EIA Registration

Eradication of Invasive Smallmouth Bass from the Miramichi Watershed

Submitted: 25 September 2020

Table of Contents

List of Appendices

Note: Appendices are included as stand alone documents and as such do not have page number associations.

List of Figures

List of Tables

1.0 THE PROPONENT

a) **Name of Proponent**: North Shore Micmac District Council, Inc.

Project partners (proponent and partners herein collectively referred to as the "Working Group" for the eradication of invasive smallmouth bass in the Miramichi watershed):
Atlantic Salmon Federation
Maliseet Nation Conservation Council
Miramichi Salmon Association
Miramichi Watershed Management Committee
New Brunswick Salmon Council
New Brunswick Wildlife Federation

b) **Address of Proponent**:
38 Micmac Road
Eel Ground, NB
E1V 4B1

c) **Principal proponent contact** (e.g., CEO, facility manager, etc.):
Name, official title and contact information:
Jim Ward, General Manager
38 Micmac Road
Eel Ground, NB
E1V 4B1
jimward@nb.aibn.com
506 627-4611

d) **Principal Contact Person for purposes of EIA** (e.g., consultant etc.):
Name, official title and telephone number (e.g., name of proponent/consultant)

- Nathan Wilbur, Director of New Brunswick Programs, Atlantic Salmon Federation
  nwilbur@asf.ca
  506 442-2185
- Neville Crabbe, Director of Communications, Atlantic Salmon Federation
  ncrabbe@asf.ca
  506 467-6804
- Jim Ward, General Manager, North Shore Micmac District Council
  jimward@nb.aibn.com
  506 627-4611

e) **Property Ownership:**
The proposed invasive species eradication will take place on provincial crown and private waters, including Miramichi Lake and its inlets, Lake Brook, East Branch Lake Brook, and approximately a 15 km reach of the Southwest Miramichi River. Project activities on the Southwest (SW) Miramichi River will extend from a location known as the "Ice Bridge" downriver to Slate Island camp. Please refer to Figures 1 and 2 for detailed maps of the project area with coordinates.

Waters within the project area require temporary access via both private and crown land. Please find attached in Appendix A letters from the landowners, J.D. Irving, Limited, and International Paper, permitting access. Refer to Figure 3 for property identification numbers (PID). We have consulted the New Brunswick Department of Natural Resources and Energy Development (DNR) regarding a Crown land License of Occupation (LOO) and were advised that that process would be initiated upon review of this EIA registration document depending upon their assessment of activities that require inclusion in the LOO.

2.0 THE PROJECT DESCRIPTION

a) Project Name: Eradication of Invasive Smallmouth Bass from the Miramichi Watershed

b) Project Overview

A written description sufficiently complete to allow the EIA Project Manager to readily identify the scope of the undertaking and to determine which agencies should be represented on the Technical Review Committee (TRC).

Illegally introduced, non-native smallmouth bass (SMB) were discovered in Miramichi Lake in 2008 and it is the first known occurrence in the Miramichi watershed. The risk of SMB invasion and establishment throughout the watershed threatens the integrity of the native ecosystem and the cultural and economic benefits that that ecosystem supports. For example, Indigenous and recreational fisheries for native species like Brook Trout and Atlantic salmon. Immediately upon discovery of the invasive species in Miramichi Lake in 2008, project partners warned provincial and federal governments that SMB would escape and colonize the river and should be eradicated quickly while the bass were still contained in the lake. A successful example in New Brunswick includes the eradication of chain pickerel in Despres Lake carried out by the Department of Natural Resources in 2001 (Connell et al. 2002).

Fisheries and Oceans Canada (DFO) alternatively chose to implement a “contain and reduce” approach at Miramichi Lake by installing a seasonal barrier at the outlet of the lake and conducting physical removal of SMB. This approach is well known to fail based on extensive experience around the world. The program has indeed failed to achieve its goal, as all age classes of SMB continue to be captured every year since DFO began the program in 2009. Further evidence of failure includes SMB being captured below the barrier at Lake Brook in several years since the installation of the barrier, and now SMB have been discovered a short distance downstream in the SW Miramichi River. This failed program is costing DFO and the province of New Brunswick ~$100,000/year and more than $1 Million taxpayer dollars have been spent since 2008. The program has also negatively impacted the native fish species of the lake through continuous control efforts.

Initially, DFO cited a lack of enabling regulation as an excuse for not pursuing chemical eradication of smallmouth bass in Miramichi Lake, even though, even though New Brunswick, British Columbia, and other provinces were having success with this method on an emergency use basis. However, in 2015, the federal Aquatic Invasive Species (AIS) Regulation was enacted, giving DFO the means of authorizing the use of approved deleterious substances registered for use in Canada by the Pest Management Regulatory Agency (PMRA) under Health Canada to control unwanted invasive species. The purpose of creating the federal regulation was to establish a tool that allows timely eradication of invasive species, which are recognized broadly as a threat to native ecosystems. It was designed to enable action in cases precisely like SMB in the Miramichi watershed. Worldwide, it is normally government agencies that undertake aquatic invasive species eradications. In New Brunswick, aquatic invasive species authority falls under the responsibility of DFO; however, the province has a role to play in managing AIS and a significant stake in conserving river ecosystems.

Following the establishment of the AIS regulations and no subsequent action by either the federal or provincial governments to pursue eradication, our Working Group hired experts in the field to assess eradication options and develop an initial eradication plan (van den Heuvel 2017). Based on this study, a feasible, practical plan with a high likelihood of success, and consistent with the new national AIS regulations, was presented to DFO and DNR in 2017.

Still on action was taken by either level of government, and the North Shore Micmac District Council voluntarily became project proponent and submitted an official application to deposit a deleterious substance through DFO's AIS program in April 2019. That application has undergone a federal scientific review (DFO 2019), several additional rounds of review and questions, and provincial review by DNR and the Department of Environment and Local Government (DELG). In April 2020 an amended application was submitted to DFO, reflecting the discovery of smallmouth bass in the Southwest Miramichi and the expanded scope of eradication to the river itself. This triggered further review , and federally the proposal is currently in the Indigenous consultation phase (AIS application provided in Appendix B).

Of the methods evaluated for eradicating SMB from the Miramichi, only the use of a rotenone formulation is feasible and practical. Health Canada's Pest Management Regulatory Agency (PMRA) has reviewed and registered rotenone formulations for use in aquatic environments, a testament to its safety profile and efficacy. The option of treating with rotenone is the most highly developed method with the greatest likelihood of success compared to all other options. Rotenone toxicity to fish species is well established, standard operating procedures (SOPs) govern its use (Finlayson et al. 2018), and it is the most widely used tool in North America, including in Canada, for eradicating unwanted aquatic invasive species. Rotenone is a naturally occurring substance found in the roots of plants in the bean family and has been used for centuries by Indigenous peoples in the Pacific rim of fire region to kill fish for food. Rotenone and rotenone formulations are now most commonly used as fisheries management tools for eradication purposes. The use of rotenone formulations is also most prevalent because it can be safely used by humans and breaks down naturally very quickly (days) in the aquatic environment. The analysis of options concludes treatment with rotenone is the best eradication option with a high likelihood of success, preventing future invasion of SMB throughout the Miramichi River system.

This registration document will provide details of the project area, rotenone treatment plan, deactivation, mitigation, fish re-establishment strategy, and monitoring plan. The urgency is greater than ever to eradicate SMB in the lake, Lake Brook, and river before they spread and establish throughout the watershed. Eradicating SMB is a remediation measure that will have a temporary impact on the environment, but will eliminate the risk of the invasive fish **permanently** establishing in the Miramichi River system to the long-term detriment of the native ecosystem and fisheries it supports. **Eradication is ultimately a conservation action** to maintain the integrity of the entire river system.

For project overview purposes, the following provides a summary of the major project components including treatment, mitigation, monitoring, fish re-establishment strategy, and public engagement:

Treatment

- The proposal is to treat Miramichi Lake, Lake Brook, and a 15 km reach of the SW Miramichi River with a rotenone formulation approved for use by PMRA, Noxfish Fish Toxicant II (PMRA #33247), to eradicate SMB from the Miramichi watershed. The plan includes one simultaneous treatment of the entire area of known SMB distribution (Miramichi Lake, Lake Brook, and ~15 km of the SW Miramichi River) in August 2021, followed by a second treatment of only Lake Brook and the 15 km reach of river approximately 30 days later in September 2021. The reason for the second treatment in flowing waters is that these habitats are more complex and therefore multiple treatments maximizes the likelihood of successful eradication. This is common practice in riverine eradications (e.g., Norway). Figures 1 & 2 provide an overview of the project area and treatment components.

Mitigation Measures

- The timing of treatment is very important. Rotenone is effective on SMB and has rapid natural breakdown at temperatures 15-18°C. Treatment timing in August/September ensures a high likelihood of eradication and a rapid breakdown of rotenone. This timing also avoids impacts to gaspereau because adults and juveniles will have already emigrated from the lake.
- Rotenone breaks down naturally very quickly (days), however as an additional safeguard, we will deactivate rotenone at the downstream end of the treatment area in the river using potassium permanganate, a commonly used water purifying agent
- A temporary barrier will be installed in the river downstream of the treatment area to prevent adult Atlantic salmon and other larger fish from entering the treatment reach. It will be removed in late September to allow upstream migration for spawning once rotenone has been deactivated
- There will be a fish rescue to remove adult salmon from the treatment reach prior to project commencement

Monitoring Plan

- The Monitoring Plan is provided in a stand-along document in Appendix C and consists of four components: (1) rotenone treatment monitoring (2) rotenone deactivation monitoring, (3) short-term and long-term SMB eradication monitoring, and (4) Five-year long-term ecological recovery monitoring
- Indigenous biologists and technicians will lead the monitoring program with support from Working Group partners and governments

Fish Re-establishment Strategy

- The Fish Re-establishment Strategy is provided as a stand-alone document in Appendix D
- In the development of the strategy, we have considered the advice provided in the DFO Canadian Science Advisory Secretariat review (DFO 2019), feedback and discussion with Miramichi Lake camp owners, and anticipated forage base recovery timing from research on eradication projects in other jurisdictions
- Migratory fish species are expected to recolonize the treatment area naturally after treatment. Based on monitoring results, if after 2 years post treatment non-migratory species are not recolonizing the lake, adults will be transplanted from nearby lakes in the watershed into Miramichi Lake to accelerate recovery, with the appropriate federal Introductions & Transfers permit

Public and First Nations Engagement

- We have carried out a comprehensive suite of engagement activities, including regular meetings with provincial and federal officials, politicians, Miramichi Lake camp owners, other landowners, and leaders in the provincial environmental NGO sector. We have held information sessions for Indigenous communities and the public and our proposal has generated significant coverage in provincial and national media. Formal Indigenous consultations are currently taking place under DFO's AIS regulatory process.

c) **Purpose/Rationale/Need for the Undertaking:**

Describe the market potential, benefit to society, economic benefits, job creation benefits, consumer and/or industrial demand, and other relevant issues that make the proposal viable and desirable for the local and/or the New Brunswick economy. If the undertaking is being conducted to remedy a specific environmental, social or economic problem (e.g., a risk to public safety, a deteriorating facility or structure, an impaired ability to achieve an economic, social or environmental benefit, flooding, erosion, unstable soils, etc.), details of the problem should be provided.

Benefit to the Environment, Society, Economy

Non-native SMB invasion throughout the Miramichi watershed threatens the integrity of the native ecosystem and associated socio-economic benefits derived from that ecosystem. Wild Atlantic salmon is a culturally and economically important component of this ecosystem. Atlantic salmon in the Miramichi supports First Nations' Food, Social, and Ceremonial fisheries as well as a recreational fishery generates $16 Million annually for the provincial GDP and provides 637 full time equivalent jobs in rural communities (Gardner Pinfold 2011). The Atlantic salmon recreational fishery on the Miramichi is renowned and attracts visitors from across Canada and around the world. In addition to the benefits derived from fisheries, millions of dollars are invested annually by government agencies, Indigenous organizations, and NGOs to conserve and recover wild Atlantic salmon stocks. The establishment of smallmouth bass risks impacting the ability of the stock to recover and thrive in the future. Eradicating invasive SMB will not only benefit the diverse native ecosystem of the Miramichi for the long term, it will also benefit the provincial economy by eliminating a threat to Atlantic salmon and the fisheries it supports. **Our eradication project therefore both solves an environmental problem and contributes positively to the New Brunswick economy.**

Assessment of Alternatives

Include a brief discussion of the alternatives that could fulfill the same goal or provide the same benefits or results as described above (alternative designs, alternative actions, etc.). Consideration of the results of the "do-nothing" approach should also be provided; in other words what would be the consequences/results of not implementing the undertaking? The rationale for choosing the selected alternative should be clearly stated. If there are no reasonable alternatives to the proposal, this should be stated and justified in the registration document.

No Action

The "do nothing" option would ensure that SMB colonize the Southwest Miramichi River and establish themselves in other rivers, streams, and lakes that comprise the watershed. These fish are known to alter community structures by decreasing abundances and diversity of native fish species (i.e. cyprinids, perch)

(Kerr and Grant 1999, MacRae and Jackson 2001), trigger resource competition and restrict habitat usage (MacRae and Jackson 2001, Morbey et al. 2007). As invasive success is strongly based on propagule pressure (van den Heuvel et al. 2017), spread increases as abundance increases.

The major threat within the Miramichi River system, is the downstream dispersal and colonization of SMB resulting in habitat overlap and predation on native species, for example, Atlantic salmon. SMB and salmon juveniles prefer similar riverine habitat features, resulting in direct competition (DFO 2009). SMB bass are also predators of juvenile Atlantic salmon (Carr and Whoriskey 2009). There is concern that SMB will also negatively impact alewife by disrupting the food web in Miramichi Lake, a primary spawning/rearing area for commercially and ecologically important alewife in the Southwest Miramichi River system. Given the significant threat to the native ecosystem and fisheries it supports, the risk of doing nothing is too high. This is why the eradication effort has garnered broad, and strong, support from Indigenous organizations and diverse stakeholder groups.

Options Analysis

A number of options (Table 1) have been evaluated by experts in eradication of invasive species (van den Heuvel et al. 2017) to identify the best option.

Table 1. Assessment of SMB control and eradication options for Miramichi Lake.

Options	Comments
Physical Removal – nets & electrofishing	Extremely limited success in achieving eradication worldwide; most promising in very simple environments. May lead to decreased intraspecific competition and accelerated maturation of SMB and thus, greater recruitment. SMB control in Miramichi Lake between 2010-2012 decreased SMB biomass, but all age classes continue to be caught annually to 2018, including young-of-the-year (YOY).
Biological Control – predator & pathogen	Rarely used for eradication due to lack of potential, selective control agents. Predators will likely attack native species too. Pathogens carry risks to non-target species and other environmental concerns. Two SMB parasites (tapeworm and protozoan) are known but would need to be tested.
Genetic Manipulation – sterile or triploid individuals	Generally not 100% sterile. More sophisticated methods such as genetic control would take years and much study.
Dewatering	Impractical due to groundwater recharge, ability of SMB to burrow in mud, and risk of SMB being discharged to nearby areas or downstream.
Explosives – detonating cord	Not effective in water depths >3 m.
Piscicide	Rotenone is the only piscicide registered in Canada to control and eradicate aquatic invasive species. Exposure times and concentrations of rotenone necessary to kill fish are well known and technologies for treatment are well

	developed. Application can be timed to avoid or mitigate impacts to non-target species.
Permanent Dam	Installing a permanent dam structure at the outlet of Miramichi Lake would not isolate the lake from the Southwest Miramichi River. Such a structure would continuously spill water and would only serve to regulate the lake level; the risk of SMB escaping the lake would remain. Furthermore, a dam would create the added complexity of upstream and downstream fish passage requirements for several migratory species like alewife, sea lamprey, American eel, Brook Trout, and Atlantic salmon. This creates a risk to alewives and the associated commercial fishery, particularly given that Miramichi Lake is a primary spawning area for the stock. The dam option would be of no advantage over the current barrier fence system. This approach would cause unnecessary further disruption and harm to the native ecosystem.

Of the methods evaluated for eradicating SMB from the Miramichi, only the use of rotenone is feasible and practical. The option of treating with rotenone is the most highly developed method with the greatest likelihood of success compared to all other options. Rotenone toxicity to fish species is well established, standard operating procedures (SOPs) govern its use (Finlayson et al. 2018), and it is the most widely used tool in North America, including in Canada, for eradicating unwanted aquatic invasive species. The use of rotenone is also most prevalent because it can be safely used by humans and breaks down naturally very quickly (days) once applied to a temperate body of water. The analysis of options concludes treatment with rotenone is the best eradication option with a high likelihood of success, preventing future invasion of SMB throughout the Miramichi River system.

A review of options was also conducted in 2010 by DFO (Halfyard 2010) soon after SMB were discovered in Miramichi. The report concluded that physical control efforts are not likely to prevent SMB from spreading throughout the system, and that the use of a piscicide is highly effective and provides the greatest potential for eradication. The report notes that early intervention is preferrable.

d) **Project Location:**

The project area is located in west-central New Brunswick approximately 20 km from the community of Juniper. It includes Miramichi Lake, Lake Brook, and approximately a 15 km reach of the SW Miramichi River. Figure 1 provides a map of the project vicinity while Figure 2 provides a detailed map of the project area with coordinates.

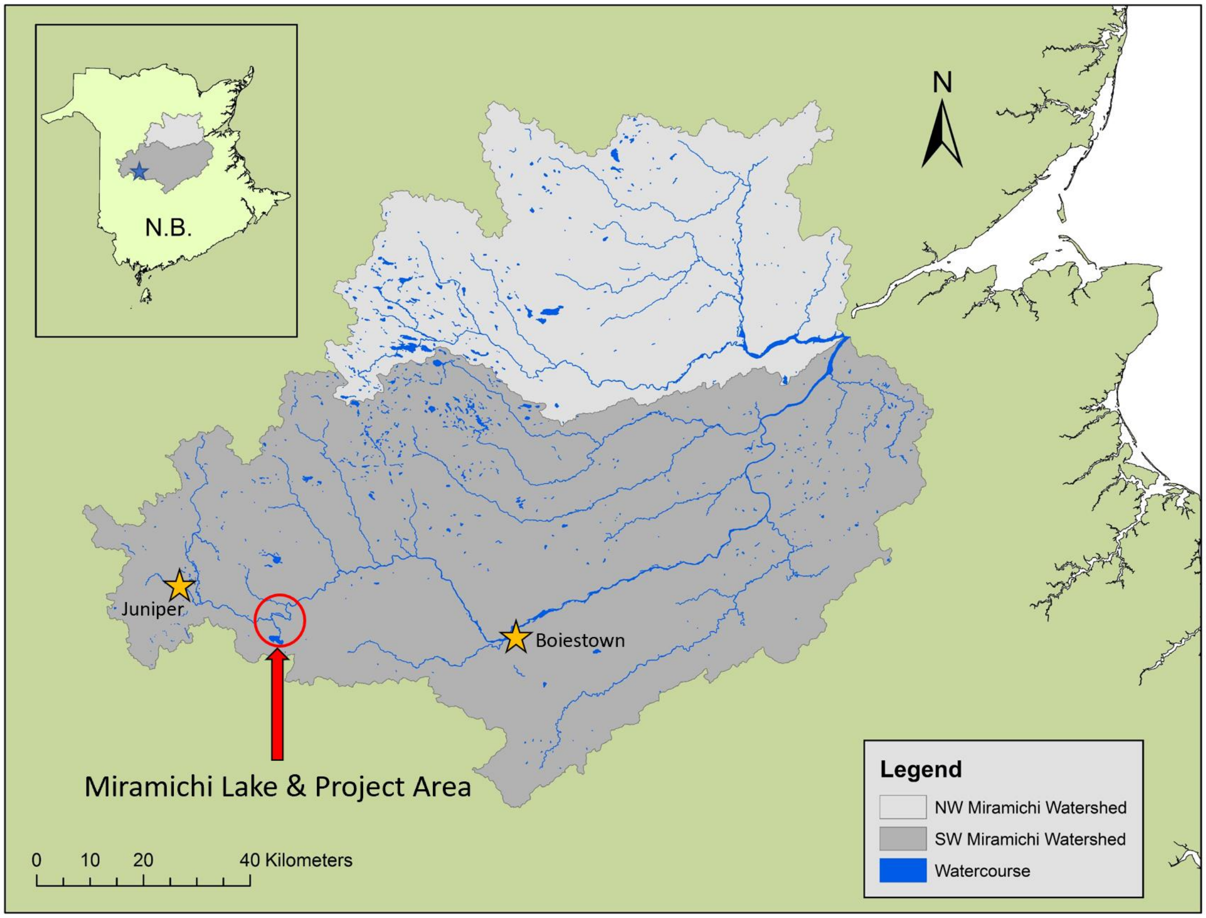


Figure 1. The Miramichi River watershed in central New Brunswick showing the location of Miramichi Lake and the smallmouth bass eradication project vicinity.

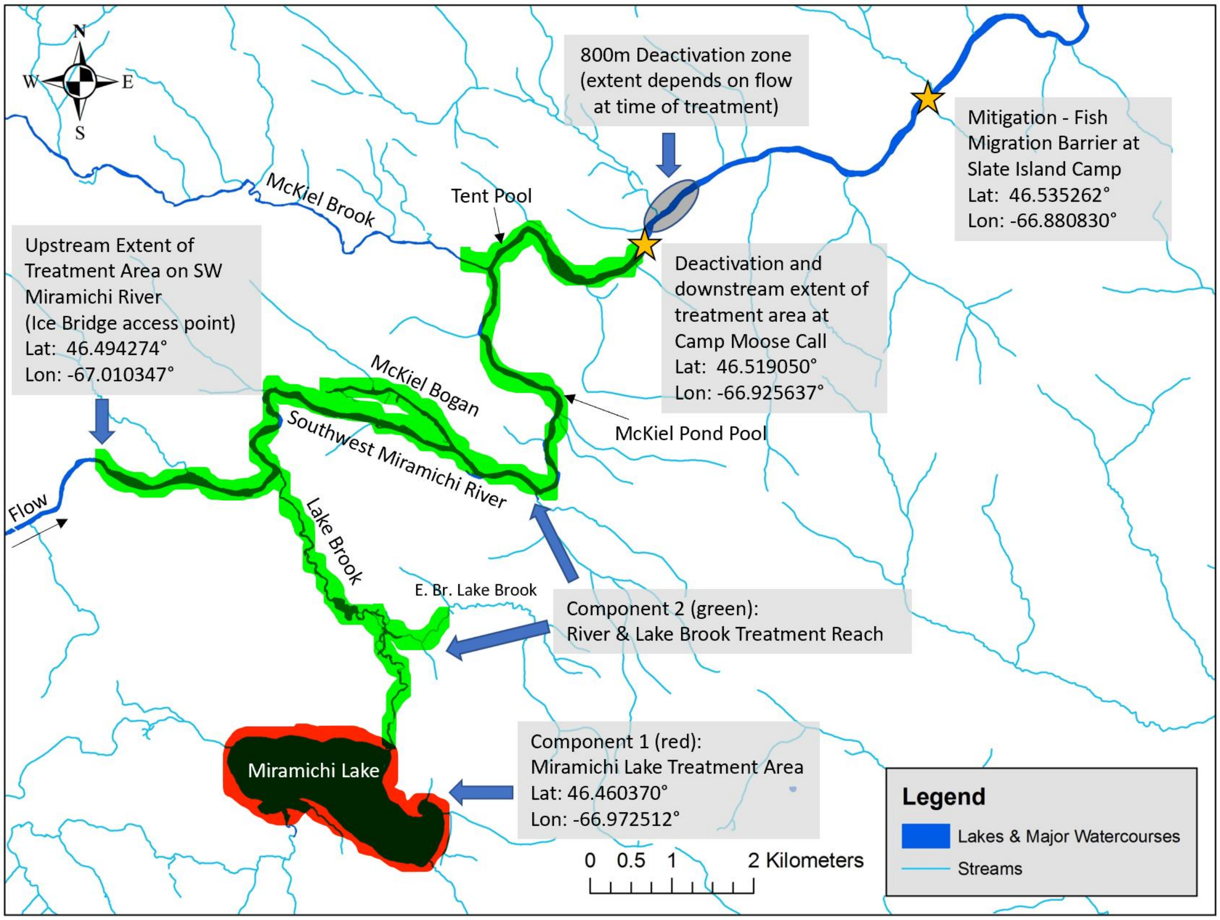


Figure 2. Detailed map of the smallmouth bass eradication project area on the upper reaches of the SW Miramichi River watershed.

e) **Siting Considerations**:

Due to the nature of this conservation project, the project area is defined by the existing distribution of invasive SMB within the SW Miramichi watershed. Environmental DNA (eDNA) surveys conducted by DFO, coupled with physical surveys by our Working Group and government partners, including electrofishing, angling, netting, snorkelling, have established the current distribution and our proposed project covers this area (Figure 2). There is urgency to carry out the eradication because SMB will continue to spread in the river and the footprint/impact of the eradication will continue to grow. For example, had eradication been carried out while SMB were limited to Miramichi Lake, the footprint would have been much smaller. SMB spread in the river is imminent and the sooner the eradication can occur, the smaller the impact will be.

While the project itself will be located on crown and private waters, land access is an important consideration. For component 1, Miramichi Lake, access will be via provincial crown land. For component 2, the entire treatment area on Lake Brook and the SW Miramichi River is surrounded by J.D. Irving, Limited freehold land (PID: 75145623; PID: 75365841; Figure 3; see support letter in Appendix A). The fish barrier will be located on International Paper land and private water (PID: 75422972); please see Appendix

A for a letter of support. Property ownership and PID information within the project vicinity are provided in Figure 3.

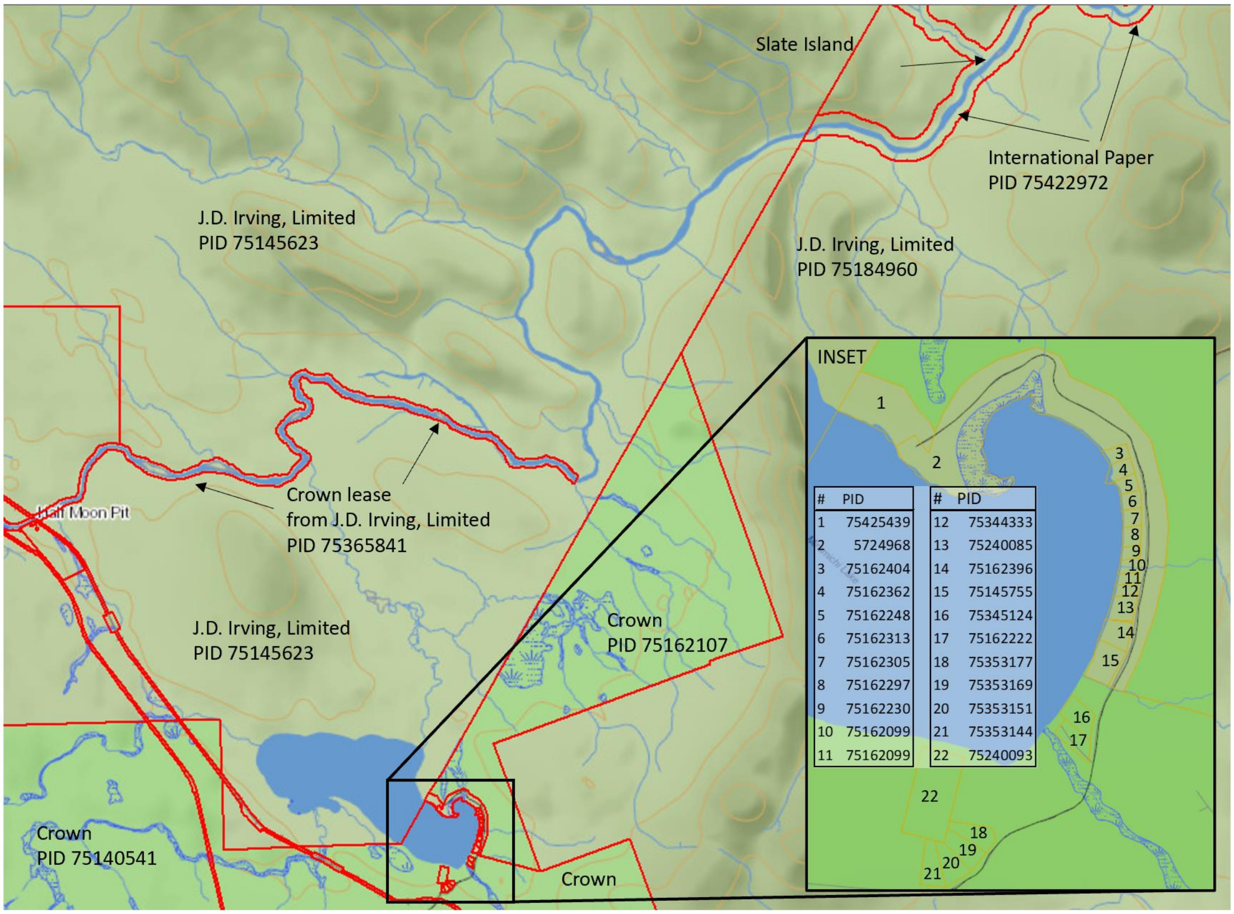


Figure 3. Property ownership and PID information within the project vicinity.

f) Physical Components and Dimensions of the Project:

The eradication is a temporary project that will have no permanent physical components. The extents/dimensions of the project are provided in the detailed project map in Figure 2. There will be several temporary physical components:

- **Floating dock in Miramichi Lake** – A floating dock will be installed in early August prior to project commencement and will be used to load boats with Noxfish Fish Toxicant II during the 2-day treatment. The dock will be removed post-treatment in late August or September. Based on water depth measurements on-site, the length of the temporary dock will be approximately 30-40 m and its location near the public boat launch is shown in Figure 4. This activity does not require a WAWA permit as per DELG’s technical guidelines.

- **Fish migration barrier on the SW Miramichi River** – A component of the mitigation plan is to install a fish migration barrier at Slate Island camp (see Figure 2) to prevent upstream migration of Atlantic salmon and other species into the treatment reach. The barrier will be installed in early August prior to treatment and removed in late September or early October after the second treatment is carried out in component 2 (Lake Brook and the river). The barrier will be a typical construction (similar to provincial salmon conservation barriers, counting fences, and to the barrier DFO uses at the outlet of Miramichi Lake), consisting of metal conduit driven into the river bed and supported by tripod supports at 3m intervals across the width of the river. We will apply to DELG for the necessary WAWA permit for this activity.

- **Drip stations** – On small streams, drip stations will be located on the banks, no structures will be installed in the water. On the river, rotenone delivery will occur at 5-10 locations along the 15 km treatment reach using one of two methods depending on site characteristics: (1) three to four drip-cans spaced at equal intervals across the width of the river. This will work at sites shallow enough to securely position the cans, or where large protruding boulders exist.; (2) a long PVC pipe elevated over the river's width with evenly spaced emitters fed by a peristaltic pump with flowmeter capable of delivering 100 to 1,000 ml/min rotenone. The PVC pipe method may require supports to span the width of the river, including protruding boulders or temporary tripod structures. As planning proceeds and we finalize details on potential supports in the river, we will consult DELG on whether this activity requires a WAWA permit and will apply if so.

- **Access to the project area** – Access to Miramichi Lake is via an existing crown gravel road. The river eradication will require stations at 5-10 locations throughout the 15-km reach and each will require access by ATV at minimum (by truck if existing road is present) to transport Noxfish Fish Toxicant II and pumps to the river for product application. Existing road and ATV access routes which have been used for SMB emergency control efforts since their discovery in the river are illustrated on the map in Figure 4. Depending on the final locations of the 5-10 treatment stations, temporary ATV access trails may need to be cut in summer 2021 to access key locations along the remote section of the SW Miramichi River. We will consult with DELG on the appropriate WAWA permits required should additional access trails be needed.

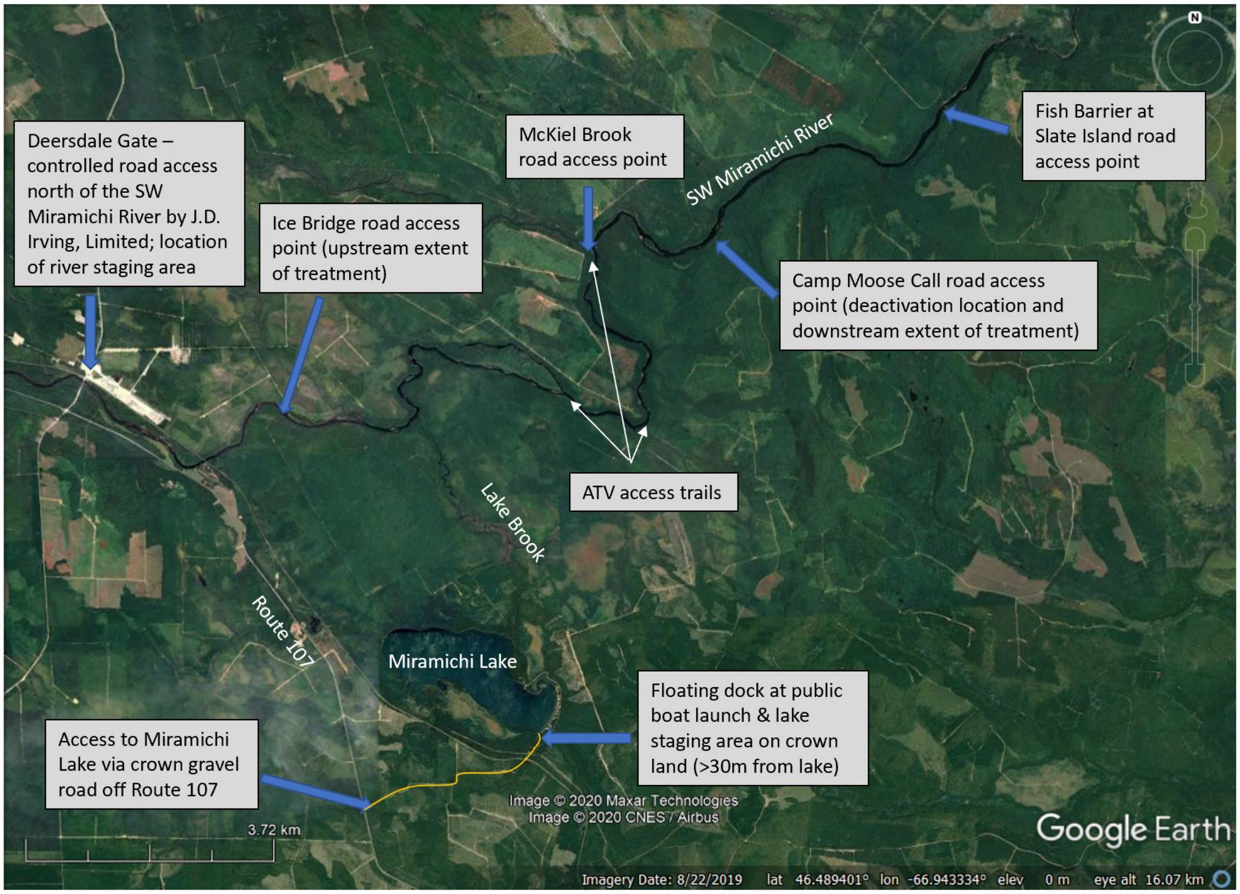


Figure 4. Annotated aerial image of project area access points and location of floating dock and staging areas.

g) **Construction Details**
h) **Operation and Maintenance Details**

This conservation project does not require construction or ongoing maintenance. A detailed operational plan is described below.

The protocol for the deposit of the deleterious substance

Treatment Overview

The deposit of PMRA-approved Noxfish Fish Toxicant II (PMRA #33247) is proposed for Miramichi Lake, Lake Brook, and a 15-km reach of the SW Miramichi River to eradicate SMB from the Miramichi watershed. The plan includes one simultaneous treatment of the entire area of known SMB distribution (Miramichi Lake, Lake Brook, and ~15 km of the SW Miramichi River as shown in Figure 2) in August 2021, followed by a second treatment of only Lake Brook and the 15 km reach of river approximately 30 days later in September 2021. The reason for the second treatment in flowing waters is that these habitats are more complex and therefore multiple treatments maximizes the likelihood of successful eradication. This is common practice in riverine eradications (e.g., Norway). The detailed protocol for monitoring rotenone during and following treatment are provided in the Monitoring Plan (Appendix C).

Optimal Treatment Timing
Several factors must be considered with regards to application timing to ensure the highest probability of success, as well as to limit impacts on non-target species, facilitate rapid and successful fish recolonization, and ensure rapid breakdown of rotenone. Mid-August to the end of September is the optimal timing window for various reasons:

- Waters in the treatment area will be >10°C based on temperature monitoring, ensuring effective toxicity to SMB
- SMB eggs will not be present as spawning is finished in July and egg incubation time is 2-9 days
- Rotenone half-life and duration of acute levels is lower at higher temperatures (i.e., >12°C)
- Deactivation with potassium permanganate ($KMnO_4$) is most effective at warmer temperatures (>10°C)
- A rotenone treatment in the fall will avoid/minimize impacts to alewife since adults spawn in the spring and then emigrate from the lake. DFO (2009; 2013) reported that young-of-the-year alewife leave the lake in significant numbers in July and August, thus the treatment timing minimizes impacts to both post-spawned adults and juveniles.
- August and September typically have low flow conditions, minimizing the quantity of Noxfish II required to achieve the design concentration (treatment rate).

Description of Treatment Rate
The 24 h LC50 value for Noxfish to young SMB (1 to 1.5 g) was 0.093 mg/L (0.0047 mg/L rotenone) in tests performed at a temperature of 12°C (Marking and Bills 1976). The minimum effective dose (MED), that which produces 100% mortality, is estimated at twice the LC50 value (Finlayson et al. 2018 SOP 5.1) or 0.0093 mg/L rotenone. Standard operating procedures recommend that the treatment rate be at a *minimum* twice the MED or 0.0186 mg/L rotenone. This minimum rate for the Miramichi system should be increased to 0.075 mg/L rotenone (1.5 mg/L rotenone formulation) due to:

- Faster degradation of rotenone through increased hydrolysis and photolysis in this warm (>10°C temperature) and shallow (<7 m depth) water;
- The high organic content of the water (evidenced by its brown color) likely is sequestering some (~44%) of rotenone's toxicity (see tests on CFT Legumine below);
- Biological variability between SMB tested by Marking and Bills (1976) and those in the Miramichi system;
- Sequestration of rotenone's toxicity by the abundant, sediment-covered submerged aquatic vegetation along most of the lake shoreline; and
- Time required for rotenone to reach areas of poor water circulation (lethal levels for SMB (>0.0130 mg/L rotenone) will persist for approximately 5 to 7 days in the lake as rotenone is dispersing)

Variability caused by environmental conditions is accounted for by increasing the minimum treatment rate. For example, a deep lake with cool water, low in organics, submerged vegetation and turbidity will require less rotenone than a shallow lake with warm water high in organics, submerged vegetation and turbidity. The minimum treatment rate was increased to 0.075 mg/L rotenone to account for the shallow lake depth that will increase the rate of photolysis, the warm water conditions that will increase the rate of hydrolysis, and the abundant submerged aquatic vegetation containing high sediment and silt loads that will sequester the rotenone, all of which will lower the rotenone concentration and increase the dissipation of rotenone from the water column. Additionally, lethal levels of rotenone must persist long enough to penetrate low water circulation shoreline areas favored by young Smallmouth Bass.

Laboratory toxicity tests using CFT Legumine (another rotenone formulation) completed by the Province of New Brunswick and the Working Group in 2017 found the 24-h LC50 to small (YOY) SMB was 0.0065 mg/L rotenone in water from Miramichi Lake, whereas Marking and Bills (1976) found the 24-h LC50 value of 0.0047 mg/L rotenone using Noxfish. Thus, the toxicity of rotenone to SMB in Miramichi Lake water may be ≈ 40% less than that reported by Marking and Bills (1976). This lower toxicity of rotenone in Miramichi Lake water supports the treatment rate of 0.075 mg/L rotenone.

The proposed rate of 0.075 mg/L rotenone may be modified based on additional on-site toxicity test(s) with SMB or a surrogate species such as yellow perch prior to the actual treatment. However, should we be required to change the treatment rate slightly, we will advise DFO and DELG and it will remain within the PMRA-specified limits of concentration. This 24-h test using on-site water and Noxfish II will test 0.025, 0.0125, 0.0062, 0.0031, and 0.0016 mg/L rotenone to confirm the previous sensitivity from 2017 tests with CFT Legumine.

Description of Rotenone and Equipment Needs
Miramichi Lake Treatment
The proposed plan is for Miramichi Lake to undergo one treatment. Rotenone will be applied to the 220 hectare (ha) lake using outboard motor boats equipped with semi-closed probe application systems (Figure 5; Finlayson et. al 2010 SOP 8.1). The 1:10 (v:v) dilution of rotenone formulation:water will be applied at or below the water surface. The shallow areas of the lake which have poor water circulation (i.e., backwater, dense aquatic macrophyte, and marshy areas) will be sprayed using a diluted solution (1-2%) of rotenone formulation using a combination of boat-based and backpack spraying (Figure 6). The backwater areas where the 4 inlets meet the lake but there is no discernible flow will be treated by backpack and boat spraying. This technique will also be used in backwater, low gradient, and peripheral areas in Lake Brook and the river to ensure treatment coverage.

In the 4 small tributary streams flowing into the lake rotenone will be applied to at least the first 100 m upstream of the lake using drip stations for the duration of the treatment to prevent refuge (See Figure 7 for drip station setup). All 4 lake inlets will be surveyed for SMB by backpack electrofishing. The survey will continue upstream including all channels until no SMB are found for 300 m. We do not expect to find SMB in these cold, small inlets; however, should SMB be found, the upstream boundaries of inhabitation are noted using GPS coordinates and flagging. To summarize, drip stations, and the upstream extent of treatment in each of the 4 inlets, will be 300 m upstream of the last SMB found or 100 m upstream from the stream/lake confluence if no SMB are present in the electrofishing surveys.

All flowing inlets will have one drip station at a minimum. If required (i.e., if SMB are present in an inlet and the drip stations is located further upstream than 100 m), additional drip stations are placed at 1-h water travel time intervals downstream of the head station and sentinel fish in cages are placed downstream ahead of the next contiguous station. We anticipate that only 1 drip station is required per inlet tributary since these streams are relatively small. Complex areas near the mouths of streams in areas that are backflooded by the lake and have no flowing water will be sprayed by hand using a backpack sprayer containing a 2% solution of Noxfish II. The response of the sentinel fish in the inlets will determine whether application adjustments are needed.

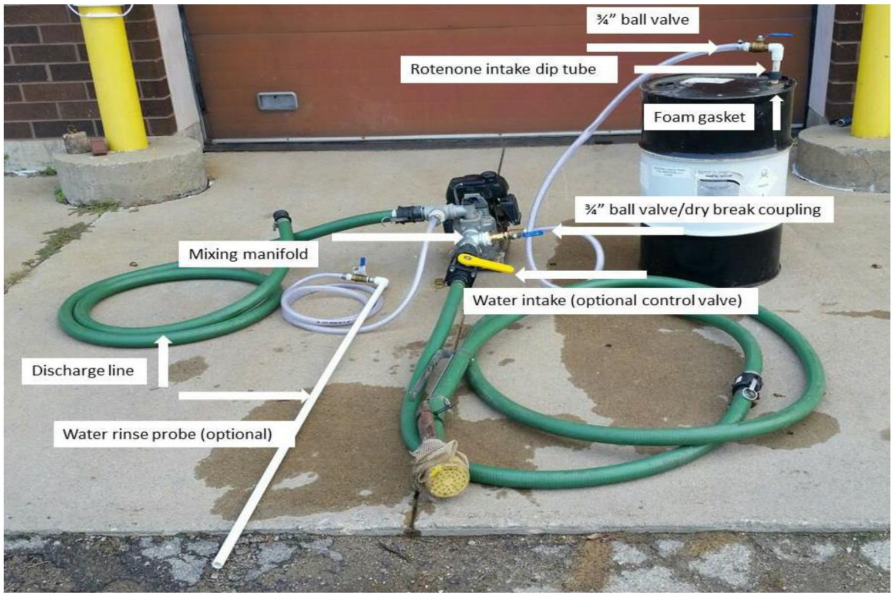


Figure 5. Semi-closed probe system used for applying liquid rotenone to lakes from a boat (See SOP 8.1; Finlayson et al. 2010).

Figure 6. Backpack sprayer used to apply diluted rotenone solution to backwater and marshy areas (See SOP 12.1; Finlayson et al. 2018).

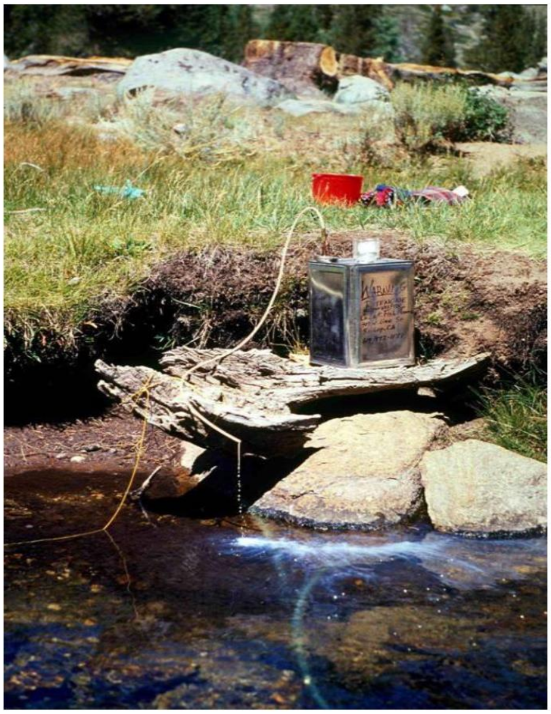


Figure 7. Drip station applying liquid rotenone to a stream (See SOP 11.1; Finlayson et al. 2018).

Based on the physical size of Miramichi Lake, the treatment rate of 0.075 mg/L rotenone, 8,040 L of 5% rotenone formulation will be required. During application, a 40 to 50 mm water pump can apply undiluted liquid rotenone at the rate of approximately 1134 L/h. At this rate, it will require approximately 7 h to apply the liquid rotenone, not accounting for transport times to/from the staging/docking area and loading time. Rotenone should be applied within a 2-day window to ensure that it won't significantly degrade during application.

Rotenone in Canada is sold in 30-gallon drums that weigh 125 kg each, and a total of 71 drums are needed for the treatment of Miramichi Lake. It will require multiple (2-3) boats to apply this quantity of rotenone evenly over a 1- to 2-day period (Table 2).

Table 2. Estimated boat resources required to apply rotenone to Miramichi Lake (Amended from van den Heuvel et al. 2017).

Parameter	**18-Foot Boat**	**22-Foot Boat**
Max Wt. Capacity (kg)	682	1342
Rotenone Wt. Capacity (kg)	501	1160
Number Drums/Trip	4	9
Total Trips	18	8
Application Time/Trip (h)	0.4	0.9
Total Trip Time (h)	0.9	1.4
Total Application Time (h)	16.2	11.2
8-h Days Required/Boat	2.0	1.4

A floating dock will be installed in early August prior to project commencement and will be used to load boats with Noxfish Fish Toxicant II during the 1 to 2-day treatment. The dock will be removed post-treatment in late August or September. Based on water depth measurements on-site, the length of the temporary dock will be approximately 30-40 m and its location near the public boat launch is shown in Figure 4. This activity does not require a WAWA permit as per DELG's technical guidelines. The drums used for the lake application will be transported from the staging area to the lake using a front-end loader or hand-cart, and a hand-cart to transport material from the lake shore to the boats via the floating dock.

Lake Brook Treatment

Lake Brook and East Branch Lake Brook will undergo two treatments. Drip stations will be located along Lake Brook and the East Branch of Lake Brook. The peripheral and backwater areas will be treated via backpack spraying. Final drip station placement on the brook will be based on flows immediately prior to treatment to ensure target concentration of 0.075 mg/L rotenone is sustained in the brook during treatment.

Due to its low gradient and its remoteness, we are considering an aerial application instead of drip stations and backpack spraying on Lake Brook and East Branch Lake Brook. Aerial application is an approved method by PMRA as per the Noxfish Fish Toxicant II label. Aerial application of the brook would be coupled with 1-2 drip stations located at the upstream extent of the brook just below its outflow from Miramichi Lake. This is to ensure coverage of the upstream reach of the brook where SMB are known to be present based on electrofishing surveys. The restrictions for aerial applications on the Noxfish II PMRA label (Appendix E) will limit and control spray drift using good practices as outlined in the National Aerial Pesticide Application Manual, so we do not expect alteration of air quality. Noxfish II will only be applied when meteorological conditions at the treatment site allow for complete and even coverage, and the drifting of spray onto land or other non-target areas is avoided using a combination of pressure and nozzle type that prevent fine particles or mist.

River treatment

Expected Environmental Conditions

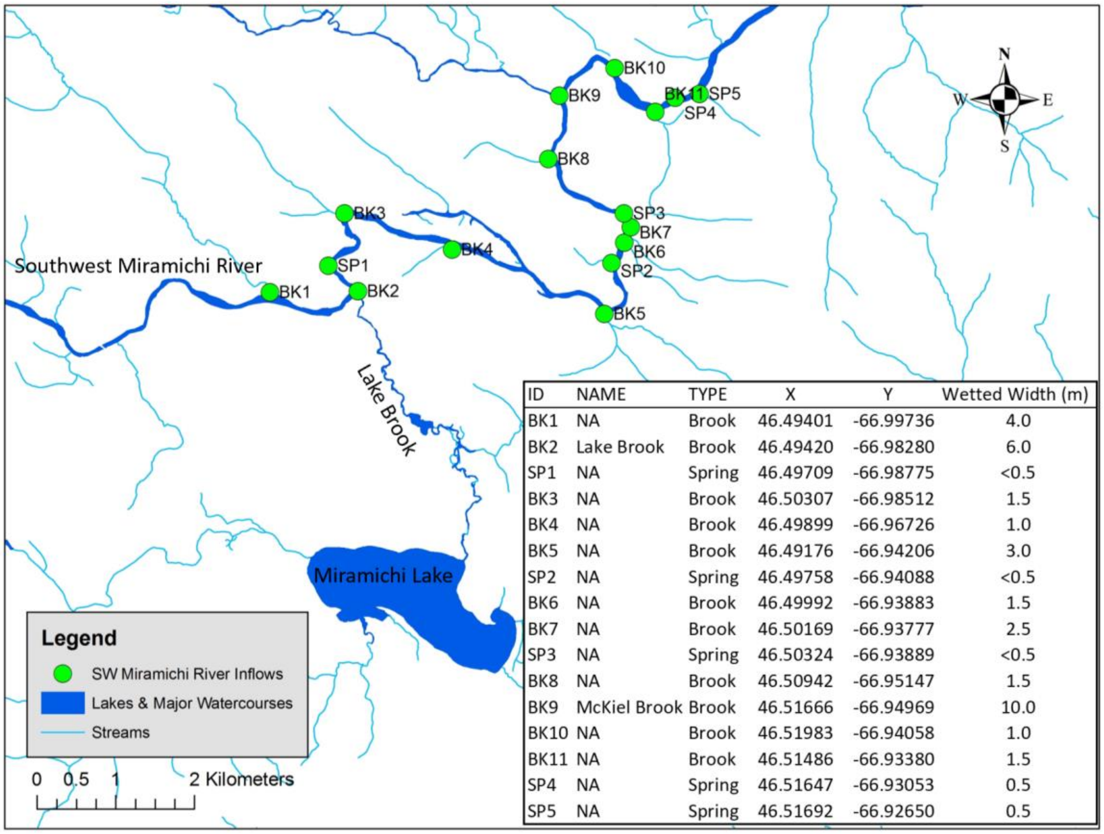
Flow: Material requirements will vary depending on flow conditions at the time of treatment. Hydrological data from nearby gauge stations and prorating flows based on upstream catchment area were used to help plan for the approximate quantity of formulation needed. Just prior to treatment, final flow measurements will be taken to determine exactly the quantity of rotenone formulation needed to achieve the design concentration on the river and at each stream drip station. Chaput and Caissie (2010) using equations of Caissie and Robichaud (2009) estimated that the 2-year low-flow estimate for the SW Miramichi River at the confluence with Lake Brook was 1.47 $m^{3/}s$. However, we estimate the stable flow (excluding storm flows, obvious data errors and flows over 10.0 m^3/s) during late-August to early-September in the range of 1.9 to 9.2 m^3/s (5.3 m^3/s average) using historic flow data from the SW Miramichi River at the Blackville Gauge and flow data from nearby Nashwaak River Gauge (Environment Canada Hydrometric Website). Flows were prorated based on upstream catchment area. Actual flow data collected just prior to treatment using the U.S. Geological Survey *Weighted Area Method* will be used to calibrate the estimated flow data from the Environment Canada Hydrometric Website. This will allow for an accurate assessment of the flows expected during the treatment period and a final determination of rotenone formulation (treatment) and potassium permanganate (deactivation) quantities to achieve the desired concentrations.

Temperature: Water temperatures in the SW Miramichi River occasionally exceed 25°C and exceed 20°C for an extended period of time from July through August. Water temperatures generally reach 15°C by early June and decline to <15 °C by later September (Caput and Caissie 2010). Treating the river in mid-August and again in mid-to-late September, when water temperatures are >10°C, ensures rotenone effectiveness, rapid breakdown, and deactivation effectiveness (Finlayson et al. 2018).

Treatment – The approximately 15 km river reach will undergo two treatments. The 6-hour treatments will involve 5-10 rotenone injection sites (one every 1.6 to 3.2 km), depending on water depth, velocity, and temperature at the time of treatment. The application rate will be the same as the lake and Lake Brook at 0.075 ppm (0.075 mg/l) rotenone (derived from van den Heuvel et al. 2017). The river treatment area begins upstream at the Ice Bridge and extends downstream to camp Moose Call where rotenone will be deactivated (see map in Figure 2). Backwater and shore areas of this stretch will be sprayed with rotenone using a combination of backpack or boat-based crews.

The river was surveyed to identify flowing tributaries, seeps and springs (Figure 8). Each will be treated near their confluence with the SW Miramichi River to avoid freshwater pockets in the river where SMB may find refuge from the treatment. The majority of the brooks flowing into this reach of river are either high gradient with no fish passage, or are low gradient and fish passage is blocked by beaver dams. The brooks that have fish passage and could potentially harbour SMB will be electrofished for 300 m upstream just prior to treatment and if no SMB are found, they will be treated within 30 m of their confluence with the river with either a drip station delivering Noxfish II (mainly used on brooks) or Vectocarb combined with Noxfish II (mainly used on small springs/seeps).

Vectocarb (SDS sheet in Appendix F) is an inert material that will be used in conjunction with Noxfish II (SDS sheet in Appendix F) to treat seeps and springs; it releases rotenone gradually over time. Its use and operating procedure is described in Kaukeb et al. (2018). It is hydroxyapatite-modified $CaCO_3$ that has excellent porosity (27 m^2/g surface area), sedimentation and carrier behaviour in aquatic systems. McKiel Brook is the largest tributary on this reach and will require a drip station to be located 100 m upstream from its confluence with the river. That distance may increase based on eDNA and electrofishing surveys just prior to treatment.



ID	NAME	TYPE	X	Y	Wetted Width (m)
BK1	NA	Brook	46.49401	-66.99736	4.0
BK2	Lake Brook	Brook	46.49420	-66.98280	6.0
SP1	NA	Spring	46.49709	-66.98775	<0.5
BK3	NA	Brook	46.50307	-66.98512	1.5
BK4	NA	Brook	46.49899	-66.96726	1.0
BK5	NA	Brook	46.49176	-66.94206	3.0
SP2	NA	Spring	46.49758	-66.94088	<0.5
BK6	NA	Brook	46.49992	-66.93883	1.5
BK7	NA	Brook	46.50169	-66.93777	2.5
SP3	NA	Spring	46.50324	-66.93889	<0.5
BK8	NA	Brook	46.50942	-66.95147	1.5
BK9	McKiel Brook	Brook	46.51666	-66.94969	10.0
BK10	NA	Brook	46.51983	-66.94058	1.0
BK11	NA	Brook	46.51486	-66.93380	1.5
SP4	NA	Spring	46.51647	-66.93053	0.5
SP5	NA	Spring	46.51692	-66.92650	0.5

Figure 8. SW Miramichi River inflows within the river treatment reach (surveyed 4 June 2020).

Rotenone will be deactivated at the downstream extent of the treatment area on the SW Miramichi River using potassium permanganate ($KMnO_4$) and is described in the deactivation section below. The following are planning assumptions & details for the river treatment:

- SWMR outflow @ 1.9 to 9.2 m^3/s & velocity of 1.6 km/h
- Treat with Noxfish Fish Toxicant II (PMRA 33247) @ 0.075 ppm rotenone for 6 h
- Space injections sites @ 1.6 to 3.2 km (5 to 10 sites)
- Tributaries and springs/seeps treated by drip or Vectocarb
- Estimated river flushing time @ 15 km/1.6 km/h = 9.4 h
- Estimated duration of deactivation injection (9.4 h x 2) + 6 h = 24.75 h
- Deactivate @ 4 ppm $KMnO_4$ to achieve residual of 1 ppm $KMnO_4$ 30 min water travel time downstream

Noxfish Fish Toxicant II and Equipment Requirements – Estimates were derived using SOPs 5.1 and 11.1 (Finlayson et al. 2018):

Minimum Noxfish II = 1.9 (m^3/s) x 1.2 x 75 (ppb rotenone) = 171 ml /min
171 ml/min x 60 min/h x 6 h = 61.56 L per site
Total for 5-10 sites 307.8 – 615.6 L [81.3 – 162.6 gal]
Maximum Noxfish II = 9.2 (m^3/s) x 1.2 x 75 (ppb rotenone) = 828 ml/min
828 ml/min x 60 min/h x 6 h = 298.1 L per site
Total for 5-10 sites 1,490 – 2,981 L [393.7 – 787.6 gal]

Equipment – Treating the river with undiluted Noxfish II will be accomplished using two methods. Three to four dripcans are spaced at equal intervals across the width of the river at each site; this method will be effective at sites shallow enough for foot access and to securely position the cans. Alternatively, a peristaltic pump (with flowmeter) capable of delivering 100 to 1,000 ml/min injects rotenone into a long PVC pipe that is elevated over the river's width and having evenly spaced emitters. The dripcan method requires no additional support equipment whereas the peristaltic pumps will require a generator for power at each site, and temporary tri-pod structures to support the PVC pipe over the river.

Deactivation

As a mitigation measure to avoid downstream impacts, rotenone will be deactivated at the downstream extent of the overall treatment area. There will be one deactivation station on the SW Miramichi River at camp Moose Call (Figure 2). Potassium permanganate ($KMnO_4$), a commonly used water purifying agent, will be used for deactivation and is listed on the PMRA product label for Noxfish II as a deactivation agent.

Granular potassium permanganate will be applied with volumetric feeders at a concentration of 4 ppm to maintain a residual concentration of 1 ppm at the end of 30-minute water travel time downstream. The deactivation process will begin by releasing potassium permanganate 2 hours before the rotenone treatment begins in the river, which will oxidize the streambed to remove interferences to oxidizing rotenone. The deactivation station will be maintained for approximately 24.75 hours pending water flows and monitoring results. The crew will be prepared with additional deactivation material to continue deactivating beyond the planned 24.75 hour period should this be necessary based on monitoring results. Deactivation will occur for each of the two river treatments, with an approximate 30-day gap in between those two treatments.

Granular $KMnO_4$ & Equipment Requirements – Estimates derived using SOP 7.1 (Finlayson et al. 2018):

Minimum $KMnO_4$ = 4 ppb $KMnO_4$ x 60.02 x 1.9 m^3/s = 456.2 g/min
Total of 456.2 g/min x 60 min/h x 24.75 h = 677.5 kg $KMnO_4$
Maximum $KMnO_4$ = 4 ppb $KMnO_4$ x 60.02 x 9.2 m^3/s = 2,208.7 g/min
Total of 2,208.7 g/min x 60 min/h x 24.75 h = 3,279.9 $KMnO_4$
Equipment = Two (one used as a backup) volumetric feeder(s) capable of delivering 300 to 3,000 g/min of granular $KMnO_4$ placed on a platform in the middle of a shallow section of the river and a generator for power. Back-up equipment will be on-site in case of equipment failure.

The deactivation crew located at the downstream extent of the treatment area on the river will remain prepared to further deactivate rotenone-treated lake water discharging from Lake Brook into the river for several days until sentinel Brook Trout can survive at the deactivation station located at camp Moose Call (Figure 2). The purpose of oxidizing the streambed is to eliminate interferences with oxidizing rotenone, and it is possible that oxidizable materials will redeposit in the streambed in the interim between the two treatments. For each of the two river treatments, we will oxidize the streambed, each time until the oxidation-reduction reaction, in the absence of rotenone, stabilizes.

After the first treatment, the rotenone-treated lake water would be discharging into the SW Miramichi River for several days after the river was treated and deactivated. This is inconsequential because the river will have been just treated and will be treated again in the coming weeks, and mitigation measures will still be in place holding adult salmon downriver behind the barrier safe outside of the treatment reach and several kilometres below the deactivation zone (Figure 2). However, to be conservative, the deactivation crew will remain on-site on the river with adequate resources to further deactivate until sentinel Brook Trout can survive. This will ensure that rotenone from lake discharge has deactivated to safe/undetectable levels at the downstream extent of the treatment area.

At the end of the treatment and deactivation of the SW Miramichi River (1.25 days after starting), the treatment of Miramichi Lake and Lake Brook will be in its second day. Although rotenone will begin to degrade as soon as it is applied, the discharge from the lake and brook may contain up to 0.075 ppm rotenone (i.e., the treatment concentration). Based on discharges, we expect the river:brook dilution level to be at least 10:1, in which case the estimated duration to reach the desired <2ppb with dilution level in the river is 5 days after the lake and brook treatment is completed. This is considered very conservative because it does not take into account the effect of natural deactivation of rotenone lake water through photolysis and metabolic pathways while it flows through ~7 km of the low gradient, slow flowing Lake Brook. Should rotenone levels >2ppb resulting from lake outflow persist in the river at the deactivation site for greater than the planned deactivation period of 24.75 h, deactivation will continue until concentrations have subsided to <2ppb.

Treatment and Deactivation Monitoring

To ensure effective treatment and deactivation, rotenone concentrations throughout the project area and potassium permanganate residual in the neutralization zone will be monitored closely. Treatment and deactivation monitoring protocols are provided in detail in the Monitoring Plan in Appendix C.

Treatment Schedule

Treatment 1: Miramichi Lake, Lake Brook, SW Miramichi River (mid August 2021)

- Time 0h: Begin drip stations on 4 inlets to Miramichi Lake and hand spray backwater areas near the inlets (duration: covering the 2 days of lake treatment)
- Time 1-2h: Begin treatment of Miramichi Lake (duration: 2 days)
- Time 1-2h: Begin drip stations on Lake Brook, East Branch Lake Brook, and backpack spraying peripheral and backwater areas (duration: 6 h) (note: treatment of the brook reaches may be via aerial application, a PMRA approved method on the product label)
- Time 2 h: Begin deactivation by first releasing potassium permanganate to oxidize the streambed and remove interferences to oxidizing rotenone at downstream extent of treatment area on the SW Miramichi River (duration: 24.75h)
- Time 4 h: Begin treatment of SW Miramichi at all sites along 15 km of river, backpack/boat spraying along edges and backwaters, drip stations on tributaries/springs entering river (duration: 6h)

Treatment 2: Lake Brook, SW Miramichi River ~30 days after treatment 1 (mid-late September 2021)

- Time 0 h: Begin drip stations on Lake Brook, East Branch Lake Brook, and backpack spraying (duration: 6 h) (note: treatment of the brook reaches may be via aerial application, a PMRA approved method on the product label)

- Time 0 h: Begin deactivation by first releasing potassium permanganate to oxidize the streambed and remove interferences to oxidizing rotenone at downstream extent of treatment area on the SW Miramichi River (duration: 24.75h)
- Time 2 h: Begin treatment of SW Miramichi at up to 10 sites along 15 km of river, backpack/boat spraying along edges and backwaters, drip stations on tributaries/springs entering river (duration: 6h)

  The second treatment is planned to be approximately 30 days after the first treatment concludes, but the gap may be slightly shorter or longer depending on environmental conditions. The exact timing will depend on weather and flow conditions. For example, if there are high flows after the first treatment, we may need to wait for flows to subside before the second treatment. Optimally, the first treatment would be in mid August, followed by the second in mid-late September, avoiding having to hold adult salmon at the downriver barrier too close to the spawning period. Salmon will need time to migrate and reach their preferred spawning areas in October.

Pesticide Applicator Certification (Provincial Licence) and Rotenone Training Course
A certified pesticide applicator team will conduct the treatment. The project team will take the Pesticide Use Training Course, and will also take the American Fisheries Society Rotenone Training Course in November, 2020.

The PMRA label and safety requirements / Drug label and safety instructions
The Noxfish Fish Toxicant II PMRA Label is provided in Appendix E and Noxfish Fish Toxicant II SDS sheet is provided in Appendix F.

Applicator Safety Requirements
The applicator is protected from exposure to rotenone through wearing personal protective equipment (PPE) as required on the PMRA label (Appendix E) and by adhering to safety procedures describe in SOPs 3.1 and 4.1 of the Rotenone SOP Manual (Finlayson et al. 2018). The applicator must wear chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-organic-vapor-removing cartridge with a pre-filter for pesticides or a NIOSH-approved canister for pesticides during mixing, loading, application, clean-up and repair.

Mixers and loaders (except mixing/loading to support backpack sprayers and drip stations) must use a closed system as described in SOP 8.1 of the Rotenone SOP Manual (Finlayson et al. 2018) that is designed by the manufacturer to remove the product from the shipping container and transfer the product into mixing tanks and/or application equipment. At any disconnect point, the system must be equipped with a dry disconnect or dry couple shut-off device that will limit drippage to no more than 2 ml per disconnect. The closed mixing/loading system must function properly and be used and maintained in accordance with the manufacturer's written operating instructions. SOP 10.1 of the Rotenone SOP Manual (Finlayson et al. 2018) provides guidance on the use of drum pumps for filling drip stations and backpack sprayers.

Crew Size and Responsibilities
American Fisheries Society Rotenone SOP Manual (Section 2.3, Finlayson et al. 2018) recommends using an Incident Control System to organize the various treatment functions into teams under the direction of an Incident Commander. The project crew will be formed as follows:

Operations Division. The Operations Section is responsible for applying Noxfish II in the lake, Lake Brook, and the river and deactivating rotenone in the river. The operations crew will collect and dispose of dead fish post-treatment (see fish collection details in Section 5.0 – Mitigation).

Rotenone Application. Miramichi Lake and Lake Brook will require a crew of 10-19 people including 6-9 staff for the Miramichi Lake boats (2 applicators and 1 operator per each of the 2-3 boats), 4 people to operate the drip stations on the 4 lake inlets for 2 days, and 4 to 6 people to operate drip stations and backpack sprayers on Lake Brook. Should we pursue the option of treating the brook area by helicopter, 1 helicopter pilot and 1-2 people on the ground will be required.

The river treatment will require 15-25 people. Five to 10 people will be required to operate the 5 to 10 rotenone delivery locations and 10 to 15 people are needed for backpack and boat spraying in peripheral and backwater areas. Those operating the drip stations will monitor the toxicity of the application by checking the caged fish immediately above their drip station.

Deactivation. This will involve 2 people at the deactivation site for a minimum of 25 hours, or three shifts of 2 people (6 people total) for that period of time.

Support Division. The Support Section will service and monitor caged acute lethality bioassay fish located throughout the treatment area to measure the efficacy of the treatment, collect water samples for rotenone analysis, install a fish migration barrier, and collect dead fish. This will involve 4 staff for 2 days and periodically for several weeks. Dead fish collection specifically will occur for 1-week post treatment, longer if necessary. The crew will also install and monitor the fish migration barrier at the downstream extent of the project area on the SW Miramichi River.

Logistics Division. The Logistics Section is responsible for obtaining, maintaining, and distributing all equipment and supplies (with exception of PPE) including rotenone. The staff will also provide and coordinate electronic communication among the entire treatment team. This will involve 2 staff for 2 days.

Safety Officer. The Safety Officer and assistant are responsible for providing safety training to the crew, issuing personal protective equipment (PPE), monitoring crew safety, and training for on-site safety procedures including a spill contingency plan. The Safety Officer will provide security oversight at the lake and river staging areas where Noxfish II will be stored, and will monitor continuously for spills.

Public Information Officer/Liaison. The lead Public Information/Liaison Officer is responsible for communicating with the general public, government agencies, media and other interested parties. An additional public communications assistant will be stationed at the lone entrance road to Miramichi Lake to inform the public of the activities and of the restricted access for the 2-day treatment and for 3 days post-treatment. This team will also be responsible for ensuring project signage is installed prior to treatment at all public access locations as described in detail in Section 5.0 – Mitigation and shown in Figure 14.

Activities Conducted Outside the Project Area

Activities conducted outside of the project area include transportation of materials to the site and the disposal of dead fish:

- Noxfish Fish Toxicant II will be transported via truck from the supplier to the staging areas near the public boat launch at Miramichi Lake and at Deersdale on private land for the river component (Figure 4). The designated storage area on-site will be a bermed, 7x10x0.5 m (35 m^3 or 9,246 gallon capacity) enclosure and large enough to contain all 71 30-gallon drums (2,130 gallons). The existing cleared area near the public boat launch at Miramichi Lake is 12m x 24 m = 288 m^2, providing more than enough area required for staging and rotenone storage. Rotenone can be delivered to the site a day or two before treatment using normal ground transportation to avoid long-term storage. The Noxfish II (with Canadian labels) will come from Dallas, Texas (USA), transported via a licensed commercial carrier to the USA-Canadian border, and transported inside Canada in a manner consistent with the Transport of Dangerous Goods Program which includes certified training, emergency response plans and the necessary permits.

- The collection of dead fish in Miramichi Lake will take place for 1-week post-treatment, and longer if necessary. We will comply with all conditions as required by the NB Department of Environment and Local Government, and will also work with the department to finalize which site is most appropriate. Two off-site candidate fish disposal sites have been identified:
  - **Site 1** is located on J.D. Irving, Limited freehold land in Deersdale approximately 13 km from Miramichi Lake (lat: 46.502080° lon: -67.030937°)
  - **Site 2** is located on crown land 1.2 km to the west of the public boat launch at Miramichi Lake at the end of a forest road (lat: 46.450966° lon: -66.976607°)

Vehicular Traffic

Increased traffic including passenger vehicles and small boats will occur temporarily around the project area during preparation and implementation in July, August, and September, 2021. However, this activity will be minimal and temporary, and will be in remote locations. There will be a one-time delivery of Noxfish Fish Toxicant II and potassium permanganate by transport truck to the staging area adjacent to Miramichi Lake, as well as a staging area at Deersdale on private land for the river component, which is secure behind closed gates and not accessible to the public (see Figure 4). Vehicular traffic also includes fish disposal activity. For a period of 1-week post-treatment (longer if necessary) pickup trucks will travel from the lake to the fish disposal site.

i) **Future Modifications, Extensions, or Abandonment**:

There are no plans for future modifications, extensions, or abandonment. The treatment will be limited to a window including August and September, 2021, as described above in the treatment schedule. If eradication efforts are unsuccessful and the likely cause of failure can be identified and corrective actions are possible, then another attempt will be made but is not expected to be required. Extensive pre- and post-treatment monitoring information on rotenone concentrations, fish toxicity, and fish presence in the treatment area will assist in the identification of potential reasons for failure.

Contingency Plan: If monitoring indicates that the eradication was unsuccessful, the contingency plan is to carry out another treatment in a future year. However, we do not expect to require another treatment. We are planning the project in significant detail with the assistance of experts to incorporate lessons learned, standard operating procedures, and best practices for the greatest likelihood of success. To minimize chances of failure and maximize likelihood of success, we have followed the key tenets for eradication success (van den Heuvel et al. 2017, developed from Finlayson et al. 2010):

- **Project planning and training:** Many treatments in the past have been done on an emergency basis with little or no time for planning. It is now widely accepted that most rotenone projects require five steps (Finlayson et al. 2018), three of which involve planning: 1) preliminary planning where the concept is developed, information is collected on-site, a feasibility analysis is conducted, and tentative approval is obtained; 2) intermediate planning with public and regulatory agency outreach and scoping boundaries and restrictions on the project; and 3) final planning where the specific operation plans for the project are developed. Many projects require the development of a rotenone application plan, monitoring plan, site safety and security plan, fish monitoring and disposal plan, spill contingency plan, and rotenone deactivation plan prior to the actual treatment. Each of these components is included in the Miramichi eradication plan. Consistent with adequate planning is adequate training of all project staff on safety, treatment and deactivation procedures, and the equipment used. The Miramichi project team will take both the American Fisheries Society rotenone training course in November 2020, and the Pesticide Use training course.
- **Project area mapping:** Complete removal of target fish from an area requires that all habitats capable of supporting target fish are treated with rotenone. Electrofishing and eDNA (Barnes et al. 2014; Goldberb 2016; Rees et al. 2014) should be used together, as they are on the Miramichi, for determining the presence/absence of smallmouth bass since neither technique by itself has an accuracy of 100%. The project team has carried out field surveys to characterize inlet tributaries to the lake and identify all inflows into the SW Miramichi River treatment reach. We have also carried out a helicopter survey to record video the project area and identify areas that require specific attention to minimize weakness in the treatment (e.g., East Branch Lake Brook, McKiel Bogan).
- **Adequate rotenone exposure:** The flow of untreated water into the treatment area must be avoided. The entire treatment area should contain lethal levels of rotenone concurrently. Lethal levels and the treatment rate for the Miramichi project have been determined and are described above in the treatment operation section. Rotenone must also be applied to seeps, backwater areas and springs to avoid refuge. These features have been mapped and are included in the treatment plan.
- **Project size and complexity:** The Norwegian Institute for Freshwater Research assessed the effectiveness of Norwegian Directorate of Nature Management's ectoparasite control program for Atlantic salmon. Johnsen et al. (2008) found a significant difference between the success rate in large rotenone treatment areas (14% success for drainages > 500 km^2) and smaller rotenone treatment areas (81% success rate for drainages < 500 km^2). Given the relatively small Miramichi Lake drainage (43.1 km^2), small lake area (220 ha), shallow lake depth (< 6m) and absence of smallmouth bass in the inlets, size and complexity are not limiting factors in the success of the rotenone treatment.
- **Bioassays/Sentinel Fish:** Until recently, sentinel fish were not commonly used during rotenone treatments as a monitoring mechanism. Thus, there was no real-time monitoring system in place that would signal whether the treatment and deactivation were effective. To provide for real-time adjustments, cages containing sentinel fish are placed at various locations and depths in lakes and downstream of all drip stations on streams to monitor the effectiveness of the rotenone treatment. Similarly, sentinel fish are used to judge the effectiveness of rotenone deactivation. Careful monitoring of sentinel fish during the treatment is used to adjust the rotenone treatment and deactivation rates. This will help ensure maximum fish mortality in the treatment area and minimal off-target impacts. In conjunction with the use of sentinel fish, water samples for rotenone analysis are collected in the treatment area to confirm lethal levels of rotenone were

present. Rotenone deactivation is often used in order to limit the spatial extent of toxicity beyond the treatment area. Potassium permanganate, a strong oxidant is used for this purpose as it oxidizes and thereby breaks down the molecular structure of rotenone, eliminating its ability to be toxic. Monitoring for permanganate and rotenone residues in conjunction with caged sentinel fish below the deactivation station are used to judge the effectiveness of deactivating the rotenone. These are described in detail for the Miramichi project in the Monitoring Plan provided in Appendix C.

- **Minimizing weaknesses:** To minimize possible weaknesses in a rotenone treatment:
  - Estimate an efficacious treatment rate through the use of a bioassay on the target species, estimated at a *minimum* of 4 times the LC_{50} value from the bioassay;
  - Treat all known standing and flowing water within treatment area capable of supporting fish.
  - Identify and treat all upwelling groundwater (i.e., seeps/springs) that were identified and mapped in Figure 8 with Noxfish II combined with Vectocarb
  - Identify all barriers to fish and water movement including aquatic vegetation, marshy areas, and beaver dams that may require special handling prior to treatment;
  - Utilize sentinel fish in strategic locations in the treatment and deactivation areas for real-time monitoring of effectiveness;
  - Treat when water temperatures are above 10°C;
  - Utilize accurate and up-to-date water volume and flow data in the planning and execution of the treatment;
  - Identify physical and chemical characteristics (i.e., pH, turbidity, alkalinity, organic content) of site water that may affect the efficacy of rotenone and potassium permanganate;
  - Avoid undertreatment and target species survival;
  - Avoid overtreatment, excessive rotenone residues, inadequate deactivation and non-target effects;
  - Use block nets where appropriate to prevent target fish escapement;
  - Train all staff on their responsibilities, proper use of PPE, and equipment operation;
  - When deactivating with potassium permanganate, begin deactivation before the rotenone application to exhaust the organic demand of the streambed;
  - Have a backup system for deactivation should the primary system fail; and
  - When deactivating, monitor rotenone and permanganate residues below the deactivation station to assess the operation's ability to deactivate rotenone.

j) Documents Related to the Undertaking:

Regulatory Processes, Agency Reviews, and Applications

This is a complex project that involves many regulatory processes happening in parallel. The Working Group, DFO and DNR, through the federal AIS process, have coordinated permit requirements and agency reviews through various federal and provincial departments including the Canadian Wildlife Service (CWS), Pest Management Regulatory Agency (PMRA; Health Canada), Environment and Climate Change Canada (ECCC), New Brunswick Department of Environment and Local Government (DELG), and DNR. Table 3 provides a list of relevant documents regarding characterization of the project area environment and a list of all regulatory processes, applications, and agency reviews in relation to this project.

Table 3. Relevant documents regarding characterization of the project area environment and a list of all regulatory processes, applications, and agency reviews in relation to the proposed eradication of smallmouth bass from the Miramichi watershed.

	Description	Status
	Documents describing environmental conditions	
1	- National Aquatic Invasive Species (AIS) amended application to deposit a deleterious substance (Appendix B)	Complete
2	- Exploring options for eradication of smallmouth bass in Miramichi Lake - van den Heuvel et al. 2007	Complete
3	- Fieldwork to support eradication planning	In Progress
4	- Fish Control Solutions river eradication feasibility assessment (Appendix B)	Complete
	Regulatory Processes/Applications Submitted/Agency Reviews	
1	DFO - Review of National AIS application to deposit a deleterious substance (Appendix B)	In Progress
2	DFO - Federal CSAS review of the initial AIS application to deposit a deleterious substance (DFO 2019)	Complete
3	DFO - Several rounds of DFO questions and proponent answers in relation to the AIS application (Appendix G)	Complete
4	DFO - Collection and Introductions & Transfers permit for fish rescue and transplantation	Not Yet Submitted
5	DELG - Questions and proponent answers on AIS application (Appendix H)	Complete
6	DELG - WAWA permits for beaver dam removals and fish migration barrier	Not Yet Submitted
7	DELG - Pesticide use permit	Not Yet Submitted
8	DELG - EIA registration and determination review	In Progress
9	PMRA - Emergency use registration for use of Noxfish II in waters downstream of Miramichi Lake* (Appendix I)	In Progress
10	PMRA - Questions and proponent answers in relation to the emergency use registration (Appendix I)	Complete
11	ECCC - DFO coordinated Federal EA screening (screened out, did not trigger)	Complete
12	CWS - DFO coordinated project review by CWS for impacts to migratory birds (screened out)	Complete
13	DNR - DFO and DNR staff consulted with DNR Species at Risk group on potential impacts and mitigation for species at risk such as brook floater, wood turtle, Atlantic salmon, and American eel	Complete

*The current PMRA label allows use of Noxfish II in lakes and in flowing waters upstream of lakes, but not downstream. Either an emergency use registration is required for flowing waters downstream of the lake or a permanent label change; both are currently being pursued with PMRA in parallel. The change will bring the label up to date and consistent with the product's labels abroad including the US and European Union.

Appendix B provides the AIS application, a parallel process to this EIA determination review which has been underway since April 2019. Appendix G provides correspondence with DFO including several rounds of questions/answers. Appendix H provides correspondence with DELG, and includes three letters notifying the Proponent that:

- 26 July 2019 - An EIA registration is required by DELG
- 15 November 2019 - An EIA registration is not required by DELG
- 13 July 2020 - An EIA registration is required by DELG

The current Noxfish II PMRA label allows use of the project in flowing waters upstream of lakes, ponds, and reservoirs, but not downstream. To enable the use downstream from Miramichi Lake, either an Emergency Use (EU) registration is required or a permanent label change. We are pursuing both. Appendix I provides the EU registration application, the EU label, correspondence with PMRA, including questions and proponent answers. Appendix I also includes a landowner support letter, letters of support from the Working Group and from the product supplier (i.e., the registrant), and a letter from DFO stating that the department agrees to be the government sponsor for the EU registration.

Watercourse and Wetland Alteration (WAWA) Permit Requirements

Based on consultations with DELG and DFO, we require WAWA permits for the following activities: beaver dam removals, fish migration barrier, and potentially ATV trail cutting (if required). The floating dock at

Miramichi Lake does not require a WAWA as per DELG's technical guidelines. The project will remain in compliance with WAWA requirements should DELG deem any additional activities require a permit.

3.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

a) Physical and Natural Features

Project Area Physical Characteristics
Located approximately 160 km upriver from the head of tide in the headwaters of the Southwest Miramichi River watershed, Miramichi Lake is a reasonably small temperate lake with several input tributaries and a single outlet that drains into Lake Brook, a 5.3 km tributary to the Southwest Miramichi River. Miramichi Lake is approximately 2.8 km long with an average width of 0.8 km (Figure 2). The surface area is 2.21 km^2.

Most areas of the lake are moderately shallow (< 4 m) with two deeper areas (> 6 m). Biron et al. (2014) described shoreline substrate characteristics throughout the lake to vary from muddy with aquatic vegetation, to sandy and exposed, to organic-rich mud, to sand-gravel mix, to mud-flats, with each characterization having some presence of naturally occurring logs and boulders. The water has a natural tea-coloured pigmentation, mostly due to the presence of humic matter from upstream and surrounding bogs. Cold, clear streams entering the lake and shoreline water seepage indicating groundwater input.

The pH of the lake water as measured June 22, 2017 was 7.3 and the conductivity 25 µS/cm. No other records of water chemistry for Miramichi Lake could be found though some may exist as unpublished data within either DFO or the New Brunswick government. The geology in the lake watershed is reported as igneous and conductivity shows very soft water characteristic of Canadian Shield geology. The presence of eroded gravel and large igneous boulders indicates the basin of the lake is predominantly glacial till. The lake sits in a deep bowl just below a plateau of land that demarcates the divide between the Miramichi and St. John River watersheds and as such can be considered a headwater lake. The sub-watershed for the lake is dominated by forests and some wetland. Figure 9 provides photographs of Miramichi Lake.

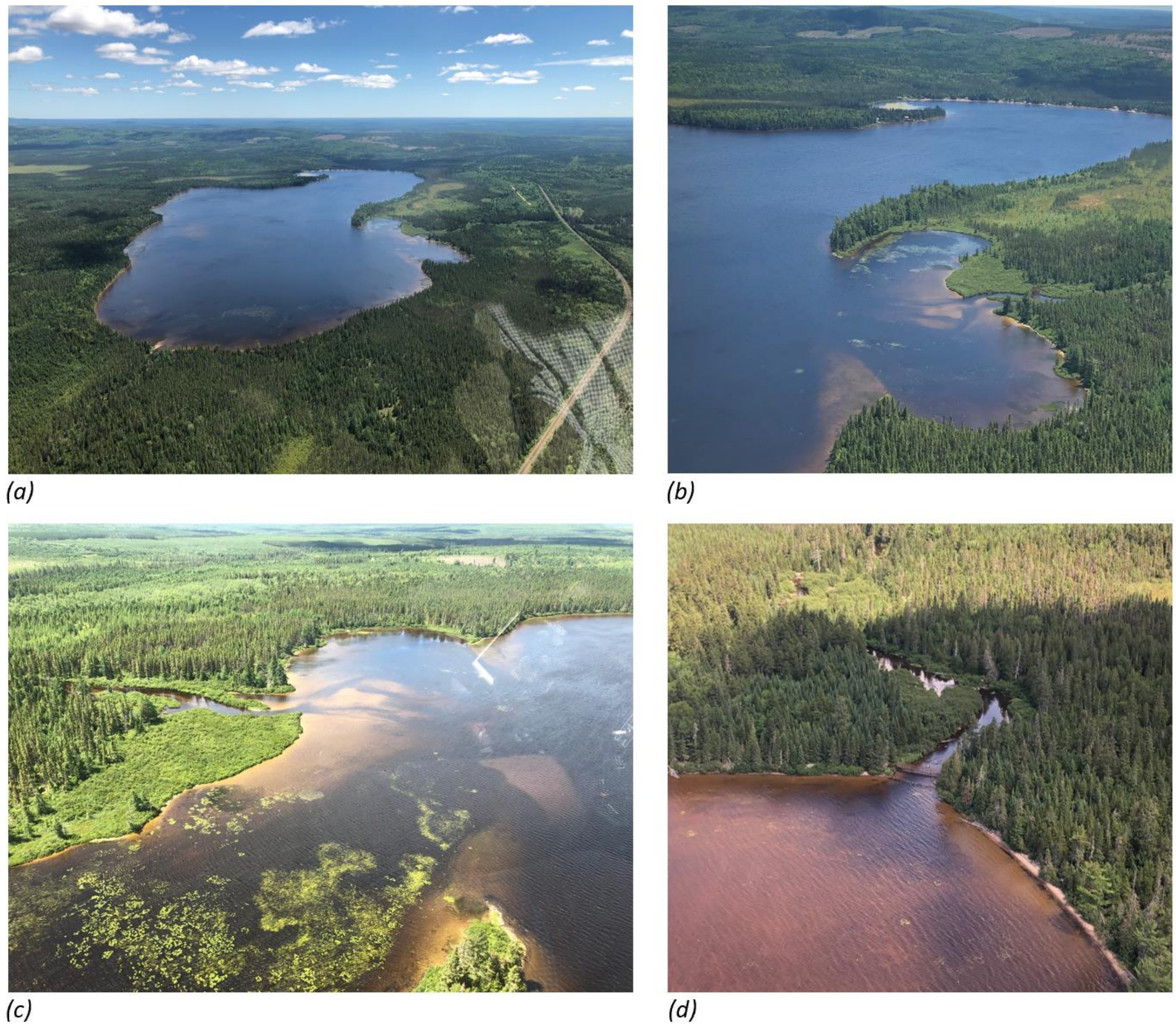


Figure 9. (a) Miramichi Lake, (b) Inlet 3 entering the lake from mid-right, (c) Aquatic vegetation near inlet 3 from mid-left, (d) Lake outlet (Lake Brook) and DFO containment barrier that has failed to contain SMB in the lake (photos taken on 21 July 2020)

The 15-km reach of the SW Miramichi that falls within the project area has an upstream catchment area of 974 km^2 (calculated from the downstream extent of the treatment area). The river has a bankfull width of approximately 50 m throughout this reach, there are several small inflows and one major inflow, McKiel Brook (Figure 8). The river flows generally to the northeast and the project and has an average gradient of 0.16% (range <0.05 – 0.56% based on 500m increments). The SW Miramichi River project reach profile is shown in Figure 10 and was produced using data provided by NB DNR based on LIDAR information. Photos of Lake Brook and the SW Miramichi River within the project reach are provided in Figure 11.

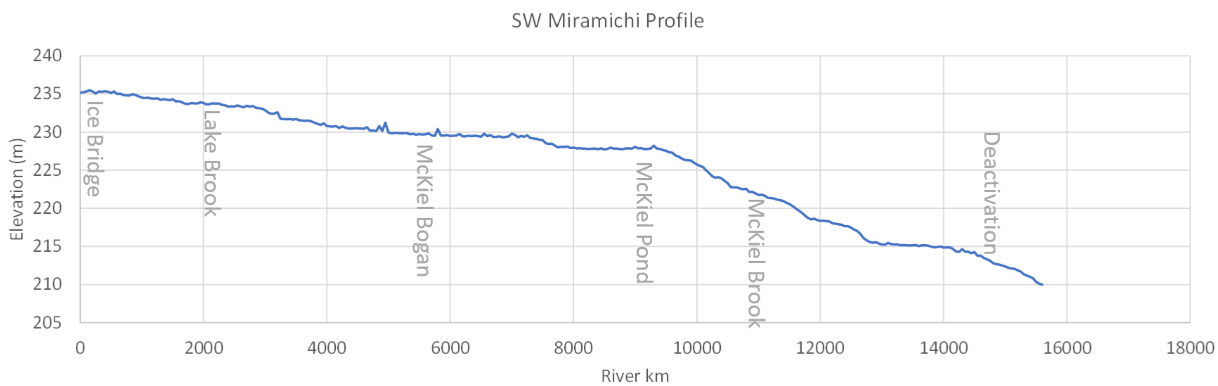


Figure 10. SW Miramichi River project reach profile (produced using data provided by NB DNR based on LIDAR).

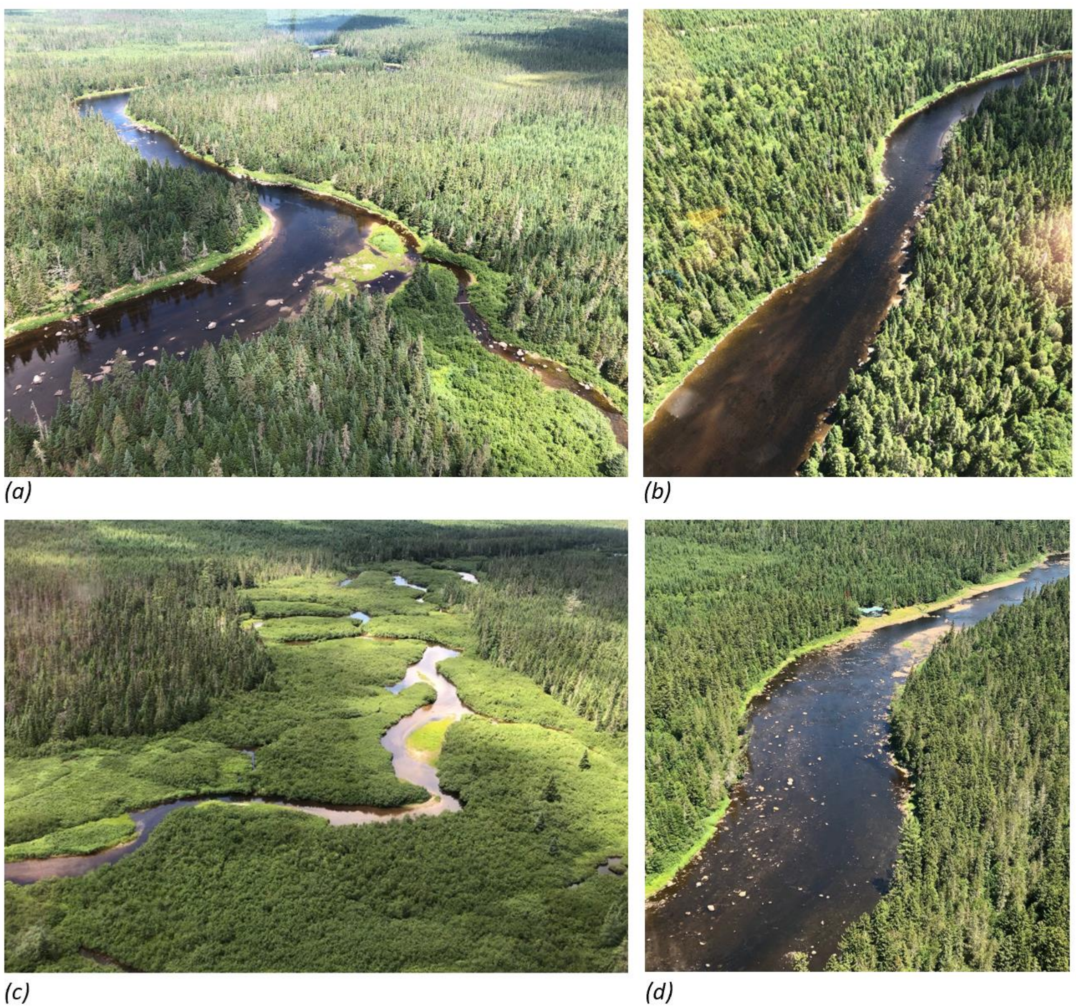


Figure 11. (a) Confluence of Lake Brook and the SW Miramichi River, (b) McKiel Pond Pool on the SW Miramichi River, (c) Lake Brook, (d) Slate Island – location of fish migration barrier (photos taken on 21 July 2020)

Miramichi Lake has an estimated water volume of 5.36 million m^3 (verified by DNR through GIS calculation using a TIN surface created from lake bathymetry). The lake's watershed area, estimated from below the outlet of the lake, is 43.1 km^2.

Lake Brook mean annual flow was determined by van den Heuvel et al. (2017) based on a regional flow model using 13 gauged stations in the region with similar precipitation (both Environment Canada and the author's data); the mean annual flow rate of Lake Brook was estimated to be 0.45 m^3/s. Manual flow measurement at the outlet of Lake Brook on June 22, 2017 showed a flow rate of 0.69 m^3/s (van den Heuvel et al. 2017). Regardless of mean annual flow calculation from models for planning purposes, an up-to-date flow measurement in Lake Brook will be taken manually immediately prior to treatment in order to calculate the accurate quantity of rotenone formulation required to achieve the treatment concentration.

Water temperature data was collected by DFO in 2010, 2011 and 2012 from May through October. From 2010-2012 mean daily water temperature varied seasonally generally ranging from 5-10°C in early May to peak around 25°C in mid-July and settle to 5°C by the end of October. Data collected by the Miramichi River Environmental Assessment Committee (MREAC), on average, followed the same temperature trends observed in 2010-2012. These temperature profiles are more detailed having been collected at 1 m intervals from surface to bottom (Figure 12) and the lake appeared to be very well mixed with little stratification when monitoring began in mid-June (van den Heuvel et al. 2017).

Thereafter, temperature increased faster in the top 4 m of water, showing a distinct thermocline around that depth. There were three distinct events occurring around July 2, July 20 and August 8, 2017 (likely wind driven) that caused loss of the thermocline and full mixing of the lake. These summer mixing events are likely common suggesting the lake is of polymictic (mixing more than two times a year). By October the thermocline disappears and the lake returns to an isothermal nature preceding ice-up. Although lake temperature will show slight variation each season, it is expected to follow similar trends each year. The temperature regime is important for planning an eradication using rotenone because its toxicity persistence, natural break down, and deactivation are temperature sensitive.

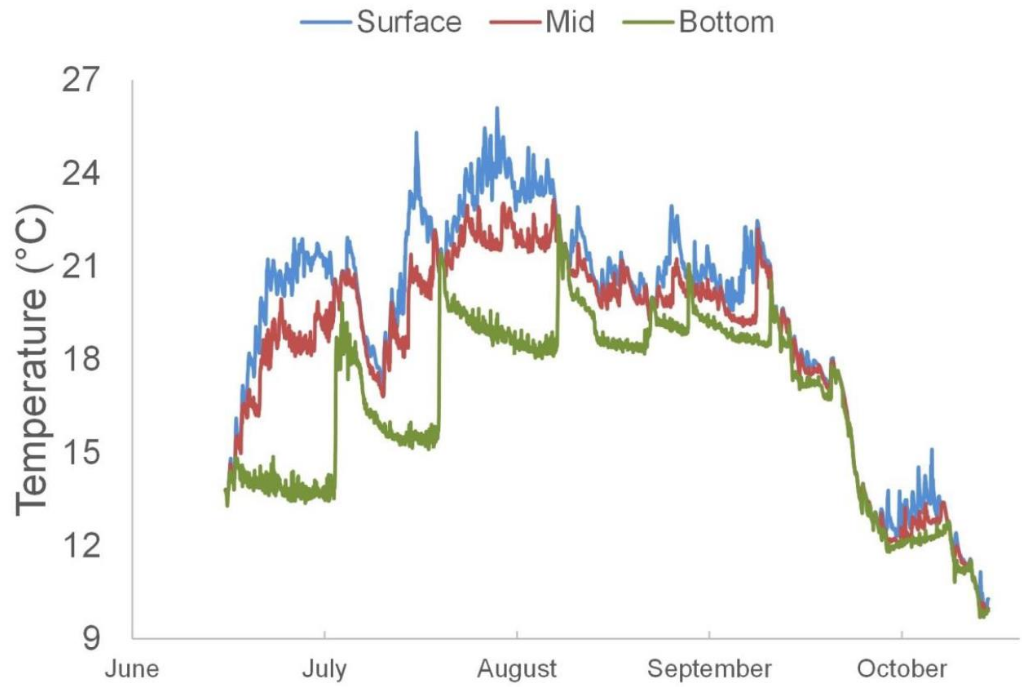


Figure 12. Mean (n = 2 loggers) temperature at surface, mid-depth, and bottom of Miramichi Lake in 2016. Figure created from raw data with permission from MREAC (van den Heuvel et al. 2017).

Biological Characteristics
SMB Distribution
Smallmouth bass were discovered in Miramichi Lake in 2008 and all life stages (young-of-the-year, juveniles, and adults) have been captured in the Lake every year since. With successful spawning each year in the lake, it is the only known established source of SMB in the Miramichi watershed.

In the spring, invasive SMB move from deeper overwintering locations to shallow near-shore spawning grounds as water temperatures increase. Feeding activity is estimated to begin at a water temperature of around 8°C (early to mid-May), while spawning typically begins in late May or early June when temperatures reach 15-18°C (Curry et al. 2005, DFO 2009). Curry et al. (2005) found in other New Brunswick lakes (Oromocto and Mactaquac) embryos hatched and young-of-the-year (YOY) are present by the end of May. Shallow (< 1.5m) waters with sand/gravel substrate, little to no aquatic vegetation or algae and close proximity to logs and large rock are preferred spawning habitats (Pflug and Pauley 1984, DFO 2009). Biron et al. (2014) classified that area of Miramichi Lake as the shallow grounds between the shore and the deep hole adjacent to the outlet (sectors 1 and 16, see Biron et al., 2014). DFO (2013) exemplifies this observation by showing the in-season habitat distribution (July and August 2010-2012) of captured YOY SMB to be concentrated in this area.

Three mature female bass were reported caught in this area by local fishermen contracted for control measures in 2017 (Brian Richard, personal communication), and YOY bass were found in July 2017. YOY/juveniles tend to frequent shallow waters under brush or rocks preying on midge larva, mayfly nymphs and small fish. Adults inhabit moderately shallow waters where rocks/large woody debris are available (DFO 2009) preying on cyprinids, *Alosa sp.* YOY and perch *sp*. (Kerr and Grant 1999). Feeding cessation is reported to occur when water temperatures decline to 7-10°C (October) (DFO 2009), and SMB are also reported to burrow in the mud at temperatures below 7°C (Kerr and Grant 1999). However, should burrowing occur for any duration it is significant in that this behavior will likely protect SMB from rotenone toxicity at temperatures below 7°C (Dawson et al. 1991). Thus, an eradication treatment should be avoided at temperatures below 10 °C; such temperatures do not occur in Miramichi Lake until late October.

Since 2008, when bass were initially discovered in Miramichi Lake and the seasonal containment barrier was erected, DFO backpack electrofishing results from the upper reach of Lake Brook (i.e., just below the barrier) showed that juveniles had escaped from Miramichi Lake past the barrier in multiple years. Environmental DNA (eDNA) results from 2017 from a UNB study (O'Sullivan et al. 2020) showed SMB DNA was found near McKiel Bogan (Figure 2) in the mainstem of the river in 2017. However, SMB were not confirmed in the river until August 22, 2019, when a UNB scientist took an underwater photograph of a SMB in Tent Pool approximately 8.7 km downriver from the confluence of Lake Brook and the SW Miramichi River (Figure 2). Further snorkelling surveys by DFO showed that SMB were present in McKiel Pond Pool (Figure 2), approximately 7 km downriver from the outlet of Lake Brook. Three SMB were subsequently angled at McKiel Pond Pool by our Working Group on September 1, 2019, the first confirmed catch of SMB in the SW Miramichi River.

The discovery of SMB in the river a short distance downstream from Miramichi Lake initiated further investigation by DFO using environmental DNA (eDNA) sampling to determine their distribution. Several rounds of eDNA were conducted in the fall of 2019 and are ongoing in the fall of 2020. Preliminary results from 2019 and 2020 indicate that SMB remain limited to the project reach (**Note:** DFO is currently preparing a summary report of the eDNA results and analysis from 2019 and 2020 and we will provide this to DELG when it is complete). eDNA is a relatively new technology and results are, on their own, not conclusive but combined with physical sampling (angling, electrofishing, netting) increase the likelihood of SMB detection.

Aggressive control efforts by the Working Group, DFO, and province of New Brunswick since the discovery of SMB in the river have been employed to reduce numbers, thus reducing propagule pressure, and the likelihood of further spread until eradication can take place. Efforts have included seining, gillnetting, angling, backpack electrofishing, and boat electrofishing. The most effective methods have been boat electrofishing, followed by angling. Table 4 provides a summary of SMB catches during control efforts in 2019 and 2020 in Lake Brook and the SW Miramichi River. Other than the one SMB observed at Tent Pool just below the mouth of McKiel Brook, and despite intensive angling, snorkelling, and backpack electrofishing throughout the river treatment area (i.e., Ice Bridge downriver to Moose Call), all SMB observed and captured have been at one location: Mckiel Pond Pool.

Table 4. Smallmouth Bass (SMB) captures in Lake Brook and the SW Miramichi River (i.e., below the containment barrier at the outlet of Miramichi Lake) since their discovery in the river on 22 August 2019.

# SMB Captured	Method	Location	Timeframe
14	Backpack Electrofishing	Lake Brook	Fall 2019
22	Angling	McKiel Pond Pool	Fall 2019
3	Angling	McKiel Pond Pool	Summer 2020
77	Boat Electrofishing	McKiel Pond Pool	Summer 2020

Non-Target Species

Based on a DFO survey from 2010, there are a total of 18 known fish species, including SMB, present in Miramichi Lake (DFO 2013). Table 5 identifies 17 native, and 1 non-native (SMB) species found in Miramichi Lake and Lake Brook. DFO (2013) used a combination of sampling techniques during their efforts to capture SMB and recorded a diverse ichthyofauna with most numerous species being yellow perch, white sucker and white perch. Capture efforts took place between April and October and included methods such as boat electrofishing, setting gillnets and fyke nets. Most of the species captured were year-round residents of the lake. Nonetheless, several diadromous species were recorded and included American eel, sea lamprey, Atlantic salmon, and alewife. Most notable of these records would be the alewife; large spawning runs (tens of thousands of fish) are known to enter Miramichi Lake each spring with significant numbers of YOY leaving in July and August (DFO 2009, DFO 2013).

Table 5. Fish species[1] found in Miramichi Lake and Lake Brook in 2009-2012 using gillnet, seine, electrofisher, and fyke net (van den Heuvel et al. 2017; O'Donnell and Reid 2009; DFO 2013).

Species	Miramichi Lake	Lake Brook
alewife *Alosa sp.*	X	X
American eel *Anguilla rostrata*	X	X
Atlantic salmon *Salmo salar*	X	X
banded killifish *Fundulus diaphanous*	X	
blacknose dace *Rhinichthys atratulus*		X
brook trout *Salvelinus namaycush*	X	X
brown bullhead *Ameiurus nebulosus*	X	X
common shiner *Luxilus cornutus*	X	X
creek chub *Scardinius atromaculuatus*	X	X
fallfish *Semotilus corporalis*	X	X
golden shiner *Notemigonus crysoleucas*	X	X
lake chub *Couesius plumbeus*	X	X
pearl dace *Margariscus margarita*	X	
sea lamprey *Petromyzon marinus*	X	X
smallmouth bass *Micropterus dolomieu*	X	X
white perch *Morone Americana*	X	
white sucker *Catostomus commersoni*	X	X
yellow perch *Perca flavescens*	X	X

[1] "Mummichug", presumably mummichog (*Fundulus heteroclitus*) were recorded in the O'Donnell and Reid (2009) report, however killifish are often misidentified as mummichog and it is improbable that mummichog are present here, so that identification is not considered valid (van den Heuvel et al. 2017).

b) Cultural Features:

List all federally, provincially, or locally recognized recreational sites or features, tourism features or attractions, tourism operations, cultural activities, hunting, fishing, gathering, traditional uses by First Nations, etc. on the subject property or adjacent lands.

List all federally, provincially, or locally recognized heritage and/or built heritage resources/areas (e.g., historic sites, historic buildings or structures, national or provincial parks, fossil site, archaeological sites, etc.) in relation to the proposed undertaking and adjacent lands.

There is a significant cultural feature at risk if no action is taken to eradicate SMB: the native ecosystem of the Miramichi and particularly wild Atlantic salmon. Federally, provincially, and locally recognized Indigenous, recreational, tourism, economic, and cultural activities centre around wild Atlantic salmon on the Miramichi River system. Non-native SMB invasion threatens the integrity of the native ecosystem and associated socio-economic benefits derived from that ecosystem. Atlantic salmon supports First Nations' Food, Social, and Ceremonial fisheries that are thousands of years old. Salmon also support a recreational fishery valued at $16 Million annually to the provincial GDP and providing 637 full time equivalent jobs in rural communities in the river valley (Gardner Pinfold 2011).

The Atlantic salmon recreational fishery on the Miramichi is renowned and attracts tourism visitors from across Canada and around the world. The establishment of smallmouth bass risks impacting the ability of the population to recover and thrive in the future.

Please also see the following section "Existing and Historic Land Uses" for characterization of recreational and cultural aspects of the project area. To our knowledge, there are no federally, provincially, or locally built heritage sites or structures in the area, either within the project area or on adjacent lands.

c) Existing and Historic Land Uses:

Historic Uses
The project area is located in a remote area of west-central New Brunswick (Figure 1). This region of the Miramichi watershed has historically been used for millennia by Wolastoqey and Mi'kmaq Indigenous peoples to hunt, fish, and travel.

Existing Uses
Land and water in the vicinity of the project area and downriver on the Miramichi river system continues to be used by Indigenous peoples to hunt and fish, and it is these native ecosystems that the project aims to protect from an invasive species so that historic uses can continue into the future. The land surrounding the project area is mainly forested and primarily managed for industrial forestry. There is no agricultural land in the vicinity and neither the lake nor any of the treated waters are used to irrigate crops. There is recreational use of Miramichi Lake with family cottages on the eastern shore of the lake, and there is recreational Atlantic salmon and Brook Trout fishing within the project area primarily on the SW Miramichi River. There is no known or suspected contamination resulting from any previous uses in the project area or adjacent properties. Land ownership adjacent to the project area is identified with PID numbers in Figure 3. The following provides a breakdown of uses in various sections of the project area:

> **Miramichi Lake –** Miramichi Lake has 16 cottages along the east side of the lake. The majority of land surrounding the lake is comprised of crown land (province of NB) and industrial freehold forestry land (J.D. Irving, Limited). Cottage owners use the lake for swimming throughout the summer months and there is occasional recreational fishing activity but the lake does not support any well known or popular fishery for the general public. It is not a fishing destination or typically used by anyone other than the cottagers. The recreational fishing season closes on September 15

each year on the Lake and Lake Brook. There are no campgrounds or hiking trails around the lake, thus the area is not normally used by the public for these activities.

Lake Brook – Lake Brook is very remote and is inaccessible by road. Due to its remoteness, it is not normally used for any recreational activity. The sole landowner along both sides of the brook is J.D. Irving, Limited (see landowner letter in Appendix A).

SW Miramichi River – The proposed treatment reach of the SW Miramichi River is remote, and land access is restricted by controlled gate. There are no public access points via land to this stretch of the river. The sole landowner along both sides of the river is J.D. Irving, Limited (see landowner letter in Appendix A). There are occasional canoers that paddle through this reach of river, but not typically in the low water conditions in late summer and early fall when we propose to treat. Signage will notify canoers at the two canoe launch points upriver of the treatment area and at the upstream extent of the treatment area, as well as personnel there operating the drip station that will be able to notify any potential canoers. The Atlantic salmon recreational angling season closes on the river on October 15. There is 1 camp on the treatment reach at the mouth of McKiel Brook, and 1 camp at the deactivation location at camp Moose Call (see Figure 2). Both are salmon fishing camps that lease the land from J.D. Irving, Limited.

4.0 IDENTIFICATION OF ENVIRONMENTAL IMPACTS

Surface Water, Riparian Areas, Fish Habitat
The treatment will not impact riparian areas; it will impact surface water only within the treatment area and deactivation zone (Figure 2). Rotenone naturally breaks down rapidly through hydrolysis (reactions with water) and photolysis (exposure to light) and at the design concentration for this treatment has a half life of 2.5 days and will be undetectable after 18 days in the lake. Rotenone will be deactivated with potassium permanganate at the downstream extent of the treatment area in the SW Miramichi River to prevent downstream impacts outside the project area. See deactivation details in Section 2.0 – Project Description (construction and operation), and in the Monitoring Plan in Appendix C.

Groundwater
Rotenone does not travel more than a few centimetres into soil and is not known as a groundwater contaminant (e.g., Finlayson et al. 2001, Finlayson et al. 2014, Hisata 2002). The ability of rotenone to move through soil is low to slight; it moves only 2 cm in most types of soil. An exception would be in sandy soils, where movement is about 8 cm. Rotenone binds strongly with organic materials in the soil and degrades rapidly. Twenty six wells adjacent to the nine California treatments have been monitored since 1987 for the presence of rotenone formulation constituents (Finlayson et al. 2001). Samples were collected between 1 and 456 days following treatments. All samples during the long-term study tested negative. No residues of rotenone or rotenolone were found in any of the wells monitored. None of the other VOC or semiVOC constituents in formulations have been detected in any of the wells monitored. Additionally, four shallow wells adjacent to Diamond Lake, Oregon that was treated in 2006 had no rotenone and rotenolone residues present up to 39 days post-treatment (Finlayson et al. 2014).

Air Quality

On the lake and river, there will be no rotenone in the air during or after the application due to its low vapor pressure (6 x 10^{-6} Pa) (Huntingdon Life Sciences 2007) and Henry's Law constant (estimated 1.1 x 10^{-13} atm-m^3/mol) (Finlayson et al. 2018). The lack of rotenone in the air following a ground-based spray application of CFT Legumine was documented in an air monitoring study done in California in 2007 (Westervelt 2007). There may be a slight solvent or chemical smell around the lake during the two days of the application of Noxfish II.

On Lake Brook, should aerial application be used, we do not expect any alteration of air quality. The restrictions for aerial applications on the Noxfish II PMRA label (Appendix E) will limit and control spray drift using good practices as outlined in the National Aerial Pesticide Application Manual, and as such, the application is not anticipated to result in the emission of contaminants into the atmosphere that would exceed local, regional or national objectives or standards. Noxfish II will only be applied when meteorological conditions at the treatment site allow for complete and even coverage, and the drifting of spray onto land or other non-target areas is avoided using a combination of pressure and nozzle type that prevent fine particles or mist.

Effects on Fish, Amphibians, Invertebrates, Birds, Reptiles, Plants, Mammals, Humans

Fish – Atlantic salmon and Brook Trout in the project area will be killed during the SMB eradication treatment as these salmonids (24 h LC50 values = 0.0018 and 0.0024 mg/L rotenone) are twice as sensitive to rotenone as SMB (24 h LC50 value = 0.0047 mg/L rotenone) based on published toxicity values (Marking and Bills 1976). Natural recolonization of the treatment area is expected because these species are migratory and the treatment area is open ended at both the upstream and downstream extents. Mitigation measures are explained below in section 5.0 – Mitigation.

Miramichi Lake is an important spawning area for alewife. A rotenone treatment in the fall would largely avoid impacting alewife, since adults spawn in the spring and then leave the lake by mid July. DFO (2009; 2013) reported that YOY alewives leave the lake in significant numbers in July and August, thus the treatment would avoid impacting both post-spawned adults and most or all juveniles.

Other native fishes inhabiting Miramichi Lake and Lake Brook include a variety of cyprinids, percids, killifish, and other species (Table 5; O'Donnell and Reid 2009; DFO 2013). If present during treatment most of these organisms will be killed, although some individuals of tolerant species including brown bullhead (*Ameiurus nebulosus*) and golden shiner (*Notemigonus crysoleucas*) are likely to survive a treatment of 0.075 mg/L rotenone based on published toxicity values (Marking and Bills 1976).

Amphibians – The sensitivity of amphibian eggs to rotenone is undetermined but is likely negligible and similar to fish eggs (rotenone is not able to cross the egg chorion). The larvae (tadpoles) of amphibians are much more sensitive than adults due to their respiration through the gills (Billman et al. 2011). Younger tadpole forms (early Gosner stages) are more sensitive to rotenone than older tadpoles (Billman et al. 2011). A treatment rate of 0.075 mg/L rotenone will be toxic to tadpoles. However, Billman et al. (2012) found no difference in tadpole abundance in rotenone-treated and control wetlands a year after rotenone treatment despite killing all of the tadpoles in the treated wetlands. This was due to the survival of non-gill-breathing juvenile and adult amphibians in the treated areas as well as immigration of amphibians from adjacent areas. Mitigation strategies to minimize impacts to amphibians include late summer/fall treatment timing, when gill-breathing amphibians are not generally present. Observations in British Columbia include increased amphibian production post rotenone treatments, as competition for food arising from illegally introduced spiny ray fish is eliminated (B.C. Ministry of Environment, 2009).

Plankton – With a treatment rate of 0.075 mg/L rotenone, impacts to zooplanktonic species are expected. However, the eggs which are laid all year, are resistant to rotenone, and lakes in the spring following a rotenone treatment show rapid plankton resurgence (Brynildson and Kempinger 1973). The impact of rotenone treatments and ecosystem recovery times depend on a variety of factors, from treatment concentration, to treatment scope (e.g., full watershed or only part of a watershed), distance to a recolonization source, whether or not there are successive rotenone treatments, environmental conditions such as water temperature, and which life stages are present at the time of treatment.

We use evidence from studies of other rotenone treatments to anticipate recovery timelines within our project area. Evidence from several studies (i.e., McGann 2018, Eilers 2008) found that both zooplankton and macroinvertebrate communities recover to provide an adequate food base for fish by the following spring post-treatment, and these communities typically recover to at least pre-treatment levels within 1 year. We use these studies to anticipate at a minimum that there will be a level of recovery in the lake by the following spring to provide a food base for fish. Our long-term ecological monitoring (full Monitoring Plan provided in Appendix C) will assess zooplankton recovery.

All of the studies we are aware of indicate that full recovery occurs within 1 week to 3 years (e.g., Kiser et al. 1963, McGann 2018 [assessed 7 treated lakes], Neves 1975, Anderson 1970). Vinson and Vinson (2007) provided a literature review of several studies documenting impacts to zooplankton and recovery times. The review found that assemblage recovery across multiple studies ranged from 1 month to 3 years, with most studies demonstrating full recovery in less than 1 year.

Rotenone at the dosage prescribed for treatment in Miramichi Lake is not toxic to phytoplankton, and no decrease in phytoplankton abundance is expected following the treatment. Conversely, there will likely be an increase in phytoplankton abundance post-treatment as nutrients from the decaying fish are released into the water column. Subsequently, an increase in zooplankton abundance is expected to occur when rotenone subsides to nonlethal levels (Bradbury 1986; Eilers et al. 2011).

Macroinvertebrates – Macroinvertebrate assemblages are usually reported to be much less impacted than planktonic species, especially Chironomids. Hobbs et al. (2006) conducted toxicity tests on various macroinvertebrate species. They reported LC50 values ranging from <0.003 mg/L rotenone for the cladocerans *Daphnia magna* and *Ceriodaphnia dubia* to about 0.200 mg/L rotenone for the midge *Chironomus tentans* and the amphipod *Hyalella azteca*. Results from studies on multiple lakes (e.g., Eilers 2008, McGann 2018) demonstrated that both plankton and macroinvertebrate communities recovered to pre-treatment levels (or greater) within 1-year post-treatment. Using the existing research, we anticipate there will be a food base adequate for fish recolonization in the treatment area by the next spring after treatment.

Similar to zooplankton, there are a variety of factors that influence the impact of a rotenone treatment on macroinvertebrates. It is important to note that our proposed treatment concentration is 0.075 mg/L (ppm) rotenone, whereas many treatments reviewed for their impact to invertebrates used a significantly greater concentration, up to 0.015 ppm rotenone. Whelen (2002), who treated a stream in Utah at 0.075 ppm rotenone for 12 to 18 hours two consecutive years, saw macroinvertebrate diversity indices return to pre-treatment levels within 3 years post-treatment; he noted that not treating upstream areas uninhabited by the target species allowed for a source of invertebrates for recolonization of treated areas through downstream drift. Many of the older treatments used concentrations higher than required and treated most or all habitat adjacent to the invasive species known distribution, and therefore had a greater impact on the invertebrate community.

In addition to a literature review on zooplankton recovery, Vinson and Vinson (2007) provides a review of several studies that monitored macroinvertebrate recovery. The study notes that aquatic invertebrates have a wide range of sensitivity to rotenone, ranging from 96hr LC50 values of 0.002 to 100 ppm. Vinson et al. (2010) notes that recent work suggests that impacts to invertebrate assemblages can be reduced and mortality to target fish species maintained at lower concentrations that have generally been used in the past (Finlayson et al. 2010). To reduce impacts and enhance recolonization, Vinson et al. (2010) recommended that headwater and tributary fishless stream reaches should not be treated so they can serve as refuges for invertebrates and rotenone should be deactivated downstream of the project area to protect downstream colonization sources.

A more recent study of the recovery of Diamond Lake, Oregon, by Eilers (2008) demonstrates that macroinvertebrate biomass not only recovers to pre-treatment levels within 1 year post-treatment, but far exceeds pre-treatment levels (17 lbs/acre to 200 lbs/acre). Furthermore, the study found taxa that had not been present in the lake for years, or only rarely present, returned to the lake post-treatment.

These responses are due in part to removing an invasive species that had been having an impact on the native ecosystem, similar to what was experienced in British Columbia (Steve Maricle, Pers. Comm.). The control efforts on Miramichi Lake have kept smallmouth bass abundance low and therefore we do not expect that they have had an impact on the invertebrate population like in these examples; however, they have now escaped into the river and have begun colonizing the watershed. If not eradicated, they will establish throughout the watershed, bringing significant impacts to the native ecosystem including aquatic invertebrates and certainly fish species.

An important consideration in assessing the timeline for recovery in aquatic invertebrates is proximity to a recolonization source (Vinson and Vinson 2007). Given that we propose to treat only a small portion of the Miramichi watershed and that the treatment area is open ended in both the downstream and upstream directions, there will be immediate opportunities for invertebrate recolonization of treated areas once rotenone levels subside to habitable conditions several days post-treatment.

Kjaerstadt et al. (2015) provides another example of macroinvertebrate recovery assessment. The study investigated recovery after 3 successive rotenone treatments and found that temperature and concentration were major drivers of the impact to macroinvertebrates. The first 2 treatments caused only temporary impact to a few sensitive taxa, while the 3rd treatment used a much higher concentration of rotenone and had the greatest impact. Densities had not returned to pre-treatment levels 8 months post-treatment, but most taxa had recolonized the treatment areas within 1 year.

Recovery times will vary between taxa, and the composition may not be exactly as it was pre-treatment; however, the data from other treatments demonstrate that we can reasonably expect an overall macroinvertebrate community recovery within several months to 3 years. We consider this to be an acceptable short-term impact that is outweighed by the long-term ecological benefit to the entire Miramichi river system by preventing the establishment of invasive smallmouth bass. Furthermore, our 5-year long-term Monitoring Plan (Appendix C) will assess the invertebrate recovery and provide a valuable contribution to the growing body of knowledge on ecosystem recovery after a rotenone treatment.

Freshwater Mussels – There are a number of freshwater mussel species in the Miramichi basin but significant toxic effects from rotenone are not expected since the proposed treatment levels are below known toxicity values. Dolmen et al (1995) studied the impacts of rotenone on the Eastern Pearlshell (*Margaritifera margaritifera*) which is the most abundant freshwater mussel species in the Miramichi River watershed. Studies in both the laboratory and field showed that no mortality to the mussels occurred when exposed to 5 mg/L rotenone formulation (1.5 mg/L rotenone formulation is proposed for the Miramichi treatment) for up to 12 hours exposure and then monitored in clean water for up to 7 days (laboratory) or 55 days (field). Six freshwater mollusk species were tested for rotenone sensitivity by Chandler and Marking (1982); the snail *Oxytrema catenaria* was the most sensitive (96-h LC50 value = 0.090 mg/L) and the clam *Corbicula manilensis* was the least sensitive (96-h LC50 value = 0.380 mg/L) to rotenone.

Birds & Reptiles – The risk to reptiles and birds is low to negligible for the following reasons:

- Limited potential for exposure to rotenone
- The United States Environmental Protection Agency (USEPA 2006; 2007) uses the sensitivity of birds as a surrogate for reptiles, and rotenone is practically non-toxic to birds because of rapid natural break down and piscivorous birds or mammals are not able to consume sufficient quantities of rotenone to result in acute toxicity.
- Whole body residues of fish killed with rotenone range from 0.22 µg/g in Yellow Perch (*Perca flavescens*) to 1.08 µg/g in Common Carp (*Cyprinus carpio*) (Jarvinen and Ankley 1998). For a 68 g Yellow Perch, this represents a total of 15 µg/fish of rotenone and for an 88 g carp, it represents 95 µg/fish. In order to reach the avian subacute dietary LC50 of 4,110 mg/kg (Hill et al. 1975), a 1000-g bird would have to minimally consume 274,000 perch or 43,000 carp. Similarly, to achieve a lethal dose of rotenone at the prescribed rate of 75 ppb, birds would have to ingest 54,800 liters of water at that rate.
- Studies have been conducted on common musk turtles and soft shelled turtles (McCoid and Bettoli 1996) which found negative effects from rotenone when used at 3mg/l of 5% concentration or greater. The proposed treatment level for Miramichi Lake is half that concentration.
- In British Columbia, painted turtles have been present in several treated lakes. Some have been held captive within active rotenone treatment areas and observed for a period of time post treatment with no mortality or negative effects observed (Steve Maricle *personal communication, Province of BC*).

Plants – The treatment will not impact plants.

Mammals – The US Environmental Protection Agency (USEPA 2007) concluded that the use of rotenone for fisheries management does not threaten mammals and birds. The potential was estimated by the USEPA using the estimate of Nagy (1987) for mammal food consumption and using an adjusted LD50 value (Mineau et al. 1996) based on the weight difference between the assessed mammal versus the test mammal exposed to rotenone. If fish were available for consumption along the shoreline, mammals would not be able to consume sufficient quantities of rotenone to result in acute toxicity. Further, rotenone continues to degrade in the environment due to a number of biological and physical mechanisms whether in water or fish flesh and has a low propensity to bioaccumulate hence, the risk to humans from consuming mammals that have fed on fish carcasses is negligible**.** The same holds true for birds.

Humans – Noxfish Fish Toxicant II is registered for use in Canada under PMRA Reg. No. 33247 by Health Canada and in the USA as Prenfish under EPA Reg. No. 89459-45 by the U.S. Environmental Protection Agency. The registrations follow government scientist reviews of rigorous standardized testing results to ensure there are no unreasonable risks to public health or the environment when used according to label directions.

Health Canada recently conducted a review of a 2020 health assessment by the United States Environmental Protection Agency (USEPA 2020) which found no association or causal relationship between rotenone exposure and any health effects in human populations. The EPA based their conclusion on a review of epidemiology studies. Similarly, a Washington State Fish and Wildlife Department comprehensive review concluded that there was no overall risk to human health and that approved rotenone formulations are a safe product when used according to the label instructions (Hisata 2002). All components of a registered end-use product (i.e., rotenone and all other formulation ingredients in Noxfish II) are reviewed by Health Canada scientists for potential environmental and health effects. Only formulations that have been determined to be effective and safe are registered for use.

The application rate for this project is 0.075 mg/L and is below the USEPA (2007) level deemed safe for public contact with water (i.e., swimming) at ≤ 0.090 mg/L rotenone. Furthermore, given the expected half-life (2.5 d) of rotenone in Miramichi Lake during the proposed treatment scenario based on data from Finlayson et al. (2001) and Finlayson et al. (2014), the initial 0.075 mg/L rotenone is expected to degrade to 0.0375 mg/L rotenone in 2.5 d, a level below the suggested safe drinking water level of 0.040 mg/L rotenone proposed by the USEPA (2007).

While the treatment rate for the Miramichi eradication is below what the USEPA deems safe for human contact, the product label requires that the public be prohibited from contact with treated water during application and for a 3-day re-entry period afterwards. Rotenone levels are expected to be ≈ 0.020 mg/L after the waiting period, well below the 0.090 mg/L deemed safe for human contact and the 0.040 mg/L safe drinking water level by USEPA (2007). A certified pesticide applicator team will conduct the treatment according to the product label and standard operating procedures (Finlayson et al. 2018) as described in the treatment operation description above.

Effects on the Use of Fish

A successful eradication will remove SMB from the Miramichi watershed and will result in a positive long-term benefit to fisheries for native species like Atlantic salmon and Brook Trout in the watershed. Furthermore, a successful eradication will mean that control efforts in Miramichi Lake (barrier, electrofishing, netting, etc.) will no longer be required; these activities currently impact native fish species.

As required on the rotenone product labels, aquatic recreation (angling, wading, swimming, boating) and access to the treated waters will be restricted for the duration of the 2-day treatment and for an additional 72 h period after the treatment is completed. The Brook Trout angling season closes on September 15 annually.

The use of Atlantic salmon will be minimally impacted by the treatment. There is no Atlantic salmon fishery in Lake Brook or Miramichi Lake. Given that the 43.1 km^2 Miramichi Lake sub-watershed represents only 0.3% of the greater Miramichi watershed (13,500 km^2), and contains primarily lacustrine aquatic habitat, there are no anticipated effects on Atlantic salmon fishing during the treatment period in this portion of the treatment area. In the river, recreational angling for salmon is open until October 15; however, the treatment reach is remote, with only one camp located on the treatment stretch, one camp at the deactivation site. Access to the project area is restricted by the J.D. Irving private gate at Deersdale. Due to low angling effort in this reach of river, temporary access restrictions during treatment and for a 3-day period post-treatment are expected to have negligible impacts on angling activity. Rapid natural breakdown of rotenone (half life of 2.5 days, undetectable after 18 days in the lake at the design concentration) and directed deactivation of rotenone in the river will prevent impacts to Atlantic salmon and other species outside the project area (i.e., downstream in the SW Miramichi River).

Late summer/early fall treatment timing will minimize or avoid impacting alewife and its associated use in the spring commercial fishery 170 km downriver in the estuary. Post-spawned adults leave the lake in July and young-of-the-year emigrate from the lake heading downstream primarily in July and August. There are no, or negligible, anticipated effects on the use of alewife.

The primary benefit of the eradication is the prevention of invasive species establishment in the Miramichi watershed, and thus preservation of the ecosystem and its native species that support Indigenous, recreational, and commercial uses of fish.

Species at Risk

There are several species at risk either known to be present or suspected within the project area that will or may be impacted by the treatment (Table 6).

Table 6. Species at Risk impacted and potentially impacted within the project area.

Species	**SARA Status**
Brook Floater mussel	Special Concern
Atlantic salmon	Special Concern
American Eel	Threatened
Wood Turtle	Special Concern

Brook Floater – Anqotum conducted a mussel survey in Miramichi Lake in September 2019 (Appendix J) and identified brook floater mussels. There are a number of freshwater mussel species in the greater Miramichi basin but toxic effects are not expected since the proposed rotenone levels are below known toxicity values for freshwater mussels (see section below on toxicity). The eradication of invasive SMB eliminates a threat to brook floater and is in-keeping with the broad strategies for addressing threats outlined in the DFO's Species at Risk Management Plan for brook floater (DFO 2018). Invasive species such as SMB pose a threat to the brook floater primarily through impacts to its host fish species. A persisting SMB population in Miramichi Lake and the risk of its spread further in the Southwest Miramichi River poses a threat to known assemblages of Brook Floater downriver. The SMB eradication will contribute to the long-term protection of the Brook Floater in the Miramichi watershed.

American Eel – The American eel is panmictic, meaning adults from many rivers in eastern North America breed together in the Sargasso Sea, eggs hatch at sea and juveniles return randomly back to rivers on the eastern seaboard. The primary reason for designation under the Species At Risk Act (SARA) in Canada is due to declines in the Great Lakes region and the upper St-Lawrence River. Abundance trends in New Brunswick based on available data from the Miramichi and Restigouche river systems have been variable but generally increasing since the 1980s (COSEWIC 2012). The treatment is expected to have lethal impacts on American eels limited temporally and spatially to within the project area during treatment. Long-term benefits from the eradication are expected for all native species, including American eel, by maintaining the integrity of the native ecosystem throughout the Miramichi watershed.

Wood Turtle – Wood turtle presence has not been documented within the project area, although it is suspected based on likely habitat. The risk to this species if present is low to negligible for the following reasons:

- Limited potential for exposure to rotenone: the species nests on land and is omnivorous, largely feeding on terrestrial organisms which are not exposed to rotenone
- The United States Environmental Protection Agency (USEPA 2006; 2007) uses the sensitivity of birds as a surrogate for reptiles, and rotenone is practically non-toxic to birds because of rapid natural break down. Piscivorous birds and mammals are not able to consume sufficient quantities of rotenone in fish to result in acute toxicity
- Studies have been conducted on common musk turtles and soft shelled turtles (McCoid and Bettoli 1996) which found negative effects from rotenone when used at 3mg/l of 5% concentration or greater. The proposed treatment level for Miramichi Lake is half that concentration.
- In British Columbia, painted turtles have been present in several treated lakes. Some have been held captive within active rotenone treatment areas and observed for a period of time post treatment with no mortality or negative effects observed (Steve Maricle *personal communication, Province of BC*).

Atlantic salmon – Atlantic salmon are present primarily in the Lake Brook and the SW Miramichi portions of the treatment area. Based on extensive netting and electrofishing activities by DFO in Miramichi Lake since 2008, Atlantic salmon are not typically found in the lake. There will be lethal impacts to Atlantic salmon in the treatment reach, primarily in Lake Brook and the 15 km reach of the SW Miramichi River. These will be mitigated by installing a fish migration barrier downstream of the project area to prevent upstream migration prior to and during treatment, and by conducting an adult salmon fish rescue prior to treatment (see full description below in Section 5.0 – Mitigation). A primary purpose of eradicating SMB is to prevent long-term impacts to salmon such as competition and predation.

DFO and DNR have coordinated reviews of potential impacts to species at risk by DNR's Species at Risk group and the New Brunswick Museum. To date they have concluded that the long-term threat of SMB establishment to the native ecosystem and species at risk outweighs the temporary and spatially limited impacts of treatment in a small portion of the Miramichi watershed. Impacts of a rotenone treatment will not be at the landscape or population levels, and the two species at risk that will be most impacted – Atlantic salmon and American eel – are migratory species that are expected to recolonize the project area in the subsequent migratory period.

Persistence in the environment

A treatment of rotenone to Miramichi Lake in August is expected to result in a half life of 2.5 days and the initial concentration of 0.075 mg/L rotenone is expected to break down to undetectable levels after 18 days (<0.002 mg/L). Treatment timing during a period when water temperature will be >10°C is an important consideration for rapid natural breakdown in the lake. Based on temperature monitoring in Miramichi Lake (Figure 12), water temperature at the proposed treatment time in mid August is expected to be 18-24°C and in mid September 15-18°C. Water temperatures in Lake Brook and in the SW Miramichi are expected to be similar. Rotenone will be deactivated in the SW Miramichi River at the downstream extent of the treatment area (Figure 2) and thus will not persist in the downstream riverine environment. Monitoring of rotenone levels and acute toxicity will be conducted throughout the application and post-treatment period (see stand-alone Monitoring Plan in Appendix C).

Toxicity monitoring is best conducted as in the Despres Lake, New Brunswick, application (Connell et al. 2002) using caged sentinel Brook Trout to assess toxicity for 24 h periods (see Monitoring plan in Appendix C). Bioassays will be conducted in the lake, Lake Brook and the river until such time as trout can survive for 24 h. As bioassay results can be assessed immediately, these provide the best indication of when water conditions have returned to being habitable by fish. If all sentinel fish locations show 24 h bioassay results with mortality equal to or less than pre-application bioassays, the project area will be deemed safe again for fish.

Rotenone concentrations in water are also monitored through laboratory analysis. The stand-alone Monitoring Plan in Appendix C provides further detail on this component of the monitoring.

Bioaccumulation in the environment

Rotenone has low to moderate mobility in soil and sediment (K_d = 3.6-194) (Dawson et al. 1991), and does not penetrate further than 2 cm into sediments, or 8 cm in sandy substrate as it binds strongly with organic materials in the soil and degrades rapidly (Finlayson et al. 2018). It has a relatively low potential for bioconcentrating in aquatic organisms (BCF < 30) (Gingerich and Rach 1985), and is not persistent in the environment due to rapid hydrolysis (Thomas 1983) and photolysis (Draper 2002) with half-lives measured in days and hours, respectively. A review of monitoring data collected over >30 years is consistent with these laboratory findings (Finlayson et al. 2018). Hence, rotenone will not persist in the environment for more than several weeks nor bioaccumulate in the environment.

Impacts to the environment under the “do nothing” approach

In assessing impacts to the environment, we must also consider what the impacts would be by taking no action to eradicate SMB. The “do nothing” approach will result in a negative impact to the environment. By not taking eradication action against invasive SMB, colonization and establishment in the Southwest Miramichi River will have negative effects on native fish species, such as the Atlantic salmon. Native species would suffer effects of predation and competition for habitat and resources, and overall food web disruption. Furthermore, continuing on with the current DFO control and containment program at Miramichi Lake impacts native species negatively through disruptions to migration patterns and netting activities.

DFO (2009) put forth a risk assessment concluding that the risk of negative consequences from SMB was high in the lake and moderate in the river. Chaput and Caissie (2010) considered the impacts to Atlantic salmon were different between lake and river environments: the overall risk to the aquatic biota in lakes is considered to be high with low uncertainty; and the overall risk for riverine environments is considered to be moderate but with high uncertainty. For lakes, the SMB will likely become a dominant component of the food web while causing significant widespread reductions in native biota. For riverine environments, a measurable decrease in abundance of native populations may occur in some locations where SMB have become a dominant component of the food web. These fish are known to alter community structures by decreasing abundances and diversity of native fish species (i.e. cyprinids, perch)

(Kerr and Grant 1999, MacRae and Jackson 2001), triggering resource competition and restricting habitat usage (MacRae and Jackson 2001, Morbey et al. 2007).

A major threat within the Miramichi River system is the inevitable SMB dispersal and colonization throughout the rivers, streams, and lakes in the watershed resulting in habitat overlap and predation on native species like Brook Trout and Atlantic salmon. Juveniles of both Atlantic salmon and SMB prefer similar riverine habitat features, resulting in direct competition (DFO 2009). SMB are also predators of juvenile Atlantic salmon (Carr and Whoriskey 2009). There is concern that SMB will also negatively impact alewife by disrupting the food web in Miramichi Lake, an important spawning/rearing area for commercially and ecologically valuable alewife in the Southwest Miramichi River system.

Anticipated impacts characterized in terms of compliance with relevant legislation, policies, guidelines and standards. Will the proposed undertaking:

a) **Result in the net loss of wetland functions or the net loss of Provincially Significant Wetland? (contrary to *New Brunswick's Wetlands Conservation Policy*),**
No

b) **Result in an Activity in Zone A or B as defined in *A Coastal Areas Protection Policy for New Brunswick* that is not listed as an acceptable activity?**
No

c) **Result in the deposit of a deleterious substance harmful to fish or migratory birds? (prohibited by federal legislation),**
No (Noxfish Fish Toxicant II is federally approved for use in Canada by PMRA under Health Canada)

d) **Emit effluent in excess of relevant provincial or federal legislation, policies, guidelines or standards?**
No

e) **Result in the loss of individuals of a threatened or endangered species listed by the federal Species at Risk Act (SARA), Committee on the Status of Endangered Wildlife in Canada (COSEWIC), or the New Brunswick *Species at Risk Act*, or damage or destruction of an individual residence or critical habitat?**
Yes, see Species At Risk section above, and associated mitigation measures.

f) **Compromise the conservation of a species of special concern listed by SARA or COSEWIC, listed as 'sensitive' or 'may be at risk' by ERD, or listed as S1, S2 or S3 by the Atlantic Canada Conservation Data Centre (ACCDC)?**
No

g) **Have the potential to impact migratory birds, thereby requiring appropriate pre-construction surveys to take place (if not, provide a justification of why not, which could include, but not necessarily be limited to, the location of the project and/or the timing of project activities)? or**
The Canadian Wildlife Service (CWS) was consulted by DFO through the AIS regulatory process and CWS deemed the eradication project would have no or negligible impacts to migratory birds; no surveys or permits are required by CWS (see Table 3).

h) Result in the emission of contaminants into the atmosphere that would result in an exceedance of local, regional or national objectives or standards?
No

5.0 SUMMARY OF PROPOSED MITIGATION

Describe the measures that will be used to reduce or eliminate the environmental impacts identified in the previous section. A wide variety of measures can be employed depending on the type of undertaking and its physical setting. Mitigation measures should be considered as a hierarchy in which primary attention and priority is given to opportunities to avoid impacts. When these opportunities have been exhausted or it has been demonstrated that they are not feasible, then measures aimed at reducing impacts can be considered. Finally consideration can be given to measures that compensate for significant unavoidable impacts.

a) **Impact Avoidance**
b) **Impact Reduction**

Impact avoidance and impact reduction details are provided in the following project mitigation and monitoring plans:

Mitigation

1) **Treatment Timing –** Several factors must be considered with regards to application timing to ensure the highest probability of success, as well as to limit impacts on non-target species, and ensure rapid breakdown of rotenone. Mid August to the late September is the optimal timing window for various reasons:
    - Waters in the treatment area are anticipated to be >10^{o}C based on temperature monitoring, ensuring effective toxicity to SMB
    - SMB eggs will not be present as spawning is finished in July and egg incubation time is 2-9 days
    - Rotenone half-life and duration of acute levels is shorter at higher temperatures (i.e., >10^{o}C)
    - Deactivation with potassium permanganate is most effective at warmer temperatures (>10^{o}C)
    - Late season treatment mitigates/minimizes impacts to zooplankton, which lay resting eggs throughout the growing season that are resistant to a rotenone treatment
    - A rotenone treatment in late summer/early fall would avoid/minimize impacting alewife, since adults spawn in the spring and then emigrate from the lake. DFO (2009; 2013) reported that young-of-the-year alewife leave the lake in significant numbers in July and August, thus the treatment timing minimizes impacting both post-spawned adults and most or all juveniles.
    - August and September typically have low flow conditions, minimizing the quantity of Noxfish II required to achieve the design concentration (treatment rate).

2) **Deactivation –** Rotenone deactivation at the downstream extent of the treatment area (Figure 2) is a primary means of mitigation by preventing downstream impacts outside of the project area in the SW Miramichi River. The deactivation process is described in detail above in Section 2.0 – Project Description, and in the Monitoring Plan in Appendix C.

3) **Re-establishment Strategy –** To re-establish native fish populations within the project area, we will take a proactive approach that combines allowing natural recolonization for migratory species and transplantation of non-migratory species into Miramichi Lake from nearby lakes in the Miramichi watershed depending on monitoring results. The fish Re-establishment Strategy is provided in detail as a stand-alone document in Appendix D. Other options were explored, including collecting fish from Miramichi Lake and holding in tanks during treatment until waters were deemed safe for re-introduction. This approach was reviewed by DFO (2018) and it is not a viable option. There are challenges in holding and feeding fish on-site and there will be low food abundance in the lake immediately after treatment. The current approach of allowing migratory species to recolonize naturally, and transplanting non-migratory species from nearby lakes based on monitoring results, was discussed in DFO's Aquatic Invasive Species regulatory process and agreed upon by our Working Group, DFO and DNR as the preferred approach for re-establishment.

4) **Dead Fish Collection** – Dead fish that remain floating in the lake or washed on shore after the rotenone treatment will be removed and buried in accordance with directives from the New Brunswick Department of Environment and Local Government (DELG). For example, similar to the Despres Lake, NB, rotenone eradication of chain pickerel carried out by DNR in 2001 (Connell et al. 2002). Remaining dead fish are not a risk to foraging wildlife and will contribute nutrients to the lake, helping to re-establish the food web; leaving dead fish to decompose is the typical practise after rotenone treatments (e.g. Hisata 2002; pers comm Steve Maricle). The collection of dead fish in Miramichi Lake and at the fish migration barrier on the SW Miramichi River at the downstream extent of the project area will take place for 1-week post-treatment, and longer if necessary. We will comply with all conditions of approval respecting fish disposal as required by the NB Department of Environment and Local Government, and will also work with the department to finalize which site is most appropriate. Two off-site candidate fish disposal sites have been identified:
   - **Site 1** is located on J.D. Irving, Limited freehold land in Deersdale (lat: 46.502080° lon: -67.030937°), approximately 13 km from Miramichi Lake
   - **Site 2** is located on crown land 1.2 km to the west of the public boat launch at Miramichi Lake at the end of a forest road (lat: 46.450966° lon: -66.976607°).

5) **Fish migration barrier on the SW Miramichi River** – A component of the mitigation plan is to install a fish migration barrier at Slate Island camp (see Figure 2) to temporarily prevent upstream migration of Atlantic salmon and other species into the treatment reach. The barrier will be installed in early August, 2021, prior to treatment and removed in late September or early October after the second treatment is carried out on Lake Brook and the river. The barrier will be a typical construction (similar to provincial salmon conservation barriers, counting fences, and to the barrier DFO uses at the outlet of Miramichi Lake), consisting of metal conduit driven into the river bed and supported by tripods at 3 m intervals across the width of the river. We will apply to DELG for the necessary WAWA permit for this activity.

6) **Fish Rescue** – An adult salmon rescue in the treatment reach of the SW Miramichi will be carried out prior to treatment. The rescue in the treatment area will consist of seining known holding pools to capture and relocate adult salmon to below the barrier at Slate Island where the salmon can safely hold in a cold water refuge. The barrier will be installed in mid August approximately 2 weeks prior to the first treatment, providing time for the fish rescue to occur. During this time of year, most of the adult salmon will be aggregating in cold water holding pools in the treatment area. The majority of adult salmon on the treatment reach are expected to be at the primary holding pool near the mouth of McKiel Brook that will be targeted for the fish rescue. Other suspected pools (Figure 13) in the reach will be snorkeled to investigate for salmon and will be seined based on what is observed and in consultation with DFO during the rescue process. Fish relocation will be via helicopter or by tank and truck depending on the remoteness of the location.

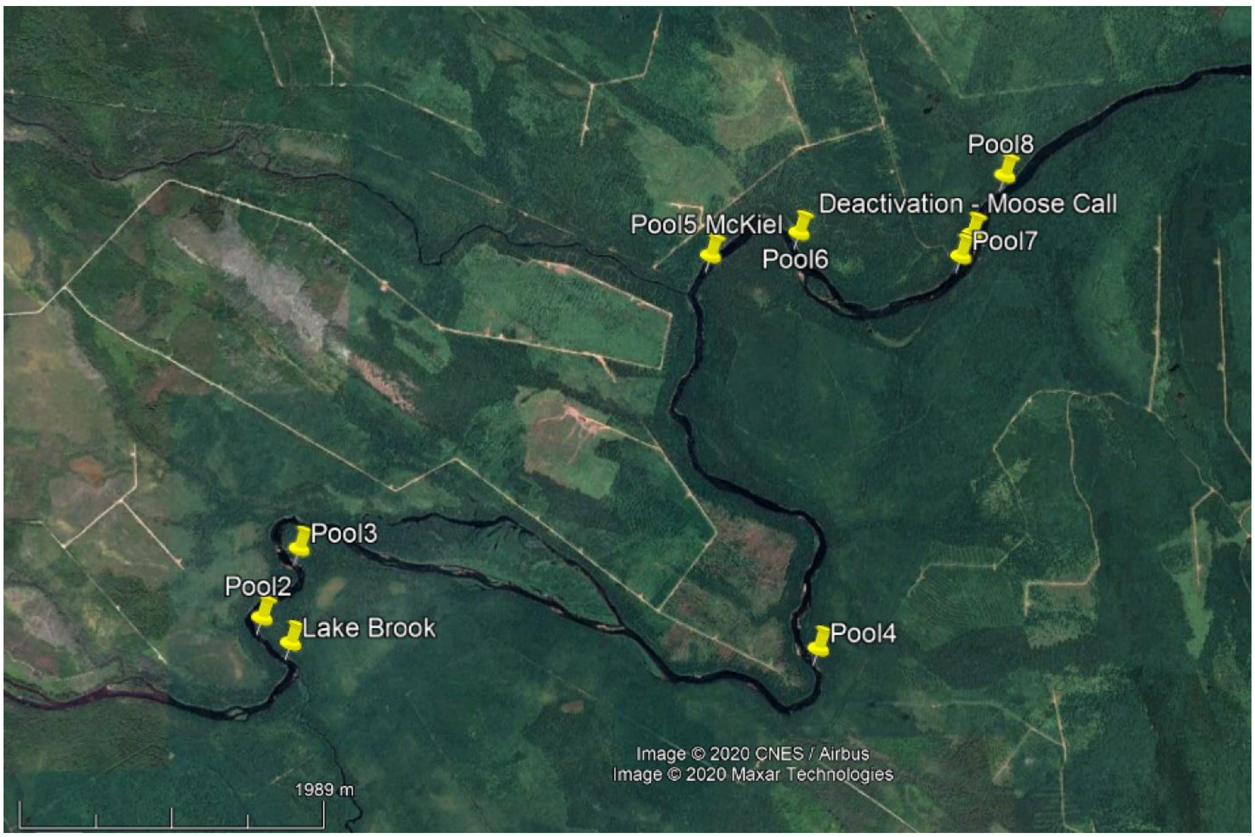


Figure 13. Potential salmon holding areas that will be investigated for salmon presence as part of the fish rescue prior to river treatment.

7) **Spill response plan (SOP 4.1, Finlayson et al. 2018)**
Spill Prevention – To minimize on-site spillage of Noxfish II, it will be stored within a plastic tarp-lined, bermed area adjacent to Miramichi Lake at the staging area (>30m from the lake and any watercourse or wetland) and at the river staging area in Deersdale secured behind controlled gates and not accessible to the public (Figure 4). Any material spilled on the tarp during opening or transferring of material will be rinsed off in the lake using lake water. All spills off-site must be

reported to the spill response unit and other units as appropriate. Small spills on-site may be contained and the collected material disposed of according to the product label. If these wastes cannot be disposed of by use according to label instructions, the New Brunswick Department of Environment and Local Government (DELG) will be contacted for guidance.

Spill Containment – The storage of Noxfish II at Miramichi Lake is at a location that is graded to allow drainage into the lake in case of an accidental spill. The 71 30-gallon containers of Noxfish II are placed on a plastic barrier >30m from the project water body. A small spill of rotenone is rinsed into the treated water.

The designated storage area on-site is a bermed, 7x10x0.5 m (35 m^3 or 9,246 gallon capacity) enclosure and large enough to contain all 71 (+10% contingency) 30-gallon drums (2,130 gallons +10% contingency). The existing cleared area near the public boat launch at Miramichi Lake is 12m x 24 m = 288 m^2, providing more than enough area required for staging and rotenone storage. Only one drum will be open on land at any one time for spraying and drip application around the lake and inlets. This will minimize spill risk and allow recovery of the material following a spill of a container. The drums used for the lake application will be transported from the staging area to the lake using a front-end loader (or hand-cart) and a hand-cart to transport material to the boats via the floating dock. The berm at the staging area is constructed of straw/hay bales and lined with heavy duty plastic fabric that is secured. A spill kit, shovels, buckets and additional personal protective equipment are maintained and readily available in the staging area, adjacent to the storage area, in case of a spill. The Certified Pesticide Applicator in charge of the treatment is responsible for all containers and equipment. Arrangements will be made to (1) provide a person responsible to maintain such control over the containers at all times or (2) store all such containers in a locked enclosure. Either shall be adequate to prevent unauthorized persons from gaining access to any of the material.

Spill Management – In the event that a spill occurs, it is important that the spilled material be contained. Shovels and other hand tools will be used for immediate containment or channelization of the spilled material into a containment area. In the event of a spill of Noxfish II in the storage area, an attempt will be made to recover and use the material in the application. If a ground spill occurs the following actions are taken. Any spill will be controlled at its source immediately and the spilled material will be diked into pools as appropriate. Recovery attempts will commence as soon as possible. Recovery methods include using absorbent materials such as clay or absorbent pads to absorb the liquid and rinsing the plastic tarp. Recovered material is incorporated into the treatment if possible.

8) **Pesticide Disposal –** There is no anticipated need for pesticide disposal as all pesticide delivered to the project site will be used in the treatment area, and the rotenone drums will be triple rinsed on site using water from Miramichi Lake. Following triple rinse cleaning, the empty drums will be made unsuitable for further use. The applicators will consult with the New Brunswick Department of Environment and Local Government for guidance in this matter and disposal of the clean drums.

9) **Public Safety & Application Hazard Mitigation –** Application procedures will comply with hazard protection measures for the applicator and the general public identified on the product label (Appendix E). The applicator is protected against exposure to rotenone through wearing personal protective equipment (PPE) as required on the PMRA Noxfish II label and by adhering to safety

procedures described in SOP 3.1 of the Rotenone SOP Manual (Finlayson et al. 2018). The applicator must wear chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-organic-vapor-removing cartridge with a pre-filter approved for pesticides or a NIOSH-approved canister approved for pesticides during mixing, loading, application, clean-up and repair. No PPE is required after the application is complete and the 72-hour waiting period has expired.

The public will be directed to keep away from the treatment area during application and for a 3-day period post-treatment as specified on the Noxfish II label. The application rate is 0.075 mg/L, and the USEPA (2007) recommends that safe public contact with water (i.e., swimming) can occur when rotenone ≤ 0.090 mg/L. Rotenone levels are expected to be ≈ 0.020 mg/L after the waiting period, less than the 0.090 mg/L deemed safe for human contact and the 0.040 mg/L suggested as the safe drinking water level by USEPA (2007). As part of the overall project monitoring, rotenone levels will be documented from the day of application until they subside to less than detection (≤ 0.002 mg/L) (see APPENDIX C for Monitoring Plan and protocol).

Signage and project safety officers will prevent public access to the lake and other treated areas during the application and 3-day no-entry period as detailed in SOP 1.1 of the Rotenone SOP Manual (Finlayson et al. 2018). Details of public access and signage are as follows:

> **Lake** - There is only one road access to Miramichi Lake; it will have signage and the access road will also be monitored for the duration of the 2-day treatment and the 3-day post-treatment period by a public safety officer informing any visitors of the eradication activity and treatment area use restrictions. The lake is typically only accessed by the few cottage owners, with little public use and so we expect low volume of traffic on the lake road during the eradication. We have provided Miramichi Lake camp owners regular project updates and they will be notified well in advance of the treatment dates.
>
> **Lake Brook** - There is no road access to Lake Brook. It can be accessed by boat from Miramichi Lake or the SW Miramichi River, which will both have signage at access points.
>
> **SW Miramichi River** - Road access to the treatment reach on the SW Miramichi River is controlled by J.D. Irving and is restricted by gate and monitored by full-time personnel. J.D. Irving is aware of the project details and plans; employees will be briefed on the eradication timing and operations prior to treatment. There are occasional canoers on this reach of river (not typically in low water conditions during the time of year we propose to treat) and signage will be placed at the known launch points at Deersdale and Half Moon. There will also be signage placed at the upstream extent of the treatment reach at the Ice Bridge, which will have personnel on-site carrying out the treatment who can inform any canoers that may have disregarded the signs upriver at Deersdale and Half Moon. McKiel Salmon Club, Camp Moose Call, and Slate Island Camp are the only camps in the project area and will be notified of treatment timing. The few camps that are located in the downriver vicinity of the project area on the SW Miramichi River (i.e., within 25 km downriver of Slate Island) will also be notified (Burnthill, Deadman, Clearwater, Rocky Bend, Rocky Brook). We do not expect any boat traffic upriver from these camps because the river will likely be too shallow to motor, and the camps do not use motor canoes in this reach regardless. Personnel at the fish migration barrier will monitor any potential upstream boat movement. Again, the entire region's road network is controlled

by J.D. Irving, so any camps in the area will be apprised of the eradication timing and restrictions. See Figure 14 for the signage locations at publicly accessible points.

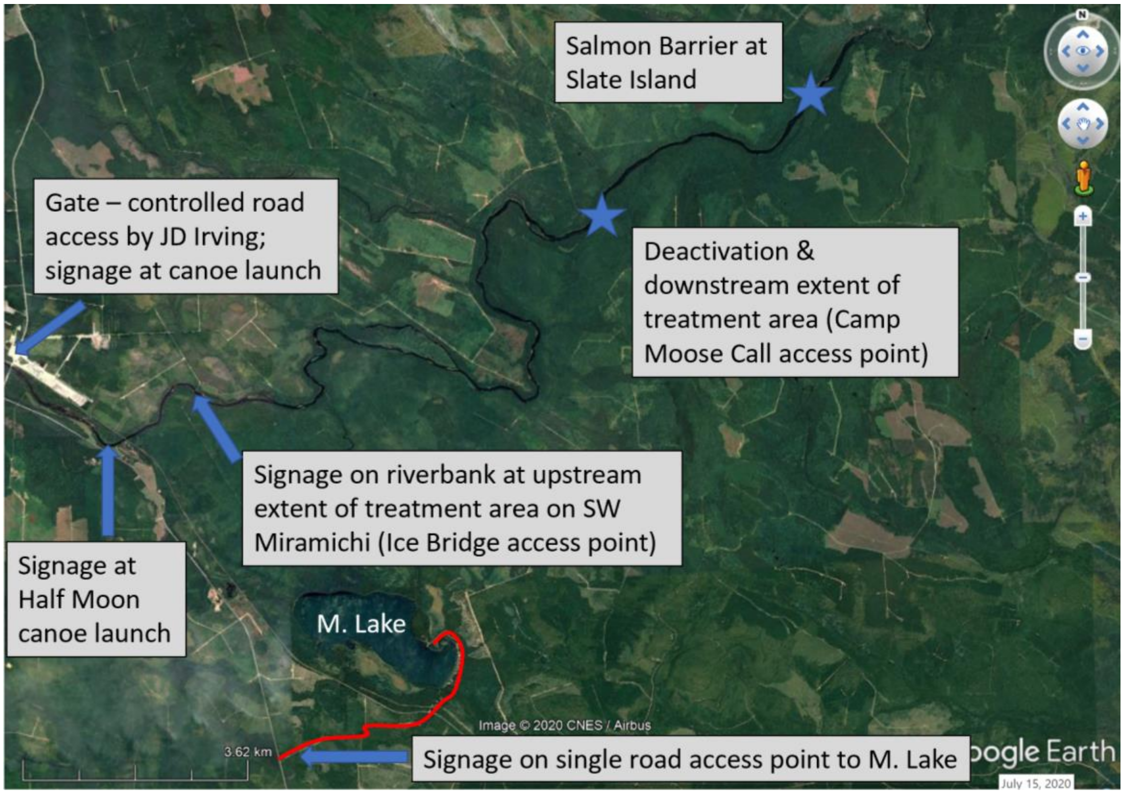


Figure 14. Signage locations at publicly accessible points throughout the treatment area.

10) **Avoidance of Vessel or Navigation Risk** - There are no risks to public vessels or navigation. Vessels used for the treatment will be operated by holders of the Canadian Boater Safety License and be certified pesticide applicators. There will be no public or private vessels in the treatment area, other than those used for the treatment, during the 2-day application and for a 3-day period following treatment.

11) **Disruptions to the routine activities of local communities, governments, or businesses -** The public will be temporarily prohibited from contact with treated water during the 2-day application and for a 3-day re-entry interval after application (required by the product label). This will primarily impact Miramichi Lake camp owners who use the lake recreationally (21 privately owned parcels of land). No businesses or government activities will be disrupted on account of the treatment.

12) **Public engagement** – Education is a key mitigation strategy to reduce the risk of re-introduction and reduce the risk of further introductions of invasive species in the region. We have taken a pro-active approach with extensive public engagement. See Section 6.0 of this document for details on our First Nations and public engagement activities. This approach is in-keeping with DFO's National Aquatic Invasive Species Program core pillars.

Monitoring Plan

The monitoring plan consists of four components: (1) rotenone treatment monitoring (2) rotenone deactivation monitoring, (3) short-term and long-term SMB eradication monitoring, and (4) 5-year long-term ecological recovery monitoring. Indigenous biologists and technicians will lead the monitoring program with support from the Working Group and government agencies. The majority of monitoring activities will be carried out at the monitoring sites identified on Figure 15; full detail is provided in the stand-alone Monitoring Plan in Appendix C.

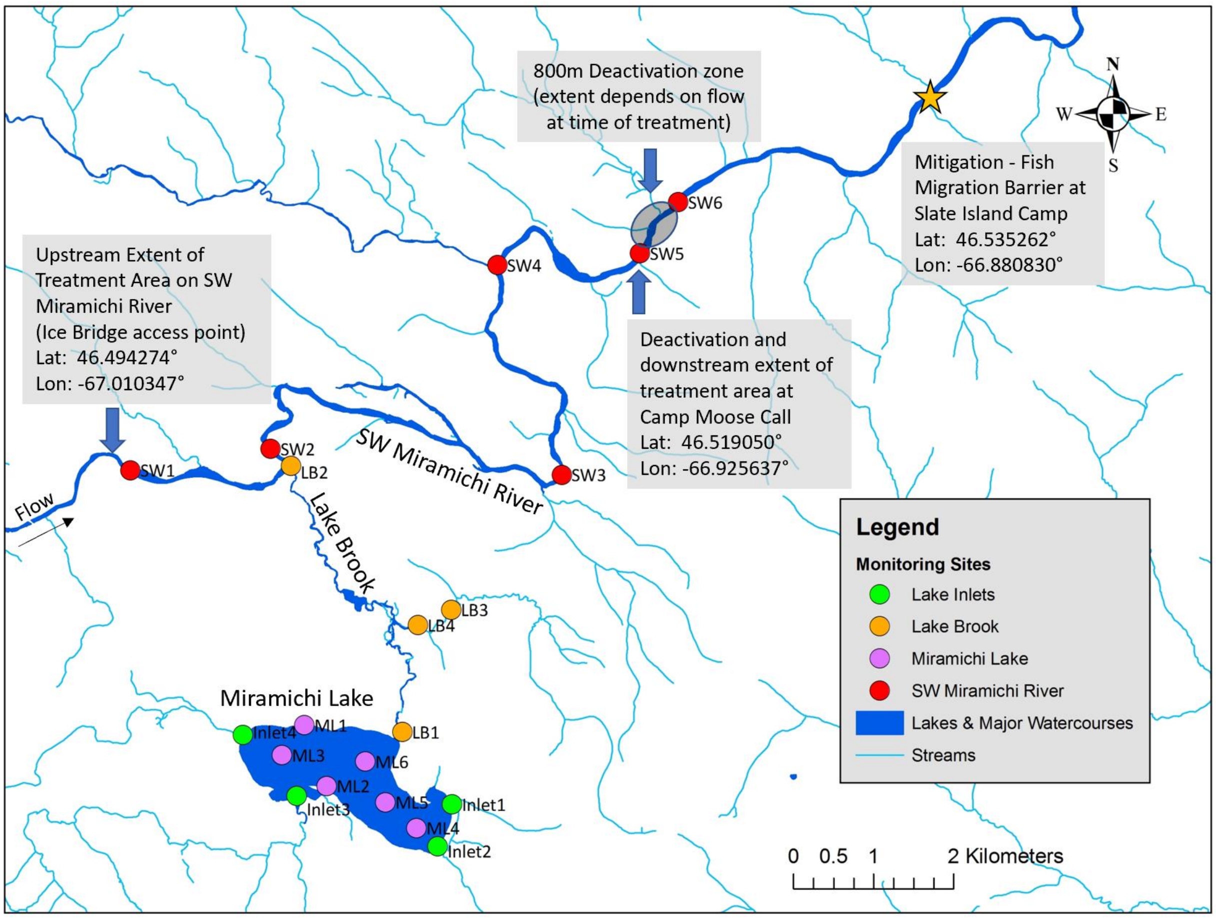


Figure 15. Monitoring sites - smallmouth bass eradication and ecological recovery.

c) **Impact Compensation**

Restoring or enhancing natural features either at the location of the undertaking or elsewhere (e.g., wetland, fish habitat)

The eradication project is itself an environmental remediation project compensating for the impact of the illegal introduction of invasive smallmouth bass into the Miramichi watershed.

Water Supply Considerations
The proposed deposit of Noxfish II conforms to the PMRA product label with regard to drinking/well water supplies, which states *"Do not use water treated with rotenone to irrigate crops or release within ½ km upstream of a potable water or irrigation water intake in a standing body of water, such as a lake, pond, or reservoir."* We will not be treating any areas within 0.5 km upstream of drinking water or irrigation sites; therefore, there are no intakes that would require temporary shut-off during treatment.

We contacted the NB Source and Surface Water Management Branch under the Department of Environment and Local Government regarding records of drinking water sources around the lake. The response from DELG was: *"From a drinking water and household perspective, the department doesn't regulate nor keep track of individual private drinking water systems from surface water bodies. Furthermore, a search all around the Miramichi Lake in our Online Well Log database doesn't return any well log report. Which means that existing cottages around the Miramichi Lake might have their drinking and household water either from the Lake or from a well drilled before 1994 or from a dug well."*

Through our direct engagement with cottage owners, we understand the majority of cottages, except two, obtain water from a communal drinking water supply fed by a small spring located uphill from the cottages (upstream from the lake) and upstream/outside of the proposed treatment area (Figure 16). Two cottage owners indicated that they share a 20-foot shallow well which they believe is fed by groundwater and surface water adjacent to the lake (Figure 16). As previously documented in this EIA, rotenone is not a groundwater contaminant (Finlayson et al. 2001; 2014) and as such we don't anticipate any alteration of the water quality in this well. However, as potential mitigation measures for the two cottages with the shallow well, we have officially offered those cottage owners three options in writing:

> **Email to cottage owner, [redacted], on July 15, 2020:**
> *"We have discussed amongst the group the matter you brought forward about your shallow well that is shared between 2 cottages and is potentially fed in part by surface water from the lake. We have consulted with Brian Finlayson and Steve Maricle to get guidance on what the standard protocol is for lakeside wells. Both of them have had experience with similar situations.*
>
> *The literature and their experience monitoring deep and shallow wells before/after rotenone treatments show that no traces of rotenone or any other formulation ingredients have been found in the well monitoring. Also, rotenone does not travel further than a few centimetres into the soil and is not known to be a groundwater contaminant. This indicates that there should be no impact to your well water; however, we understand your genuine concerns and recognize that drinking water is one of the most basic and important aspects of life anywhere, and that one needs to be comfortable with their drinking water source.*
>
> *As such, we have put together 3 options for you to consider. All 3 options include a request that you not use the well for the duration of the project as a precaution. Should the project go ahead, we offer to:*
>
> 1. *Provide drinking water to your two cottages on the well for the duration of rotenone presence in the lake (2-3 weeks), and test the well water before and after the treatment; or*
> 2. *If logistically possible, connect your two cottages to the existing spring water source used by the other cottages that is upstream of the treatment area; or*
> 3. *Drill you a new proper deep well with no surface water input*

Alternatively, if some combination of these options is favourable to you or you have another option in mind, we are certainly open for discussion on the approach that makes you feel most comfortable."

Figure 16 shows the location of the shallow well that supplies two cottages, including coordinates and the distance from lake shore. The map also shows the location of a spring water source and reservoir tank that supplies most cottages along the lake, located 500 m uphill from Miramichi Lake.

Figure 16. Locations of two water sources used by cottages for drinking water and household use nearby to Miramichi Lake.

The sampling approach for monitoring the shallow well will be as follows:

1. One day pre-treatment of Miramichi Lake,
2. When rotenone is gone from the lake (est. 18-d post-treatment), and
3. One month post-treatment.

A laboratory will analyze water samples for rotenone with an MDL of 1 ppb and a RL of 2 ppb using liquid chromatography (LC) or LC/mass spectrometry (MS) and the methods described by Dawson et al. (1983), Vasquez et al. (2012), and Sandvik et al. (2018). We will test for rotenone since literature indicates that formulants degrade quicker or concurrently with the active ingredient. The sample containers, sample volume and analytical turnaround time are dependent on the analytical laboratory. Typically, results can be available within a day or two from a local laboratory. Samples would be collected in duplicate utilizing travel blanks. The well would need to be purged prior to each sampling to ensure that the quality of the water is reflective of the surrounding aquifer. Typically, the well would be sampled from an exterior faucet closest to the well. Most of this is detailed in SOP 16.1 of the Rotenone SOP Manual (Finlayson et al. 2018).

6.0 PUBLIC AND FIRST NATIONS INVOLVEMENT

Summary report of public and First Nations engagement

The Working Group has been extensively engaged with the public and First Nations regarding our proposal to eradicate invasive smallmouth bass from the Miramichi watershed using Noxfish Fish Toxicant II.

Our July 2017 expert report (van den Heuvel et al. 2017) included a communications and engagement plan. It identified Maliseet and Mi'kmaq First Nations, cottagers with property adjacent to the project area, nearby communities, NGOs, and elected leaders as important constituencies to reach. The expert report and federal regulatory submissions provided a science-based foundation for engagement and Tables 7 through 10 detail our interactions with these groups.

At the time of submission of this registration document, Fisheries and Oceans Canada's formal Indigenous consultation process on this project is well advanced. The duty to consult is a component of the DFO's national mandate and the AIS program.

Note: This section does not include Working Group interaction federal and provincial staff. This information is captured in Table 3, which summarizes the regulatory processes that this project has already been subjected to and in Appendices G, H, and I which detail multiple rounds of questions asked of the proponent by reviewing officials.

Maliseet and Mi'kmaq First Nations

It is important to note that the eradication itself is an Indigenous-led project. The North Shore Micmac District Council is proponent, supported by the Working Group, whose members include the Maliseet Nation Conservation Council. Table 7 provides a summary of major engagement activities with First Nations communities and organizations. Supporting documentation for each action denoted with an asterisk (*) is included in Appendix K.

Table 7. Summary of Indigenous engagement (supporting documentation in Appendix K).

August 26th, 2016	First meeting held of Mi'kmaq Indigenous organization, the North Shore Micmac District Council, with conservation NGO organizations that eventually form the Working Group on Smallmouth Bass Eradication in the Miramichi.
April 17, 2017	Representatives of ASF, MSA, MWMC, NBSC, NBWF, NSMDC sign a letter of intent and mutual support saying that each party is committed to

	eradicating SMB and will work collaboratively toward the goal. *
October 10, 2018	Advised by Jim Ward that Miramichi Lake straddles the traditional divide between Maliseet and Mi'kmaq territory, Working Group co-chairs Peter Cronin (NBSC) and Mark Hambrook (MSA) draft letter to Patricia Saulis of the Maliseet Nation Conservation Council stating that public communications would be delayed until meaningful discussions with MNCC can be had, and inviting MNCC to join the Working Group.*
November 2, 2018	Representatives of the Working Group join Patricia Saulis and Blake Daly, both employees of the Maliseet Nation Conservation Council, at Miramichi Lake for a water ceremony to mark MNCC's joining of the Working Group.
January 10, 2019	Meeting held at St. Mary's First Nation between members of the Working Group and representatives of Wolastoqey Nation in New Brunswick to discuss the eradication project.*
January 27, 2020	Working Group members held a public meeting open to community members from Metepenagiag and Natoaganeg First Nations at the Natoaganeg Community Food Centre. Presentations were made by Brian Finlayson and Steve Maricle, consultants with expertise in the use of rotenone to eradicate invasive fish. Questions and answers followed. Anqotum advertised the meeting in the communities. A similar meeting with representatives of Maliseet organizations is attempted, but no mutually workable time is found. *
Spring/Summer 2020	DFO commences formal Crown/Indigenous consultations as part of the federal AIS application regulatory process. Working Group representatives contact Indigenous organizations offering to present on the details of the proposed eradication.
June 30, 2020	Working Group members join DFO staff and representatives of the New Brunswick Aboriginal People's Council and Maritime Aboriginal People's Council for a formal consultation meeting. A presentation on the proposed action was delivered by Nathan Wilbur, representing the Working Group and a question and answer period followed. *

July 6, 2020	WNNB submits questions to the proponent as part of DFO's formal Indigenous consultation process. *
July 21, 2020	Working Group members are copied on correspondence from the New Brunswick Aboriginal People's Council and Maritime Aboriginal People's Council to Fisheries and Oceans Canada and are asked to respond to several questions about the smallmouth eradication proposal. *
August 6, 2020	Proponent provides response to WNNB questions from July 6 as part of the DFO-led Indigenous consultation process. *
August 27, 2020	Proponent and Working Group provide response to NBAPC from July 21 as part of the DFO-led Indigenous Consultation process. *

Miramichi Lake Cottage Owners & Families

There are private camp lots in the proposed treatment area on Miramichi Lake, concentrated along the southeastern shore. A search of Service New Brunswick records returned 21 PAN numbers. Table 8 is a summary of major engagements with this important stakeholder group. All supporting documentation denoted by an asterisk (*) can be viewed in Appendix L.

Table 8. Summary of Miramichi Lake Cottage Owner and Family engagement (supporting documentation in Appendix L).

Date	Activity
October 31, 2019	Letter to registered property owners adjacent to Miramichi Lake informing people of our intention to eradicate smallmouth bass, including details on the proposed project. We provided contact information and invited people to visit our project website or contact the Working Group directly with questions. *
December 27, 2019	Letter to registered property owners inviting them to the AYR Motor Centre in Woodstock on January 26th, 2020, to hear presentations from two visiting experts on rotenone use and ask questions. *
January 10, 2020	Detailed letter to [redacted], cottage owners, addressing six questions sent to the Working Group. *
January 26th, 2020	Public meeting in Woodstock with 35 people in attendance. The group consisted of registered property owners and family members. We streamed the meeting for camp owners who

	couldn't be in attendance. Presentations were made by Brian Finlayson and Steve Maricle, consultants with expertise in the use of rotenone to eradicate invasive fish. An extended question and answer period followed (see *What We Heard* below). Updated contact information was provided by [redacted] to ensure future communications reached all appropriate cottagers and family. *
February 5, 2020	Detailed reply to request for information from [redacted], cottage owner, on the number of smallmouth bass caught at the seasonal barrier erected at the outflow of Miramichi Lake since containment and removal efforts started in 2009. On February 15th followed up with additional information. *
March 8, 2020	Follow-up meeting between a committee of camp owners, NSMDC, and members of the Working Group in Fredericton. Meeting was also attended by representatives of GNB and MLA Andrew Harvey. Meeting minutes taken. *
May 21, 2020	Email update sent to all cottagers and families informing the group that a revised application to eradicate SMB, now including a section of the SW Miramichi River, had been submitted to DFO. It was mentioned that a project description had been sent to DELG for an EIA registration decision. *
July 15, 2020	Detailed email communication to all cottagers and families informing the group that NB DELG decided the proponent/Working Group must register the project for an EIA screening review. *
July 15, 2020	Email sent by Nathan Wilbur to cottagers using a shallow well offering mitigative measures, including drilling a new deep water well and monitoring the existing well. *
July 20, 2020	Email to all cottagers and family members informing the group that Nathan Wilbur and Neville Crabbe, Working Group representatives, would be at Miramichi Lake that day to collect data needed for treatment plan. *
August 17, 2020	Email communication sent to all cottagers and family members following up on the July 20 notification and providing other details to update the group on the DFO AIS regulatory review process. *

September 21, 2020	Email sent to all cottagers and family members informing the group that the EIA registration document is anticipated to be submitted on Friday, September 25 and that when it becomes available to the public for review, we will send them notification and a link to the documents. *

Elected Officials

Members of the Working Group have informed elected Members of Parliament and Members of the New Brunswick Legislature about smallmouth bass eradication and answered any questions they have had. Table 9 provides a summary of major engagements. All supporting documentation denoted by an asterisk (*) can be viewed in Appendix M.

Table 9. Summary of communications & engagement with elected officials (supporting documentation in Appendix M).

December 9, 2016	Working Group representatives, Peter Cronin and Nathan Wilbur, meet with Green Party Leader David Coon to discuss invasive smallmouth bass in the Miramichi and the need for eradication. Mr. Coon advised to first find experts, explore options, and develop a science-based plan. The Working Group heeded the advice of Mr. Coon by commissioning an expert report.
April 17, 2018	Working Group co-chairs Peter Cronin (NBSC) and Mark Hambrook (MSA) co-sign a letter to then DFO Minister Dominic LeBlanc, urging him to direct his officials to follow-through on commitments made during a July 2017 meeting, nearly a year earlier, where the expert report was reviewed.* Working Group emphasized the urgency of eradication and stressed that DFO's Aquatic Invasive Species Regulations guide and permit such activities. *
July 5, 2018	Letter received from Minister Dominic LeBlanc in reply to April 17 correspondence. Letter indicates that DFO will only regulate and accept applications to eradicate from outside groups. *
November 25, 2019	Letter sent to all NB MPs and MLAs from Working Group co-chairs Mark Hambrook and Nathan Wilbur alerting them to the discovery of smallmouth bass in the Southwest Miramichi River, reiterating that DFO's inaction since SMB discovery in 2008 in the lake is responsible for their spread into the river, and pointing out that

	the only group willing to act is the Working Group. *
January 31, 2019	Working Group sends letter to DNR Minister Mike Holland and DELG Minister, Jeff Carr, requesting meeting to discuss the eradication of SMB. *
March 6, 2019	Working Group meets with DNR Minister Mike Holland and DELG Minister Jeff Carr to present findings of the expert report on SMB eradication, to discuss options explored, and a presentation on the eradication plan including treatment, mitigation, monitoring and cost. *
January 22, 2020	Nathan Wilbur and Neville Crabbe, representing the Working Group, meet with NB Southwest MP John Williamson who requested a briefing on the smallmouth eradication project. An information sheet was presented to MP Williamson to guide discussion. *
January 27, 2020	Email with presentations and supporting documentation sent to Liberal MLA Andrew Harvey who attended the earlier meeting with camp owners and family members in Woodstock
January 28, 2020	Working Group members meet Ministers Holland, Carr, and Stewart, along with senior staff, in Fredericton. Presentations are done by Brian Finlayson and Steve Maricle. Questions and discussion ensue. *
June 3, 2020	Following up on email correspondence, Neville Crabbe sends letter on behalf of the Working Group to N.B. Green Party leader David Coon addressing Mr. Coon's questions about the project. *
September 3, 2020	Nathan Wilbur and Neville Crabbe, on behalf of the Working Group meet MP and Fisheries Critic Richard Bragdon in Fredericton and present on details of the proposed eradication.

Media Coverage

Since smallmouth bass were discovered in the Southwest Miramichi River in August 2019, the Working Group has been active in digital, social, and traditional media, proactively giving updates and providing information. Developments have been regularly shared on social media and with ASF's 25,000 email address contact list. Table 10 documents news coverage, including links where available.

Table 10. Summary of communications & engagement with media.

August 25, 2019	'Invasive Bass Threaten Atlantic Salmon Population' by Kris McDavid, Miramichi Leader. Story details discovery of smallmouth bass in the Southwest Miramichi (https://www.asf.ca/news-and-magazine/salmon-news/invasive-bass-threaten-atlantic-salmon-population)
August 26, 2019	'DFO, stakeholders to think up plan for invasive bass' by Kris McDavid, Miramichi Leader. Story follows Aug. 26 report with comments from DFO. (https://www.asf.ca/news-and-magazine/salmon-news/dfo-stakeholders-to-think-up-plan-for-invasive-bass)
August 27, 2019	'Alarm raised after invasive smallmouth bass spotted in Miramichi' by Connell Smith, CBC. Story gives early details of field work in response to discovery of smallmouth in SW Miramichi. (https://www.asf.ca/news-and-magazine/salmon-news/alarm-raised-after-invasive-smallmouth-bass-spotted-in-miramichi)
August 28, 2019	Neville Crabbe, on behalf of the Working Group, speaks about the discovery of smallmouth on the CBC radio program Maritime Noon. (https://www.cbc.ca/listen/live-radio/1-38-maritime-noon/clip/15733333-invasive-smallmouth-bass-discovered-in-miramichi-river-coastal-access)
August 30, 2019	'MP says DFO 'incompetent' in handling of smallmouth bass case' by Connell Smith, CBC. Story quotes Conservative MP Robert Sopuck who is critical of DFO's lack of decisive action to eradicate. (https://www.asf.ca/news-and-magazine/salmon-news/mp-says-dfo-incompetent-in-handling-of-smallmouth-bass-case)
September 3, 2019	'No time to waste on smallmouth bass' is the title of an editorial that appeared in the Miramichi Leader. (https://www.asf.ca/news-and-magazine/salmon-news/editorial-no-time-to-wast-on-smallmouth-bass)
September 5, 2019	'ASF Conservationist Hooks Smallmouth Bass on the Miramichi' by Nathan Delong. Story breaks news of Nathan Wilbur's capture of three smallmouth bass at McKiel Pond Pool, the first bass caught and retained in the SW Miramichi. (https://www.asf.ca/news-and-magazine/salmon-news/asf-conservationist-hooks-smallmouth-bass-on-the-miramichi)
October 1, 2019	'Invasive smallmouth bass total reaches 30 in Miramichi River' by Connell Smith, CBC. Story details capture and removal efforts at McKiel Pond Pool since August.

	(https://www.asf.ca/news-and-magazine/salmon-news/invasive-smallmouth-bass-total-reaches-30-in-miramichi-river)
October 28, 2019	'DFO considers release of toxins to control an invasive species in Miramichi Lake' by Connell Smith. Story gives details on the plan to eradicate smallmouth using rotenone. (https://www.asf.ca/news-and-magazine/salmon-news/dfo-considers-release-of-toxins-to-control-an-invasive-species-in-miramichi-lake)
October 30, 2019	'Conservation groups look to wipe out bass from New Brunswick lake to protect Miramichi salmon' by Kevin Bissett, Canadian Press. National coverage of smallmouth issue carried in Toronto Star. (https://www.asf.ca/news-and-magazine/salmon-news/conservation-groups-look-to-wipe-out-bass-from-new-brunswick-lake-to-protect-miramichi-salmon)
November 7, 2019	'Considering the nuclear option in controlling invasive species,' by Brian Owens, Hakai Magazine. Story gives insight and analysis for a national audience on the use of rotenone in fisheries management. (https://www.hakaimagazine.com/news/considering-the-nuclear-option-in-controlling-invasive-species/)
January 8, 2020	'Conservation groups expand plan to eradicate invasive fish to Miramichi River' CBC Shift interview with Neville Crabbe, representing the Working Group. (https://soundcloud.com/atlantic-salmon-federation/conservationists-expand-smallmouth-eradication-effort)
Jan 10, 2020	'Salmon officials aim to eradicate Miramichi smallmouth bass' by Nathan DeLong, Miramichi Leader. Story announces intention to submit revised application to eradicate to DFO, including treating SW Miramichi. (https://www.asf.ca/news-and-magazine/salmon-news/salmon-officials-aim-to-eradicate-miramichi-smallmouth-bass)
February 4, 2020	'Plan to kill smallmouth bass will require restocking of Miramichi Lake, says biologist' by Connell Smith, CBC. Story mentions needs to restock Miramichi Lake after smallmouth eradication. (https://www.asf.ca/news-and-magazine/salmon-news/plan-to-kill-smallmouth-bass-will-require-restocking-of-miramichi-lake-says-biologist)
March 17, 2020	'Invasive species: smallmouth bass' by Maria Hernandez, The Brunswickan. Student newspaper coverage of smallmouth. (https://www.asf.ca/news-and-magazine/salmon-news/invasive-species-smallmouth-bass)

May 1, 2020	'Salmon groups push ahead with fish kill in face of COVID-19 emergency' by Connell Smith, CBC. Story announces determination of Working Group to eradicate in 2020 even with COVID-19 restraints. (https://www.cbc.ca/news/canada/new-brunswick/rotenone-fish-eradication-invasive-species-native-first-nations-atlantic-salmon-1.5550905)
May 7, 2020	'Cottage owners concerned about poisoning of lake' by Nathan DeLong, Miramichi Leader. Story explains cottage owner concerns. (https://www.asf.ca/news-and-magazine/salmon-news/cottage-owners-concerned-about-proposed-poisoning-of-lake)
June 25, 2020	'Eradicating Invasive Fish in the Miramichi Watershed' Working Group commentary in the Daily Gleaner, Times Transcript, and Telegraph Journal arguing for prompt decision by DFO on application to eradicate. (https://www.asf.ca/news-and-magazine/salmon-news/opinion-eradicating-invasive-fish-in-miramichi-watershed)
June 25, 2020	ASF Quebec program director Charles Cusson is interviewed by Michel Nogue on smallmouth eradication for Radio Canada Acadie.
September 22, 2020	'NB Rotenone Plan Delayed by Environmental Assessment' by Connell Smith, CBC. Story provides information about Working Group progress over the summer, foreshadows EIA submission. (https://www.asf.ca/news-and-magazine/salmon-news/nb-rotenone-plan-delayed-by-environmental-assessment)

Digital Communication, Stakeholder Engagement, Educational Materials

In addition to proactively sharing information with the public through traditional media outlets, the Working Group has used digital communication and direct contact to reach the public and stakeholders. Table 11 details these engagements activities. All supporting documentation denoted by an asterisk (*) can be viewed in Appendix N.

Table 11. Summary of digital communications and stakeholder engagement (relevant documents provided in Appendix N).

August 28, 2019	Working Group publishes a blog entitled Clear and Present Danger, introducing to the public plans to use rotenone to eradicate smallmouth bass. (https://www.asf.ca/news-and-

	magazine/salmon-news/clear-and-present-danger)
September 3, 2019	Working Group publishes a blog titled 'Update: Three smallmouth bass caught in Southwest Miramichi.' (https://www.asf.ca/news-and-magazine/in-the-field/update-three-smallmouth-bass-caught-in-southwest-miramichi)
September 5, 2019	Neville Crabbe on behalf of the Working Group engages with other conservation NGOs in the province, including CCNB, CPAWS, CWF, WWF, NTNB, and Nature NB, providing an update on our eradication project and contact info for questions and concerns.
October 31, 2019	Working Group launches project website at www.miramichismallmouth.com
January 26, 2020	Working Group develops informational pamphlet on the threat of invasive SMB to the Miramichi system and includes biographies of experts Steve Maricle and Brian Finlayson. *
April 28, 2020	ASF hosts webinar for the public on smallmouth bass eradication. More than 150 people attend. Video and copies of presentations available here: https://www.asf.ca/news-and-magazine/in-the-field/webinar-recap-alien-invaders
July 15, 2020	Working Group publishes statement on Minister Carr's decision that the eradication project must be registered for a provincial EIA determination review. (https://www.asf.ca/news-and-magazine/news-releases/statement-on-environmental-assessment-registration)

What We Heard

The following is a summary of concerns and questions the Working Group has received from members of the public, Indigenous organizations and individuals, stakeholders, government officials, and elected leaders. The questions are grouped thematically and represent the essence of significant lines of inquiry rather than verbatim queries. Our general answers are provided in response.

Is rotenone/Noxfish II safe for humans?

When presented with the plan to chemically eradicate smallmouth bass from the Miramichi watershed, several people expressed concern regarding human health impacts, including comparing rotenone to DDT. Working Group members provided the following science-based information:

- Rotenone (Noxfish II) is approved and registered for use by Health Canada's Pest Management Regulatory Agency. The registration follows government scientific reviews of rigorous standardized testing results to ensure there are no unreasonable risks to public health or the environment when used according to label directions.

- Health Canada recently considered a 2020 health assessment by the United States Environmental Protection Agency (USEPA 2020) which found no association or causal relationship between rotenone exposure and any health effects in humans based on a review of epidemiology studies.

- Studies have shown that rotenone and other formulants that make up Noxfish II do not penetrate into soil and are not known to contaminate groundwater sources. Rotenone does not travel more than a few centimetres into soil (e.g., Finlayson et al. 2001, Finlayson et al. 2014, Hisata 2002).

- The rotenone application rate for this project is 0.075 mg/L, which is below the USEPA (2007) level deemed safe for public contact with water (i.e., swimming) at ≤ 0.090 mg/L rotenone. The initial 0.075 mg/L rotenone is expected to degrade to 0.0375 mg/L rotenone in 2.5 days, a level below the suggested safe drinking water level of 0.040 mg/L rotenone proposed by USEPA (2007).

- While the treatment rate on the Miramichi eradication is below what the USEPA deems safe for human contact, the product label requires that the public is prohibited from contact with treated water during application and for a 3-days afterwards.

- A certified pesticide applicator team will conduct the treatment according to the product label and standard operating procedures (Finlayson et al. 2018).

- Rotenone products are used safely and effectively in Canada and around the world each year and have become the most common tool for eradication and management of invasive fish species.

Is there a connection between rotenone and Parkinson's Disease?

Emory University (Betarbet et al. 2000) conducted a study that injected rotenone directly into the bloodstream of laboratory rats, which then showed symptoms that were similar to Parkinson's disease symptoms. This study has raised concern in the past and therefore has been the subject of further review and analysis which has firmly established that there is no connection between rotenone and Parkinson's disease. Here is how we have explained this knowledge:

- A detailed review of the literature by the Washington Department of Fish and Wildlife (Hisata 2002) established that there is no connection between Parkinson's disease. In fisheries management, when used according to the label instructions, registered rotenone products are safe for humans.

- The Emory University study injected rotenone into the bloodstream of rats which transports rotenone directly to the brain. This is not the normal exposure route when using rotenone and bypasses the body's natural defences, such as the gut, which metabolizes rotenone to water soluble compounds and then excretes them (Rotenone Stewardship Program 2001).

- Dr. Joseph Borzelleca of the Virginia Commonwealth University Department of Pharmacology and Toxicology critically reviewed the Emory University study (Borzelleca 2001) and concluded that it was not relevant for humans (Hisata 2002). Dr. Borzelleca is an extensively published Pharmacologist/Toxicologist; researcher; journal editor; consultant to the World Health Organization and member of the National Academy of Science Committee on Toxicology.

- Dr. Borzelleca notes that Marking (1988) introduced rotenone into the diet of rats for two years at 30 times greater the concentration used in the Emory University study and for 20 times longer exposure. All of the rats survived, with no changes to the brain, and none exhibited any Parkinson's disease symptoms. This study is relevant for humans because entry was via ingestion, inhalation, or through skin (i.e., the normal exposure routes).

- Several researchers in Parkinson's disease (including J. Langston, former Director of the Parkinson's Institute) have stated that the Emory University study does not show direct evidence that rotenone causes Parkinson's disease. The method of exposure in the Emory University study cannot be used as a model for any form of rotenone exposure resulting from its use in fisheries management (Rotenone Stewardship Program 2001).

What will smallmouth eradication mean for the ecosystem of the treated area?

Indigenous organizations, stakeholders, and elected officials also expressed reservation about the lasting ecological impacts of using a rotenone product to eradicate smallmouth bass from the Miramichi watershed. Our replies were consistent, science-based, and are summarized below:

- An extensive body of evidence shows that ecosystems rebound quickly after rotenone is applied to eradicate an invasive species. In the case of Miramichi Lake, Lake Brook, and the Southwest Miramichi, the treatment area is continuous with unaffected habitat on both the upstream and downstream ends, which will help speed recovery as native species can move freely to recolonize vacant habitat.

- Rotenone is not toxic to birds and mammals. Studies show that piscivorous animals cannot consume enough fish killed by rotenone to have toxicity impacts.

- Plankton and macro invertebrates will be affected by the treatment; however, studies from other treatments show that invertebrate communities rebound within several weeks to 3 years, but typically recover within 1 year after treatment.

- The effects of rotenone will be limited to the surface water in the treatment area. Aquatic vegetations and plants in the riparian zone will be unaffected and rotenone does not bioaccumulate in the environment. It breaks down rapidly in the natural environment and does not pose a risk to humans through consumption of fish and wildlife.

- Our plan includes a five-year monitoring program to be carried out by Indigenous scientists and technicians with Anqotum. The monitoring program will document the ecosystem's recovery, and in some cases facilitate intervention if necessary. For example, based on monitoring results after two years, if some native non-migratory fish species are not recolonizing Miramichi Lake, individuals will be transplanted from nearby lakes within the watershed to accelerate recovery.

Can people still eat fish and wildlife they harvest through hunting and fishing in the area?

- Yes, people can still eat fish and wildlife they harvest in the area after the treatment.

- Rotenone does not bioaccumulate in the environment. It breaks down rapidly in nature due to a number of biological and physical mechanisms whether in water or fish flesh and does not pose a risk to humans through consumption of fish and wildlife.

Will there be downstream impacts below the project area on the SW Miramichi River?

- No. As a mitigation measure to avoid downstream impacts beyond the project area rotenone will be deactivated at the downstream extent of the treatment area on the SW Miramichi River at camp Moose Call. Potassium permanganate ($KMnO_4$), a commonly used water purifying agent, will be used for deactivation and is listed on the PMRA product label for Noxfish II as a deactivation agent.

Why bother if someone can simply dump smallmouth back in?

Several people we encountered in our public and Indigenous engagement activities expressed a defeatist attitude; that the situation was too far gone, or the work of eradication would be undone by a reintroduction. We responded with the following logic, fact, and argument:

- This lazy logic could be applied to almost any situation with the conclusion being the same – do nothing because work could be undone. We have used the forest fire analogy: if there is a forest fire, humans don't simply let it burn because someone could potentially start another one at some point in the future; we take action to put the fire out. We choose to act to conserve the native ecosystem.

- Our efforts, including direct public and First Nations engagement, creation of educational materials, and the significant number of news stories generated, has raised public awareness of invasive species and their consequence. Furthermore, the eradication project will act as an educational component and deterrent to future illegal introductions. Our organizations are willing to partner on public education projects similar to those that sensitized the public to the danger of second-hand smoke and the scourge of litter.

7.0 APPROVAL OF THE PROJECT

List of permits, licenses, approvals, and other forms of authorization required for the undertaking in addition to its requirements under the *EIA Regulation*

A comprehensive list of all regulatory processes, agency reviews, and permits involved in this project are provided in Table 3. To summarize, permits required are:

DFO – National Aquatic Invasive Species Core Program Authorization to Deposit a Deleterious Substance
DFO – Collection and Introductions & Transfers permits required for (1) fish transplantation under the reestablishment strategy, and (2) adult salmon rescue in river prior to treatment
PMRA – Emergency use registration for use of Noxfish II in flowing waters downstream of Miramichi Lake
DELG – WAWA permits for beaver dam removal, installation of fish migration barrier, and additional ATV temporary access trails to the river that may be required.
DELG – Pesticide use permit
DELG – Permit TBD for dead fish disposal
DNR – Licence of Occupation for Miramichi Lake staging area on Crown land (specific requirements TBD by DNR during the EIA registration review)

8.0 FUNDING

Identification of applications for a grant or loan of capital funds from any government agency

Given the responsibilities of governments to control aquatic invasive species, and responsibilities to conserve native fish species and ecosystems, we have submitted applications to both DFO and NB DNR to assist in the funding of this conservation project.

The cost of treatment, deactivation and associated equipment is approximately $600,000; the Working Group has collectively committed 50% of this cost ($300,000) in private funding and we have submitted an official request to NB DNR for a 50% contribution ($300,000). For the long-term ecological monitoring to be carried out by Indigenous biologists and technicians, we have submitted an official request to DFO to fund the monitoring program for 5 years in the amount of $906,000.

9.0 SIGNATURE

Date Signature of Main
Proponent Contact

Jim Ward, General Manager, North Shore Micmac District Council

10.0 SUBMITTING THE REGISTRATION DOCUMENT

The registration document is being submitted digitally on USB.

Address for hand delivery or courier
Director, Environmental Impact Assessment Branch
Department of Environment and Local Government
20 McGloin Street, Fredericton, NB
E3A 5T8
Telephone: (506) 444-5382

Mailing address
Environmental Impact Assessment Branch
Department of Environment and Local Government
PO Box 6000,
Fredericton, NB E3B 5H1

References

American Public Health Association. 1998. Standard methods for the examination of water and wastewater, 20th edition. American Public Health Association, Washington, D.C.

Anderson, R.S. 1970. Effects of rotenone on zooplankton communities and a study of their recovery patterns in 2 mountain lakes in Alberta. J. Fish Res Board Can 27: 1335- 1356.

Betarbet, R., T. Sherer, G. Mackenzie, M. Garcia-Osuna, A. Panov, and J. Greenamyre. 2000. Chronic systemic pesticide exposure reproduces features of Parkinson's disease. Nature Neuroscience 3:12 1301-1306.

Borzelleca, J.F. 2001. Letter, rotenone and Parkinson's disease. American Fisheries Society Rotenone Task Force Member, Prentiss Incorporated, Floral Park, New York. 2 pp.

Billman, H., St-Hilaire, S., Kruse, C., Peterson, T., Peterson, C. 2011. Toxicity of the piscicide rotenone to Columbia spotted frog and boreal toad tadpoles. Transactions American Fisheries Society 140:919-927.

Billman, H., Kruse, C. St-Hilaire, S., Koel, T., Arnold, J., and Peterson, C. 2012. Effects of rotenone on Columbia spotted frogs *Rana luteiventris* during field app. North American Journal of Fisheries Management 32:781–789.

Biron, M., Clément, M., Moore, D., Chaput, G. 2014. Results of a multi-year control and eradication program for Smallmouth Bass (*Micropterus dolomieu*) in Miramichi Lake, New Brunswick, 2011-2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/073.

Biron, M. 2015. Summary of the control and monitoring activities for Smallmouth Bass (*Micropterus dolomieu*) in Miramichi Lake, NB, in 2013 and 2014. Can. Data Rep. Fish. Aquat. Sci. No. 1257: viii + 8 p.

Bradbury, A. 1986. Rotenone and trout stocking. A literature review with special reference to Washington Department of Game's Lake Rehabilitation Program. Washington Department of Game. 181 pp.

Brynildson, O.M., Kempinger, J.J. 1973. Production, food and harvest of trout in Nebish Lake, Wisconsin. Wisconsin Department Natural Resources Technical Bulletin 65. 20 pp.

Carr, J. W., Whoriskey, F. 2009. Atlantic salmon (*Salmo salar*) and smallmouth bass (*Micropterus dolomieu*) interactions in the Magaguadavic River, New Brunswick. DFO Can. Sci. Adv. Secr. Res. Doc. 2009/074.

Chandler, J.H., Marking, L.L. 1982. Toxicity of rotenone to selected aquatic invertebrates and frog larvae. Progressive Fish Culturist 44:78-80.

Chaput, G., Caissie, D. 2010. Risk assessment of smallmouth bass (*Micropterus dolomieu*) introductions to rivers o Gulf Region with special consideration to the Miramichi River (N.B.). DFO Can. Sci. Advis. Sec. Research Doc. 2010/065.

Connell, C. B., Dubee, B. L., Cronin, P.J. 2002. Using rotenone to eradicate chain pickerel, *Esox niger*, from Despres Lake, New Brunswick, Canada. NB DNRE. Fisheries Management Report 2002-01-E.

COSEWIC. 2012. COSEWIC assessment and status report on the American Eel Anguilla rostrata in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 109 pp.

Curry, R.A., Currie, S.L., Arndt, S.K., Bielak, A.T. 2005. Winter survival of age-0 Smallmouth Bass, *Micropterus dolomieu*, in north eastern lakes. Environmental Biology of Fishes 72:111-122.

Dawson, V. K., Gingerich, W.H., Davis, R.A., Gilderhus, P.A. 1991. Rotenone persistence in freshwater ponds: effects of temperature and sediment adsorption. North American Journal of Fisheries Management 11:226-231.

DFO. 2009. Potential impact of smallmouth bass introductions on Atlantic Salmon: A Risk Assessment. DFO Canadian. Science Advisory Secretariat Advisory Report 2009/003.

DFO. 2013. Review of control and eradication activities in 2010 to 2012 targeting Smallmouth Bass in Miramichi Lake, New Brunswick. DFO Canadian. Science Advisory Secretariat Science Response 2013/012.

DFO. 2019. Review of elements of proponent application to use rotenone for the purpose of eradicating Smallmouth Bass (*Micropterus dolomieu*) from Miramichi Lake, New Brunswick. DFO Can. Sci. Advis. Sec. Sci. Resp. 2019/040.

Dolmen, D., Arnekleiv, J., and Haukebo, T. 1995. Rotenone tolerance in the freshwater Pearl Mussel Margaritifera margaratifera. Nordic J. Freshw. Res. 70: 21-30.

Draper, W. 2002. Near UV quantum yields for rotenone and piperonyl butoxide. Analyst 127: 1370-1374.

Eilers, J. 2008. Benthic Macroinvertebrates in Diamond Lake, 2007. Prepared for the Oregon Department of Fish & Wildlife Roseburg, Oregon. MaxDepth Aquatics.

Eilers, J. Truemper, L. Jackson, B. Eilers, and D. Loomis. 2011. Eradication of an invasive cyprinid (Gila bicolor) to achieve water quality goals in Diamond Lake, Oregon (USA). Lake and Reservoir Management 27:194-204

Environment Canada Hydrometric Website https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html

Finlayson, B. J., S. Siepman, and J. Trumbo. 2001. Chemical residues in surface and ground waters following rotenone applications in California lakes and streams. Pages 37-54 *in* R.L. Cailteux, L. DeMong, B. J. Finlayson, W. Horton, W. McClay, R. A. Schnick, and C. Thompson, editors. Rotenone in fisheries science: are the rewards worth the risks? American Fisheries Society, Trends in Fisheries Science and Management 1, Bethesda, Maryland.

Finlayson B., Schnick, R., Skaar, D., Anderson, J., Demong, L., Duffield, D., Horton, W., Steinkjer, J. 2010. Planning and standard operating procedures for the use of rotenone in fish management – rotenone SOP manual. American Fisheries Society, Bethesda, MD, USA.

Finlayson, B., J. Eilers and H. Huchko. 2014. Fate and behavior of rotenone in Diamond Lake, Oregon, USA following invasive Tui Chub eradication. Environmental Toxicology and Chemistry 33(7):1650-1655.

Finlayson, B., Skaar, D., Anderson, J., Carter, J., Duffield, D., Flammang, M., Jackson, C., Overlock, J., Steinkjer, J., and Wilson, R. 2018. Planning and standard operating procedures for the use of rotenone in fish management – rotenone SOP manual, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Gardner Pinfold. 2011. Economic value of Atlantic Wild Atlantic Salmon. Report prepared for the Atlantic Salmon Federation. 70 p.

Gingerich, W. and H., Rach, J. 1985. Uptake, biotransformation, and elimination of rotenone by bluegills (*Lepomis macrochirus*). Aquatic Toxicology, 6: 179 – 196

Halfyard, E.A. 2010. A review of options for the containment, control and eradication of illegally introduced smallmouth bass (*Micropterus dolomieu*). Can. Tech. Rep. Fish. Aquat. Sci. 2865: vi + 71 p.

Haukeb, T., Steinkjer, J., Finlayson, B. 2018. Infrared imagery and inert media used in treating upwelling groundwater with rotenone. North American Journal of Fisheries Management. American Fisheries Society. DOI: 10.1002/nafm.10234.

Hill, E., R. Heath, J. Spann, and J. Williams. 1975. Lethal dietary toxicities of environmental pollutants to birds. U.S. Fish and Wildlife Service, Special Scientific Report Wildlife No. 191. Washington, D.C.

Hisata, J.S. 2002. Lake and Stream Rehabilitation: Rotenone Use and Health Risks. Final Supplemental Environmental Impact Statement. Washington Department of Fish and Wildlife, Fish Program, Fish Management Division.

Hobbs, M.S., Grippo, R.S., Farris, J.L., Griffin, B.R., Harding, L.L. 2006. Comparative acute toxicity of potassium permanganate to nontarget aquatic organisms. Environmental Toxicology Chemistry 25:3046-3052.

Huntingdon Life Sciences. 2007. Rotenone, chemical-physical properties TRG0001/072344. Cambridgeshire, PE28, $HS, United Kingdom.

Jarvinen, A., and G. Ankley. 1999. Linkage of effects to tissue residues: development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. Society of Environmental Toxicology and Chemistry Technical Publication Series (ISBN 1-880611-13-9).

Kerr, S.J., Grant, R.E. 1999. Ecological impacts of fish introductions: evaluating the risk. Fish and Wildlife Branch, Ontario Ministry of Natural Resources, Peterborough Ontario.

Kiser, R., Donaldson, J., and P. Olson. 1963. The effect of rotenone on zooplankton populations in freshwater lakes. Transactions of the American Fisheries Society 92(1) 17-24.

Kjaerstad, G. Arnekleiv, J.V., Speed, J.D.M. 2015. Effects of three consecutive rotenone treatments on the benthic macroinvertebrate fauna of the River Ogna, central Norway. River Research and Applications. Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.2873.

MacRae, P.S.D., Jackson, D.A. 2001. The influence of smallmouth bass (*Micropterus dolomieu*) predation and habitat complexity on the structure of the littoral zone fish assemblages. Canadian Journal of Fisheries and Aquatic Sciences 58:342-351.

Marking, L., Bills, T. 1976. Toxicity of rotenone to fish in standardized laboratory tests. Investigations in Fish Control 72. U.S. Fish and Wildlife Service, Washington, D.C.

McCoid, M.J. and Bettoli, P.W. 1996. Additional evidence for rotenone hazards to turtles and amphibians. Herpetol.Rev. 27(2): 70-71

McGann, B.N. 2018. "Recovery of Zooplankton Communities to Whole-Lake Disturbance". Portland State University. *Dissertations and Theses.* Paper 4344.

Mineau, P., B. Collins and A. Baril. 1996. On the use of scaling factors to improve interspecies extrapolation of acute toxicity in birds. Regulatory Toxicology and Pharmacology 24:24-29.

Morbey, Y.E., Vascotto, K., Shuter, B.J. 2007. Dynamics of piscivory by lake trout following a smallmouth bass invasion: A historical reconstruction. Transactions of the American Fisheries Society. 136:477-483.

Nagy, K. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecological Monographs 57:111-128.

Neves, R. 1975. Recolonization of a lake cove treated with rotenone. Transactions of the American Fisheries Society 104(2): 390-393.

O’Donnell, T., Reid, J. 2009. Preliminary data from Miramichi Lake and Lake Brook 2009. Miramichi Salmon Association and Miramichi Watershed Management Committee, August 31, 2009.

O'Sullivan AM, Samways KM, Perreault A, et al. 2020. Space invaders: Searching for invasive Smallmouth Bass (*Micropterus dolomieu*) in a renowned Atlantic Salmon (*Salmo salar*) river. *Ecol Evol*. 2020;00:1–9. https ://doi.org/10.1002/ece3.6088

Pflug, D.E., Pauley, G.B. 1984. Biology of smallmouth bass (*Micropterus dolomieu*) in Lake Squammish, Washington. Northwest Science 58:118-130.

Rotenone Stewardship Program. 2001. Relationship between rotenone use in fisheries Management and Parkinson’s disease. American Fisheries Society, Bethesda, Maryland.

4 pp.

Thomas, R. 1983. Hydrolysis of [6-^{14}C]-rotenone. Borriston Laboratories, Inc. Borriston Project No. 0301A

USEPA. 2006. Environmental fate and ecological risk assessment chapter in support of Phase IV of the reregistration eligibility decision on rotenone. Environmental Risk Branch, Environmental Fate and Effects Division, Office of Pesticide Programs, Washington, DC 20460 (May 24, 2006).

USEPA. 2007. Registration eligibility decision for rotenone, EPA 38-R-07-005. U.S. Environmental Protection Agency, Prevention, Pesticides and Toxic Substances, Special Review and Registration Division, March 2007.

USEPA. 2020. Rotenone: Human Health Risk Assessment for Registration Review (EPA-HQ-OPP-2015 0572-006). United States Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention. Washington, DC. 20460.

van den Heuvel, M., Pater, C., Finlayson, B., and Skaar, D. 2017. Exploring options for eradication of smallmouth bass in Miramichi Lake. Report prepared for the Working Group on Smallmouth Bass Eradication in Miramichi Lake. September 2017.

Vinson, M., and Vinson, D. 2007. An analysis of the effects of rotenone on aquatic invertebrate assemblages in the Silver King Creek Basin, California. Report prepared by Moonlight Limnology for the United States Department of Agriculture, U.S. Forest Service, Humboldt-Toiyabe National Forest, Carson City, Nevada, USA.

Vinson, M., Dinger, E., Vinson, D. 2010. Piscicides and invertebrates: after 70 years, does anyone really know? Fisheries. Vol. 35 No. 2. www.fisheries.org

Westervelt, J. 2007. Lake Davis pike eradication project personal air monitoring report. California Department of Fish and Game, Office of Spill Prevention and Response, Sacramento. 12 pp.

Whelan, J.E. 2002. Aquatic Macroinvertebrate Monitoring Results of the 1995 and 1996 Rotenone Treatments of Manning Creek, Utah. Utah Department of Natural Resources. Publication 02-04.