PROTECTING OUR WATERS FROM AQUATIC INVASIVE SPECIES: PHASE II (PROJECT NO: F-F16-27)

***Report Prepared for*:**

Fish and Wildlife Compensation Program

***Report Prepared by*:**

Jennifer Vogel, P.Ag, Executive Director
Khaylish Fraser, Aquatic Invasive Species Program Coordinator
Chris Harkness, B.Sc., Consultant

ACKNOWLEDGEMENTS

The Central Kootenay Invasive Species Society (CKISS) (formerly the Central Kootenay Invasive Plant Committee) would like to acknowledge that this project was completed with the financial support of the "Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and the public". Further leveraged funding was provided by Columbia Power Corporation and Columbia Basin Trust.

In addition we would like to gratefully acknowledge the following organizations and representatives for lending their assistance, expertise and in-kind support to the success of this project:

- CKISS Aquatic Invasive Species Working Group
- BC Hydro
- BC Parks
- Columbia Shuswap Invasive Species Society
- Eastshore Freshwater Habitat Society
- Friends of Kootenay Lake
- Fish and Wildlife Compensation Program Invasive Plant Summer Crew
- Invasive Species Council of BC
- Hamish Kassa, Columbia Shuswap Regional District
- Matthias Herborg, BC Ministry of Environment
- Martina Beck, BC Ministry of Environment
- Marley Bassett, Ministry of Forests, Lands and Natural Resource Operations
- Jolene Raggett, BC Ministry of Environment
- Salmo Watershed Streamkeepers Society
- Sheila Street, FortisBC Electric Inc.
- Slocan Lake Stewardship Society
- Teck Metals Ltd.
- Thomas Woolf, Idaho State Department of Agriculture
- Terry Anderson, BC Ministry of Environment
- Tim Hicks, Columbia Basin Trust
- Todd Larsen, East Kootenay Invasive Species Council
- Tom Woolf, Idaho Department of Agriculture
- Val Miller, Ministry of Forests, Lands and Natural Resources

EXECUTIVE SUMMARY

Aquatic invasive species (AIS) pose a significant threat both economically and ecologically to waterbodies in the West Kootenay region of British Columbia. It is known that the aquatic invasive plants Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus)* are present throughout Kootenay Lake and the Columbia and Kootenay Rivers. In addition, there are confirmed populations of flowering rush (*Butomus umbellatus*), yellow flag iris (*Iris pseudacorus*) and purple loosestrife (*Lythrum salicaria*) within the Pend D'Oreille River on the American side of the border (note: yellow flag iris is confirmed throughout the Canadian portion of the Pend D'Oreille River). Species such as zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugenis*) have been detected in western states as close as Colorado and Utah and in Manitoba.

The popularity of the Kootenays as a recreational boating destination increases the potential risk of an accidental introduction of a number of high priority AIS. In addition, species already present within the region could easily be introduced to other waterbodies currently free of AIS. The public play an important role in preventing the introduction and spread of AIS. While knowledge and awareness of AIS is growing, it is essential to continue to educate the public on methods and behaviours to minimize impacts. A number of presentations and interviews were given to the general public and target audiences on identification, sampling and Invasive Species Council of BC (ISCBC) supported programs such as "Clean, Drain, Dry" (for boaters and anglers), and "Don't Let it Loose" (pet and aquarium trade).

In 2015, the Province launched their mandatory watercraft inspection program, and this program will continue in 2016. The CKISS and two other regional invasive species societies provided three additional mobile boatwash units for use within the Canadian Columbia Basin. Dedicated inspection crews inspected and completed decontaminations of mussel-infested boats as required.

Priority waterbodies within the region were surveyed and sampled for the presence of invasive aquatic plants and zebra and quagga mussels (ZQM). Substrate equipment used to detect the presence of juvenile and adult ZQM were inspected monthly from July through October. In total, 49 plankton samples were collected and analyzed for ZQM veligers from 17 waterbodies. Littoral surveys for invasive plants were conducted on Whatshan, Mosquito, Catherine, Nancy Greene, Staubert, Wilson, Little Wilson, Summit, Box, Upper Little Slocan, Fish, Bear, Cottonwood, Six Mile, Sasquatch, Rosebud and Erie Lakes as well as on the west-end of Trout Lake and the Tye Beach area of Kootenay Lake. High risk/use areas such as boat launches, marinas and fishing access sites were visited and surveyed on Slocan Lake, the Lower Columbia River and Arrow Lake south of Syringa Park to determine the presence or extent of AIS infestations in these systems.

Plankton samples were analysed using cross-polarized light microscopy in the laboratory by a certified analyst. All samples were negative for the presence of Dreissenid larvae. Similarly, no juvenile or adult zebra or quagga mussels were detected on any of the substrate equipment.

Slocan and Trout Lakes were both found to be free of aquatic invasive plants. No submerged aquatic invasive plants were discovered as a result of the littoral surveys. A small patch of fragrant water lily (*Nymphaea odorata*) discovered in Nancy Greene Lake in 2014 has been substantially reduced as a result of mechanical control. Known infestations of *I. pseudacorus* at Nancy Greene Lake were visited and no plants were found to be growing. One clump of Nymphaeae *odorata* was found growing near

the boat launch on Erie Lake and the flower head was removed. Numerous patches of yellow flag iris were present in the riparian zone of Erie Lake. In addition, riparian surveys and mechanical control of seedheads for yellow flag iris and purple loosestrife were conducted at the Bird Marsh and Slocan Pools on Kootenay River and for yellow flag iris on the Pend D'Oreille; funds were provided by partner stakeholders.

P. crispus and *M. spicatum* have increased both in densities and distributions from 2014 at most sites sampled in the Lower Columbia River. *M. spicatum* was present at all sampling points on Kootenay Lake where native vegetation occurred. *P. crispus* was only discovered at one sampling point near Tye Beach. Watercress (*Nasturtium officianale)* was reported to have been found in a drainage ditch near the Kootenay Lake community of Boswell by a concerned citizen. This sighting will be confirmed in 2016.

Management and control measures should be implemented in order to stop and reverse the continued expansion of populations of AIS present in the region. At current levels of infestation hand removal methods are recommended due to their selectiveness and low ecological impacts. No large monotypic stands of AIS were detected to warrant the use of mechanical harvesters. This could change rather rapidly however if no action is taken.

Zebra and quagga mussel and aquatic plant monitoring should continue on priority waterbodies in order to detect new infestations early thus allowing for the implementation of a rapid response plan. Continued outreach and education to the public on best management practices coupled with collaborative activities with bordering districts and states will greatly assist in preventing the establishment and spread of AIS throughout the region.

TABLE OF CONTENTS

List of Figures

List of Tables

1.0 INTRODUCTION

Aquatic invasive species (AIS) include non-native fish, animal and plant species that have been introduced into an aquatic ecosystem (ocean, lake, river or stream), where they have not been found historically. The risk of AIS introductions to British Columbia's waters in general, is escalating rapidly, due to a number of factors including, but not limited to, increased global trade, illegal dumping of horticultural and aquarium species, and water-based recreation. Once introduced, AIS such as Eurasian watermilfoil (*Myriophyllum spicatum),* flowering rush (*Butomus umbellatus*), zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis bugensis*) can spread aggressively and rapidly, resulting in harmful consequences for native species found in natural aquatic ecosystems (CKISS, 2016).

The waterbodies in the Columbia basin specifically, have been assigned a high-very high risk status for the survival and subsequent invasion of zebra and quagga mussels (Therriault et al., 2012). Moreover, freshwater ecosystems are more vulnerable to aquatic invasive species invasions than terrestrial ecosystems (Vander Zanden and Olden, 2008; Loo et al., 2007; Hanson, 2012). For instance, more than 70 percent of North America's native freshwater mussel species are extinct or imperiled, to which many factors have been attributed, including the introduction of nonindigenous mollusks (Williams et al., 1992; Barnhart and Neves, 2005).

As a result of previous surveys, it was determined that aquatic invasive plants were present in waterbodies throughout the Central Kootenays. *M. spicatum* and *P. crispus* are present throughout the Kootenay-Columbia system and have expanded their range and abundance since 2010. (Golder Associates Ltd. and Poisson Consulting Ltd., 2015) have observed a gradual increase in aquatic vegetation (dominantly *M. spicatum)* in low water velocity areas throughout the Lower Columbia River.

In 2011, the CKISS Aquatic Working Group (AWG) was formed to guide CKISS in prioritizing aquatic invasive species management. In 2015, a new regional Columbia Basin (CB) Steering Committee was struck. Several members of the CKISS AWG transferred over to the CB Steering Committee to better serve the regional Columbia Basin perspective. The CKISS AWG will serve to provide a venue for information and knowledge sharing and an opportunity to collaborate on funding and management activities where appropriate at a CKISS regional level. The CB Steering Committee inaugural meeting will take place in April 2016.

In 2014 and 2015, with support from the Fish and Wildlife Compensation Program (FWCP), Columbia Power Corporation (CPC), Columbia Basin Trust (CBT), FortisBC Electric and Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Phase I and II activities of the *Protecting Our Waters from Aquatic Invasive Species Project* were implemented throughout the CKISS region. This has resulted in the coordination and delivery of an extensive aquatic invasive species-monitoring program.

2.0 GOALS AND OBJECTIVES

The goals and objectives of this project were to:

1) Monitor high priority waterways with the CKISS region for Early Detection Rapid Response (EDRR) species, such as zebra and quagga mussels (ZQM) and provincially listed plant species.
2) Survey priority waterbodies in the region for the presence of AIS.
3) Record area, density and distribution levels at sites where AIS are found in accordance with the province's Invasive Alien Plant Program (IAPP) standards.
4) Collect plankton samples from priority waterbodies to be analysed for the presence of zebra and quagga mussel veligers.
5) Monitor substrate samplers for the presence of juvenile or adult zebra and quagga mussels.
6) Collaborate with local stewardship groups and other partners to increase the region's capacity to prevent the introduction and spread of AIS.
7) Increase public awareness of AIS and educate about best practices such as Clean, Drain, Dry.
8) Support regional, provincial, and cross-border initiatives to ensure a coordinated approach to AIS prevention and management.

3.0 STUDY AREA

The study area for this project is the Central Kootenay Invasive Species Society's (CKISS) working region, which is approximately 30,500 km^2 (Figure 1). This region is located in the southwestern portion of the Canadian Columbia River basin. There were 20 waterbodies surveyed for plants and 16 surveyed for ZQM in the CKISS region, as well as two waterbodies for plants and one for ZQM that lie just outside of this region to the north (Staubert and Trout Lakes). All of the surveyed waterbodies eventually flow into the Columbia River.

Surveys for aquatic invasive plants and zebra and quagga mussels (ZQM) occurred on Box, Cottonwood, Erie, Fish, Upper Little Slocan, Mosquito, Nancy Greene, Rosebud, Staubert, Whatshan, Wilson, Slocan, Kootenay, and Lower Arrow Lakes, and the Columbia River. Whereas, Catherine, Bear, Trout, Summit, Little Wilson, Sasquatch, and Six Mile Lakes were surveyed for aquatic invasive plants only, while Upper Arrow Lake and Pend D'Oreille River were surveyed only for ZQM.

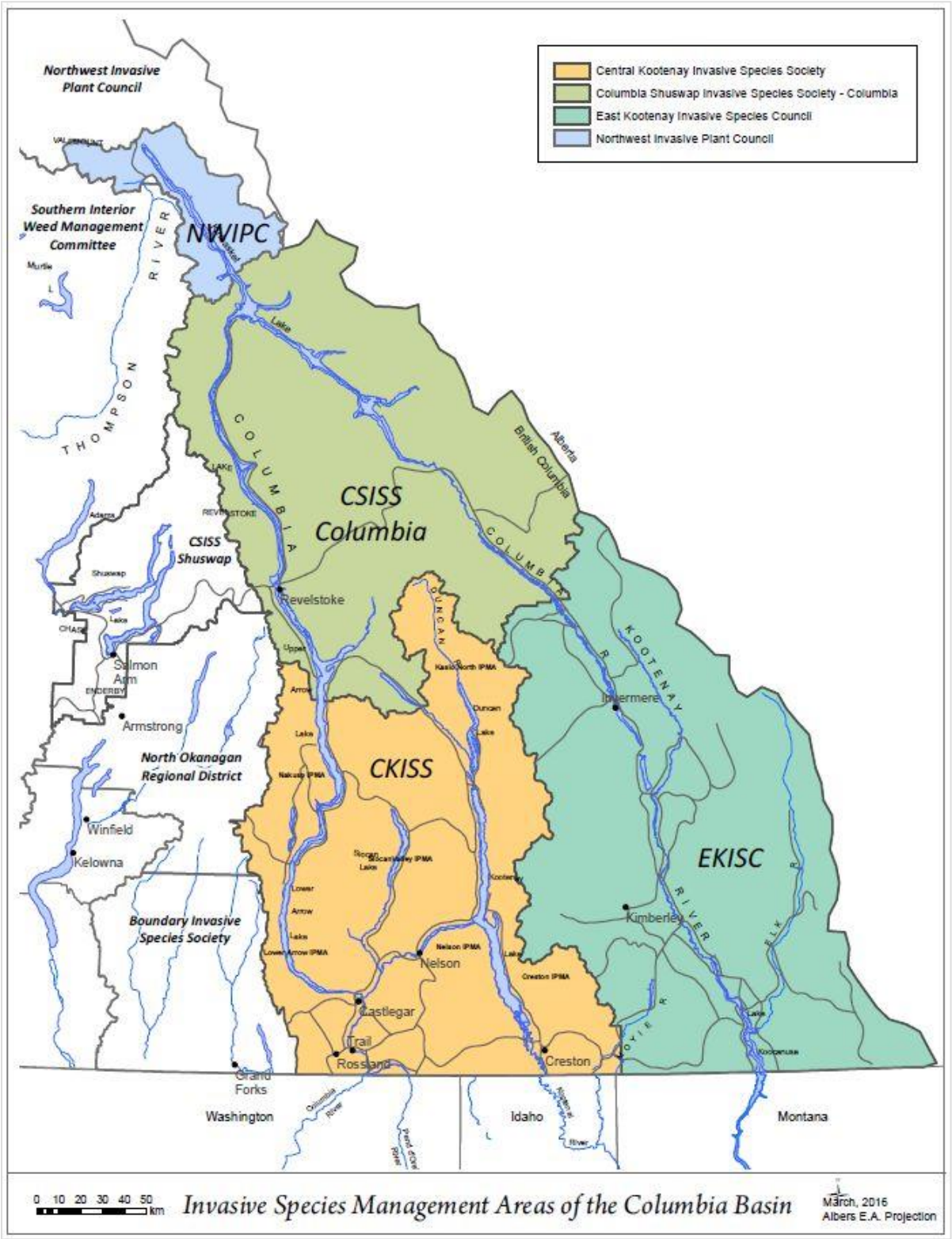

FIGURE 1. MAP OF THE INVASIVE SPECIES MANAGEMENT AREAS WITHIN THE UPPER CANADIAN COLUMBIA BASIN

4.0 METHODS

4.1 AQUATIC INVASIVE PLANTS

Aquatic invasive plant surveys were carried out in accordance with the *British Columbia Aquatic Invasive Species Survey Methods* developed by the BC Ministry of Environment (https://www.for.gov.bc.ca/hra/invasive-species/Publications/BC_Aquatic_Sampling_March2015.pdf). The list of 2015 target species for aquatic invasive plant surveys can be found in Appendix A.

The entire littoral zones of Cottonwood, Rosebud, Erie, Nancy Greene, Fish, Bear, Box, Little Slocan, Staubert, Little Wilson, Sasquatch and Six Mile Lakes were surveyed by kayak or canoe while a motorized watercraft was used to survey Summit and Wilson Lakes. An employee from the Columbia Shuswap Invasive Species Society assisted with surveys on Staubert and Trout Lakes for training purposes. The littoral zone of the southern portion of Whatshan Lake was surveyed with the use of a canoe. The western end of Trout Lake near the wharf and highest concentration of cabins, as well as the Tye Beach area of Kootenay Lake were also surveyed with the use of a motorized watercraft. A hard rake attached to a rope was deployed at approximately 100m intervals throughout the littoral zone and aquatic plants (if present) were retrieved and identified using a dichotomous key (Warrington, 1980). Between rake tosses, the littoral zone was visually scanned in order to detect any vegetation that seemed out of the ordinary (resembling a target species, growing aggressively, etc.). For each sampling point UTM's, depth, substrate, plants found (native and non-native), invasive riparian plants present and other relevant data was recorded. Where riparian or aquatic invasive plants were found, the data was entered into the IAPP (Invasive Alien Plant Program) database following provincial standards.

Slocan Lake, Arrow Lake (south of Syringa Provincial Park) and the Lower Columbia River were surveyed using the "Lake and Reservoir Shore Surveys" protocol outlined in the *British Columbia Aquatic Invasive Species Survey Methods* document. High risk/use sites such as boat launches, marinas and fishing access points were visited. Rake tosses were conducted at 25m intervals (where possible) along the shoreline for 100m in either direction from the original access point. Data was recorded as described in the littoral surveys in the previous paragraph.

After consultation with Ministry of Forests, Lands and Natural Resource Operations staff, it was ascertained that the Ministry would conduct aquatic invasive plant surveys in the Pend D'Oreille Reservoir. However, treatment and management of yellow flag iris was completed by CKISS staff and FWCP staff members. In addition, yellow flag iris and purple loosestrife was mechanically controlled at the Bird Marsh and Slocan Pools through additional stakeholder funds.

4.2 ZEBRA AND QUAGGA MUSSEL MONITORING

VELIGER (LARVAE) MONITORING

Monitoring for zebra and quagga mussel (*D. polymorpha and D. rostriformis bugensis*) veligers occurred during the months of July, August, September, and October. All monitoring activity was in accordance with the *British Columbia Aquatic Invasive Species Survey Methods* developed by the BC Ministry of

Environment. CKISS employees, project contractors, local stewardship groups and other partners undertook monitoring for veligers and adults.

In total, twenty-eight sites were monitored in 2015 (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. Samples were condensed into collection bottles and preserved for shipment to a certified analyst to detect any presence of zebra or quagga mussel veligers.

In 2015, the BC Ministry of Environment collected plankton sample(s) at Summit and Trout Lakes; therefore, the CKISS did not monitor these waterbodies.

TABLE 1. LOCATIONS WHERE ZEBRA AND QUAGGA MUSSEL VELIGER SAMPLING OCCURRED AROUND THE CENTRAL KOOTENAY REGION IN 2012, 2014 AND 2015

Waterbody	Common site name	Location	Sampled in 2012	Sampled in 2014	Sampled in 2015
Columbia River	Gyro Park boat launch	11 U 448416 E 5438837 N	x	x	x
Columbia River	Old Bridge, Trail	11 U 449030 E 5437859 N	x	x	-
Columbia River	Robson boat launch	11 U 449159 E 5464857 N	-	-	x
Slocan Lake	New Denver boat launch	11 U 472937 E 5536986 N	x	x	x
Slocan Lake	Silverton boat launch	11 U 474012 E 5533607 N	x	x	x
Slocan Lake	Slocan boat launch	11 U 465959 E 5513126 N	x	x	x
Kootenay Lake	Balfour boat launch	11 U 502978 E 5496721 N	x	x	x
Kootenay Lake	Kokanee Creek Provincial Park boat launch	11 U 491774 E 5495242 N	-	x	x
Kootenay Lake	Lakeside Park boat launch	11 U 479581 E 5484086 N	-	x	x
Kootenay Lake	Kaslo boat launch	11 U 506664 E 5529470 N	x	-	x
Kootenay Lake	Riondel Marina	11 U 510285 E 5513027 N	-	x	x

Waterbody	Common site name	Location	Sampled in 2012	Sampled in 2014	Sampled in 2015
Kootenay Lake	Kuskanook Marina	11 U 524508 E 5460867 N	-	x	x
Kootenay Lake	Boswell Marina	11 U 516895 E 5478782 N	-	-	x
Upper Arrow Lake	Nakusp boat launch	11 U 443099 E 5565193 N	x	x	x
Lower Arrow Lake	Syringa Creek Provincial Park boat launch	11 U 436701 E 5465721 N	x	x	x
Lower Arrow Lake	Scottie's Marina	11 U 439709 E 5465863 N	-	-	x
Pend D'Oreille River	Buckley campground boat launch	11 U 464006 E 5431944 N	x	x	x
Pend D'Oreille River	Boat launch	11 U 459550 E 5428779 N	x	-	-
Pend D'Oreille River	Boat launch	11 U 472683 E 5429718 N	-	-	x
Upper Little Slocan Lake	Boat launch	11 U 452640 E 5503327 N	-	x	x
Summit Lake	Three Island Lodge boat launch	11 U 452951 E 5556340 N	-	x	-
Box Lake	Boat launch	11 U 449084 E 5561866 N	-	x	x
Nancy Greene Lake	Boat put-in	11 U 431397 E 5456224 N	-	x	x
Rosebud Lake	Boat put-in	11 U 480334 E 5432608 N	-	x	x
Trout Lake	Boat launch	11 U 462126 E 5610471 N	-	x	-
Trout Lake	Boat put-in	11 U 480303 E 5595508 N	-	x	-
Staubert Lake	Boat put-in	11 U 454841 E 5614426 N	-	x	x
Fish Lake	Boat put-in	11 U 486998 E 5543674 N	-	x	x
Wilson Lake	Boat launch	11 U 456954 E 5564743 N	-	x	x
Mosquito Lake	Boat launch	11 U 424222 E 5576051 N	-	-	x
Erie Lake	Boat launch	11 U 474368 E 5448649 N	-	-	x
Whatshan Lake	Boat launch	11 U 419801 E 5530251 N	-	-	x

Waterbody	Common site name	Location	Sampled in 2012	Sampled in 2014	Sampled in 2015
Cottonwood Lake	Boat launch	11 U 481529 E 5475280 N	-	-	x

JUVENILLE AND ADULT MONITORING

The installation of substrate samplers was dependent on approval from the appropriate authority, public safety, and depth requirements. In 2015, four substrate samplers were in place at various locations around the Central Kootenay region, and were monitored in accordance with the *British Columbia Aquatic Invasive Species Survey Methods* developed by the BC Ministry of Environment (Table 2). Samples were collected from substrates only if suspect organisms were seen or felt.

TABLE 2. LOCATIONS OF SUBSTRATE SAMPLERS AROUND THE CENTRAL KOOTENAY REGION, 2015

Waterbody	Common site name	Nearest town	Location	Monitoring Organization
Kootenay Lake	Riondel Marina	Riondel	11 U 510285 E 5513027 N	Eastshore Freshwater Habitat Society
Kootenay Lake	Tye beach Marina	Ymir	11 U 515246 E 5464080 N	Nature Conservancy of Canada
Kootenay Lake	Kuskanook Marina	Creston	11 U 524508 E 5460867 N	CKISS
Slocan Lake	Slocan boat launch	Slocan	11 U 465959 E 5513126 N	CKISS

4.3 EDUCATION AND OUTREACH

The Central Kootenay Invasive Species Society engaged in a variety of outreach activities directed at the general public and specific target audiences in order to raise awareness about aquatic invasive species, such as zebra and quagga mussels, and to promote the province-wide Clean, Drain, Dry, and Don't Let it Loose programs (Table 3).

TABLE 3. EDUCATION AND OUTREACH ACTIVITIES FOCUSED ON AQUATIC INVASIVE SPECIES UNDERTAKEN BY THE CENTRAL KOOTENAY INVASIVE SPECIES SOCIETY IN 2015 AND 2016

Date	Details	Target Audience	Number of people reached
January 8	Presentation: West Kootenay Fly Fishing Club members	Anglers	21
March 21 & 22	Hosted aquatic invasive species (AIS) educational booth: Fly Fishing Symposium	Anglers and general public	1500
April 21	Presentation: Kootenay Lake Partnership Steering Committee members	Professionals	17
May 6	Hosted AIS educational booth: Columbia Mountains Institute of Applied Ecology *Regulated Rivers* Conference	Professionals	125
May 25	Hosted AIS roundtable discussion: Columbia Basin Watershed members	General public	35
May 29 & 30	Outreach event: Western Painted Turtle Awareness	General public	18
June 11	Advertisement: West Kootenay Go & Do magazine, Summer/Fall 2015 issue	Tourists, general public	Distribution: 40,000 publications
June 12	Hosted AIS educational booth: Wild and Scenic Film Festival	General public	58
June 20	Hosted AIS educational booth: BC Parks Family Fishing Day	Anglers and general public	37
June 21	Hosted AIS educational booth: Nelson Rod and Gun Club's Family Fishing Day	Anglers and general public	190
June 27	Hosted AIS educational booth: CKISS 10th Anniversary Biodiversity Bonanza	General public	43
July 8	Article: The Spokesman-Review newspaper	Topic: American bullfrog	Distribution: Spokane and the Inland Northwest and online
July 12	Article: The Boundary Sentinel newspaper	Topic: BC's Mussel Defense Program and mandatory watercraft inspection stations	Distribution: 10 communities and online
July 13	Article: Cranbrook Daily Townsman newspaper	Topic: BC's Mussel Defense Program and mandatory watercraft inspection stations	Distributed throughout the Cranbrook region
July 15	Article: The Valley Voice newspaper	Topic: AIS and volunteer recognition	Distribution: 22 communities and online
August 11	AIS outreach event: Where the Wild Things Are	Topic: American bullfrog	12
August 12	Hosted AIS educational booth: Toadfest	General public	200
August 26	Article: Rossland Telegraph newspaper	Topic: AIS and mandatory watercraft inspection stations	Distributed online
September 11	Interview: Sport Fishing on the Fly TV show	Topic: AIS and mandatory watercraft inspection stations	Distribution: 2 channels across

Date	Details	Target Audience	Number of people reached
			N.A. and online
September 13	Hosted AIS educational booth: Hills Garlic Festival	General public	4600
September 16	CKISS Field Tour and AGM	CKISS members and Board of Directors and general public	23
September 27	Hosted AIS educational booth: BC Rivers Day	General public	100
September 24	Presentation and Field Trip: Wildflower School	Grades 6-8 students	30
October 24	Hosted AIS educational booth: Friends of Kootenay Lake's Annual Summit	General public, Stewardship groups, First Nations	120
November 2	Presentation: Selkirk College	Recreation, Fish, and Wildlife students	28
February 4, 2016	Presentation: West Kootenay Fly Fishing Club members	Anglers	12

5.0 RESULTS

5.1 AQUATIC INVASIVE PLANTS

No submerged aquatic invasive plants were discovered at any of the small or medium sized lakes (Bear, Box, Cottonwood, Rosebud, Fish, Erie, Nancy Greene, Wilson, Little Wilson, Mosquito, Catherine, Sasquatch, Upper Little Slocan, Summit, Staubert, Sasquatch or Six Mile Lakes) as a result of this study. Points sampled on Trout, Whatshan and Slocan lakes were also found to be free of aquatic invasive plants. All survey data for plant surveys (UTM's, substrate, depth, vegetation present, etc.) is presented in the attached Microsoft Excel file with a separate spreadsheet allocated to each waterbody.

Eleven relatively small patches of yellow flag iris (three less than in 2014) were present on the shores of Erie Lake just west of Salmo (Figures 2 and 3). These patches varied in size from less than $0.5m^2$ with one individual plant to $20m^2$ containing several clumps of plants. Clumps or individual plants were found sporadically encircling the entire shoreline of the lake, with the greatest densities occurring in the southwest corner. On Nancy Greene Lake, known locations of infestations of *I. pseudacorus,* which have been manually treated for several years, were visited. No *I. pseudacorus* plants were found growing at any of these sites. The riparian zone on Nancy Greene Lake was also scanned during the course of the littoral survey for invasive plants and no *I. pseudacorus* was discovered, suggesting there is a possibility that this species may have been eradicated Nancy Greene Lake.

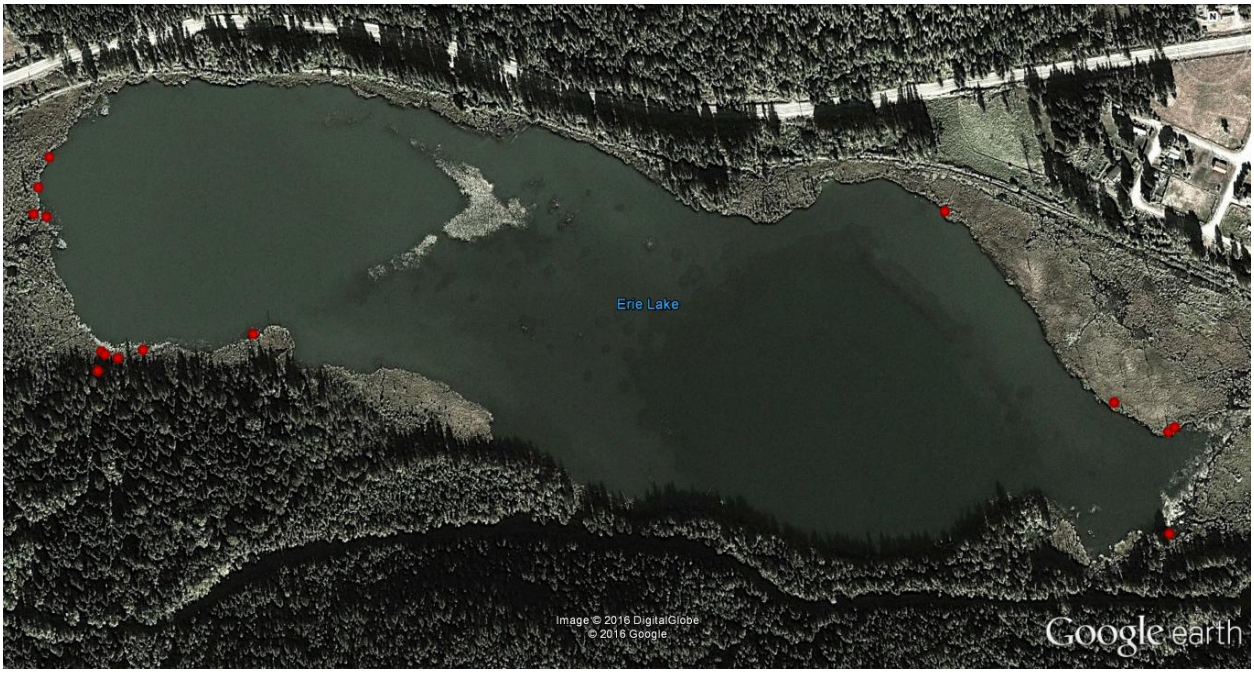

FIGURE 2. SAMPLING POINTS ON ERIE LAKE FROM 2014 INDICATING PRESENCE OF ● *IRIS PSEUDACORUS*

FIGURE 3. SAMPLING POINTS ON ERIE LAKE FROM 2015 INDICATING PRESENCE OF ● *IRIS PSEUDACORUS* AND ● *NYMPHAEA ODORATA*

A small patch (1m x 2m*)* of *Nymphaea odorata* discovered and treated in Nancy Greene Lake in 2014 (Figure 4) was manually treated again in early July. The lake was then surveyed in September and although the area of the patch had not decreased, the density had been cut in half. This patch of plants was found growing at the end of a trail leading from a pullout on Hwy 3. This species is listed on CKISS's

EDRR (Early Detection-Rapid Response) list as a species not currently present in CKISS's region. It has become established in Christina Lake, the next community west of Nancy Greene Provincial Park on Hwy. 3. One clump of *N. odorata* (<0.1 m^2) was found growing close to a boat launch on Erie Lake (also located at the end of a trail leading from a pullout on Hwy. 3) and the lone flower head was removed.

FIGURE 4. LOCATION OF ● *NYMPHAEA ODORATA* AT NANCY GREENE LAKE

In the section of Kootenay Lake surveyed from Tye Beach south to Next Creek, *M. spicatum* was present at each sampling point where native vegetation (*Myriophyllum sibiricum, Elodea canadensis, Potamogeton gramineus, P. richardsonii* or *Stuckenia pectinatus*) was growing and was the only macrophyte found in five other sampling points. *P. crispus* was present at only one location. *P. crispus* and *M. spicatum* have increased both in area, distributions and densities at many sites sampled in the Lower Columbia River over 2014 levels. The results of these point surveys are presented in Tables 4 and 5.

TABLE 4. DENSITY, DISTRIBUTION AND ESTIMATED AREA OF CURLYLEAF PONDWEED (*P. CRISPUS*) AT SAMPLING SITES ON THE LOWER COLUMBIA RIVER IN 2014 AND 2015

				2014		2015	
Site Location	Zone	Easting	Northing	Estimated area (ha)	Distribution : Density[1]	Estimated area (ha)	Distribution : Density[1]
Beaver Ck Provincial Park	11	455309	5435001	0.105	5 : 2	0.1	5 : 2
Fort Sheppard	11	454891	5434319	0.0045	2 : 1	0.009	4 :1
Fort Sheppard	11	454874	5431447	0.0001	1 : 1	0.004	2 : 1
Sunningdale, East Trail	11	447835	5440176	0.5	5 : 2	0.5	5 : 2
Gyro Park boat launch	11	448338	5430952	0.0001	2 : 2	0.0009	4 : 2
Millennium Park, Fish Habitat Compensation	11	452518	5463096	0.0375	2 : 1	0.004	2 : 1
Millennium Park, Dog Walk Park	11	452390	5462882	0.0001	2 : 2	0.0002	3 : 2
Robson, Lion's Head boat launch	11	450888	5464656	0.003	5 : 2	0.003	5 : 2
Millennium Park, Dog Walk Park	11	452394	5462998	0.003	3 : 2	0.004	3 : 2
Millennium Park, Dog Walk Park	11	452387	5462910	0.002	2 : 1	0.003	2 : 1

TABLE 5. DENSITY, DISTRIBUTION AND ESTIMATED AREA OF EURASIAN MILFOIL (*MYRIOPHYLLUM SPICATUM*) AT SAMPLING SITES ON THE LOWER COLUMBIA RIVER IN 2014 AND 2015

				2014		2015	
Site Location	Zone	Easting	Northing	Estimated area (ha)	Distribution : Density[1]	Estimated area (ha)	Distribution : Density[1]
Zuckerberg Island slough	11	452154	5462793	0.075	2 : 1	0.09	4 :1
Zuckerberg Island	11	452210	5462627	0.15	4 : 3	0.15	4 : 3

[1] Distribution and Density are codes commonly used in BC's Invasive Alien Plant Program protocol as outlined at https://www.for.gov.bc.ca/hra/plants/forms/FS1260.pdf pg. 2.

				2014		2015	
Site Location	Zone	Easting	Northing	Estimated area (ha)	Distribution : Density[1]	Estimated area (ha)	Distribution : Density[1]
slough							
Millennium Park	11	452394	5462998	0.003	2 : 1	0.01	5 : 1
Millennium Park	11	452387	5462910	0.002	4 : 2	0.015	4 : 2
Beaver Ck Provincial Park	11	455309	5435001	0.004	2 : 1	0.009	4 : 2

5.2 ZEBRA AND QUAGGA MUSSEL MONITORING

On the four submerged substrate samplers, no juvenile or adult zebra or quagga mussels (ZQM) were detected. A total of 49 plankton samples were analyzed for the presence of ZQM veligers, and all samples were negative. Results of 2015 monitoring can be found in Appendix B.

5.3 EDUCATION AND OUTREACH

The Central Kootenay Invasive Species Society reached over 7000 Columbia Basin residents in 2015 through various workshops, events, field tours, presentations, and exhibition opportunities; this is three times more than in 2014.

Through engagement in various outreach methods, the Central Kootenay Invasive Species Society was able to disseminate thousands of educational resources, increase awareness about aquatic invasive species (AIS) and their impacts, provide training for AIS identification and sampling techniques, and promote best practices such as Clean, Drain, Dry (for water-based recreational equipment) and Don't Let it Loose (for pet and aquarium trade).

Through our improved marketing and communication, the CKISS engaged with the regional media in the following ways:

- 9 interviews completed with local radio stations and the CBC
- Over 20 press releases were sent to regional media contacts, resulting in 18 published articles
- Clean, Drain, Dry advertising in West Kootenay Go & Do (magazine) publication
    - Over 40,000 copies were printed and available throughout the region
- Interviewed by Sport Fishing on the Fly, which airs across North America
    - Highlighted the provincial watercraft inspection stations and promoted the Clean, Drain, Dry program

CKISS would like to acknowledge that FWCP and their generous contribution were mentioned verbally at all associated events and/or during media interviews.

6.0 DISCUSSION

It is well documented that non-native, highly invasive aquatic species such as zebra and quagga mussels (ZQM) cause significant negative impacts to the natural function of aquatic ecosystems (Therriault et al., 2012; Turner, 2010). Moreover, there is no method by which to eradicate these species once they have become established in a water body. Therefore, through the implementation of a proactive ZQM surveying and monitoring program, which would enable the enactment of the Provincial Early Detection Rapid Response (EDRR) plan were they to be discovered, the CKISS' *Protecting Our Waters from Aquatic Invasive Species* project has continued to protect the habitat quality, biodiversity, and overall ecological integrity of water bodies in the Central and West Kootenay portions of the Columbia Basin.

Furthermore, zebra and quagga mussels have the greatest impact on pelagic fish species due to their high-volume filter feeding of select phytoplankton (Ontario, 2016).. It is known that the region's native Kokanee salmon stocks are currently in decline and that several other native fish species, such as burbot, bulltrout, and westcoast cutthroat trout are already listed provincially and/or federally (Burrows, 2016; Gov., 2016). So, in turn, this program has also provided protection to the viability of basin fisheries.

Through the protection of native fish populations, the CKISS' AIS project has indirectly protected the native mussel populations that are present in our regions waterbodies because native mussels' life cycles require native fish species as hosts. Native freshwater mussels are ecologically significant because they are indicators of ecosystem health, important components of freshwater biodiversity, and a major food source. Unfortunately, more than 70 percent of North America's native freshwater mussel species are extinct or imperiled, to which many factors have been attributed, including the introduction of nonindigenous mollusks (Williams et al., 1992).

Once introduced into a system, a relatively small window of opportunity is available for preventing the establishment of invasive plant species such as *M. spicatum, U. butomus* and *N. odorata*. Early detection and rapid response (EDRR) is critical in preventing these species from becoming established. Once established it becomes difficult if not impossible to eradicate AIS from a waterbody and the expense increases exponentially. EWM removal has been ongoing yearly in Christina and Champion Lakes for the past thirty years. In 2010 a budget of $136,000 was allocated for *M. spicatum* management and crews were unable to meet their objectives, leaving some known sites untreated (Caswell, 2010). The ponds at VanDusen Botanical Gardens are cleared of *N. odorata* twice yearly, only to return as a dense mat within a few weeks (C. Sayre, Curator of Collections, personal communication, July 15, 2015). Based on a 2013 economic impact report released by the Ministry of Environment, the projected economic losses to BC are estimated at $21.7 million considering only impacts to hydro generation, recreational use, and water utilities (ISCBC, 2013). It is therefore essential to make all efforts to prevent AIS from entering previously uninfected waterbodies and to detect and treat new infestations as quickly as possible.

The recent discovery of new infestations of *N. odorata* in the region highlight the importance and effectiveness of the EDRR program. Left untreated this species will colonize the entire littoral zone up to a water depth of approximately 2.75m. A thick mat of leaves will reduce light penetration and prevent wind mixing in the littoral zone, resulting in extensive areas of low oxygen and a reduction in native species (Dept. of Ecology, Washington State, n.d.). Erie and Nancy Greene Lakes are particularly vulnerable to extensive colonization by *N. odorata* due to the presence of large areas of relatively

shallow water depths. *N. odorata* is a highly attractive plant and is therefore quite popular with water gardeners. It has been spread to numerous waterbodies throughout BC including Christina Creek on Hwy 3 in the Boundary region. Nancy Greene and Erie Lakes are both located on major highways and in each case *N. odorata* was discovered at the end of a trail leading from the highway. This suggests that this species was intentionally transported to and disposed of at these sites.

In the Kootenay-Columbia system, the levels of infestation of both *M. spicatum* and *P. crispus* had surpassed an EDRR situation by 2010. From a management perspective this system presents a number of challenges. Its large size, varied topography and remoteness of sections in the system limit management options. To further complicate issues, it is suspected that hybridization is occurring between *M. spicatum* and the native milfoil *M. sibiricum* in Kootenay Lake. Leaf segment numbers and leaf length measurements can effectively distinguish *M. spicatum* and *M. sibiricum*; however, hybrids are intermediate for these characters and such measurements frequently overlap with respect to their parental taxa (Moody and Les. 2007). This was the case in the Tye Beach area of Kootenay Lake where *M. spicatum* (>16 leaf segments) and *M. sibiricum* (<12 leaf segments) were identified to be growing amongst plants with 12-14 leaf segments. It is believed that hybrids have the potential to out-compete *M. spicatum* in certain environmental circumstances due to hybrid vigour and selection for competitive traits and may result in the loss of native milfoils through genetic contamination (Moody and Les. 2002). Should hybrids be introduced to a new environment, they may also escape detection due to difficulties in positively identifying them without costly DNA analysis.

Collaboration and information sharing with other agencies continue to be key strategies in combatting AIS. Staubert and Trout Lakes lie within the jurisdiction of the Columbia Shuswap Invasive Species Society (CSISS) however they are just beginning to develop an AIS program of their own. CSISS staff has accompanied CKISS for the past two years for plant surveys for these lakes with the intention that they will take over monitoring activities in 2016.

CKISS has recently collaborated with the Okanagan Nation Alliance and Golder Associates Ltd. on a proposal to control *M. spicatum* in the Lower Columbia River. This would be a pilot program, pending funding, to evaluate the efficacy of treating known infestations with the use of divers and benthic barriers. CKISS has to date only conducted shoreline surveys in the Columbia River. Data collected by (Golder and Poisson, 2015) over the past several years illustrate the limitations of the "Shore Survey Method" as populations of *M. spicatum* have been observed and recorded in areas only accessible by boat. In Lake Revelstoke, *M. spicatum* was found growing approximately 200m from a popular Provincial Park boat launch even though there was ample suitable habitat close to the launch (Harkness, 2015). This infestation may have been missed if a boat had not been used for surveying, however many areas (shallow water habitats, sloughs, marinas, etc.) are more effectively surveyed by shore. *M. spicatum* and *P. crispus* are beginning to infiltrate many of these shallow water habitats and may begin to displace native vegetation if not controlled.

Preventative actions can drastically reduce the introduction and spread of AIS in waterbodies, and as such are a critical component of various regional, provincial, and cross-border initiatives such as the Canadian Columbia Basin Regional AIS Program, the 100th Meridian Initiative, and the Idaho Invasive Species Program (Vander Zanden and Olden, 2008). By working collaboratively with the organizations involved in these initiatives to deliver internationally accepted behaviour change programs such as Clean, Drain, Dry (CDD), the CKISS' AIS project has ensured a proactive, strategic, and coordinated

approach to AIS prevention and management. Education and outreach programs that focus on prevention, in conjunction with mandatory watercraft inspection stations, have proven to be effective at preventing the introduction of ZQM in places such as Idaho and Montana despite these species being present in neighbouring jurisdictions (T. Woolf, personal communication, Feb 3, 2016; U.S. Geological Survey, 2016). Considering this, it is reasonable to assume that the preventative actions initiative, CDD, which the CKISS has been promoting since 2012, as well as our partnership with the BC Mussel Defense Program's watercraft inspection stations, could be a major contributing factor to the absence of ZQM in the region's waterbodies.

The CKISS' education and outreach activities also continued to expand the capacity to collaboratively prevent the introduction and spread of AIS throughout the Columbia Basin. Local stewardship groups and other partners, as well as thousands of local residents were educated by various means such as, but not limited to, workshops, events, field tours, presentations, exhibitions, training and media. These activities provided the opportunity for residents to learn about AIS; their environmental, ecological, and social impacts; how they spread; identification techniques; monitoring techniques; best management practices; legislation, and reporting.

Volunteer efforts by stewardship groups (Salmo Watershed Streamkeepers Society) and concerned citizens have undoubtedly attributed to the reduction and/or control of *I. pseudacorus* populations at Erie Lake. Since beginning to treat *I. pseudacorus* several years ago, the Salmo Watershed Streamkeepers Society feel they have reduced population levels substantially on Erie Lake (B. Henderson, personal communications). This same group of volunteers could also begin controlling *N. odorata* at this lake. In Washington State, *N. odorata* infestations were eliminated in three years when residents faithfully removed all emerging leaves and flowers (Dept. of Ecology, Washington State, n.d.).

7.0 RECOMMENDATIONS

Since all of the waterbodies in the Columbia basin have been assigned a high-very high risk status for the survival and subsequent invasion of zebra and quagga mussels (ZQM) it is essential that annual monitoring for ZQM continue because it is critical for early detection, which would allow the Province to enact an Early Detection Rapid Response plan. Moreover, the vulnerability of aquatic ecosystems to invasive species in general, the drastic decline of native mussels, and the many listed native aquatic species present in this region's waterbodies, further highlight the need for a long-term zebra and quagga mussel monitoring program. Monitoring for mussel veligers via plankton collection and analysis is the first line of defence in this program and the more samples that can be collected from a waterbody the greater the confidence of presence/absence sampling.

The inclusion of mandatory watercraft inspection stations into the Provincial Mussel Defense Program in 2015 was an important contributing factor to keeping Columbia basin waters free from zebra and quagga mussels, and allowed the CKISS additional AIS prevention partnership opportunities. It is recommended that these stations continue to be active around the region, that the number of stations be increased, and that the stations are active for a longer period throughout the year in an effort to intercept all high-risk watercraft.

Recreational boating activity and the overland transport of watercraft are key pathways of the introduction and spread of AIS, therefore, public outreach and educational initiatives that promote preventative actions and best practices such as Clean, Drain, Dry and Don't Let it Loose must be ongoing. Other effective means by which to prevent the spread of AIS while simultaneously providing education include collaboration between fishing derby and regatta organizers and BC Mussel Defense Program staff so that watercraft inspection stations are active for these events. Because of the association between boating and AIS spread, marina operators should continue to be encouraged to install and monitor substrate samplers for juvenile/adult zebra and quagga mussels. Marinas are preferred locations for this type of equipment because they are near access points, moored boats are more susceptible to mussel attachment than boats than frequently enter/exit water, and substrates that have not been installed in marinas have been targets of vandalism and theft in the past.

Current infestations of *P. crispus* and *M. spicatum* in the region allow for easy dispersal and spread to other waterbodies. Recent discoveries of *N. odorata* in the region indicate that there is a continued threat of new species entering the regions waterbodies. Parrotfeather (*Myriophyllum aquaticum),* water hyacinth (*Eichhornia crassipes)* and flowering rush (B*utomus umbellatus)* have all been discovered growing in regions bordering the Central Kootenays (Stewart, 2014, J. Parsons, Washington State Dept. of Ecology, personal communications). Annual monitoring of priority waterbodies should continue in order to facilitate a rapid response should new infestations of aquatic invasive plants be discovered.

Removal measures should be undertaken in order to control the growth of *P. crispus* and *M. spicatum.* Currently hand removal and localized benthic barriers would be the best options available. If funded, the pilot program proposed by Golder, the Okanagan Nation Alliance and CKISS could provide an excellent opportunity to gauge the effectiveness of these control methods in this system and could possibly be implemented in Kootenay Lake and the Kootenay River.

Areas targeted for removal should be prioritized based on factors including; benefits or harm to native species (particularly species listed as threatened or endangered) and sensitive ecosystems, impacts and effectiveness of control method chosen, accessibility, safety, cost and desired objectives.

Control methods should be site specific. Before control methods are undertaken sites should be pre-surveyed as aquatic plant communities can change drastically from year to year. It is also important to have pre- and post-treatment data to measure successes and gauge efficiency.

Populations of *P. crispus* and *M. spicatum* have expanded at a number of shallow water habitats on the Columbia River. These situations still represent localized EDRR opportunities and should be controlled by hand. At low water some of these sites (such as the shallow sloughs around Millennium Park, Castlegar) can be accessed with waders or by snorkeling. These methods would greatly reduce associated costs.

Genetic testing of milfoil populations in the Kootenay-Columbia system should be conducted in order to determine if hybridization is occurring. This will help with future management decisions in controlling *M. spicatum* populations. Currently the geographical extent of invasive hybrid watermilfoils in North America is unknown and should be pursued by additional sampling (Moody and Les. 2002).

A more detailed survey of Slocan Lake should be conducted by watercraft. *M. spicatum* is likely to invade areas in oligotrophic lakes that have native species already present because these areas provide an optimal environment for growth (Madsen and Wersal, 2009). Galena Environmental Ltd. has mapped

the macrophyte beds for this lake in 2006 and these could be revisited. No aquatic invasive plants were discovered at the time of this previous mapping.

The existing populations of *N. odorata* at Nancy Greene and Erie Lakes should continue to be treated and monitored. This species reproduces by seed and spreads by rhizomes. Plants and rhizomes should be removed in mid-July prior to seed development and again in mid-September. The littoral zone of the lake should be surveyed at these times in order to detect new infestations.

In addition to cross-border management of invasive plant species, CKISS should continue to collaborate with cross-border partners, regional stakeholders and the Province on the implementation of an American Bullfrog Surveillance and Eradication program, given the recent confirmation of their presence in the Central Kootenay region.

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 aquatic invasive species, and mitigating their impacts where they do exist, will continue to be an effective strategy to protect the ecological integrity of our waters.

8.0 REFERENCES

Barnhart C. and Neves D. 2005. Overview of North American Freshwater Mussels. Available from: https://owpubauthor.epa.gov/scitech/swguidance/standards/criteria/aqlife/ammonia/upload/II-Barnhart.pdf. Accessed 2016 Feb 9.

Burrows J. 2016. Kootenay Lake Fisheries Update &West Arm Shore Spawning Intro. Presented at: 2015 Kootenay Lake Summit; Nelson, BC.

Caswell D. 2010. Eurasian Milfoil Control 2010-Regional District of Kootenay Boundary Christina Lake Eurasian milfoil control program report. Available from: http://www.rdkb.com/LinkClick.aspx?fileticket=bQsNsDZQXwA%3D&tabid=525. Accessed 2014 Nov 7.

CKISS. 2016. Aquatic Invasive Species. Available from: http://ckiss.ca/species/aquatic/. Accessed 2016 May 5.

Department of Ecology, Washington Stat. N.d. Non-Native Invasive Freshwater Plants. Fragrant Water Lily (*Nymphaea odorata*). Available from: http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua005.html. Accessed 2016 Feb 21.

Golder Associates Ltd. and Poisson Consulting Ltd. 2015. Lower Columbia River Fish Population Indexing Surveys – 2014 Investigations. Report prepared for BC Hydro generations, Water License Requirements, Castlegar, BC. Golder Report No. 1314920102: 66p. + 8 app.

Government of B.C. 2016. B.C. Conservation Data Centre Home. Available from: http://www.env.gov.bc.ca/cdc/. Accessed 2016 Feb 12.

Hanson E. 2012. Watercraft inspection and decontamination for quagga/zebra mussels. Proceedings of the Take Action Training Conference; 2012 May 7-10; Kamloops.

Harkness C. 2015. North Columbia Priority Aquatic Invasive Species Surveys 2015. Prepared for the Columbia Shuswap Invasive Species Society. Available from: http://columbiashuswapinvasives.org/wp-content/uploads/2013/08/North-Columbia-Priority-Aquatic-Invasive-Species-Surveys-2015.pdf. Accessed 2016 Feb 23.

ISCBC. 2013. Invasive Species Council of BC Take Action (CDD) Program 2012 Final Report. Available from: http://bcinvasives.ca/documents/ISCBC_Take_Action_-_Clean_Drain_Dry_Project_Report_FINAL.pdf. Accessed 2015 Feb 20.

Loo S.E., R.P. Keller and B. Leung. 2007. Freshwater invasions: using historical data to analyse spread. Available from: http://biology.mcgill.ca/faculty/leung/articles/Loo_DD07.pdf. Accessed 2016 Feb 4.

Madsen J.D. and R.M. Wersal. 2009. Aquatic Plant Community and Eurasian watermilfoil (*Myriophyllum spicatum* L.) Management Assessment in Lake Pend Oreille, Idaho for 2008. Available from: http://www.gri.msstate.edu/publications/docs/2009/03/5706GRI_5032_2009.pdf. Accessed 2015 Feb 27.

Moody M.L. and D.H. Les. 2002. Evidence of hybridity in invasive watermilfoil (*Myriophyllum)* populations. Available from: http://www.pnas.org/content/99/23/14867.full. Accessed 2016 Feb 22.

Moody M.L. and D.H. Les. 2007. Geographic distribution and composition of invasive hybrid watermilfoil (*Myriophyllum spicarum* x *M. sibiricum)* populations in North America. Available from: http://hydrodictyon.eeb.uconn.edu/people/les/Manuscript_Files/Biol_Inv_9(559)%5B2007%5D.pdf. Accessed 2016 Feb 22.

Ontario's Invading Species Awareness Program. 2016. Zebra Mussels Invade Ontario Waters. Available from: http://www.invadingspecies.com/invaders/invertebrates/zebra-and-quagga-mussels/. Accessed 2016 Feb 2.

Stewart, B. 2014. Boundary Invasive Aquatic Species Surveys Awareness 2014. Boundary Invasive Species Society. Available from: http://www.rdkb.com/LinkClick.aspx?fileticket=pZ_bxYjBx2Y%3d&tabid=590. Accessed 2016 Feb 23.

Therriault T.W., Weise A.M., Higgins S.N., Guo Y., and Duhaime J. 2012. Risk Assessment for Three Dreissenid Mussels (*Dreissena polymorpha, Dreissena rostriformis bugensis*, and *Mytilopsis leucophaeata*) in Canadian Freshwater Ecosystems. Available from: http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2012/2012_174-eng.html. Accessed 2016 Feb 4.

Turner C.B. 2010. Influence of Zebra (*Dreissena polymorpha*) and Quagga (*Dreissena rostriformis*) Mussel Invasions on Benthic Nutrient and Oxygen Dynamics. Canadian Journal of Fisheries & Aquatic Sciences [serial online]; 67(12): 9. Available from: EBSCOhost/Academic Search Complete. Accessed 2014 Mar 18.

U.S. Geological Survey. 2016. Nonindigenous Aquatic Species. Available from: http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/. Accessed 2016 Feb 3.

Vander Zanden M.J. and Olden J.D. 2008. A Management Framework for the Secondary Spread of Aquatic Invasive Species. Canadian Journal of Fisheries and Aquatic Sciences [serial online}; 65: 11. Available from: EBSCOhost/Academic Search Complete. Accessed 2012 Oct 13.

Warrington. 1980. Studies on Aquatic Macrophytes Part XXXIII. Aquatic Plants of British Columbia. Province of British Columbia. Ministry of Environment. Available from: http://www.env.gov.bc.ca/wat/wq/plants/plantbook.pdf. Accessed 2015 Sep 20.

Williams J.D., Warren M.L., Cummings K.S., Harris J.L. and Neves R.J. 1992. Conservation Status of Freshwater Mussels of the United States and Canada. Available from: http://www.researchgate.net/publication/239794675_Conservation_Status_of_Freshwater_Mussels_of_the_United_States_and_Canada. Accessed 2016 Feb 9.

2015 TARGET SPECIES FOR AQUATIC INVASIVE PLANT SURVEYS IN BC

Common Name	Scientific Name	Type
American beachgrass	Ammophila breviligulata	Semi-aquatic tidal
Amphibious yellow cress	Rorippa amphibian	Semi-aquatic emergent
Bigfoot clover	Marsilea macropoda	Semi-aquatic emergent/terrestrial ground cover
*Brazilian elodea	Egeria densa	Aquatic submerged
*Cabomba	*Cabomba caroliniana*	Aquatic submerged
*Common cordgrass	Spartina anglica	Semi-aquatic tidal
Common frogbit	Hydrocharis morsus-range	Aquatic submerged
Curly leaf pondweed	Potamogeton crispus	Aquatic submerged
*Dense-flower cordgrass	Spartina densiflora	Semi-aquatic tidal
Eurasian watermilfoil	Myriophyllum spicatum	Aquatic submerged fresh water/brackish
European beach grass	Ammophila arenaria	Semi-aquatic tidal
*European common reed	Phragmites australis subsp australis	Semi-aquatic freshwater/tidal
European lake sedge	Carex acutiformis	Semi-aquatic emergent
European water clover	Marsilea quadrifolia	Aquatic
European waterlily	Nymphaea alba	
Evergreen blackberry	Rubus laciniatus	Semi-aquatic freshwater/tidal
Fanwort	Cabomba caroliniana	
Feathered mosquito-fern	Azolla pinnata	Aquatic
*Flowering rush	Butomus umbellatus	Aquatic submerged/Semi aquatic emergent freshwater/brackish
Fragrant water lily	Nymphaea oderata	Aquatic emergent
*Garden yellow loosestrife	Lysimachia vulgaris	Semi-aquatic emergent
Giant chickweed	Myosoton aquaticum	Semi-aquatic emergent
Giant knotweed	Fallopia sachalinensis	Semi-aquatic emergent
Giant manna grass	Glyceria maxima	Semi-aquatic emergent
*Giant reed	Arundo donax	Semi-aquatic emergent
Giant salvinia	Salvinia molesta	
Himalayan balsam	Impatiens glandulifera	Semi-aquatic emergent
Himalayan blackberry	Rubus armeniacus	
*Hydrilla	Hydrilla verticillata	
Japanese knotweed	Fallopia japonica	Semi-aquatic emergent
Johnson grass	Sorghum halepense	Semi-aquatic emergent

*Kudzu	Pueraria montana	Semi-aquatic emergent
*Major oxygen weed	Lagarosiphon	Aquatic submerged
Parrot feather	Myriophyllum aquaticum	Aquatic submerged
Purple loosestrife	Lythrum salicaria	Semi-aquatic emergent
Russian olive	Elaeagnus angustifolia	
*Salt meadow cordgrass	Spartina patens	Semi-aquatic tidal
Saltcedar/Tamarisk	Tamarix ramosissima	Semi-aquatic emergent
*Smooth cordgrass	Spartina alterniflora	Semi-aquatic tidal
Variable-Leaf-Milfoil	Myriophyllum heterophyllum	
*Water chestnut	Trapa natans	Aquatic submerged
*Water hyacinth	Eichhornia crassipes	Aquatic emergent
*Water lettuce	Pistia stratiotes	Aquatic
*Water soldier	Stratiotes aloides	Aquatic submerged/emergent
Watercress	Nasturtium officinale	Semi-aquatic emergent
Yellow flag iris	Iris pseudacorus	Riparian
Yellow floating heart	Nymphoides peltata	Aquatic submerged

APPENDIX B

Results of the zebra and quagga mussel veliger monitoring program around the Central Kootenay region in 2015

Waterbody	Common site name or Nearest town	Date sampled	Zebra/Quagga Veliger	Others
Box Lake	Boat launch	09/16/2015	-	ostracoda
Columbia River	Gyro Park boat launch	07/16/2015	-	ostracoda
Columbia River	Gyro Park boat launch	08/12/2015	-	-
Columbia River	Gyro Park boat launch	09/18/2015	-	-
Columbia River	Robson boat launch	07/08/2015	-	ostracoda
Columbia River	Robson boat launch	08/20/2015	-	ostracoda
Columbia River	Robson boat launch	09/23/2015	-	-
Cottonwood Lake	Boat launch	09/09/2015	-	-
Erie Lake	Boat launch on NW shore	10/09/2015	-	ostracoda
Fish Lake	New Denver	09/15/2015	-	ostracoda
Kootenay Lake	Kaslo Bay	07/13/2015	-	-
Kootenay Lake	Kaslo Bay	08/10/2015	-	ostracoda
Kootenay Lake	Kuskanook Marina	07/31/2015	-	ostracoda
Kootenay Lake	Kuskanook Marina	08/28/2015	-	ostracoda
Kootenay Lake	Kuskanook Marina	10/02/2015	-	ostracoda
Kootenay Lake	Boswell Marina	07/31/2015	-	-
Kootenay Lake	Boswell Marina	08/20/2015	-	-
Kootenay Lake	Boswell Marina	09/30/2015	-	-
Kootenay Lake	Riondel boat launch	08/27/2015	-	-
Kootenay Lake	Riondel boat launch	10/02/2015	-	-
Kootenay Lake	Lakeside Park boat launch	07/27/2015	-	ostracoda
Kootenay Lake	Lakeside Park boat launch	09/01/2015	-	ostracoda
Kootenay Lake	Lakeside Park boat launch	09/29/2015	-	ostracoda
Kootenay Lake	Balfour boat launch	09/01/2015	-	-
Kootenay Lake	Balfour boat launch	09/29/2015	-	-
Kootenay Lake	Kokanee Ck. Provincial Park boat launch	09/01/2015	-	-
Kootenay Lake	Kokanee Ck. Provincial Park boat launch	09/29/2015	-	-
Upper Little Slocan Lake	Boat put-in	09/17/2015	-	ostracoda
Lower Arrow Lake	Syringa Ck. Provincial Park boat launch	07/21/2015	-	-
Lower Arrow Lake	Scotties Marina wharf	09/23/2015	-	-
Mosquito Lake	Forest Rec. site boat launch	07/23/2015	-	-

Waterbody	Common site name or Nearest town	Date sampled	Zebra/Quagga Veliger	Others
Nancy Green Lake	Boat launch	09/11/2015	-	-
Pend D'Oreille River	Buckley Campground boat launch	07/08/2015	-	ostracoda
Pend D'Oreille River	Buckley Campground boat launch	08/20/2015	-	ostracoda
Pend D'Oreille River	Buckley Campground boat launch	09/13/2015	-	ostracoda
Pend D'Oreille River	Remac	09/12/2015	-	ostracoda
Rosebud Lake	Boat launch	09/09/2015	-	ostracoda
Slocan Lake	Slocan boat launch	07/16/2015	-	-
Slocan Lake	Slocan boat launch	08/21/2015	-	-
Slocan Lake	New Denver boat launch	07/16/2015	-	-
Slocan Lake	New Denver boat launch	08/19/2015	-	-
Slocan Lake	Silverton boat launch	07/19/2015	-	-
Slocan Lake	Silverton boat launch	08/19/2015	-	-
Staubert Lake	Boat put-in at east end	09/30/2015	-	-
Upper Arrow Lake	Nakusp boat launch	07/20/2015	-	-
Upper Arrow Lake	Nakusp boat launch	08/18/2015	-	ostracoda
Upper Arrow Lake	Nakusp boat launch	09/25/2015	-	-
Whatshan Lake	Whatshan Lk. Retreat boat launch	07/22/2015	-	ostracoda
Wilson Lake	Boat put-in at Rec. site	10/02/2015	-	-