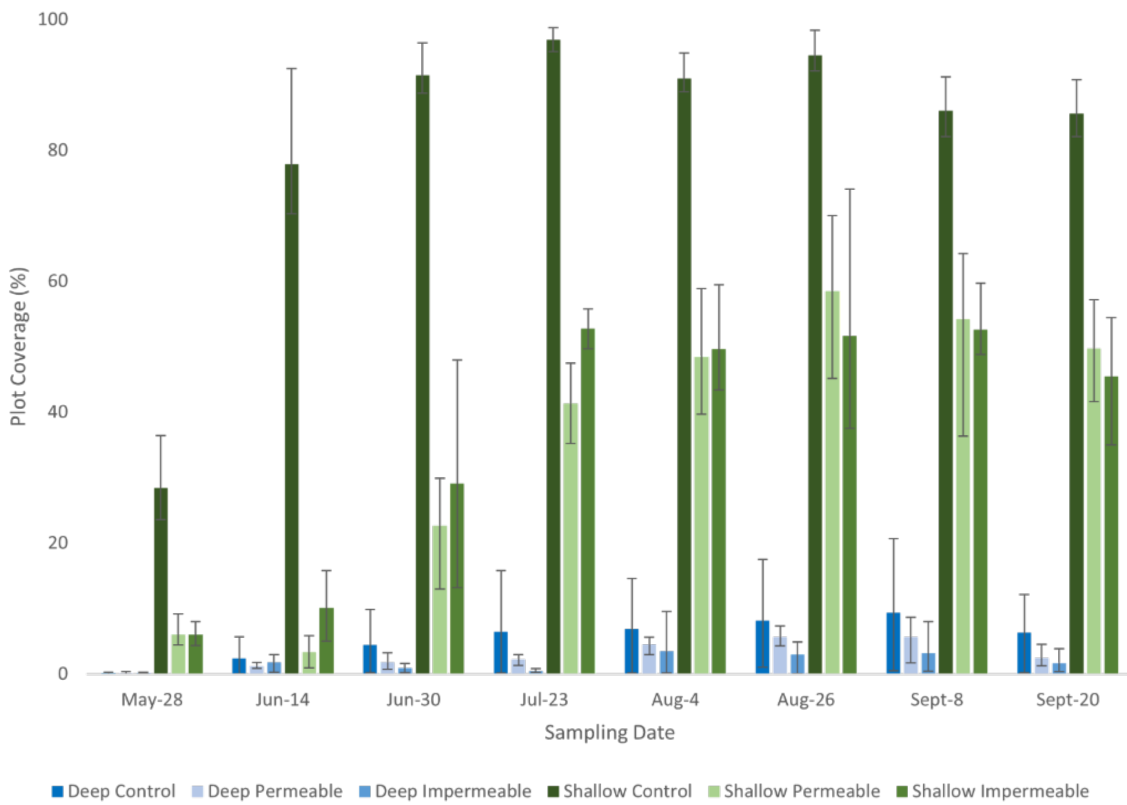

Figure 6. Mean aerial coverage of treatment group plots by YFH during the study period, error bars showing range of observed values.

Two barriered plots in the shallow zone had YFH growth occur in the centre of the plot. This growth was not rooted past the plot's edge, but on/through the barrier itself. The two plots in which this happened had different barrier types installed. Figure 7 shows the failed barriers in the shallow study zone. The permeable plot where this occurred, 14P, had a large amount of YFH growth, and by the end of the study period, the growth in this plot was so intense that the barrier was determined to have failed. In the impermeable plot where this occurred, 17I, the growth was minimal in comparison and contained to the centerline of the plot. Both plots were included in the statistical analysis.

The degree to which the barriers were able to prevent YFH from covering the water surface was determined by finding the percent of the plot area that was covered with YFH and comparing it to the percent coverage of control plots. In the shallow zone, control plots were maximally covered on July 3rd, but because this day is missing some data, a peak coverage date of August 26th was used instead. On August 26th shallow area control plots were 92 – 98 % covered. In the deep zone, control plots reached maximum coverage later in the season, on September 8th, when control plots were 0.5 – 20 % covered.

Figure 7. Failed barriers in shallow study zone, photographs taken on September 20th, left: plot 14P (permeable barrier), right: plot 17I (impermeable barrier).

4.2 Maintenance and Inspections

During the monthly maintenance inspections carried out by *Dominion Diving*, study plots were individually examined for: trapped gas, plants growing on barriers, sediment accumulation on top of barriers, and the repair state of the barrier material, rebar, blocks, and buoys. This information is summarized in Table 1. No barriers sustained damage throughout the study period, so this category was not included in the summary. Trapped gas found under a barrier was released by divers as part of the maintenance plan. Successive months showing trapped gas represents new build-up each month. All maintenance and inspection reports are available in APPENDIX C.

Table 1. Summary of maintenance and inspection reports from monthly inspections by Dominion Diving, full reports available in APPENDIX C

Plot type	Plot location	Gas under barriers	YFH on barriers	Sediment on barriers
Impermeable	Deep	July and August	Some in June and September	1 – 2 mm throughout study period
	Shallow	Consistent throughout study period	Variable throughout study	Minimal (≤1 mm) throughout study
Permeable	Deep	1 mat, only in August and September	Some noted most months	Small layer of sediment on most mats throughout study period
	Shallow	July - September	All plots throughout study	Variable (≤5 mm) through study

Permeable barriers in both study areas performed similarly in terms of plant growth and sediment accumulation, but differently in gas accumulation. In the shallow zone, barriers did not have trapped accumulated gasses on the June inspection dive, but accumulated gas was noted at every inspection from July onwards. The presence and amount of sediment on the barriers varied throughout the project, with the largest sediment accumulation of 5 mm on mat 10P noted in September. All shallow permeable barriers had plants growing on them at every inspection dive, though sometimes plant growth was minimal (APPENDIX C). Plant presence on shallow permeable barriers did not always correspond with sediment presence.

In the deep zone, two of the three permeable barriers did not have accumulated gasses throughout the project. One barrier (1P) had accumulated gasses in August but was noted as minimal in September. Plant growth and sediment on barriers varied throughout the project. Plant growth did occur even without sediment presence; however, one barrier (8P) accumulated a large amount of sediment in August which remained there for the rest of the project. This barrier also experienced considerable plant growth in these months (APPENDIX C)

After the permeable barriers were removed from the lake, it was evident that plants had been able to grow through the mesh and root into the sediment beneath the barriers. Figure 8 illustrates the state of the barriers after removal, with visible growth through permeable barrier material. The mesh fabric did not prevent gasses from building up under the barriers, especially in the shallow zone where gasses needed to be routinely released from under the barriers. If installed at a larger scale, these barriers would require routine maintenance to release trapped gasses and prevent large amounts of sediment deposition on the barriers, and YFH growth may still occur in barriered areas.

Impermeable barriers performed similarly in both study areas in all inspection categories, except for gas accumulation which was more prominent in the shallow zone. In the shallow zone, impermeable barriers had accumulated gases underneath them at every inspection dive. A minimal amount of sediment (1 – 2 mm) was noted on most barriers during most inspections. The presence of sediment on the barriers was sometimes accompanied by a small amount of plant growth on the barriers. Plant growth did not occur without sediment presence. In the deep zone, impermeable barriers had considerable accumulated gasses underneath them in August, minimal gas accumulation was noted in other months. Two of the three impermeable barriers had a small amount of sediment present throughout the project. Plant growth on impermeable mats in the deep zone fluctuated throughout the project but did not occur in the absence of accumulated sediment. No plants appeared to have grown through the barrier material, though some were tangled around the horizontal rebar upon barrier removal (Figure 8). Sediment that accumulates on impermeable barriers may facilitate plant growth on top of the barriers. If installed, sediment should be cleared from barriers on a regular basis to prevent plant growth. In shallow areas, gas accumulates quickly under the barriers and should be released regularly. Compared to permeable barriers, impermeable barriers appeared to be more durable and resistant to YFH growth. Therefore, if this approach is to be used within a full-scale restoration program, it is recommended that impermeable barriers are used.

Overall, it was observed that gas buildup occurred in all barriered shallow zone plots, regardless of barrier type. In the deep zone, impermeable mats were more prone to gas build-up than permeable mats. Plants grew through the permeable mesh barriers in both study areas. Plant growth also occurred on impermeable barriers, but only when sediments had accumulated on top of the barriers. Additionally, green algae were observed throughout the deep zone during the September inspection. The sparse growth of emergent plants in this area may have increased light availability allowing for increased algal growth.

Figure 8. Barriers after removal from Little Albro Lake on September 29th, top: impermeable barrier, bottom: permeable barrier showing YFH growth through material.

4.3 Impact on Benthic Environment

The use of benthic barriers has been shown to have adverse effects on the chemistry and biology/ecology of the benthic environment (Eakin & Barko, 1995; Ussery et al., 1997). These were monitored by completing physical and chemical analysis of sediments of each treatment group and an analysis of the macroinvertebrate community to observe any direct effects the barriers might have on the ecology of the lake.

4.3.1 Physical and Chemical Impacts

Benthic barriers, especially impermeable mats, can trap a small volume of water between the sediment and the barrier which can alter the chemistry at this interface (Eakin & Barko, 1995; Gunninson & Barko, 1992). The sediments at each study plot were monitored for changes in chemistry including oxidation-reduction potential (ORP), metal concentrations, pH, and other parameters.

Sediment ORP was measured to determine differences between the ORP of barriered and control plots. ORP is closely related to oxygen concentration, with high values (> 100 mV) indicating oxygen rich environments and lower values corresponding with lower oxygen environments (Wetzel, 2001). Barriers in the deep zone appeared to affect the ORP of the sediments below them (Figure 9). Plots covered with barriers (of either type) had mostly negative ORP values, while control plots in this area had positive values. The only barriered plot that had a positive ORP measurement was 8P, which was a permeable barrier that had been covered with a moderate amount of sediment for the last two months of the project and experienced considerable plant growth.

When all three deep zone plot treatments were compared in a one-way ANOVA, no significant statistical difference was found between any treatments (control, permeable, impermeable) ($p = 0.149$). However, when data from barriered plots (impermeable and permeable) is combined to create a 'barrier treated' category, barrier treated plots are found to be significantly different from control plots ($p = 0.043$) (APPENDIX D).

Barriers in the shallow zone did not appear to affect the ORP of the sediments below them. The ORP values measured in these plots were close to those of control plots, with ORP values in all shallow zone plots being positive. ORP measurements taken at control plots ranged from 63 – 106 mV, while measurements at most of the barriered plots measured between 55 – 86 mV, with one plot (15I) having a lower ORP measurement of 40 mV (Figure 9). No plot type was found to be significantly different from another ($p = 0.302$). Barriers in the areas deeper than 2 m altered the ORP of the lake sediments to be more strongly reducing environments than the sediments in control plots at the same depth. This difference was not dependent on barrier type. Sediment ORP in the shallow zone (~1 m) were not greatly altered by the barriers.

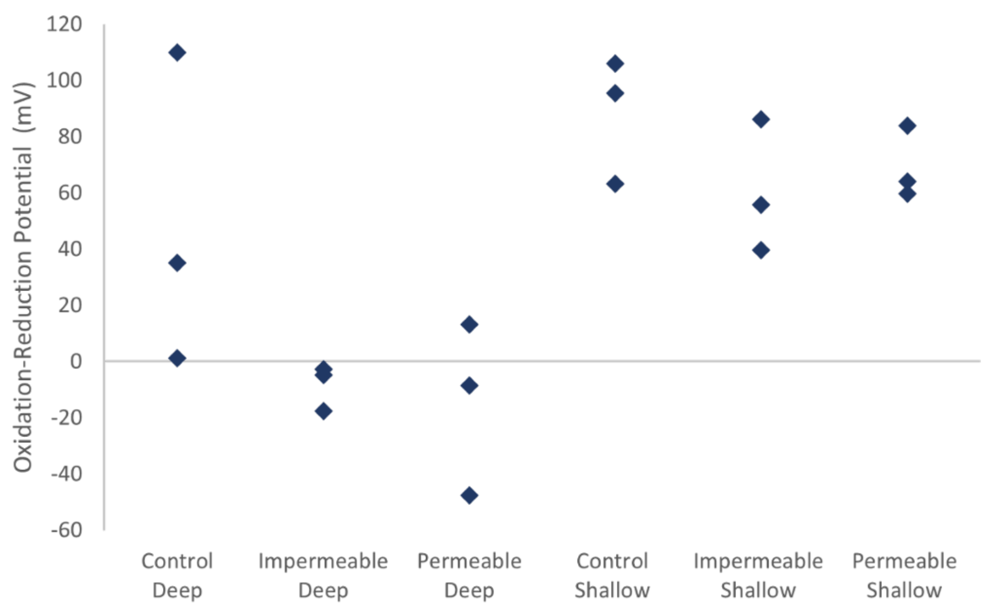

Figure 9. Oxidation-reduction potential measurements taken from sampled sediments of study plots after barrier removal, control plots: September 28th, barriered plots: September 29th.

Particle size analysis was completed on the post – pilot study composite sediment samples. Samples from the shallow and deep zones, for each plot treatment, had similar particle size distributions. Particle size analysis indicated that the Little Albro Lake sediments are finer textured sediments (60 % fines (< 63 um), 23 % sand, and 16 % gravel).

A summary of the sediment metals analysis is provided in Table 2 and the complete dataset is provided in APPENDIX E. When compared to CCME Sediment Quality Guidelines for the Protection of Aquatic Life in freshwater systems, most parameters were within an acceptable range (CCME, 2021). The CCME guidelines include three ranges:

- Below the interim sediment quality guidelines (ISQG), the minimal effect range within which adverse effects rarely occur,
- Between the ISQG and the probable effect level (PEL), the possible effect range within which adverse effects occasionally occur,
- Above the PEL, the probable effect range within which adverse effects frequently occur.

Arsenic levels in Little Albro Lake sediment were above the PEL (17 mg/kg) for both the shallow and deep study areas, in all plot treatments. Pre- and post – pilot study arsenic levels are within similar magnitudes but slightly increased post – pilot study. Arsenic is redox sensitive and can be released from the sediment to the water column during anoxic conditions at the sediment – water interface (Chen et al., 2019). As arsenic levels are elevated in Little Albro Lake sediment, the introduction of benthic barriers at a larger scale in the lake could promote the mobilization of arsenic into the water column due to the anoxic environment under the barriers.

The only other metal that exceeded the PEL threshold was lead, in the shallow control plots. Lead concentrations were variable throughout the treatments, with the shallow area generally possessing higher concentrations.

Table 2. Sediment metals concentrations pre and post pilot study for each treatment, compared to CCME guideline thresholds. Below ISQG – green, between ISQG and PEL – yellow, and above PEL – red.

Parameter	SPRING		FALL					
	SHALLOW	DEEP	SHALLOW			DEEP		
			Control	Permeable	Impermeable	Control	Permeable	Impermeable
Arsenic	30	35	106	46	46	44	60	53
Cadmium	0.5	0.6	1.1	0.9	0.5	0.5	0.7	0.5
Chromium	15	31	31	30	21	15	23	16
Copper	33	62	72	60	34	23	45	30
Lead	27.0	39.2	99.0	81.1	60.8	26.7	46.5	31.1
Zinc	137	281	253	216	126	99	200	121

Nutrient and organic matter analysis was also completed on the sediment samples post – pilot study. Nitrogen levels were consistent throughout both study zones and between plot treatments. The organic matter content in the lake sediment was consistent throughout the shallow and deep zones, and between plot treatments, averaging 8 % (APPENDIX E).

4.3.2 Biological Impacts

The most abundant macroinvertebrates across both study areas were *chironomidae* (chironomids) and *oligochaeta* (aquatic worms), appearing in eight and eleven of the twelve analyzed plots, respectively. Other organisms were present but appeared in only one or two of the analyzed samples (APPENDIX F). The high abundance of these two taxa indicates poor, highly impacted water quality in the lake (Timm & Haldna, 2019).

Macroinvertebrate abundance was generally very low, with most samples containing less than 25 organisms. Among treatment groups, average macroinvertebrate abundance appeared to be lower in the impermeable plots in both study areas. Mean sample macroinvertebrate abundances were 4 and 5.5 for the impermeable deep and shallow treatment groups, while permeable and control groups had means of 14 and 15 in the deep study zone, and 19.5 and 37 in the shallow study zone (APPENDIX F). Additionally, average taxa richness appeared to be higher in control plots (deep 4, shallow 3) than treated plots (deep: impermeable 2.5, permeable 2; shallow: 2, both barrier types) in both study areas (APPENDIX F). However, there was a large amount of variability within treatment groups.

Macroinvertebrate populations did not appear to be affected by the lower ORP measurements observed in the treated deep zone plots but may have been affected by barrier type and barrier presence in general, regardless of study area.

The Family Biotic Index (FBI) was calculated based on the macroinvertebrate community composition for each treatment group. A higher score in this index indicates a more impacted system, with poorer water quality (Hilsenhoff, 1988). The FBI results, which yielded relatively high values, are shown in Figure 10. Most FBIs were above the 'very poor' threshold of 7.26 and were not dependant on plot type, indicating very poor water quality throughout the lake. High scores were seen at both control and barriered treatment groups in both study zones. Macroinvertebrates are indicators of both short-term and long-term stress in aquatic systems (Carter et al., 2006). These results indicate that Little Albro Lake is currently providing poor habitat for macroinvertebrates, even in the absence of benthic barriers.

It should be noted that FBI scores are usually calculated for samples containing 100 – 500 organisms (Carter et al., 2006). Group treatment scores were calculated to demonstrate the similarities between treatment and control groups, however the minor differences between samples should be viewed with caution due to the small number of organisms recovered. Pooling the results of all the sediment samples yields an overall FBI score of 7.81 for the lake, indicating very poor water quality (Carter et al., 2006).

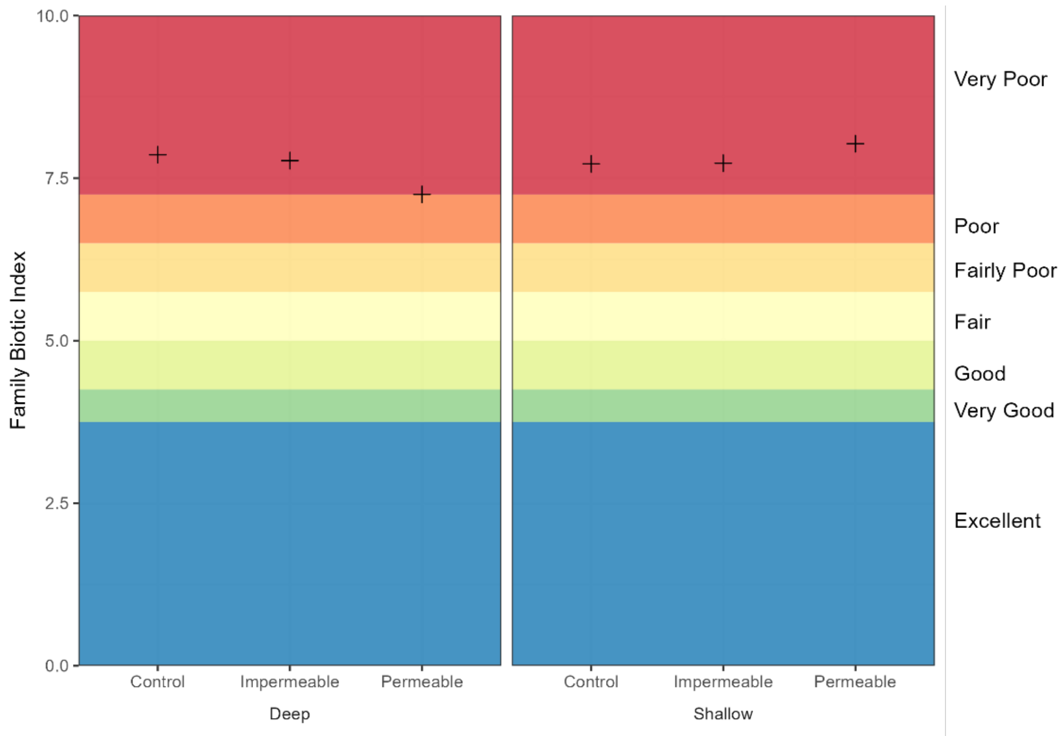

Figure 10. Family Biotic Index results for all plot treatments in the shallow and deep study zones. Water quality thresholds are illustrated by colors.

4.4 Lake Ecosystem Characteristics

A suite of additional measurements were collected to better understand the physical, chemical, and biological characteristics of Little Albro Lake. This included water quality parameters, temperature and dissolved oxygen profiles, and sediment particle size distributions.

4.4.1 Nutrient Concentrations

Little Albro Lake is meso-eutrophic with moderately high nutrient levels. Total phosphorus levels measured during August and September generally were between 20 – 35 µg/L, placing the lake in the meso-eutrophic trophic status category (Table 3: CCME, 2004). The mean total phosphorus concentration during the study was 22 µg/L, though values ranged from 12 to 44 µg/L. Soluble reactive phosphorus (SRP) concentrations were also elevated with a mean concentration of 3 µg/L during the study, and a maximum concentration of 8 µg/L measured in a sample taken at the surface of the shallow study area in September.

Table 3. CCME trophic status trigger ranges based on phosphorus concentration for Canadian lakes (CCME, 2004).

Trophic Status	Total phosphorus (µg/L)
Ultra-oligotrophic	< 4
Oligotrophic	4 – 10
Mesotrophic	10 – 20
Meso-eutrophic	20 – 35
Eutrophic	35 – 100
Hyper-eutrophic	> 100

Total nitrogen concentrations were typical of an urban lake in Nova Scotia with a mean concentration of 0.30 mg/L. The highest total nitrogen concentration observed during the project was 1.2 mg/L, measured in a sample taken from the bottom of the water column at the deep study area on August 26th. All nutrient concentration data from analysis performed by the CWRS can be found in APPENDIX G and results from analysis by *AGAT Laboratories Ltd.* can be found in APPENDIX H.

4.4.2 Additional Water Quality Parameters

Little Albro Lake has a neutral pH with in-situ observations ranging between 6.4 and 7.4. Values reported by *AGAT Laboratories Ltd.* ranged from 7.1 - 7.2.

Additional water quality measurements were compared to CCME Guidelines for the Protection of Aquatic Life. Concentrations were also compared to those observed in upstream Albro Lake. Chloride concentrations in Little Albro Lake exceeded the CCME Long Term Guideline of 120 mg/L in the spring (132 mg/L) but were lower than the guideline in the fall. Both lakes have elevated chloride concentrations with all observations exceeding 100 mg/L. Accompanying these high chloride concentrations are high electrical conductivity measurements (487 µmho/cm spring, over 400 µmho/cm for all other observations), elevated sodium concentrations (86 mg/L in the spring, over 60 mg/L for all other observations), and elevated total dissolved solids concentrations (248 mg/L in the spring, all other observations > 190 mg/L). These elevated values are likely caused by inputs of road salt.

Water colour was higher in Little Albro Lake (spring: 7.9 TCU, fall: 12.5 TCU) compared to Albro Lake (spring: < 5.0 TCU, fall: 7.3 TCU). The turbidity in Little Albro Lake during the fall was 1.4 NTU (1.0 NTU in Albro Lake). During the fall sampling dissolved organic carbon concentrations were higher in Little Albro Lake (7.9 mg/L) than in Albro Lake (4.0 mg/L). These elevated values may be due to the high macrophyte abundance, including YFH, in Little Albro Lake and the decay of floating plant matter after senescence.

Total iron concentrations in Little Albro Lake during the fall were elevated (501 ug/L) and exceeded the CCME guideline of 300 µg/L. Total manganese was also elevated in Little Albro Lake in the fall at (95 µg/L) compared to Albro Lake (53 µg/L). No other metals were measured at concentrations exceeding CCME guidelines. A summary of water quality data is available in APPENDIX H .

4.4.3 Mixing Regime

As Little Albro Lake is shallow (< 7 m), it was expected to be completely mixed throughout the study period. However, temperature and dissolved oxygen measurements taken on August 26th indicated that the lake had become thermally stratified (Figure 11). A temperature difference of 1.6 °C was observed between a depth of 1 m and 2 m and dissolved oxygen saturation dropped from 74 % to 9 %. The lake became anoxic with depth with a dissolved oxygen saturation measurement of 2.1 % (0.18 mg/L) at a depth of 2.5 m (Wetzel, 2001). Thermal stratification and associated anoxia near the bottom of the water column can negatively impact water quality, and aquatic organisms, and is important to consider in future lake restoration and management plans. All in-situ data collected during the pilot study is available in APPENDIX I.

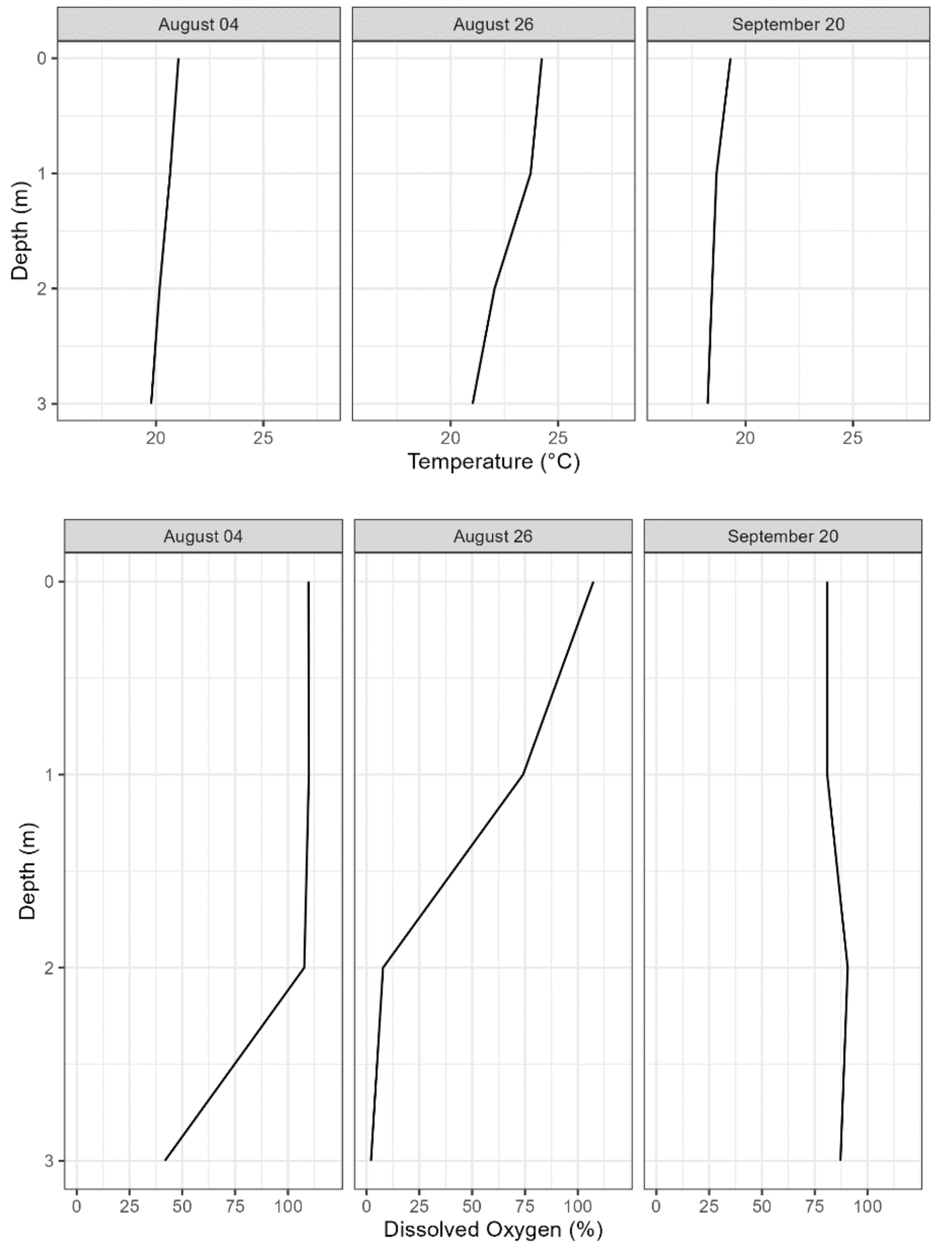

Figure 11. Temperature and dissolved oxygen profiles in Little Albro Lake, showing thermal stratification on August 26th.

4.4.4 *Other Primary Producers*

During sampling events it was observed that areas of the lake not densely colonized by YFH had dense communities of other submergent vegetation. These plants were not identified but are believed to be bladderworts and other aquatic macrophytes, which were also noted in a plant survey completed in 2007 (Boates & Elderkin, 2009). In areas with dense YFH growth, this submergent vegetation was either not observed or was far less dense. It is likely that YFH is outcompeting this submergent vegetation by shading the water column and reducing light availability (Kelly & Maguire, 2009).

In the deep study zone, where growth of YFH was relatively sparse, green algae was noted during the September maintenance inspection (APPENDIX C). It is important to note that if YFH is eradicated from the lake and the water column is no longer shaded, other fast growing primary producers, such as algae or cyanobacteria, may fill the niche before native macrophytes have a chance to establish.

4.5 Scale-up Feasibility

An image classification was performed on a 40 cm resolution GeoEye-1 satellite image taken September 1st, 2021, to determine the areal coverage of YFH during the peak of the growing season. The satellite image was acquired from Apollo Mapping and analyzed in ArcGIS Pro 2.7.0 using the Spatial Analyst extension. YFH was estimated to cover 55% of the lake surface on September 1st, 2021, at a maximum depth of 3.1 m. This YFH coverage is illustrated in Figure 12. To cover this area with benthic barriers, adding an extra 10% (65% lake surface area) to account for wastage and overlapping sections, would require approximately 19,500 m^2 of material. The impermeable barrier product (Lake Bottom Blanket) costs approximately $14/$m^2$, therefore the costs of the barriers for a full-scale application would be in the range of $270,000. Other potential costs would include (i) additional materials (e.g., rebar), (ii) labour for installation, maintenance, and removal of the barriers, (iii) consulting fees for planning, permitting, and monitoring of the restoration program, (iv) laboratory fees for sediment and water quality monitoring, and (v) disposal of the barriers in an appropriate landfill facility at the end of the project. It should be noted that the barriers may need to be installed and removed annually for several years to eradicate and/or control YFH.

Figure 12. GE1 satellite image of YFH coverage of Little Albro Lake (40 cm resolution) acquired September 1, 2021

Although the barriers did impede the growth of YFH, this technique should be carefully compared to other potential restoration options before initiating a full-scale restoration program. For example, until recently, there were no herbicide options that had been proven to be effective in controlling YFH and approved for general use in aquatic systems. During the summer of 2021 a peer reviewed study was published on the use of a new aquatic herbicide to control YFH in a drinking water reservoir in Oklahoma, USA. The aquatic herbicide ProcellaCOR™ (active ingredient = florpyrauxifen-benzyl) was shown to be very effective at decreasing surface coverage of YFH infestations. The 55-acre infestation in the reservoir was reduced to less than 3 acres following a single application. The surface coverage of YFH was decreased by more than 90% within 15 days of treatment (Lamb et al., 2021). ProcellaCOR™ is a systematic herbicide that can be applied below the water surface. It is a synthetic auxin herbicide for selective control of common nuisance or invasive weeds (SEPRO Corp., 2019). It has been approved by the United States Environmental Protection Agency as a reduced risk pesticide. In Canada, an application for research authorization has been approved by the Pest Management Regulatory Agency (Government of Canada, 2017).

5 Conclusions

The primary objective of the study was to assess the applicability of benthic barriers as a method to control the growth of YFH in Little Albro Lake. The main conclusions of the pilot study are as follows:

- Barriers of both types (permeable and impermeable) were able to impede YFH growth in both the shallow and deep study zones. The permeable and impermeable barriers performed equally well, with neither type showing significantly less YFH growth than the other. However, when the barriers were removed and inspected at the end of the study, it was noted that YFH had been able to grow through some sections of the permeable barriers. If this approach is to be used within a full-scale restoration program, it is recommended that impermeable barriers (Lake Bottom Blanket) are used.

- Inspection of the barriers throughout the study revealed several maintenance issues that would need to be addressed within a full-scale restoration program. Gas build-up was observed under both permeable and impermeable barriers and would need to be vented at regular intervals. Sediment deposition on top of the barriers was also observed, and YFH growth within these deposits was noted.

- Permeable and impermeable benthic barriers had measurable effects on the lakebed environment. Barriers in areas deeper than 2 m produced more strongly reducing environments (negative ORP) in sediments than those observed in the control plots at the same depth. This could have negative impacts on aquatic biota and lead to mobilization of redox sensitive metals, like arsenic, from the sediment into the water column. Arsenic concentrations in Little Albro Lake sediments exceeded CCME Sediment Quality Guidelines for the Protection of Aquatic Life. This would need to be monitored in the future if benthic barriers were used to control YFH. An analysis of benthic macroinvertebrate populations in sediments collected from the study plots revealed only minor differences between control and barriered plots. However, all samples possessed very low numbers of organisms, including the control plot samples, and ecological quality metrics indicated that the lake has poor water quality.

- Little Albro Lake is a shallow, meso-eutrophic water body, with a neutral pH. The water column was observed to be weakly stratified in late August, with low dissolved oxygen levels measured near the sediment water interface. If YFH is removed from the lake, other primary producers (plants, algae, cyanobacteria) will thrive. A variety of other aquatic plants were observed in the lake, but it should also be noted that cyanobacteria could also proliferate in this type of ecosystem. This risk should be properly considered within future restoration and lake monitoring plans.

- YFH was estimated to cover 55% of the lake surface at its peak during the 2021 growing season. If barriers were to be placed in all areas of the lake currently infested by YFH, this would require 19,500 m^2 of barrier material, costing approximately $270,000. This is only the cost of the barrier materials, and does not include other materials costs (rebar), or labour costs for installation, maintenance, and removal of the mats. Other potential costs would include consulting fees for planning, permitting, and monitoring the restoration program, laboratory analysis of water and sediment samples, and eventual disposal of the barrier materials in an appropriate landfill.

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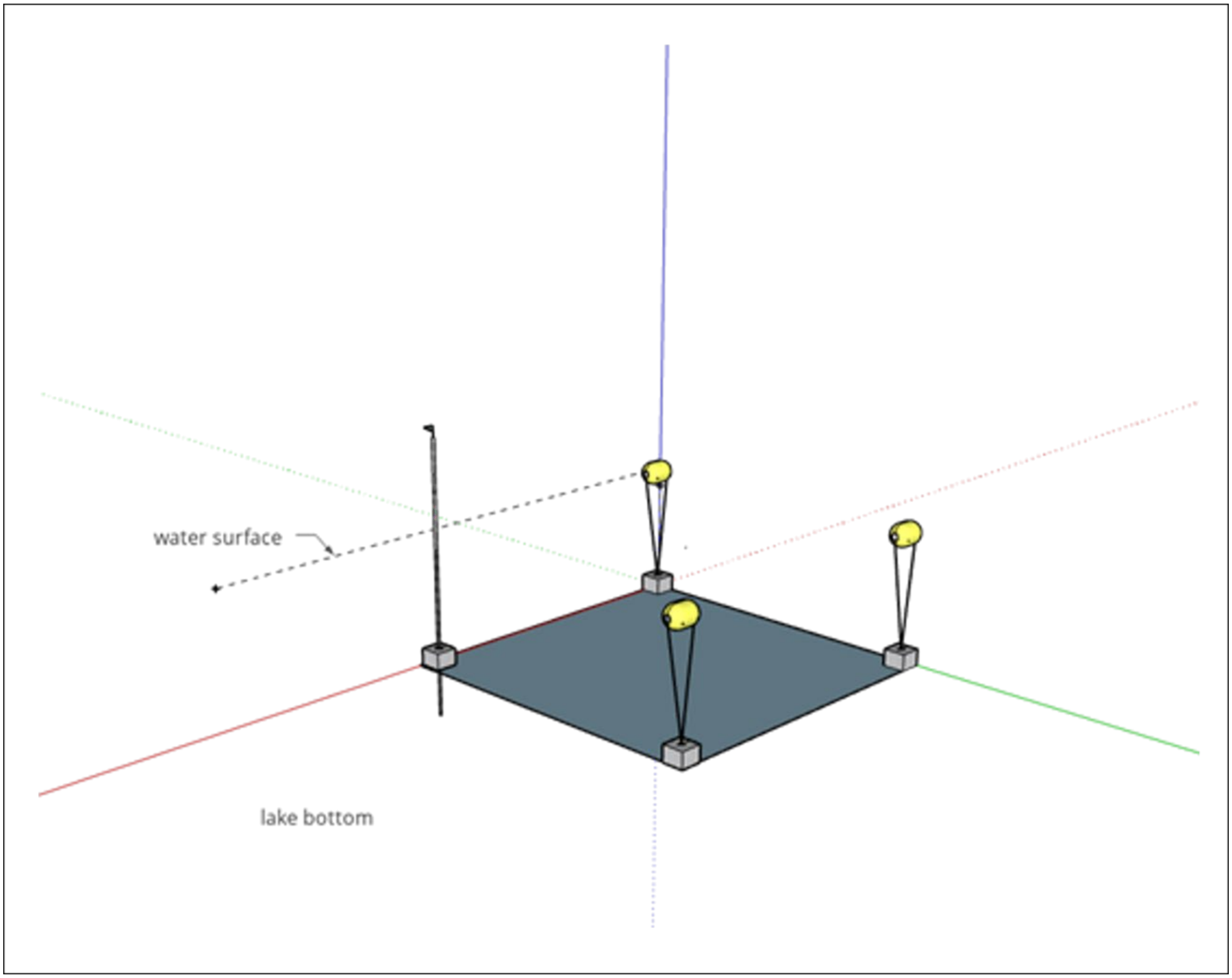
APPENDIX A

Design schematic of barriered (permeable and/or impermeable) study plots, isometric view.

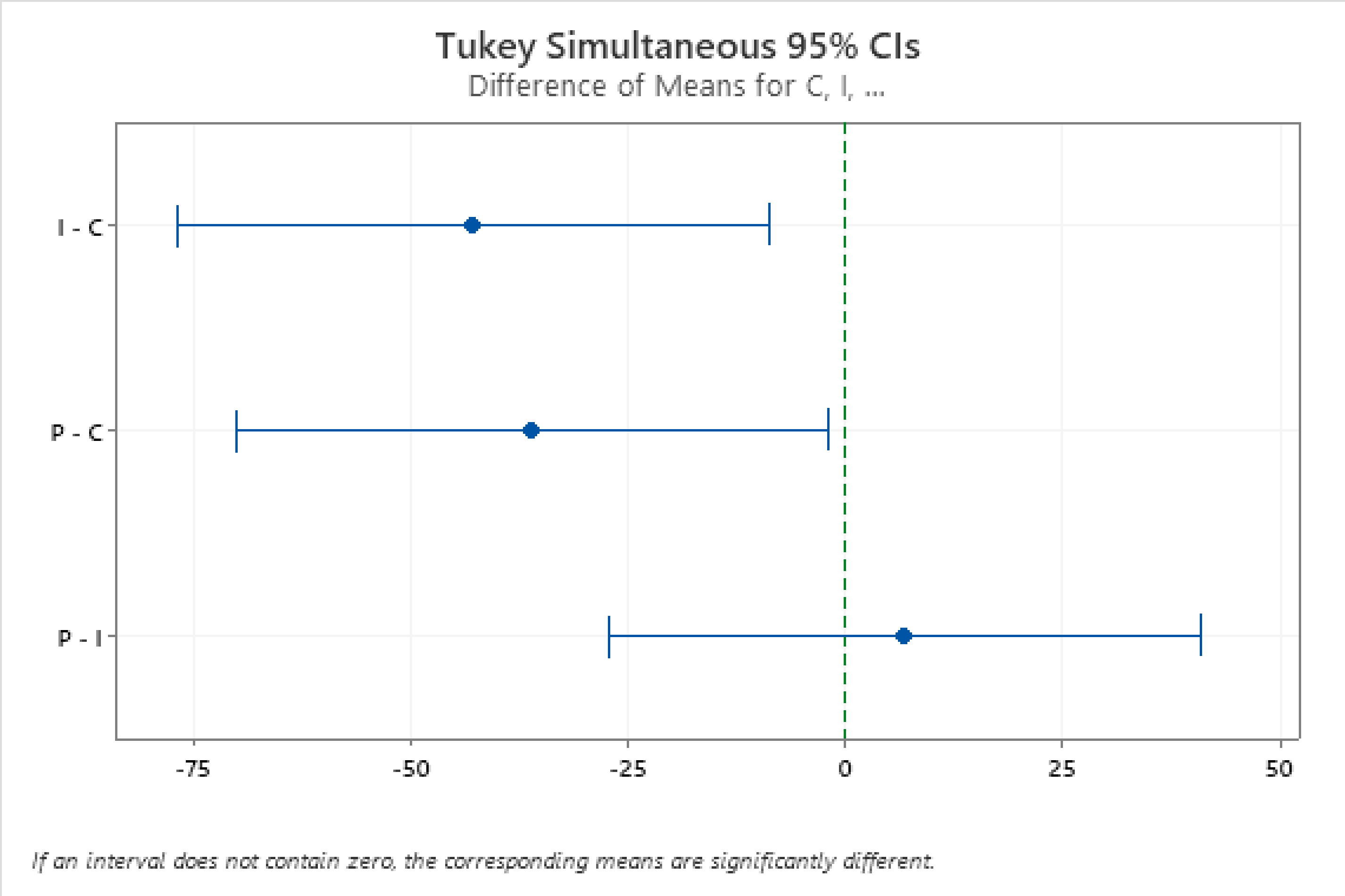


APPENDIX B

Plot coverage data for each sampling event of benthic barrier pilot project at Little Albro Lake. Plot numbers 1-9 are in the deep study zone, plot numbers 10-18 are in the shallow study zone. Letters indicate plot type: C = control (no barrier), I = impermeable barrier, P = permeable barrier. Images analyzed on FIJI ImageJ software

	Percent Aerial Coverage of Plot by Yellow Floating Heart							
	Date							
Study Plot	**May-28**	**Jun-14**	**Jun-30**	**Jul-23**	**Aug-4**	**Aug-26**	**Sept-8**	**Sept-20**
1P	0.09	1.75	3.22	2.48	4.98	5.22	6.64	4.51
2C	0.29	5.68	9.84	15.76	14.55	17.46	20.63	12.10
3I	0.27	2.13	0.98	0.75	0.84	4.88	1.19	0.72
4C	0.16	1.34	3.29	3.53	6.10	5.98	6.86	6.70
5I	0.26	2.95	1.62	0.35	9.51	3.97	7.99	3.84
6P	0.00	0.84	0.72	2.90	2.94	4.30	1.65	1.24
7I	0.01	0.26	0.17	0.28	0.14	0.05	0.39	0.33
8P	0.34	0.86	1.31	1.30	5.64	7.33	8.62	1.60
9C	0.00	0.08	0.15	0.12	0.09	0.97	0.49	0.20
10P	4.41	0.93	12.96	35.23	39.70	45.14	36.32	41.58
11I	4.32	9.43	13.16	*	43.41	37.52	49.26	47.01
12P	4.40	5.83	25.03	*	46.81	60.18	62.13	50.47
13C	25.35	70.30	96.43	98.73	89.20	98.37	91.26	82.07
14P	9.15	3.27	29.88	47.42	58.91	69.99	64.20	57.15
15I	5.65	5.03	26.19	49.72	46.02	43.31	48.80	35.02
16C	23.56	70.80	88.70	*	88.92	92.11	82.11	90.75
17I	7.99	15.79	47.98	55.77	59.49	74.12	59.71	54.43
18C	36.39	92.51	89.27	95.10	94.84	93.05	84.88	84.12
Mean deep control (2C, 4C, 9C)	0.15	2.37	4.43	6.47	6.91	8.14	9.33	6.33
Mean deep impermeable (3I, 5I, 7I)	0.18	1.78	0.93	0.46	3.50	2.97	3.19	1.63
Mean deep permeable (1P, 6P, 8P)	0.14	1.15	1.75	2.23	4.52	5.62	5.64	2.45
Mean shallow control (13C, 16C, 18C)	28.43	77.87	91.47	96.91	90.99	94.51	86.08	85.65
Mean shallow impermeable (11I, 15I, 17I)	5.99	10.08	29.11	52.74	49.64	51.65	52.59	45.49
Mean shallow permeable (10P, 12P, 14P)	5.99	3.34	22.62	41.32	48.47	58.44	54.22	49.73

Tukey's pairwise comparison of mean aerial coverage by plot type in the shallow study zone on August 26th (peak coverage). Analysis completed on Minitab software.



APPENDIX C

Maintenance reports from plots inspections by *Dominion Diving*

Date - June 03, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Shallow Zone - West Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Control	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A
- North Center - Impenetrable	Yes	No	Yes / few snails	Yes	Yes	Good	Good	Released majority of trapped gas.
- North East - Control	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A
- Center West - Control	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A
- Center Center - Penetrable	No	No	Yes / snails	Yes	Yes	Good	Good	None
- Center East - Impenetrable	Yes	No	Yes / few snails	Yes	Yes	Good	Good	Released majority of trapped gas.
- South West - Penetrable	No	No	Yes / snails	Yes	Yes	Good	Good	None
- South Center - Impenetrable	Yes	No	Yes / few snails	Yes	Yes	Good	Good	Released majority of trapped gas.
- South East - Penetrable	No	No	Yes / snails	Yes	Yes	Good	Good	None

Date - June 03, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Deep Zone - East Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Impenetrable	Minimal	No	Minimal	Minimal	Yes	Good	Good	No
- North Center - Penetrable	No	No	Minimal	Minimal	Yes	Laying on bottom	Good	Re-install vertical rod with blocks.
- North East - Control	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A
- Center West - Control	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A
- Center Center - Impenetrable	Minimal	No	Minimal / few snails	Minimal	Yes	Good	Good	No
- Center East - Penetrable	No	No	Minimal / few snails	Minimal	Yes	Good	Good	No
- South West - Penetrable	No	No	Minimal / few snails	Minimal	Yes	Good	Good	No
- South Center - Control	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A
- South East - Impenetrable	No	No	Minimal / few snails	Minimal	Yes	Good	Good	Adjust anchor block on mat.

Date - July 2, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Shallow Zone - West Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Control	N/A	N/A	N/A	N/A	N/A	Good	Good	No
- North Center - Impenetrable	Yes	No	No	No	Yes	Good	Good	Released majority of trapped gas.
- North East - Control	N/A	N/A	N/A	N/A	N/A	Good	Good	No
- Center West - Control	N/A	N/A	N/A	N/A	N/A	Good	Good	No
- Center Center - Penetrable	Yes	No	No	Small plants	Yes	Good	Good	Released majority of trapped gas.
- Center East - Impenetrable	Yes	No	No	Small plant Few snails	Yes	Good	Good	Released majority of trapped gas.
- South West - Penetrable	Yes	No	No	Small plant Few snails	Yes	Good	Good	Released majority of trapped gas.
- South Center - Impenetrable	Yes	No	1mm of sediment	Lots of snails	Yes	Good	Good	Released majority of trapped gas.
- South East - Penetrable	Yes	No	1mm of sediment	Small plants Lots of snails	Yes	Good	Good	Released majority of trapped gas.

Date - July 2, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Deep Zone - East Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Impenetrable	Yes	No	1mm of sediment	Lots of snails	Yes	Good/ missing tag	Good	Released majority of trapped gas.
- North Center - Penetrable	No	No	No	A few snails	Yes	Good	Good	No
- North East - Control	N/A	N/A	N/A	N/A	N/A	Good/ missing tag	Good	No
- Center West - Control	N/A	N/A	N/A	N/A	N/A	Good/ missing tag	Good	No
- Center Center - Impenetrable	No	No	No	A few snails	Yes	Good/ missing tag	Good	No
- Center East - Penetrable	No	No	1mm of sediment	Small plants	Yes	Good/ missing tag	Good	No
- South West - Penetrable	No	No	No	Lots of snails	Yes	Good	Good	No
- South Center - Control	N/A	N/A	N/A	N/A	N/A	Good/ missing tag	Good	No
- South East - Impenetrable	No	No	1mm of sediment	No	Yes	Good/ missing tag	Good	No

Date - Aug 13, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Shallow Zone - West Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Control	N/A	N/A	N/A	YES	N/A	PLUMB	GOOD	NO
- North Center - Impenetrable	YES	NO	Light Amount	NO	YES	PLUMB	GOOD	Released Gas
- North East - Control	N/A	N/A	N/A	YES	N/A	PLUMB	GOOD	NO
- Center West - Control	N/A	N/A	N/A	YES	N/A	PLUMB	GOOD	NO
- Center Center - Penetrable	YES	NO	Large Amount	YES	YES	PLUMB	GOOD	Released Gas
- Center East - Impenetrable	YES	NO	Light Amount	YES	YES	PLUMB	GOOD	Released Gas
- South West - Penetrable	YES	NO	Light Amount	YES	YES	PLUMB	GOOD	Released Gas
- South Center - Impenetrable	YES	NO	Light Amount	YES	YES	PLUMB	GOOD	Released Gas
- South East - Penetrable	YES	NO	Large Amount	YES	YES	PLUMB	GOOD	Released Gas

Date - Aug. 13, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Deep Zone - East Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Impenetrable	YES	NO	Slime Present	NO	YES	PLUMB	GOOD	Released Gas
- North Center - Penetrable	NO	NO	Large Amount	YES	YES	PLUMB	GOOD	NO
- North East - Control	N/A	N/A	N/A	YES	N/A	PLUMB	GOOD	NO
- Center West - Control	N/A	N/A	N/A	YES	N/A	PLUMB	GOOD	NO
- Center Center - Impenetrable	YES	NO	Slime Present	NO	YES	PLUMB	GOOD	Released Gas
- Center East - Penetrable	NO	NO	Slime Present	YES	YES	PLUMB	GOOD	NO
- South West - Penetrable	YES	NO	Slime Present	YES	YES	PLUMB	GOOD	Released Gas
- South Center - Control	NO	N/A	N/A	YES	N/A	PLUMB	GOOD	NO
- South East - Impenetrable	YES	NO	Slime Present	NO	YES	PLUMB	GOOD	Released Gas

Date - September 9, 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

Shallow Zone - West Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Control	N/A	N/A	N/A	N/A	N/A	Good	Good	No
- North Center - Impenetrable	Yes	No	No	No	Yes	Good	Good	Released majority of trapped gas.
- North East - Control	N/A	N/A	N/A	N/A	N/A	Good	Good	No
- Center West - Control	N/A	N/A	N/A	N/A	N/A	Good	Good	No
- Center Center - Penetrable	Yes	No	2mm of sediment	Small plants	Yes	Good	Good	Released majority of trapped gas.
- Center East - Impenetrable	Yes	No	1mm of sediment	Small plant Few snails	Yes	Good	Good	Released majority of trapped gas.
- South West - Penetrable	Yes	No	5mm of sediment	Small plant Few snails	Yes	Good	Good	Released majority of trapped gas.
- South Center - Impenetrable	Yes	No	1mm of sediment	Small plant Few snails	Yes	Good	Good	Released majority of trapped gas.
- South East - Penetrable	Yes	No	1mm of sediment	Small plant Few snails	Yes	Good	Good	Released majority of trapped gas.

Date - September 9 2021
Client - McCallum Environmental Ltd.
Contact - Jeff Bonazza, Project Coordinator
Location - Little Albro Lake
Task - Inspection & Maintenance

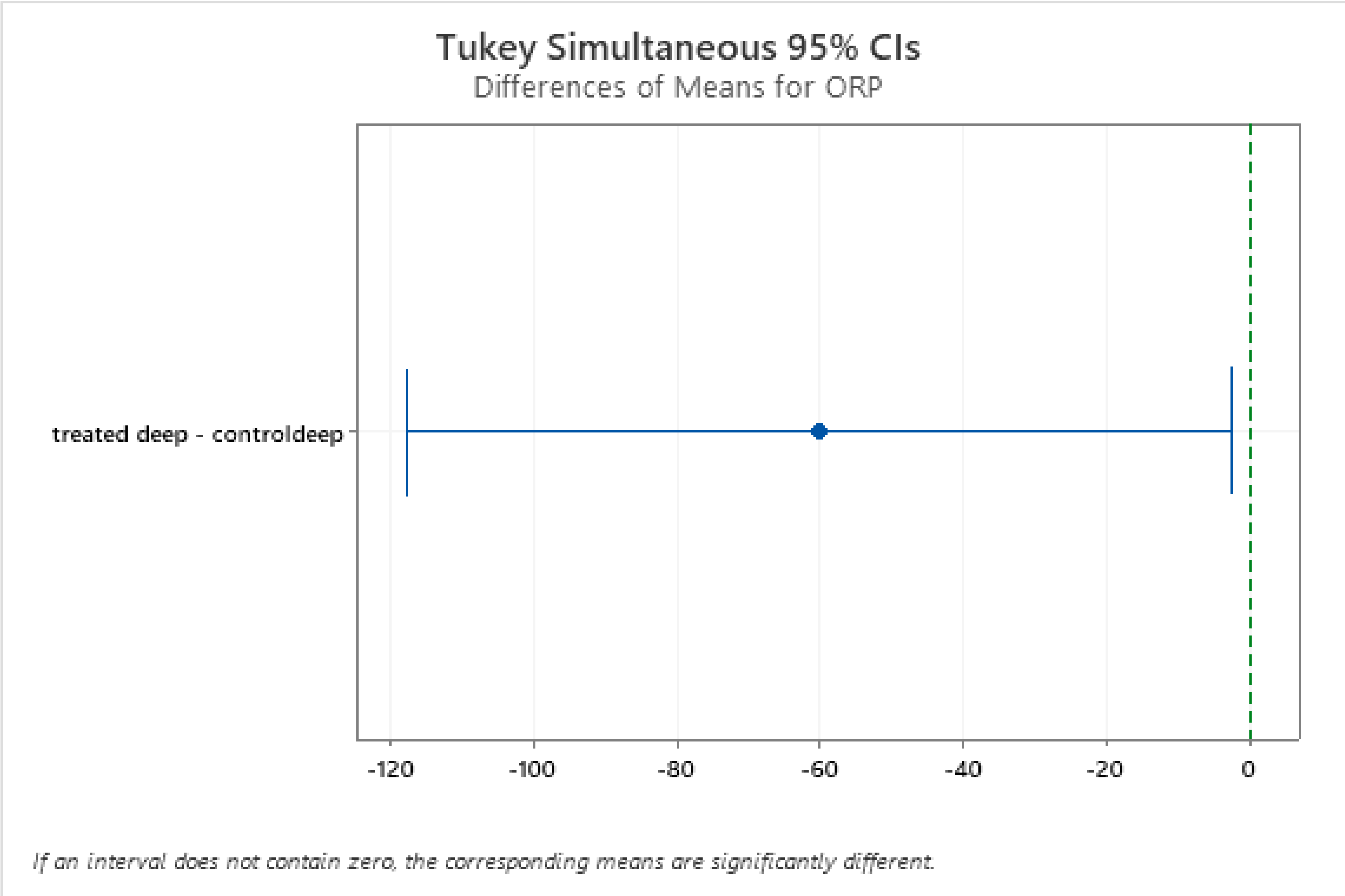
Deep Zone - East Location

- Mat Position - Mat Type	1. Gas trapped under mat.	2. Tears or Rips in mat.	3. Sediment on top of mat.	4. Plants growing on top of mat.	5. Mat positioned correctly.	6. State of vertical rebar.	7. State of buoys.	8. Repairs completed.
- North West - Impenetrable	No	No	1-2mm of sediment	Small plants	Yes	Good/ missing tag	Good	Yes-reinstalled rebar and pole
- North Center - Penetrable	No	No	5mm of sediment	Lots of plants few snails	Yes	Good	Good	Yes extended plastic pole
- North East - Control	N/A	N/A	N/A	N/A	N/A	Good/ missing tag	Good	No
- Center West - Control	N/A	N/A	N/A	N/A	N/A	Good/ missing tag	Good	No
- Center Center - Impenetrable	No	No	1mm of sediment	Green algae	Yes	Good/ missing tag	Good	No
- Center East - Penetrable	No	No	1mm of sediment	Small plants lots snails	Yes	Good/ missing tag	Good	No
- South West - Penetrable	Small Gas	No	1mm of sediment	Small plants lots snails	Yes	Good	Good	Released majority of trapped gas.
- South Center - Control	N/A	N/A	N/A	N/A	N/A	Good/ missing tag	Good	No
- South East - Impenetrable	Yes	No	1-2mm of sediment	Small plants	Yes	Good/ missing tag	Good	Released majority of trapped gas.

General comment- bright green algae on everything in the deep water site.

APPENDIX D

Tukey's pairwise comparison of mean ORP measurements in deep control plots and deep treated plots (permeable and impermeable). Analysis completed using Minitab software.



APPENDIX E

Results of sediment chemistry analysis performed by *AGAT Laboratories Ltd.* and the Nova Scotia Department of Agriculture and Fisheries Analytical Services Laboratory Department on samples collected from deep and shallow zones for each plot treatment, spring and fall of 2021.

Parameter	Unit	RDL	SPRING		FALL					
			SHALLOW	DEEP	SHALLOW			DEEP		
					Control	Permeable	Impermeable	Control	Permeable	Impermeable
Aluminum[A]	mg/kg	10	7310	12200	12700	14400	12000	10300	12700	9930
Antimony[A]	mg/kg	1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic[A]	mg/kg	1	30	35	106	46	46	44	60	53
Barium[A]	mg/kg	5	29	40	32	42	36	31	40	30
Beryllium[A]	mg/kg	2	<2	<2	<2	<2	<2	<2	<2	<2
Boron[A]	mg/kg	2	2	4	<2	<2	<2	<2	3	<2
Cadmium[A]	mg/kg	0.3	0.5	0.6	1.1	0.9	0.5	0.5	0.7	0.5
Chromium[A]	mg/kg	2	15	31	31	30	21	15	23	16
Cobalt[A]	mg/kg	1	9	15	14	16	13	12	16	12
Copper[A]	mg/kg	2	33	62	72	60	34	23	45	30
Iron[A]	mg/kg	50	13000	20200	17700	16400	13800	11700	18400	12900
Lead[A]	mg/kg	0.5	27.0	39.2	99.0	81.1	60.8	26.7	46.5	31.1
Lithium[A]	mg/kg	5	12	21	18	15	14	9	11	11
Manganese[A]	mg/kg	2	430	571	315	300	263	294	516	345
Molybdenum[A]	mg/kg	2	4	4	5	8	7	8	7	7
Nickel[A]	mg/kg	2	20	33	33	33	24	21	32	24
Nitrogen[B]	%	-	0.68	0.53	0.41	0.47	0.44	0.48	0.79	0.56
Organic Matter[B]	%	-	10.5	8.3	7.2	7.6	7.2	6.3	10.6	7.5
pH[B]	pH units	-	5.80	5.64	5.61	5.69	5.92	5.77	5.70	5.73
P_2O_5[B]	kg/ha	-	125	111	211	213	184	210	174	211
Selenium[A]	mg/kg	1	1	1	2	2	2	2	2	2
Silver[A]	mg/kg	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium[A]	mg/kg	5	12	16	12	11	9	9	13	10
Sulfur[B]	kg/ha	-	289	379	117	112	101	162	336	252
Thallium[A]	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin[A]	mg/kg	2	3	4	4	4	2	<2	<2	<2
Uranium[A]	mg/kg	0.1	0.6	0.7	0.9	1.2	1.1	1.1	1.1	1.1
Vanadium[A]	mg/kg	2	35	61	64	63	35	30	76	42
Zinc[A]	mg/kg	5	137	281	253	216	126	99	200	121

[A] *AGAT Laboratories Ltd.*, [B] Nova Scotia Department of Agriculture and Fisheries Analytical Services Laboratory Department

APPENDIX F

Benthic macroinvertebrates analysis from sediment samples collected after barriers were removed from Little Albro Lake in September 2021, identification and enumeration completed by Envirosphere Laboratories. Family Biotic Index (FBI) scores were calculated from methods in, and tolerance values were taken from (Carter et al., 2006), unless otherwise indicated. 'Excluded and Non-aquatic taxa' were included in the calculation of FBI.

					Deep Study Zone						Shallow Study Zone					
Phylum & Class	Order	Family	*Genus & Species*	Tolerance Score	4 C	9 C	3 I	7 I	6 P	8 P	16 C	18 C	11 I	17 I	10 P	12 P
Arthropoda Insecta	Diptera	Ceratopogonidae	unidentified	6			1									
		Chaoboridae	*Chaoborus* sp	*8*		14	1									
		Chironomidae	unidentified	*7	2	2	3	1	6		9		1	2		
		Sciomyzidae	unidentified	**10												2
	Trichoptera	Polycentropodidae	*Polycentropus* sp	*6*											1	
Arthropoda Crustacea	Amphipoda	Hyalellidae	*Hyalella azteca*	*8*		1										
Mollusca Bivalvia	Veneroida	Pisidiidae	unidentified (juvenile)	8		2										
Mollusca Gastropoda	Basommatophora	Ancylidae	*Ferrissia* sp	****6*							2					
		Valvatidae	*Valvata sincera*	****8*		1					1					
		unidentified (no shell)		****7*						1						
Annelida Clitellata	Aquatic Worms (Oligochaeta)	unidentified		8	1	1	2		4	13	24	2	7	1	7	64
	Hirudinida	Glossiphoniidae	*Helobdella stagnalis*	*10*							1					
Excluded and Non-aquatic Taxa (not included in Envirosphere analyses)																
Cladocera				***8		2										
Copepoda				***8		1			5							
Ostracoda				***8		1			1							
				SUMMARY												
				Abundance #/sample	3	25	7	1	16	14	37	2	8	3	8	66
				Taxa Richness per sample	2	6	4	1	2	2	5	1	2	2	2	2
				Biomass (grams/sample)	0.0002	0.0457	0.006	0.0002	0.0117	0.0088	0.0187	<0.0001	0.0287	0.0054	0.0168	0.0782
				FBI	7.33	7.92	7.29	7.00	7.63	7.93	7.70	8.00	7.88	7.33	7.75	8.06
				TREATMENT GROUP	Deep control		Deep impermeable		Deep permeable		Shallow control		Shallow impermeable		Shallow permeable	
				Mean Abundance	14		4		15		20		6		37	
				Mean Taxa Richness	4		3		2		3		2		2	
				FBI (pooled)	7.86		7.25		7.77		7.72		7.73		8.03	

*Tolerance score averaged between blood-red (8) and other chironomids (6), **(Valley City State University Macro-invertebrate Lab, n.d.), ***(Soil & Water Conservation Society of Metro Halifax, 2015)

APPENDIX G

Nutrient concentrations from samples analyzed at the CWRS laboratory. Total phosphorus (TP) and soluble reactive phosphorus (SRP) analyzed using the low range ascorbic acid method, total nitrogen (TN) analyzed using HACH total nitrogen test kits.

Sample			**Units**	**Date**					
				28-May*	**04-Aug**	**26-Aug**	**08-Sep**	**20-Sep**	**04-Oct**
Deep Study Zone	Surface	TP	µg/L	16	13	30	16	17	18
		SRP	µg/L	< 1	< 1	6	1	1	2
		TN	mg/L	-	2.0*	< 0.1	0.3	0.3	< 0.1
	Bottom	TP	µg/L	13	25	27	18	18	-
		SRP	µg/L	0.4	0.9	4.1	2.1	2.1	-
		TN	mg/L	-	2.7*	1.2	0.2	0.3	-
Shallow Study Zone	Surface	TP	µg/L	-	21	28	34	31	-
		SRP	µg/L	-	1	7	6	8	-
		TN	mg/L	-	2.5*	< 0.1	0.9	0.4	-
	Bottom	TP	µg/L	-	31	25	22	22	-
		SRP	µg/L	-	1	7	4	4	-
		TN	mg/L	-	2.1*	0.2	0.1	< 0.1	-

*Collected at the location of the deepest area of the lake

APPENDIX H

Results of standard water analysis performed by *AGAT Laboratories Ltd.* on surface samples collected from the location of the deep zone of each lake during well mixed conditions, spring and fall of 2021.

Parameter	CCME guideline	Units	Little Albro Lake		Albro Lake	
			Spring	Fall	Spring	Fall
pH			7.16	7.20	7.14	7.19
Reactive Silica as SiO_2		mg/L	< 0.5	2.0	1.3	2.8
Chloride	120	mg/L	132	101	102	106
Fluoride	0.12	mg/L	< 0.12	< 0.12	< 0.12	< 0.12
Sulphate		mg/L	10.0	7.0	9.0	8.0
Alkalinity		mg/L	11	23	12	17
True Color		TCU	7.9	12.5	< 5	7.3
Turbidity		NTU	1.0	1.4	0.8	1.0
Electrical Conductivity		µmho/cm	487	418	402	406
Nitrate + Nitrite as N		mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate as N		mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Nitrite as N		mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia as N		mg/L	< 0.03	< 0.03	< 0.03	0.72
Total Organic Carbon		mg/L	3.4	7.9	3.8	4.0
Total Sodium		mg/L	86.4	60.6	72.6	65.3
Total Potassium		mg/L	1.0	0.4	0.8	0.8
Total Calcium		mg/L	11.3	8.9	9.3	9.6
Total Magnesium		mg/L	1.1	1.0	1.0	1.0
Bicarb. Alkalinity (as $CaCO_3$)		mg/L	11	23	12	17
Carb. Alkalinity (as $CaCO_3$)		mg/L	<10	<10	<10	<10
Hydroxide		mg/L	<5	<5	<5	<5
Calculated TDS		mg/L	248	193	202	202
Hardness		mg/L	32.7	26.3	27.3	28.1
Langelier Index (@20C)		NA	-2.37	-2.10	-2.43	-2.22
Langelier Index (@ 4C)		NA	-2.69	-2.42	-2.75	-2.54
Saturation pH (@ 20C)		NA	9.53	9.30	9.57	9.41
Saturation pH (@ 4C)		NA	9.85	9.62	9.89	9.73
Anion Sum		me/L	4.15	3.45	3.30	3.50
Cation sum		me/L	4.44	3.19	3.73	3.48
% Difference/ Ion Balance		%	3.4	3.9	6.0	0.3
Total Copper	2	ug/L	<1	<1	<1	<2
Total Iron	300	ug/L	< 50	501	70	52
Total Manganese	2026*	ug/L	21	95	27	53
Total Zinc	41*	ug/L	< 5	< 5	< 5	< 5
Total Aluminum	100	ug/L				5

*Calculated based on water hardness

APPENDIX I

Deep study zone in-situ data collected during benthic barrier pilot project in Little Albro Lake, all data collected using a YSI multiparameter sonde.

Date	Depth (m)	T (°C)	DO (%)	DO (mg/L)	Conductivity (μS/cm^2)	pH
04-Aug	0	21.1	110	9.8	422	7.0
	1	20.7	110	9.9	420	6.9
	2	20.2	108	9.7	422	6.9
	3	19.8	42	3.8	435	6.6
26-Aug	0	24.2	107	9.0	419	6.4
	1	23.7	74	6.3	422	6.3
	2	22.0	8	0.7	474	6.2
	2.5	21.0	2	0.2	494	6.3
08-Sep	0.5	19.1	76	7.0	428	7.0
	1	19.0	76	7.1	428	6.9
	1.5	19.0	78	7.12	428	6.8
	2	19.0	76	7.1	428	6.8
	2.5	18.9	64	5.9	428	6.7
	3	18.8	28	2.6	428	6.6
20-Sep	0.5	19.1	76	7.0	428	7.0
	1	19.0	76	7.1	428	6.9
	1.5	19.0	78	7.2	428	6.8
	2	19.0	76	7.1	428	6.8
	2.5	18.9	64	5.9	428	6.7
	3	18.8	28	2.6	428	6.6

Shallow study zone in-situ data collected during benthic barrier pilot project in Little Albro Lake, all data collected using a YSI multiparameter sonde.

Date	Depth (m)	T (°C)	DO (%)	DO (mg/L)	Conductivity (μS/cm^2)	pH
04-Aug	0	21.0	105	9.4	415	6.9
	0.5	20.7	103	9.2	420	6.8
	0.9	20.6	96	8.5	423	6.8
26-Aug	0	24.2	87	7.3	410	6.4
	0.5	24.1	78	6.5	413	6.3
	0.75	24.0	60	5.0	419	6.3
08-Sep	0.5	18.4	62	5.7	422	6.4
	0.9	18.8	55	5.1	416	6.4
20-Sep	0	18.4	68	6.4	427	7.5
	1	17.4	58	5.5	436	7.4

In-situ data collected from the deepest area of Little Albro Lake during the benthic barrier pilot project. All data collected using a YSI multiparameter sonde.

Date	Depth (m)	T (°C)	DO (%)	DO (mg/L)	Conductivity (μS/cm^2)	pH
29-Apr	0.5	10.9	103	11.4	458	7.2
	1	10.9	103	11.4	458	7.1
	2	10.8	106	11.7	458	7.2
	3	10.8	104	11.5	458	7.1
	3.5	10.8	104	11.5	458	7.0
26-Aug	0	24.2	107	8.9	420	6.4
	1	23.6	92	7.7	421	6.4
	3.5	19.4	4	0.4	532	6.4
04-Oct	0	16.4	67	6.6	406	6.3
	3	15.9	60	6.0	405	6.3

ATTACHMENT B

Health Canada / Santé Canada

Your health and safety… our priority. *Votre santé et votre sécurité… notre priorité.*

Regulatory Directive DIR2017-03

Registration of Pesticides for Emergency Use: Revised Procedures

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The purpose of this document is to inform registrants, user groups, government agencies and other interested stakeholders about the procedure for registering pesticides or amending registrations for emergency control of pest infestations where currently registered pesticides and non-chemical control methods or practices are insufficient to address the pest outbreak.

This regulatory directive replaces Regulatory Directive DIR2001-05, *Registration of Pesticides for Emergency Use*, dated 17 August 2001.

1.0 Introduction

Under section 18 of the Pest Control Products Regulations, the Minister of Health may register a pest control product or amend the registration of a pest control product to permit its use, for a period not exceeding one year, for the emergency control of seriously detrimental pest infestations. In addition, under paragraph 18(1)(a), an emergency registration may not be extended beyond one year.

The process outlined in this document addresses emergency pest situations only. Emergency registrations are not a tool for early or extended access to pest control products (pesticides) not currently registered for that use. For known or ongoing pest problems where no registered product is available, applicants will be referred to the normal registration processes in place to address such situations.

An emergency is generally deemed to exist when both of the following criteria are met:

A. An unexpected and unmanageable pest outbreak or pest situation occurs that can cause significant health, environmental or economic problems; and

B. Registered pesticides and cultural control methods or practices are insufficient to address the pest outbreak.

Examples of emergency pest situations may include, but are not limited to, invasion by a new pest organism, a sudden and significant increase in pest pressures due to environmental or other conditions, or the need for an alternative application method due to adverse weather conditions.

When an emergency pest situation persists beyond the expiry date of the original emergency registration, the applicant may make a new emergency use application for the same pest. However, the application package should be accompanied by a pre-submission application request from the product registrant for the full registration of that use. The use should also be prioritized within the sponsor province to demonstrate the need for the registration. Any subsequent applications for an emergency use for the same pest situation must be accompanied by a new, updated data package, including justification for the continued need for the emergency use, and considering any newly registered alternatives that may address the pest situation.

As a condition of the emergency request, the Pest Management Regulatory Agency (PMRA) may impose special terms and / or conditions on the emergency use, such as additional precautionary label statements, personal protective equipment, specific application equipment or engineering controls, or the requirement for additional studies or post-use monitoring activities.

Because emergency registrations require and receive immediate attention, consideration will be given first to products that are registered in Canada where the risks to human health and the environment have been assessed previously for the product. When no Canadian-registered product is available, consideration may be given to products registered in other jurisdictions, provided the active ingredient is registered in Canada. The emergency use will be considered only if there is evidence that the health and environmental risks are acceptable and the product has value in addressing the emergency pest situation.

2.0 Sponsorship

Emergency registrations are sponsored by the provincial ministry or federal agency that supports the management of the pest problem (for example, the provincial Ministry of Agriculture). The sponsor is responsible for compiling all information and rationales as well as the required letters of support or no-objection from each province participating in the emergency use application before submitting them to the PMRA in one application package. The onus is on the sponsor to ensure that there is discussion with the ministry responsible for pesticide regulation (such as the Ministry of the Environment) in each province involved, and that any issues related to the emergency use of the proposed pesticide are resolved at the provincial level before the application package is submitted to the PMRA.

3.0 Application Process

All information pertaining to the emergency registration application must be compiled by the sponsor and submitted to the PMRA using the Electronic Pesticide Regulatory System (e-PRS) Secure Web Portal, or sending the PMRA Regulatory Zip (PRZ) file to hc.pmra.docs.arla.sc@canada.ca. Information regarding this process can be found on the Pesticides and Pest Management section of the Canada.ca website (*https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/registrants-applicants/electronic-pesticide-regulatory-system.html*).

The sponsor should ensure that the compiled package is complete, including all letters of support or no-objection, including those from the provincial ministry responsible for pesticide regulation, before submitting it to the PMRA, since the review process cannot be completed until all supporting information has been received. A checklist of the information required for an emergency registration application can be found in Appendix I.

4.0 Submission Organization

The following subsections will outline the information required for an emergency registration application. In addition to the administrative requirements (letters, forms and labels), all technical information, including the supporting health, environmental and value information, should be in MS Word format and organized under the headings listed under Subsections 4.1 to 4.4.

4.1 Administrative and Regulatory Requirements

A cover letter, letters of support or no-objection, required forms, the processing fee, and draft supplemental labels should be submitted with the emergency registration application. Specific information on these requirements can be found in Appendix II.

4.2 Health and Environmental Information

The PMRA will use all available relevant information in its possession to support the health and environmental assessments. In addition, information may be required under the Health and Environmental Information section of the application as specified below.

Human activities associated with the emergency use of the product

Additional information specific to the emergency registration application may be required regarding mixer/loader/applicator and/or postapplication activities.[1]

Residue Data

For emergency registration requests in which a food or feed use is proposed, relevant residue data (either in PMRA's possession or provided by the applicant), must demonstrate the level of residues anticipated in the crops when treated according to the proposed use pattern.

During the review of an emergency registration, the Agency will determine a residue limit that is specific for the pesticide-commodity combination use within the context of the emergency registration. The PMRA will notify the relevant stakeholders, accordingly.

Environment

Additional information on environmental exposure specific to the emergency registration request may be required.

4.3 Value Information

The following information should be provided under the Value Information section of the application.

Description of emergency situation

In the dossier of information supporting the application, a description of the nature and scope of the pest problem, including geographical distribution of the pest infestation, should be provided.

[1] For additional information, refer to Guidance for Developing Datasets for Conventional Pest Control Product Applications (DACO Part 5.2) https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/policies-guidelines/guidance-developing-applications-data-codes-parts-1-2-3-4-5-6-7-10.html

Rationale for emergency use

The sponsor must describe how the application meets both criteria for an emergency use described in Section 1.0. It must include a rationale addressing why the pest outbreak is considered to be a seriously detrimental infestation with respect to health or the environment, or why it would result in significant economic loss. The rationale should also address why the pest was not considered to be a problem in recent years, and why the situation cannot be addressed either with the currently registered alternatives, or through registration via the normal regulatory process. The sponsor should also justify why the emergency use is required for the requested time period**.**

Description of proposed product and use pattern

A summary of the proposed product and use pattern should be provided, including: the common, trade and chemical (International Union of Pure and Applied Chemistry) names for pesticide(s) proposed, the *Pest Control Products Act* registration number(s), the application rate (of both the product and active ingredient), maximum number of applications per use season or crop cycle, number of crop cycles per year (if applicable), initial application timing, application intervals, application method, re-entry interval, and pre-harvest interval (if for crop use). The applicant is encouraged to provide this information in table format. If the proposed product is approved for the same use in another country, the registration number in the country in which the product is registered, and a copy of the label of the approved product should also be provided.

Registered alternatives and cultural control methods

Applicants should provide the product names, registration numbers, and indicate the type of control measure (for example, conventional or non-conventional pesticide, pheromone, or cultural control method) for each alternative end-use product and an explanation for why these are not acceptable to manage the pest outbreak. The applicant is encouraged to provide this information in table format.

Explanation for choice of product and proposed use pattern

The applicant should describe what level of pest management is required to mitigate the outbreak, and provide evidence that the product will deliver an acceptable level of pest control when applied as proposed. Applicants can provide efficacy data (including foreign data), use history, scientific rationales or other scientific information to address product performance, resistance management and crop tolerance (where applicable). If resistance to other registered alternatives is cited as justification for the emergency use, evidence supporting this should be submitted.

Description of socio-economic impact

Applicants should discuss the anticipated economic, social, and environmental costs that may occur without the emergency registration. For agricultural emergency uses, a description of crop value can be included, as well as the expected percent field loss or percent economic loss of gross or net revenues without the emergency registration. For non-agricultural emergency uses, the impact of not accessing a pest control product can be described, including the potential ecological loss or any adverse effects on the environment or human health.

4.4 Other information

Other information related to the emergency use may be requested during the assessment period, including information such as if the product has to be imported for use, and the need for Canadian labels prior to distribution and use within Canada. Products being imported into Canada should be accompanied by the Canadian emergency label.

Emergency registrations may require additional supporting information or action under other legislation such as the *Food and Drugs Act* and *Regulations*, or the *Fisheries Act.* The granting of an emergency registration allows a product to be imported, distributed and used under the *Pest Control Products Act*, but it is up to the registrant or sponsor, as the case may be, to ensure that any other applicable legislation has been satisfied.

5.0 Emergency Registration in Subsequent Years

An emergency registration cannot be granted for longer than one year, and may not be renewed. Where the pest infestation is predicted to remain an ongoing issue in future years, the PMRA expects the sponsor and registrant to prioritize the pest issue, and pursue full registration of the use through normal regulatory processes as soon as possible. If the pest situation persists beyond the initial emergency registration period, a new emergency registration application that includes all documentation listed above must be submitted for review. Recent information is required demonstrating that the pest outbreak still meets the criteria for an emergency registration, what progress has been made to register the use through normal regulatory channels, and when the application package for full registration will be submitted to the PMRA. The application should also be accompanied by a pre-submission request from the product registrant for the full registration of that use. If the new emergency application no longer meets the criteria of an emergency pest situation, or insufficient progress has been made towards full registration, then the application will be denied.

Appendix I

Table 1 Checklist of the information required for an emergency registration application.

1.0 Administrative Requirement (refer to Section 4.1)	☑
Cover letter from sponsor	
Letter of registrant support	
Letter of provincial / territorial support from the department[2] responsible for pesticide use (for example, Ministry of Agriculture, Ministry of Health) signed by FPT member or a higher level of authority for each participating province or territory.	
Letter of provincial / territorial support or no-objection from the department responsible for pesticide regulation (e.g., Ministry of Environment) signed by FPT member or a higher level of authority for each participating province or territory.	
Application form (PMRA/ARLA 6005)	
Proposed New Uses form (PMRA/ARLA 6023)	
Fee Form (PMRA/ARLA 6011) and fees[3]	
Statement of Product Specification Form (PMRA/ARLA 6003); applicable only for end-use products not currently registered in Canada	
Draft English emergency use label in MS word format	
Draft French emergency use label in MS word format	
2.0 Technical Information (refer to Sections 4.2 to 4.5): ***Please note that all technical information (Value, Health, Environmental, Other) must be provided in MS Word.***	☑
Health and Environmental Information	
Human activities associated with emergency use of the product	
Crop Field Trial Residue Data (if applicable)	
Relevant Environmental Information	
Value Information	
Description of emergency situation.	
Rationale for emergency use.	
Description of proposed product and use pattern.	
Summary of registered alternatives (table format).	
Explanation for choice of product and use pattern.	
Description of socio-economic impact.	
Other Information	
Requirements for product importation or re-labelling	
Information on progress towards full registration of the use through normal regulatory channels[4]	

[2] For provinces or territories with more than one department responsible for pesticide use, a letter of support from each department is required. See Appendix II

[3] If paying by cheque, make it payable to the Receiver General of Canada.

[4] Required for any request for the same emergency use in subsequent years.

Appendix II

2.0 Letters

With each application, a cover letter, a letter of support from the registrant, and letters of provincial or territorial support or no-objection are required. Letters of support from grower's groups or associations may also be included as additional supporting information.

- The cover letter from the sponsor should explain the purpose of the application. The letter from the registrant should indicate support for the proposed emergency use of their product and confirm that there is sufficient product available to address the emergency situation for the period of time required. Please note that any issues between the sponsor and the registrant regarding liability of use (for example, efficacy and/or crop tolerance) should be resolved prior to submitting an application for emergency registration.

- A letter of support or no-objection must be provided from the provincial department or agency responsible for pesticide use (for example, Ministry of Agriculture). **The letter** must be signed by the sitting member of the Federal, Provincial and Territorial Committee on Pest Management and Pesticides at a minimum. Letters from these departments or agencies must be provided from each province or territory listed on the emergency use application.

- A letter of support or no-objection must also be provided from the provincial department or agency responsible for pesticide regulation (for example, Ministry of Environment). **The letter** must be signed by the sitting member of the Federal, Provincial and Territorial Committee (FPT) on Pest Management and Pesticides at a minimum. Depending on the nature of the emergency, letters of support or no objection may involve more than one department and/or require written approval by an authority above the FPT level. Letters from these departments or agencies must be provided from each province or territory listed on the emergency use application.

2.1 Forms

The following forms are required:

- Application for New or Amended Registration form (PMRA/ARLA 6005),

- Proposed New Uses form (PMRA/ARLA 6023),

- Fee form (PMRA/ARLA 6011), along with payment,

- A Statement of Product Specification form (PMRA/ARLA 6003) is also required for the proposed use of any end-use product not currently registered in Canada.

2.2 Fees

Fees are normally provided by the sponsor but may be provided by a grower association or other stakeholders. The processing fee applies to all emergency registration applications. Refer to the Processing Fee at the following link for current fees (http://www.gazette.gc.ca/rp-pr/p2/2017/2017-02-22/html/sor-dors9-eng.php).

2.3 Labels

Draft emergency use labels in both English and French, in MS Word format, must be obtained from the registrant and submitted. Only information directly related to the emergency use should be included on the emergency use labels, and reference to all other uses should be deleted. The labels must clearly indicate the proposed directions for use, precautions, restrictions and all other label requirements related to the emergency use request.

The front panel of the labels must state that it is "For 'Emergency Use Only', indicate the nature of the emergency use (list the pest and host or use site), list the proposed province(s), and indicate the proposed end date of use (which is not to exceed a one year period from the date the emergency registration was granted).

Example: "**FOR EMERGENCY USE ONLY**. For sale and use only in British Columbia to suppress cottonball rot on cranberry, until 30 September 2016."