Working Together to Promote Invasive Species Prevention

Protecting Our Waters from Aquatic Invasive Species, Phase 4 (COL-F18-F-2443)

Prepared for: Fish and Wildlife Compensation Program

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EXECUTIVE SUMMARY

Aquatic invasive species include non-native fish, animal, and plant species that have been introduced into an aquatic ecosystem where they have not been found historically. Aquatic invasive species can spread aggressively and rapidly due to a lack of natural controls, resulting in harmful consequences for native species found in aquatic ecosystems. Priority waterbodies within the Central Kootenay Invasive Species Society operational region were surveyed and monitored for the presence of invasive aquatic and riparian plants and animals, and response plans were implemented where feasible. This project aligns with the Large & Small Lakes Action Plans and the associated actions include, research & information acquisition and monitoring & evaluation.

Full littoral surveys for invasive plants were conducted on Bear, Box, Cottonwood, Fish, Rosebud, Nancy Greene, and Summit Lakes, and points were sampled on Whatshan, Slocan, Lower Arrow, and Duncan Lakes. These surveys resulted in no riparian nor aquatic invasive plants found. On Erie Lake, previously treated patches of fragrant waterlily (*Nymphaea odorata*) and yellow flag iris (*Iris pseudacorus*) were found to be reduced. At Champion Pond (Mel Deanna), of two previously treated patches of *N. odorata,* no plants were detected at one site, and the area and density of plants at the other site was found to be reduced. Watercress (*Nasturtium officinale*) was confirmed to be growing sporadically on the shoreline of Kootenay Lake near Boswell. Aside from this one occurrence of *N. officinale*, no previously undetected species of aquatic invasive plants were detected at other sampling points on Kootenay Lake.

Surveys for zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugenis*) were conducted at thirty-five sites on seventeen waterbodies resulting in the collection of eighty-seven plankton samples. These samples were analyzed at a certified lab using cross-polarized light microscopy to detect any presence of invasive mussel veligers (larvae). Artificial settlement substrates were deployed and monitored at five locations throughout the region to detect the presence of juvenile and adult invasive mussels. Of the eighty-seven analyzed plankton samples, no veligers were detected. Similarly, no juvenile nor adult mussels were present on any of the substrates.

Management and control measures should continue, or be implemented, where they do not currently exist, in order to stop and reverse the continued expansion of populations of aquatic and riparian invasive plants present in the region. At current levels of infestation, mechanical and cultural removal methods are sufficient; however, this could change rapidly if no action is taken. Invasive mussel monitoring should continue on priority waterbodies in

order to detect new infestations early, thereby ensuring a rapid response with the aim of preventing establishment and spread.

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SECTION I. INTRODUCTION

Aquatic invasive species (AIS) include non-native fish, animal, and plant species that have been introduced into an aquatic ecosystem where they have not been found historically. Once introduced, AIS such as fragrant water lily (*Nymphaea odorata*), zebra mussels (*Dreissena polymorpha*) and spiny waterflea (*Bythotrephes longimanus*) can spread aggressively and rapidly due to a lack of natural controls. This can result in harmful consequences for native species found in aquatic ecosystems, by radically altering habitat and rendering it inhospitable (Environment Canada, 2004). AIS have been implicated in vast reductions or the outright extinction of indigenous fish populations, devastating local fisheries (Therriault, Weise, Higgins, Guo, & Duhaime, 2013). Recent studies have shown that the establishment of non-native species can facilitate the survival of other non-native species thereby amplifying invasions in what is referred to as the invasional meltdown hypothesis (Adams, Pearl, & Bury, 2003). Considering this, the need to prevent the introduction of any new non-native species into Columbia region waterbodies is heightened. The risk of AIS introductions to British Columbian waters is escalating rapidly, due to a number of anthropogenic factors, including but not limited to, water-based recreation/tourism, illegal dumping of horticultural and aquarium species, and increased global trade (Levine & D'Antonio, 2003; Hulme, 2009).

The risk of AIS introductions to British Columbian waters is escalating rapidly, as it is elsewhere in the country with approximately 15 non-native species becoming established in Canadian waters every decade (Canadian Council of Fisheries and Aquaculture Ministers Aquatic Invasive Species Task Group, 2004). All waterbodies in the Columbia basin specifically, have been assigned a high to very high risk status for the survival and subsequent invasion of zebra and quagga mussels (ZQM) (Therriault, Weise, Higgins, Guo, & Duhaime, 2013). Furthermore, freshwater ecosystems in general are more vulnerable to AIS than terrestrial ecosystems (Vander Zanden & Olden, 2008). This increased vulnerability, coupled with the inability to utilize chemicals for control or eradication, emphasizes the critical importance of preventative and early-detection activities.

The threat of AIS to waterways in the Kootenay region is also increasing with 25 invasive mussel fouled watercraft intercepted at the provincial watercraft inspection stations in 2017. While only one of the 25 fouled watercraft intended to launch in Kootenay waters, only one watercraft transporting viable ZQM is needed to cause permanent, biological pollution to a waterway. Moreover, species such as virile crayfish (*Orconectes virilis*), parrotsfeather (*Myriophyllum aquaticum*), and flowering rush (*Butomus umbellatus*) have been confirmed in neighbouring jurisdictions (Stewart, 2014; Noxious Weed Control Board, 2016; U.S. Department of the Interior, 2018). A number of AIS are currently present in the Central

Kootenay Invasive Species Society (CKISS) region including, but not limited to, *M. spicatum*, *N. odorata,* and American bullfrog (*Lithobates catesbeianus*), which presents an ongoing risk that these species will be accidentally or intentionally introduced to uninfested waterbodies within the region. Should new introductions of AIS remain undetected for an extended period, they may cause significant damage to the ecosystem before they are managed. A delayed detection and response time can greatly increase costs and reduce effectiveness of control methods while potentially increasing the AIS in question's range of establishment. To address the risk of new introductions, the provincial government has developed an Early Detection Rapid Response (EDRR) Plan[1] in order to find, identify, and systematically eradicate, contain or control new invasive species before they can reproduce and disperse beyond their point of entry, thereby substantially reducing control efforts and costs. This same concept can be applied to smaller geographic units including individual waterbodies ensuring that small, localized infestations are discovered promptly and treated where feasible.

In 2012, representatives from FortisBC Inc., Teck Metals Ltd., BC Ministry of Environment, and Slocan Lake Stewardship Society (past members of the CKISS Aquatics Working Group) carried out the Columbia and Kootenay Sentinel (Calcium and Dreissenid Larvae) Monitoring Program[2]. This program surveyed for the presence of non-native, highly invasive ZQM veligers in Slocan, Kootenay, Upper and Lower Arrow Lakes, and Pend D'Oreille and Lower Columbia Rivers. This was the first time that surveys for these species occurred at a widespread scale in the Columbia region.

In 2014, the Canadian Columbia Basin Regional Aquatic Invasive Species Program was initiated by multiple partners and stakeholders to address the ecological, economic, and social impacts of AIS in a proactive and collaborative way. Through this partnership, a guiding framework document[3] was developed for use by all steering committee members and their partners, to create new, or expand current, AIS programs to achieve common goals in a coordinated manner.

From 2014 - 2017, with support from the FWCP, four phases of the "Protecting Our Waters from Aquatic Invasive Species" project were delivered throughout the CKISS region resulting in the coordination and delivery of an extensive AIS monitoring program. Throughout these project phases, surveying for high priority AIS has occurred in 30 waterbodies. Highlights include:

[1] https://www.for.gov.bc.ca/hra/invasive-species/Publications/Prov_EDRR_IS_Plan.pdf

[2] https://ckiss.ca/wp-content/uploads/2015/04/Zebra-Quagga_mussel_2012_EDF_final.pdf

[3] https://ckiss.ca/wp-content/uploads/2015/04/Use-This-Version-ONLY-2016-CB_AIS_Regional_Program_Framework_FNLRevised-April2016.pdf

- Monitoring of 52 sites on 22 waterbodies resulting in the collection of 272 plankton samples and analyzed for any presence of ZQM. Result: to date, no veliger, juvenile, nor adult ZQM have been detected.
- Twenty-nine waterbodies have been surveyed for high priority regional and provincial invasive aquatic plants. Result: these surveys have detected new or manageable infestations of *N. odorata, N. officinale*, and *I. pseudacorus.*
- Promotion of Clean, Drain, Dry; Don't Let it Loose; and PlantWise best practices through 26 radio interviews, 31 print articles, 5 online articles, 3 television interviews, 3 paid advertisements, and over 29,000 people reached in-person at community events.

SECTION II. GOALS AND OBJECTIVES

The objective of this project was to ensure productive and biologically diverse aquatic ecosystems within the Central and West Kootenay region. The goals of this project were to develop and implement an invasive species monitoring and response plan for the purposes of research and information acquisition, and to conduct invasive species surveys and monitoring for the purposes of monitoring and evaluation through the implementation of the following actions:

- Surveying for over 40 high priority provincial and regional AIS
- Monitoring and managing, where feasible, existing infestations of invasive aquatic plants for the purposes of eradication or containment
- Collaborating with relevant partners to engage in EDRR plans should certain high priority species be detected
- Supporting regional, provincial, and cross-border initiatives to allow for coordinated delivery of key messaging and the promotion of best practices
- Increasing education and awareness of AIS across a broad spectrum of audiences

SECTION III. STUDY AREA

The study area for this project was the Central Kootenay Invasive Species Society operational region, which is approximately 30,500 km^2 (Figure 1). This region is located in the southwestern portion of the Canadian Columbia River basin.

Surveys for invasive aquatic and riparian plants were conducted in Summit, Box, Rosebud, Cottonwood, Slocan, Whatshan, Lower Arrow, Duncan, Kootenay, Erie, Nancy Greene, Fish and Bear Lakes, and Champion Ponds.

Surveys for invasive mussels were conducted on Whatshan, Summit, Slocan, Rosebud, Nancy Greene, Kootenay, Fish, Erie, Duncan, Cottonwood, Champion, Box, and Upper and Lower Arrow Lakes, and on the Columbia, Kootenay, and Pend D'Oreille Rivers.

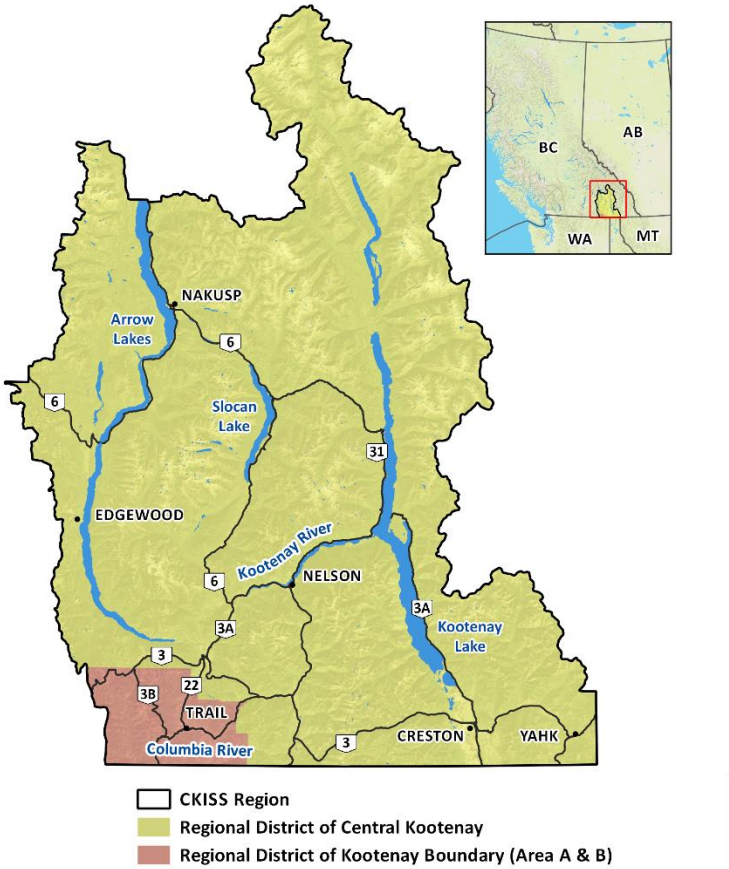

Figure 1. Map of the Central Kootenay Invasive Species Society Region.

SECTION IV. METHODS

ZEBRA AND QUAGGA MUSSEL VELIGER MONITORING

Monitoring for ZQM veligers occurred during the months of July, August, and September. All survey techniques were in accordance with the *British Columbia Aquatic Invasive Species Survey Methods*[4] developed by the BC Ministry of Environment (MoE). Waterbodies that were selected for invasive mussel monitoring were those deemed to be high priority according to a risk-ranking matrix developed by the Canadian Columbia Basin Regional Aquatic Invasive Species Program Steering Committee (Appendix A). Waterbodies are ranked according to their probability for AIS introductions and the severity of consequence of AIS establishment and spread. In addition, several of the waterbodies selected for ZQM sampling are those listed in the FWCP's Large and Small Lakes Action Plans as high priority.

In total, thirty-five sites were monitored in 2017 (Table 1). At all monitoring sites, a 64-micron plankton net was deployed into the water to a maximum depth of six metres, and not less than one metre for vertical tows, or to a distance of six metres for horizontal tows. Multiple plankton tows were collected at each site to increase the likelihood of collecting veligers. Plankton tows were also collected in different areas of the site to further increase the likelihood of collecting veligers. Samples were condensed into collection bottles and preserved for shipment to a certified analyst (recommended by MoE) to detect any presence of ZQM veligers.

All ZQM monitoring data was submitted to the MoE, who is responsible for entering the data into the Pacific States Marine Fisheries Commission online database, and other relevant databases, where applicable.

Table 1. Locations where zebra and quagga mussel veliger sampling was conducted throughout the Central Kootenay Invasive Species Society region, 2017.

Waterbody	Common site name	UTM
Columbia River	Gyro Park, boat launch	11 U 448332 E 5439045 N
Columbia River	Robson, boat launch	11 U 449159 E 5464857 N
Slocan Lake	New Denver, boat launch	11 U 472925 E 5536943 N

[4] https ://www.for.gov.bc.ca/hra/invasive-species/Publications/BC_Aquatic_Sampling_March2015.pdf

Slocan Lake	Silverton, boat launch	11 U 473994 E 5533621 N
Slocan Lake	Slocan, boat launch	11 U 465959 E 5513126 N
Kootenay Lake	Kokanee Creek Provincial Park, boat launch	11 U 491741 E 5495260 N
Kootenay Lake	Lakeside Park, boat launch	11 U 479610 E 5484065 N
Kootenay Lake	Kaslo Marina	11 U 506611 E 5529018 N
Kootenay Lake	Riondel Marina	11 U 510285 E 5513027 N
Kootenay Lake	Kuskanook Marina	11 U 524508 E 5460867 N
Kootenay Lake	Kokanee Park Marina	11 U 491872 E 5495299 N
Kootenay Lake	Kootenay Lake Provincial Park, Lost Ledge Site, boat launch	11 U 504379 E 5549941 N
Upper Arrow Lake	Nakusp, boat launch	11 U 443096 E 5565192 N
Upper Arrow Lake	McDonald Creek Provincial Park, boat launch	11 U 442048 E 5553611 N
Upper Arrow Lake	Burton campground boat launch	11 U 436445 E 5538249 N
Upper Arrow Lake	BC Hydro boat launch	11 U 434086 E 5535105 N
Lower Arrow Lake	Syringa Creek Provincial Park, boat launch	11 U 436701 E 5465721 N
Lower Arrow Lake	Scottie's Marina	11 U 439768 E 5465856 N
Pend D'Oreille River	Buckley campground, boat launch	11 U 464006 E 5431944 N

Summit Lake	Summit Lake Provincial Park, boat launch	11 U 453147 E 5556255 N
Box Lake	Boat launch	11 U 449195 E 5561760 N
Nancy Greene Lake	Boat put-in	11 U 431491 E 5456489 N
Rosebud Lake	Boat launch	11 U 480291 E 5432470 N
Fish Lake	Boat put-in	11 U 487081 E 5543753 N
Erie Lake	Boat launch	11 U 474320 E 5448793 N
Whatshan Lake	Public beach boat launch	11 U 419513 E 5532383 N
Whatshan Lake	Whatshan Lake campground, boat launch	11 U 419359 E 5530889 N
Whatshan Lake	Stevens Creek Rec. Site, boat launch	11 U 422021 E 5548621 N
Whatshan Lake	Richy Rec. Site, boat put-in	11 U 422330 E 5546808 N
Cottonwood Lake	Boat launch	11 U 481482 E 5475302 N
Duncan Lake	Howser Creek Rec. Site, boat launch	11 U 503977 E 5572259 N
Duncan Lake	Glacier Creek Regional Park, boat launch	11 U 505405 E 5569673 N
Kootenay River	Taghum boat launch	11 U 472098 E 5481542 N
Kootenay River	Slocan pool, boat put-in	11 U 462108 E 5476393 N
Champion Lake	Third lake, boat launch	11 U 455434 E 5448363 N

Zebra and Quagga Mussel Juvenile and Adult Monitoring

Monitoring for ZQM at the juvenile and adult life stages was conducted by means of substrate samplers. The installation of substrate samplers was dependent on approval from the appropriate authority, public safety, and depth requirements. In 2017, five substrate samplers were in place at various locations throughout the CKISS region (Table 2). Three of the substrates were the responsibility of the CKISS, and were installed and monitored in accordance with the *British Columbia Aquatic Invasive Species Survey Methods* during the months of July, August, and September. Substrates that were donated by CKISS to regional partner organizations were monitored and maintained on a regular basis as per the training provided by the CKISS.

High boat traffic areas were chosen for substrate installation as the overland transport of contaminated watercraft is the primary vector for ZQM. Substrate samplers were deployed in covered areas (e.g. undersides of docks) with some water flow, and as deep as possible (up to 8 m). Samples were collected from substrates only if suspect organisms were seen or felt. When monitoring the installed substrates, which are a small surface area, the opportunity was taken to check additional nearby substrates (e.g. docks, pilings, boat hulls, etc.), as well as the shoreline, for any presence of ZQM.

Table 2. Locations of substrate sampling equipment for zebra and quagga mussel monitoring throughout the Central Kootenay Invasive Species Society region, 2017.

Waterbody	Common site name	Nearest town	UTM	Monitoring Organization
Kootenay Lake	Kuskanook Marina	Creston	11 U 524508 E 5460867 N	CKISS
Lower Arrow Lake	Scottie's Marina	Robson	11 U 439768 E 5465856 N	CKISS
Kootenay Lake	Riondel Marina	Riondel	11 U 510285 E 5513027 N	Eastshore Freshwater Habitat Society
Kootenay Lake	Tye Marina	Ymir	11 U 515246 E 5464080 N	Nature Conservancy of Canada
Kootenay Lake	Kokanee Park Marina	Nelson	11 U 491872 E 5495299 N	CKISS

Aquatic Invasive Plants

All aquatic invasive plant surveys were carried out in accordance with the *British Columbia Aquatic Invasive Species Survey Methods* protocols developed by MoE for littoral or shoreline surveys. A list of target aquatic and riparian plant species for the province is provided in Appendix B. This list was provided by the Provincial EDRR Coordinator with the Ministry of Forests, Lands, Natural Resource Operations and Rural Development prior to commencing surveying. Waterbodies identified were ranked in priority based on a variety of factors including, but not limited to, ease of access for illegal dumping (lakes on major routes with rest stops), gaps in past survey data, popular public boat launches (provincial parks), and those listed in the FWCP's Small Lakes Action Plan as high priority. Occurrences of invasive plants were recorded following provincial protocols and data will be entered into the provincial Invasive Alien Plant Program database.

The entire littoral zones of Rosebud, Nancy Greene, Erie, Summit, Box, Fish, and Bear Lakes were surveyed. Sections of the littoral zones of Whatshan, Duncan, Kootenay, and Slocan Lakes near high-risk areas (boat launches, marinas, recreation sites) were also surveyed. For littoral surveys a hard rake was deployed at 100 m intervals from a watercraft (motorized when possible) retrieving plants from the substrate. At each sampling point UTM's, depth, substrate, plants found (native and non-native), and other relevant data (riparian usage, flow, inflow creeks, etc.) was recorded. The riparian zone was also scanned for the presence of target invasive plants. The shoreline method was utilized at Champion Ponds, as boat access is challenging, and sections of Lower Arrow, Kootenay, and Duncan Lakes due to extreme winds. For this method, the rake was tossed from shore at 25 m intervals and UTM's, substrate, and plants present were recorded. The shoreline was also scanned for the presence of invasive plant fragments.

Modified surveys were conducted at two sites where invasive plant sightings were reported by concerned citizens to determine the extent of colonization. In Boswell (eastside of Kootenay Lake), where *N. officinale* was confirmed in 2016 in a small creek, the shoreline of Kootenay Lake at the outflow of this creek was surveyed by watercraft to determine the extent of the colonization. In Champion Ponds, where *N. odorata* was reported and identified in 2016, a small kayak was used to survey the main section of the pond. Many areas of Champion Ponds were inaccessible by kayak due to its complexity and large amount of semi-submerged woody debris. These sections of the pond were surveyed from shore where accessible and with the aid of binoculars from vantage points along the path that encircles the wetland. Particular attention was paid to the outflow and around the main entrance and major access points.

Known infestations of *I. pseudacorus* were mechanically treated by the Salmo Watershed Streamkeepers Society within Erie Lake (the CKISS provided a stipend for their efforts). Seed heads were removed from any remaining plants at the time of surveying. In 2017, a member of the public reported a sighting of *I. pseudacorus* at Summit Lake, so particular attention was given to the shoreline throughout the bay in which the sighting occurred.

Education and Outreach

The CKISS engaged in various outreach activities for community engagement, and in media directed at specific target audiences and the general public to raise awareness about AIS through education, and to promote the province-wide Clean, Drain, Dry; Don't Let it Loose; and PlantWise programs. Outreach strategies associated with these programs to prevent human-caused AIS introductions are based on the concept of community based social marketing, whereby key messages are promoted to encourage specific behaviours.

The CKISS also developed and delivered two workshops titled, "Teaching about Native and Invasive Species" for primary school teachers. The workshop focused on developing new, or modifying existing school programs to be in line with the updated B.C., K-12 curriculum by including place-based learning, community connections, "big ideas", and curricular competencies.

The CKISS would like to acknowledge that the FWCP's generous contribution was recognized at all relevant events and media opportunities. In addition, the FWCP logo is present on all associated presentation materials and on the CKISS 'Has your watercraft been outside of BC in the last 30 days?' rackcard and 'Protect our Waters' brochure.

Section V. Results and Outcomes

Zebra and Quagga Mussel Monitoring

In 2017, the CKISS collected eighty-seven plankton samples. A certified analyst, approved by MoE, analyzed samples for any presence of ZQM veligers using cross-polarized light microscopy. Subject matter experts in many jurisdictions have identified this method as the standard method that is required for veliger detection and appropriate monitoring for ZQM. The results of all samples were negative for ZQM veliger presence. For all of the submerged substrate samplers that were installed in the region, no juvenile nor adult ZQM were detected.

Aquatic Invasive Plants

Survey data for each sampling point is presented in the attached MS Excel workbook titled "CKISS AIS Sampling Points 2017" with a separate worksheet allotted to each waterbody. Also included in each worksheet are Secchi depths, elevations, dates, and access points for

each waterbody. All points sampled on Rosebud, Summit, Box, Fish, Bear, Cottonwood, Nancy Greene, Duncan, Whatshan, Slocan, and Arrow Lakes were free of invasive plants, both riparian and aquatic.

At Erie Lake, known infestations of *N. odorata* were monitored. These sites were treated mechanically in 2016 and have shown a significant decrease in size or density. All three patches of this plant at Erie Lake remained relatively unchanged in area, but the density of plants has been reduced. The clump of *N. odorata* (discovered and treated in 2015 and 2016) on the west side of the boat launch has been reduced to three leaves and exhibited no flowers. No new patches of *N. odorata* were discovered at Erie Lake in the course of the littoral survey. This suggests that there is a small portion of rhizome remaining in the substrate. The larger clumps present to the east of the boat launch (Figure 2) have had a very minor reduction in area (<5 m^2), but there are now gaps of open water between the leaves. Each of these patches now covers an area of approximately 20 m^2. Previously these clumps were continuous mats of leaves and flowers with no visible patches of water between them. No new patches of *N. odorata* were discovered at Erie Lake in the course of the littoral survey. The two known sites of *N. odorata* discovered in Champion Ponds in 2016 were also monitored. The area directly in front of the A-frame, where several small clumps were present in 2016, was free of plants. This area had also been dewatered as a result of an extremely dry summer. This may have contributed to the disappearance of this species from this sampling point. The larger infestation of *N. odorata* at Champion Ponds had been substantially reduced in area from 22 m^2 to approximately 14 m^2. When visited in 2016, a section of plants was inaccessible for treatment due to the depth of the water (2 m).

At Nancy Greene Lake, a lone patch of this plant has been mechanically treated since 2014, exhibiting a drastic reduction in size year after year. During this field season, no *N. odorata* plants were found growing in this lake. In addition to being free of *N. odorata,* no *I. pseudacorus* plants were found for the third year in a row. At Summit Lake, no *I. pseudacorus* plants were found in the course of a littoral survey of the lake. The member of the public who reported the sighting also mechanically removed the plant, and the removal effort appeared to be complete and successful.

On Erie Lake, clumps or individual *I. pseudacorus* were present at 19 separate sampling points. This is a small decrease in the number of sites observed in 2016, but an increase from 2015 (Figs. 2, 3, 4). A number of single, individual plants were located on the northeast shore and near the outflow of the lake, while larger patches were located on the west and southwest shoreline.

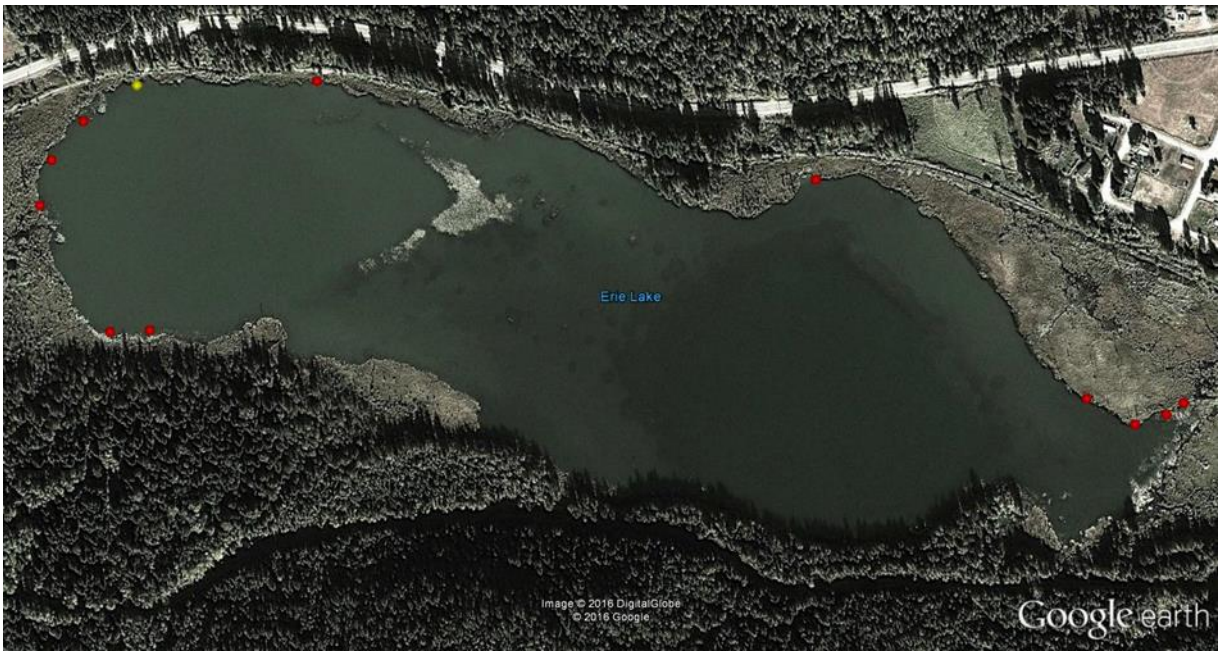

Figure 2. Sampling points on Erie Lake from 2015 indicating presence of ● Iris pseudacorus and ● Nymphaea odorata.

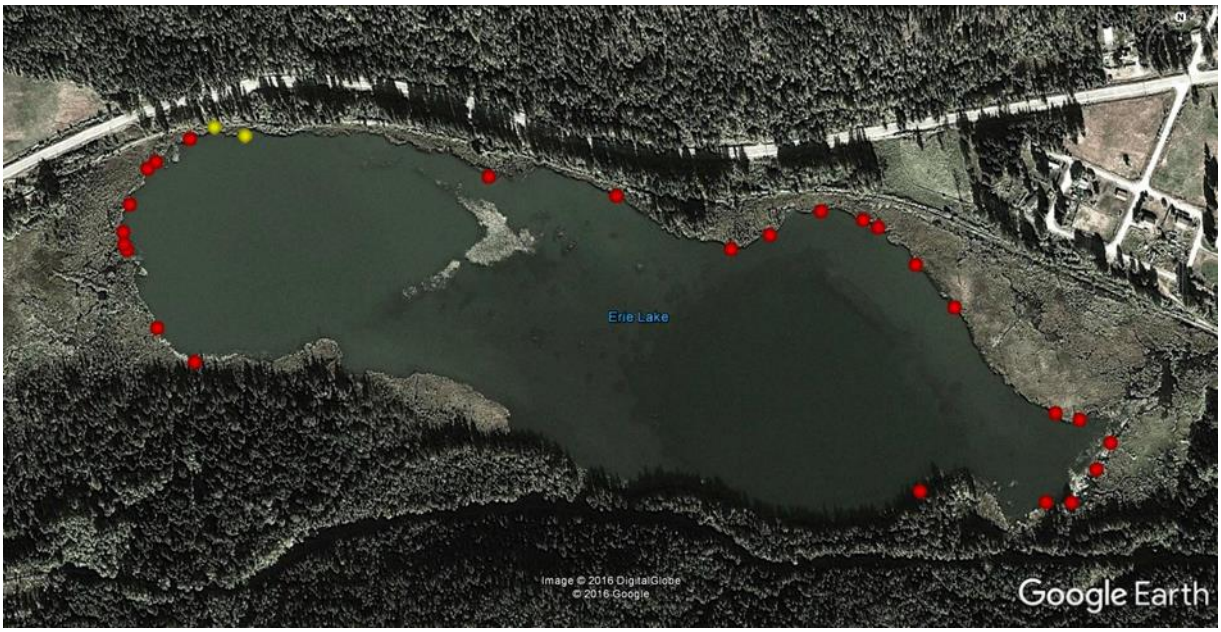

Figure 3. Sampling points on Erie Lake from 2016 indicating presence of ● Iris pseudacorus and ● Nymphaea odorata.

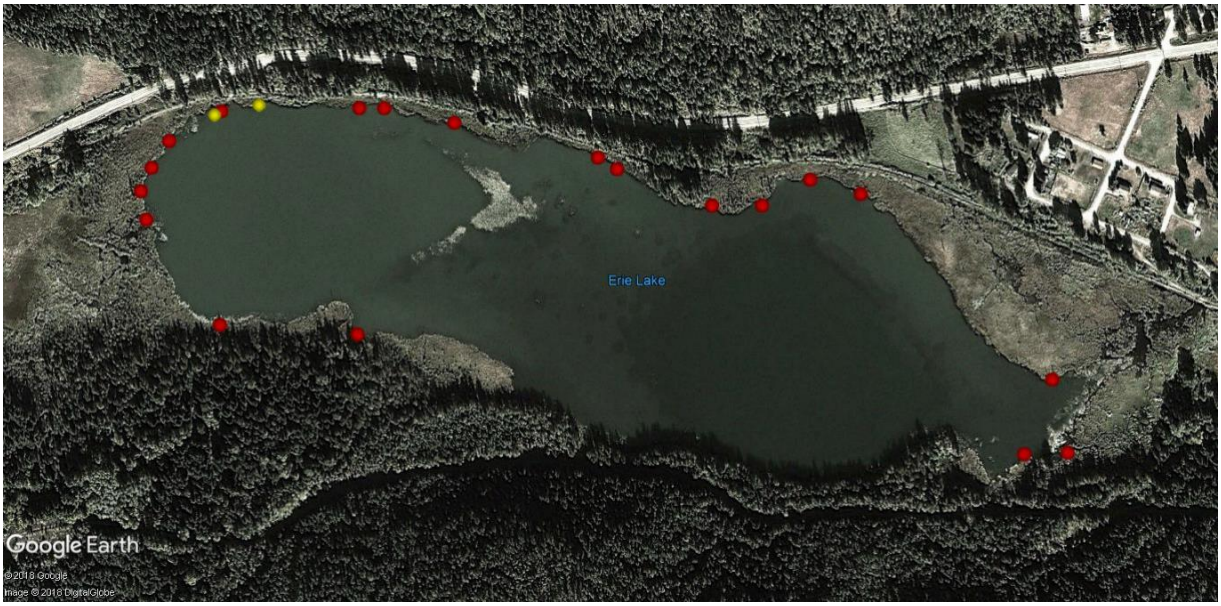

Figure 4. Sampling points on Erie Lake from 2017 indicating presence of ● Iris pseudacorus and ● Nymphaea odorata.

N. officinale was confirmed to be growing in a small creek and ditch on Hepher Road close to the community of Boswell in 2016. The shoreline of Kootenay Lake at the outflow of this creek was surveyed and *N. officinale* was growing sporadically for 10 – 15 m on either side of the creek. *P. crispus* and *M. spicatum* were present at numerous sampling points on Kootenay Lake. No *M. spicatum* plants nor fragments were found at any sites north of Shroeder Creek, suggesting that it may still not have established in the north end of Kootenay Lake. Numerous small, immature *Myriophyllum sp.* were discovered growing at the swim beach area at Kokanee Creek Provincial Park.

Education and Outreach

Education and outreach activities are a cornerstone of the CKISS, and over the course of the year, we engaged in thirty-one community events that allowed us to reach over 9,500 people directly to raise awareness about AIS and the best practices that prevent their introduction and spread (Table 3). In addition to our dynamic website, which had 75,698 visits in 2017, the CKISS also produced a range of print and online articles, two paid advertisements in the Kootenay Mountain Culture, installed 5 Clean, Drain, Dry billboards in the region, and conducted several radio interviews (Table 4).

Table 3. Education and outreach activities delivered by the Central Kootenay Invasive Species Society for aquatic invasive species awareness, 2017.

Date	Details	Target Audience	Number of people reached
March 25 & 26	Hosted CKISS education booth: Fly Fishing Symposium	Anglers	900
April 3	Workshop: Teaching about Native and Invasive Species	School teachers	11
April 28 & 29	Hosted CKISS education booth: Creston spring trade show	General public	2200
May 5 & 6	Hosted CKISS education booth: BC Wildlife Federation Annual Convention	Anglers/Hunters/Outdoor Recreationalists	200
May 10	Event: Habitat Restoration	Youth	50
May 12	Presentation: Adopt a Highway volunteers	General public	8
May 13	Hosted CKISS education booth: Critter Day	Youth	562
May 13	Hosted CKISS education booth: Eco Society garden fest	General public	800
May 17	Event: Nakusp Education Day	Youth	85
May 23	Event: Bio Blitz 2017	Youth	210
May 26	Event: Sustainable Jobs Fair	Youth	220
May 27	Hosted CKISS education booth: Castlegar garden fest	General public	100
May 31	Presentation: Columbia Basin Environmental Educators Network	Teachers/environmental educators	45
June 1 & 2	Workshop: Community Based Social Marketing (CBSM)	Environmental educators	40
June 2 & 3	Hosted CKISS education booth: Sunfest	General public	3000
June 6	Event: Habitat Restoration	Youth	43
June 7	Presentation: FWCP Board of Directors	Topic: Aquatic invasive species programs	10
June 22	Event: Habitat Restoration	Youth/Wildsight Educator	25
June 17	Hosted CKISS education booth: Champion Lake Fishing Derby	Anglers	42
June 18	Hosted CKISS education booth: Cottonwood Lake Fishing Derby	Anglers	20
July 10	Presentation: Placed Based Consciousness and Inquiry	School teachers	25
August 3	Event: Aquatic invasive species education	Youth	50
August 27	Hosted CKISS education booth: Redfish Festival	General public	500
August 29 & 30	Hosted CKISS education booth: Toadfest	General public	200
September 19	Event: Habitat Restoration	Youth	31
October 11	Event: Aquatic invasive species education	Youth	8
October 21	CKISS Annual General Meeting	Members & general public	24
November 1	Hosted CKISS education booth: CBSM surveys	General public	50
November 14	Hosted CKISS education booth: CBSM surveys	General public	50

November 23	Presentation: Aquatic Invasive Species	2nd Year RFW students, Selkirk College	32
February 9, 2018	Workshop: Teaching about Native and Invasive Species	School teachers	6

Table 4. Mass media activities delivered by the Central Kootenay Invasive Species Society for aquatic invasive species awareness, 2017.

Date	Details	Topic	Number of people reached
April 20	Radio Interview: The Goat FM	Zebra & quagga mussels	-
April 24	Radio Interview: EZ Rock	Zebra & quagga mussels	200,000
April 25	Radio Interview: CBC Daybreak South	Zebra & quagga mussels	-
April 27	Print Article: The Nelson Star	Zebra & quagga mussels	Distribution: eight communities
April 27	Online Article: BC Local News	Zebra & quagga mussels	-
May 3	Online Article: The Nelson Daily	Invasive Species Action Month	100,000 online viewers monthly
May 3	Online Article: The Rossland Telegraph	Invasive Species Action Month	100,000 online viewers monthly
May 3	Online Article: The Castlegar Source	Invasive Species Action Month	100,000 online viewers monthly
May 30	Print Article: Arrow Lakes News	Clean, Drain, Dry; zebra & quagga mussels	Distribution: eight communities
June 22	Radio Interview: EZ Rock	CKISS programs update & membership drive	200,000
July 13	Print Article: Castlegar News	Teaching about Invasives in the new BC Curriculum	Distribution: eight communities
July 17	Radio Interview: Juice FM	Mapping yellow flag iris with drones; PlantWise program	-
July 21	Radio Interview: EZ Rock	Mapping yellow flag iris with drones; PlantWise program	200,000
July 21	Print Article: Creston Valley Advance	Mapping yellow flag iris with drones; PlantWise program	Distribution: five communities
September 11	Print Article: Arrow Lakes News	PlantWise program & yellow flag iris	Distribution: eight communities
September 18	Online Article: Kootenay Mountain Culture	Zebra & quagga mussels; Clean, Drain, Dry program	-
October 12	Print Article: The Nelson Star	Invasive knotweeds	Distribution: eight communities
October 17	Radio Interview: Eco Centric Radio Show	Invasive knotweeds	25,000
October 12	Radio Interview: Juice FM	Invasive knotweeds	-
October 30	Radio Interview: EZ Rock	CKISS field season summary	200,000
2017	Advertisement: Kootenay Mountain Culture Magazine	Clean, Drain, Dry & PlayCleanGo	Distribution: 12,500 publications

April 2018	Billboard: Clean, Drain, Dry	Billboards installed in Creston, Nelson, Castlegar, Rossland, Grand Forks	-

SECTION VI. DISCUSSION

The result of treating the small infestations of *N. odorata* and *I. pseudacorus* at Nancy Greene Lake highlights the importance and effectiveness of the EDRR program. The patch of *N. odorata* was discovered as a single dense mat in 2014 and was immediately mechanically treated by removing all floating leaves and flowers and digging the rhizome from the substrate. It was treated again in the fall of 2014, and again in 2015 and 2016, resulting in no *N. odorata* plants being found on this lake in 2017. A small clump of *N. od*orata in Champion Ponds that was treated in 2016 was also absent at the time of this survey. Preliminary results indicate that these species may have been eradicated from Nancy Greene Lake with a relatively small effort and cost. In contrast, Hicks Lake in Washington State (where *N. odorata* covers approximately 10 ha of the littoral zone) has an estimated annual treatment cost of $8,000.00 USD using herbicides, while manual treatment of this lake has been calculated to be in excess of $60,000.00 USD (Herrara Environmental Consultants, 2016). The littoral zones of Erie and Nancy Greene Lakes that are susceptible to colonization by *N. odorata* are 18 ha and 7.5 ha respectively.

If left to grow unchecked, *N. odorata* will rapidly colonize the entire littoral zone up to a depth of approximately 2.75 m. The littoral zone provides critical habitat for native plants, wildlife, fish, and invertebrates. The leaves and flowers produced from a single rhizome can cover up to 15 m^2 of the water surface in as little as five years (Seago Jr, Peterson, Kinsley, & Broderick, 2000). Champion Pond, Erie Lake, and Nancy Greene Lake are all highly vulnerable to extensive colonization by *N. odorata* due to their large areas of shallow littoral habitat. *N. odorata* can have negative impacts on many levels of organization, including population, community, and ecosystem. This species also acts as an ecosystem engineer, which is any organism that significantly modifies or destroys the native physical habitat. Large mats of floating leaves decrease available sunlight, prevent mixing of the littoral zone by wind, and increase water temperatures resulting in an altered pH and lower levels of dissolved oxygen (Northey, 2014). The large amount of decaying leaves undoubtedly adds a significant amount of detritus to the benthic zone altering the benthos and substrate composition. Preventing the spread of *N. odorata* throughout the littoral zone therefore ensures the protection of native fish and associated wildlife communities while preserving ecosystem function.

The populations of *I. pseudacorus* at Erie Lake and Champion Ponds were most likely well established prior to detection, thereby eliminating rapid response opportunities. There are

other contributing factors to the expanding populations of *I. pseudacorus* in Erie Lake, including a larger proportion of suitable habitat around the shoreline. The majority of the shoreline at Nancy Greene Lake is mildly sloping, dry, and forested. In contrast, Erie Lake is dominated by areas of moist, low gradient, marsh-like substrate, providing a large amount of suitable habitat for the establishment and proliferation of this plant. This is also the case at Champion Ponds. The presence of many new individual plants arising at different locations at Erie Lake (Figs. 2, 3, 4) suggests that there may be a persistent seedbank present, or that new seeds are being released. Unfortunately, there is a lack of information available on the persistence of *I. pseudacorus* seeds in the soil (Stone, 2009). Removal efforts by a team of volunteers from the Salmo Watershed Streamkeepers Society has been ongoing for several years; the CKISS will be assisting with removal efforts more directly in 2018, to ensure proper removal.

N. officinale can become highly invasive, outcompeting native species, but is generally restricted to freshwater streams that are colder and gently flowing (Barker, 2009). This species is also considered an ecosystem engineer, creating a dense mat that can block stream flow and cause flooding (Les & Merhoff, 1999). The suitable habitat for *N. officinale* is most likely minimal and the plant is currently confined to a narrow sporadic band along the shoreline of Kootenay Lake. Its growth does not appear to be impeding the flow of water in the ditch along Hwy 3A and Hepher Road. The plant begins growing as the small creek exits the woods from a private property, indicating that it has most likely escaped from an intentional planting in a water garden. This will present a problem with control, as there may be a continuous input of seeds. There is a continued risk of this plant being transported to other areas where impacts may be increased. Watercraft, wind and water currents, birds and other wildlife, as well as intentional movements by humans can spread *N. officinale.*

The Kootenay-Columbia system also presents great challenges in managing existing populations of *M. spicatum* and *P. crispus.* Previous studies have confirmed *M. spicatum* to be present in the Kootenay and Pend D'Oreille Rivers in Idaho and in Lake Revelstoke, thus providing a constant input of plant materials (AquaTechnex, 2007; Madsen, Wersal, & Woolf, 2015; Harkness, 2015). Hybrid milfoils (crosses between *M. spicatum* and native *M. sibricum*) have recently been confirmed to be present in many lakes in northern Idaho (Thum, 2016). These hybrids have been shown to have the potential to be more invasive than pure *M. spicatum* lineages (LaRue, Zuelig, Netherland, Heilman, & Thum, 2012). At many sampling points on Kootenay Lake where *M. spicatum* is growing, native milfoils are also present (Vogel, Fraser, & Harkness, 2015). Data compiled by Thum (2016) suggest that Idaho hybrids are resulting from independent hybridization events that occurred in or near Idaho. Hybrids may therefore be entering the Kootenay-Columbia system from Idaho or from Lake Revelstoke via Arrow Lakes, or local hybridization may be occurring.

Through engagement in various outreach methods and media activities, such as, but not limited to, community events, field tours, presentations, and interviews, the CKISS disseminated thousands of educational resources; raised awareness about AIS and their ecological, economic, and social impacts; improved the public's ability to identify and report AIS; promoted best practices such as Clean, Drain, Dry (water-based recreationists), Don't Let it Loose (pet and aquarium owners), and PlantWise (gardeners and horticulture industry); and brought attention to the purposes of and legislation associated with the provincial mandatory watercraft inspection stations. These activities provide the opportunity for Columbia Basin residents to play an important role in preventing the introduction of new AIS, as well as reducing or eliminating the spread of existing AIS.

The preventative actions associated with the aforementioned programs can drastically reduce the introduction and spread of AIS, and because human activities, such as the movement of AIS fouled watercraft from one body of water into another, pose the greatest risk for AIS movement between in-land waterways (Canadian Council of Fisheries and Aquaculture Ministers Aquatic Invasive Species Task Group, 2004), the absence of ZQM suggests that education about AIS and best practices is effective at preventing the introduction of these species into the region's waterways. New infestations of invasive plants (*N. odorata*, *N. officinale, I. pseudacorus*) that have been confirmed based on reports by concerned citizens educated in the threat of invasive species provides further evidence that public education and outreach efforts contribute positively to preventing the establishment and further spread of AIS. This in turn contributes to the conservation of the biodiversity and overall ecological integrity of the region's waterbodies.

The Central and West Kootenay region has an abundance of freshwater ecosystems, most of which are still free from the negative impacts caused by AIS. These waterbodies provide many social benefits for the local communities in addition to the economic benefits that are derived from the water-based recreational opportunities that generate tourism. Many local businesses rely on the income generated by sport fishing, rafting, watercraft rentals, moorage and marina usage. However, the presence of non-native, invasive aquatic plant and animal species can negatively impact the aforementioned benefits by reducing or eliminating recreational opportunities, as well as reducing waterfront property values and degrading water quality, thereby affecting drinking water sources (The Lake Superior Work Group of the Lake Superior Lakewide Action and Management Plan, 2014). Furthermore, water-based infrastructure that is contaminated with AIS requires increased maintenance and these additional costs impact regional economies (Alley, Simes, & Lemon, 2017). Therefore, by changing people's behaviours through education on the best practices that prevent the movement of AIS, and through pro-active monitoring and management activities, this program is protecting the social and economic values of the region.

The introduction of ZQM would have many profound ecological impacts. Invasive mussels reduce planktonic food available for pelagic fish species, such as juvenile sockeye/kokanee salmon, and invasive mussels have extirpated native mussel species in other areas. The introduction of invasive mussels has been identified as one of the main threats to the persistence of the SARA-listed Rocky Mountain Ridged Mussel in the Columbia River basin (BC Inter-Ministry Invasive Species Working Group, 2018). Invasive mussels are extremely problematic to control, and virtually impossible to eradicate once they have become established and widespread in a waterbody. These mussels have been present in North America since 1986 and yet there has been only one documented case of a complete eradication of an established population from a waterbody. In this case, the waterbody was small and contained, and eradication was achieved by application of 174,000 gallons of potassium chloride solution (Heimowitz & Phillips, 2014). The current lack of chemicals approved for open water use reduces the options available for eradication in BC, and in turn highlights how critically important it is that ZQM be detected via early detection methods at the primary point of introduction, well before dispersal occurs.

Therefore, in addition to education and outreach programs, the continuation of an extensive and comprehensive monitoring program is an important line of defense against the introduction and establishment of ZQM. Monitoring of high-risk waterbodies will assist in identifying new introductions early, thereby ensuring a rapid response with the aim of preventing establishment and spread of ZQM. Moreover, the prevention of their introduction through multi-jurisdiction collaboration is of paramount importance.

The CKISS partners with many government and non-government agencies and organizations, stakeholders, regional stewardship groups, and other relevant partners, both within BC and from neighbouring provinces and states such as Alberta, Idaho, Washington, and Montana in order to facilitate multi-jurisdictional collaboration and coordination with respect to AIS prevention and management. Such collaborative activities ensure that resources are not lost to duplicative efforts, and allow for consistent messaging to the public about their role in preventing the spread of AIS.

SECTION VII. RECOMMENDATIONS

Current infestations of *P. crispus, N. odorata,* and *M. spicatum* in the region allow for easy dispersal and spread to other waterbodies. New discoveries of species such as *M. aquaticum*, water hyacinth (*Eichhornia crassipes*), and *B. umbellatus* in neighbouring jurisdictions can also be easily transported into the region's waterbodies. Many aquatic invasive plant species are still being sold by nurseries, aquarium shops, and online. Therefore, annual monitoring of priority waterbodies should continue in order to facilitate EDRR should new infestations of aquatic invasive plants be discovered. Utilizing EDRR methods is strongly recommended as

the cost and effort required to treat established populations of AIS increases exponentially over time and eradication becomes difficult, if not impossible. For example, control efforts for *M. spicatum* in Christina Lake (RDKB Area C) have been occurring since 1987, and yet complete eradication has never been achieved. This control program costs the taxpayers of that region as much as $289,454.00 annually (Maki, 2016). Residents on Hicks Lake in Washington State have been organizing treatments of *N. odorata* for over thirty years and yet populations have been expanding (Herrara Environmental Consultants, 2016). Lower priority waterbodies should also be monitored periodically (every three-five years) for aquatic invasive plants. Champion Ponds was not considered a high-risk waterbody for the introduction of aquatic invasives based on its accessibility (although *I. pseudacorus* was confirmed several years ago). This illustrates that aquatic invasive plants can be transported to relatively remote locations.

The existing populations of *N. odorata* at Erie Lake and Champion Ponds are still quite small and should continue to be treated mechanically and monitored. New patches of *N. odorata* can arise from a small piece of cut rhizome or stem, so removal must be done with great care to prevent dispersal of plant fragments (DiTomaso, et al., 2013). Netting or mesh can be placed around the periphery of patches exposed to open water in order to trap plant materials. Plants and rhizomes should be removed in mid-July prior to seed development and again in mid-September. Lower water levels in September may allow for hand removal of most plants without the use of divers or snorkelers. The littoral zone of the lake should be surveyed at these times in order to detect new infestations.

Sites on Nancy Greene Lake and Champion Ponds where *N. odorata* was not growing, but had previously been detected, should be monitored. It is recommended that these sites be monitored for several years as the rhizome can lay dormant and seeds may persist for several years (King County Noxious Weed Board, 2010).

The existing populations of *I. pseudacorus* at Erie Lake should continue to be treated and monitored. The presence of many new individual plants suggests that there may be a persistent seedbank, or that new seeds are being released. It is recommended that continued control efforts for this species include seed head removal by clipping prior to seed maturity, accompanied with the removal of the rhizomes by digging and hand pulling. The CKISS will be working more directly with the Salmo Watershed Streamkeepers Society on *I. pseudacorus* removal in 2018, to ensure effective control.

The relatively recent confirmation of hybrid milfoils in Idaho waters have increased the probability that hybrids have entered or that hybridization is occurring in our region. Milfoil hybrids have morphological characteristics that are intermediary to Eurasian and native

milfoils. This makes traditional methods of field identification (number of pairs of leaflets, distance between leaflets on rachis, etc.) more difficult. Should hybrid milfoils be present in the region, there is a chance that they could go undetected if introduced to a new system, particularly if native milfoils are already present in said system. Baseline aquatic plant inventories have been conducted on a number of local lakes as a result of phases II and III of this project. Discoveries of *Myriophyllum sp.* at lakes where these species were previously undetected or existing populations of *M. sibricum* exhibiting invasive characteristics should be closely monitored and subjected to genetic testing. Currently, the geographical extent of invasive hybrid watermilfoils in North America is unknown; additional sampling should be pursued (Moody & Les, 2002). To date, no genetic testing for hybrid watermilfoils has been conducted in the region.

Prevention is the best line of defence against the introduction of AIS, as well as the most cost-effective and ecologically protective measure (Western Regional Panel on Aquatic Nuisance Species, 2010; Arthur, Summerson, & Mazur, 2015); however, prevention cannot be 100% effective (Locke, Mandrak, & TW, 2010). It is documented that invasive mussel fouled watercraft have been destined for BC waters since 2011 (Therriault, Weise, Higgins, Guo, & Duhaime, 2013), and while the provincial watercraft inspection stations provide the first line of defence, they are not always in operation; hence, it is only a matter of time before a mussel fouled vessel contaminates a BC waterbody. In order to address this risk, and facilitate the enactment of the second line of defence – rapid response – a long-term, early-detection monitoring program must remain in place. Furthermore, we recommend that the ZQM monitoring program remain extensive in scope with high sampling frequency because the more samples collected from a waterbody, the greater the confidence level of presence/absence sampling. It has been stated that an estimated 300 – 400 samples would need to be collected from a waterbody in order to have a 95% confidence level that ZQM were not present (Counihan & Bollens, 2017)(M. Herborg, personal communication, November 19, 2015).

The continued expansion of the Provincial Invasive Mussel Defence Program's mandatory watercraft inspection stations has been an important contributing factor to keeping Columbia basin waters free from ZQM, with the interception of 25 watercrafts that were confirmed to have invasive mussels in 2017. Since the inception of these stations in 2015, one or more of the following has occurred each year: an increase in the total number of stations, an increase in the operational hours per day, and/or an increase in the operational months. As the inspection station program has increased each year, so to has the number of intercepted invasive mussel fouled watercraft (2015, 15; 2016, 17; 2017, 25). Given this fact, it is reasonable to assume that the annual increase of intercepted fouled watercraft is a

result of the increased station activity, and less likely that it is the result of a consistent annual increase in boating activity. If this is accurate, then what this suggests is that invasive mussel fouled watercraft have been entering BC without detection, and have either been transporting non-viable ZQM or have in fact contaminated a waterbody that has as of yet, gone undetected. As such, we strongly recommend that these stations be in operation 24 hours/day during from April to November, in order to intercept an even greater number of transported watercraft. We also recommend legislative changes requiring all watercraft entering BC outside of inspection station hours to report to the Conservation Officer Service in order to receive an inspection prior to launching.

While immediate eradication of ZQM from BC waterways (if detected) is the province's primary goal (Inter-Ministry Invasive Species Working Group, 2015), eradication of AIS in general is a possibility only in extremely limited circumstances, for example, before a species has the opportunity to disperse. Species that are allowed to spread make future eradication efforts virtually impossible (Locke, Mandrak, & TW, 2010); therefore, early-detection monitoring is critical to identify new incursions and enable the activation of a rapid response that can maximize the opportunity for eradication.

Many of the AIS that cause problems in Canada and internationally are not yet present in our region, which provides an exceptional opportunity to prevent the introduction of these species. Through the continued use of targeted education using proven behaviour change programs, species such as ZQM can be addressed through the Clean, Drain, Dry program for water recreationalists; *M. aquaticum* can be addressed through the Don't Let it Loose program for aquarium owners; and *B. umbellatus* can be addressed through the PlantWise program for gardeners and horticulturalists.

Jurisdictional boundaries are not recognized by invasive species, which highlights the importance of creating or continuing collaborative efforts between BC, Alberta, and the USA. Expanding the network of partners working towards the common goals of preventing the introduction and spread of AIS, and mitigating their impacts where they do exist, will continue to be an effective strategy to protect the ecological integrity of our waters.

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APPENDICES

APPENDIX A: RANKING MATRIX FOR MONITORING PRIORITY OF WATERBODIES

Factor	Ranking	Comments
Probability of AIS Introduction		
# Boat Launches into waterbody	One point per launch	This is a proxy for the amount of boat traffic into this waterbody.
Motorized watercraft	If a waterbody allows motorized watercraft, the waterbody is given one point.	Motorized watercraft have the potential to transport more AIS than do non-motorized watercraft.
Moorage	If a waterbody has boat moorage facilities, the waterbody is given 4 points.	This information was used to factor in long term boater usage (vs. "day tripper" use). Long-term usage is seen as higher risk for inoculation of a waterbody.
Water-based events e.g. fishing/wakeboard/kayak festivals, tournaments	Waterbodies that have at least one event per year are given 3 points.	This data was factored into use due to the large number of out-of-province boats that compete in these events.
Ease of Access	By paved road (5 points) By gravel road (2 points) By foot (1 point)	More tourism and boat traffic with easier access, therefore more likelihood of AIS introduction
Proximity to source population	Upstream source of AIS (of category being monitored) (3 points)	Waterbodies that already have an upstream AIS population would be more likely to have natural introduction
Severity of Consequence of AIS Establishment and Spread		
Endangered/Threatened Species	If a waterbody has endangered species, it is given 6 points; if a waterbody has threatened species, it is given 3 points.	The presence of these species is a proxy for ecological impacts of invasion. Use Ecosystem Explorer for amphibians and fish species.
# Hydro-electric facilities and water intakes	Water intakes: 1 to 4 = 1 point 5 to 9 = 3 points 10+ = 5 points Large dams & hydroelectric facilities = 5 points	The number of these facilities is a proxy for the economic impacts of invasion.

Recreation	Points for # recreation icons in the Backroads Mapbook (1=1; 2 to 4=2; 5+=3)	The number of these icons is a proxy for the recreational impacts of AIS on this waterbody.
Size of waterbody (as measured at longest/widest point)	< 2 km = 1 point 2 to 4 km = 2 points Greater than 4 km = 3 points	This is a proxy for the difficulty of control. Small discrete lakes may have more control options than larger or connected waterbodies.

Appendix B: 2017 Target Species For Aquatic And Riparian Invasive Plant Surveys

Common Name	Scientific Name
American beachgrass	Ammophila breviligulata
Amphibious yellow cress	Rorippa amphibian
Bigfoot clover	Marsilea macropoda
Brazilian elodea	Egeria densa
Cabomba	*Cabomba caroliniana*
Common cordgrass	Spartina anglica
Common frogbit	Hydrocharis morsus-range
Curly leaf pondweed	Potamogeton crispus
Dense-flower cordgrass	Spartina densiflora
Eurasian watermilfoil	Myriophyllum spicatum
European beach grass	Ammophila arenaria
European common reed	Phragmites australis
European lake sedge	Carex acutiformis
European water clover	Marsilea quadrifolia
European waterlily	Nymphaea alba
Evergreen blackberry	Rubus laciniatus
Fanwort	Cabomba caroliniana
Feathered mosquito-fern	Azolla pinnata
Flowering rush	Butomus umbellatus
Fragrant water lily	Nymphaea oderata
Garden yellow loosestrife	Lysimachia vulgaris
Giant chickweed	Myosoton aquaticum
Giant knotweed	Fallopia sachalinensis
Giant manna grass	Glyceria maxima
Giant reed	Arundo donax
Giant salvinia	Salvinia molesta
Himalayan balsam	Impatiens glandulifera
Himalayan blackberry	Rubus armeniacus
Hydrilla	Hydrilla verticillata
Japanese knotweed	Fallopia japonica
Johnson grass	Sorghum halepense
Kudzu	Pueraria montana
Major oxygen weed	Lagarosiphon
Parrot feather	Myriophyllum aquaticum
Purple loosestrife	Lythrum salicaria
Russian olive	Elaeagnus angustifolia

Salt meadow cordgrass	Spartina patens
Saltcedar/Tamarisk	Tamarix ramosissima
Smooth cordgrass	Spartina alterniflora
Variable-Leaf-Milfoil	Myriophyllum heterophyllum
Water chestnut	Trapa natans
Water hyacinth	Eichhornia crassipes
Water lettuce	Pistia stratiotes
Water soldier	Stratiotes aloides
Watercress	Nasturtium officinale
Yellow flag iris	Iris pseudacorus
Yellow floating heart	Nymphoides peltata