PROTECTING OUR WATERS FROM AQUATIC INVASIVE SPECIES (REFERENCE NO:F-F15-20)

***Report Prepared for*:**

Fish and Wildlife Compensation Program

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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 from a monitoring survey carried out in 2010 by the Invasive Species Council of BC (ISCBC) 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, a recent survey by the Pend D'Oreille County Weed Board, indicates that flowering rush (*Butomus umbellatus*), yellow flag iris (*Iris pseudacorus*) and purple loosestrife (*Lythrum salicaria*) are present in extensive distribution and density within the Pend D'Oreille River on the American side of the border. 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 ISCBC supported programs such as "Clean-Drain-Dry" (for boaters and fishermen) and "PlantWise" (horticulture industry).

Priority waterbodies (as identified by a multi-stakeholder working group) in the study area were surveyed and sampled for the presence of invasive aquatic plants and zebra or quagga mussel veligers (larvae). Substrate samplers to detect the presence of juvenile mussels were also installed and inspected monthly from July through October. In total, 23 sites were sampled on 14 waterbodies for mussel veligers and five substrate samplers were installed. Littoral surveys for invasive plants were conducted on Nancy Greene, Staubert, Wilson, Little Wilson, Summit, Box, Upper Little Slocan, Fish, Bear, Cottonwood, Six Mile, Sasquatch, Rosebud and Erie Lakes. High risk/use areas such as boat launches, marinas and fishing access sites were visited and surveyed on Slocan, Trout and Kootenay Lakes and the Kootenay and Columbia Rivers to determine the presence or extent of AIS infestations in these systems. 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 River; funds were provided by partner stakeholders.

Veliger samples were analysed in the laboratory by a certified analyst and all came back negative for the presence of *Dreisseinid* larvae. Similarly no juvenile or adult mussels were detected on any of the substrate samplers.

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. Fragrant water lily (*Nymphaea odorata*) was discovered in a small pocket in Nancy Greene Lake. It was removed the following day with support from Terry Anderson, Habitat Officer, with the Ministry of Environment. Numerous patches of yellow flag iris were present in the riparian zone of Erie Lake.

Since 2010, *P. crispus* has greatly expanded its range and abundance. It is now confirmed to be present throughout the Kootenay-Columbia system and has outcompeted and displaced *M. spicatum* at sites with some level of water velocity in Creston. It has now reached as far north as Argenta and Lardeau in Kootenay Lake and has spread from Balfour to Fort Shepherd Conservancy Area south of Trail on the Columbia River. A small patch of *P. crispus* was found at a boat launch on the Columbia River upstream from the confluence with the Kootenay River. *M. spicatum* was not detected as far north in Kootenay Lake as in 2010, but was found in the Columbia River south of Trail where it had previously been undetected. *M. spicatum* has colonized and increased in density primarily in protected, low flow areas such as sloughs, bays and marinas.

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.

Veliger and aquatic plant monitoring should continue on priority waterbodies in order to detect new infestations and enact a rapid response. Continued outreach and education to the public on best management practices coupled with collaboration with bordering districts and states will greatly assist in preventing the establishment and spread of AIS throughout the region.

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1.0 INTRODUCTION

Aquatic invasive species 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 aquatic invasive species introductions to British Columbian waters 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, aquatic invasive species 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 result in harmful consequences for native species found in natural aquatic ecosystems. Aquatic invasive species have been implicated in vast reductions or the outright extinction of indigenous fish populations across Canada, devastating local fisheries (CKIPC, 2013a).

In 2010, an aquatic invasive species survey was completed by the Invasive Species Council of BC (ISCBC), in collaboration with the Central Kootenay Invasive Plant Committee (CKIPC), within the Central Kootenay Regional District and the Regional District Kootenay Boundary Area A and B. Prior to this survey there was limited information as to the extent of aquatic invasive species, such as Eurasian watermilfoil (*Myriophyllum spicatum)*, in the region. This initiative was limited to high-use boat launches along the Kootenay-Columbia river system, Nancy Greene Lake, Box Lake, Wilson Lake, Slocan Lake, Summit Lake and Kootenay Lake. As a result of this study, it was determined that *M. spicatum* was established throughout the Kootenay River and Kootenay Lake (with the exception of the north end of Kootenay Lake) and the Columbia River. Curlyleaf pondweed (*Potamogeton crispus)* was also discovered, but presented limited distribution from the Creston area to Crawford Bay and a few isolated patches at a handful of marinas between Balfour and Shroeder Creek (north of Kaslo) and on the West Arm to Nelson.

At the 2011 CKIPC AGM, the need for a collaborative approach to address the impacts of aquatic invasive species and prevent their introduction and spread was identified as a high priority. This call to action, lead to the establishment of a multi-agency Aquatic Working Group (AWG) (www.ckipc.ca/about-us/subcommittees), which has the goal of providing a forum for discussion, coordination and action with respect to aquatic invasive species including prevention, early detection, monitoring and outreach in the CKIPC region. Since its inception, the AWG has become widely recognized for its role in coordinating regional programs, participating in cross-border initiatives, strengthening partnerships, and securing support for monitoring, prevention and education and outreach initiatives.

The majority of lakes and reservoirs in BC have been assigned a medium-high risk status for introduction and establishment of zebra and quagga mussels (*D. polymorpha and D. rostriformis bugensis*) (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, approximately 70 percent of North America's native freshwater mussel species are of conservation concern or presumed extinct, to which many factors have been attributed, including the introduction of nonindigenous mollusks (Williams et al., 1992; Barnhart and Neves, 2005).

In 2012 and 2013, representatives from FortisBC Inc., Teck Metals Ltd., BC Ministry of Environment, and Slocan Lake Stewardship Society carried out the *Columbia and Kootenay Sentinel (Calcium and Dressinid Larvae) Monitoring Program* (CKIPC, 2013b). This was the first time that Slocan Lake, Upper and Lower

Arrow Reservoir, Kootenay Lake, Pend D'Oreille River, and Lower Columbia River were sampled for zebra and quagga mussel veligers, and the need for ongoing monitoring was deemed critical, as no positive results were found.

With support from the following partners in 2014, the Fish and Wildlife Compensation Program (FWCP), Columbia Power Corporation (CPC), Columbia Basin Trust (CBT), FortisBC Electric (FElec) and Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), *Phase I* of the *Protecting Our Waters from Aquatic Invasive Species Project* was implemented, which resulted in the coordination and delivery of an extensive aquatic invasive species monitoring program throughout the CKIPC region.

Priority aquatic invasive species include those identified by the AWG, which includes, but is not limited to, Eurasian watermilfoil, purple loosestrife, yellow flag iris, flowering rush, and zebra and quagga mussels.

2.0 GOALS AND OBJECTIVES

The goals and objectives of this project were to:

1) Determine the extent of Eurasian watermilfoil and curlyleaf pondweed colonization in the Columbia-Kootenay system.
2) Survey priority waterbodies (as identified by the AWG) 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) Install and monitor substrate samplers for zebra and quagga mussels.
5) Collect plankton samples from priority waterbodies to be analysed for the presence of zebra or quagga mussel veligers.
6) Collaborate with local stewardship groups and others to increase the region's capacity for assisting the Province in monitoring for zebra and quagga mussels.
7) Increase public awareness of the impacts of AIS on our waterways and provide education about best management practices such as the "Clean-Drain-Dry" (CDD) program.

3.0 STUDY AREA

The study area for this project was the Central Kootenay Invasive Plant Committee's working region, which is approximately 30,500 km^2 (see Figure 1). This region is located in the southwestern portion of the Canadian Columbia River basin. There were 19 waterbodies surveyed within the CKIPC region, as well as three waterbodies that lie just outside of this region to the north (in the Columbia Shuswap Regional District). All of the surveyed waterbodies eventually flow into the Columbia River.

Surveys for aquatic invasive plants and zebra and quagga mussels occurred on Lower Arrow, Slocan, Kootenay, Trout, Upper Little Slocan, Fish, Staubert, Nancy Greene, Rosebud, Summit, Box, and Wilson Lakes, Pend D'Oreille River and on the Columbia River. On Little Wilson, Armstrong, Cottonwood, Bear, Sasquatch, Six Mile, and Erie Lakes, and on the Kootenay River, surveys were conducted for aquatic invasive plants. Surveys for zebra and quagga mussels occurred on Upper Arrow Lake. Appendix A provides a map of all sampling points for this survey and previous surveys.

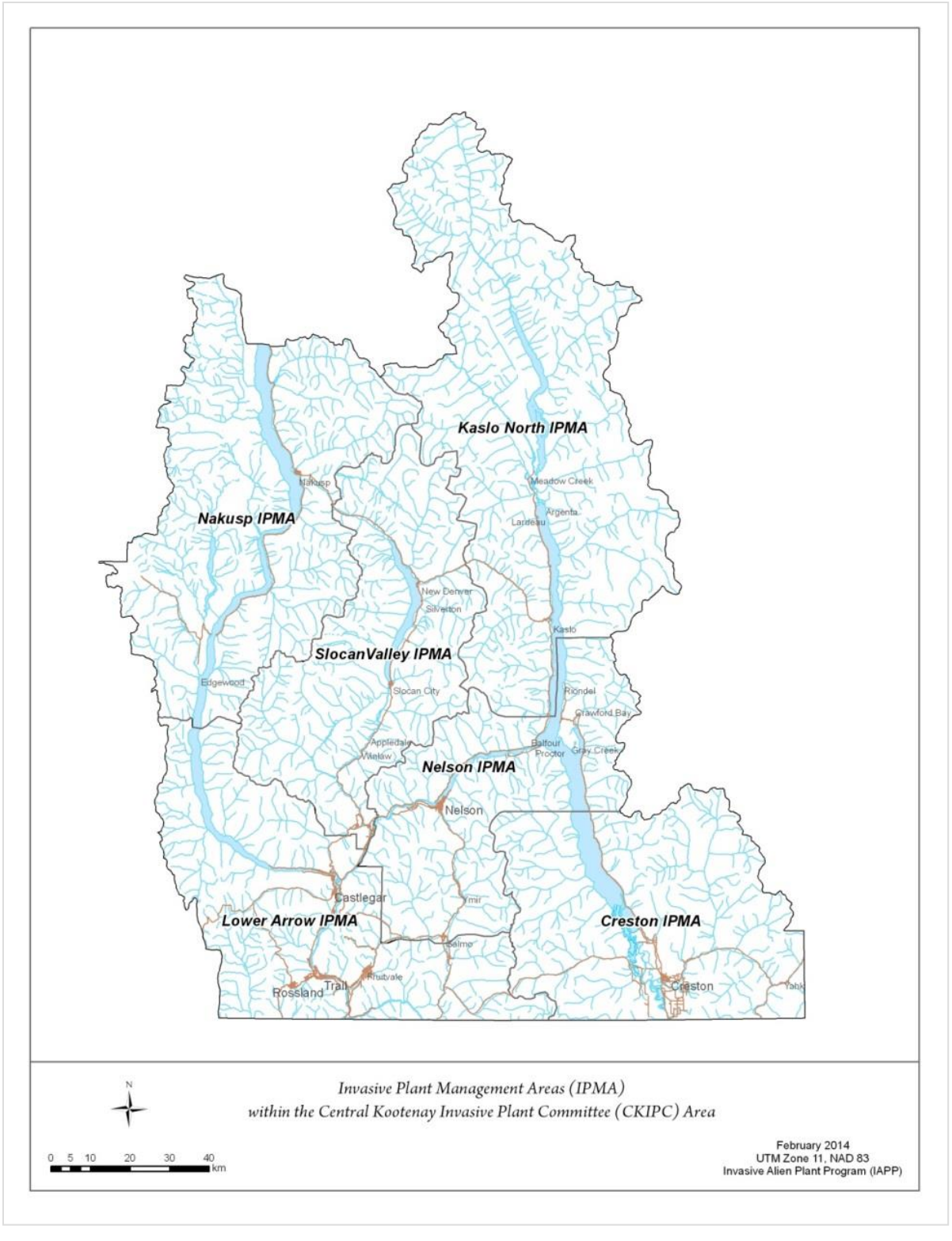

FIGURE 1. *MAP OF THE CENTRAL KOOTENAY INVASIVE PLANT COMMITTEE REGION*.

4.0 METHODS

4.1 AQUATIC INVASIVE PLANTS

Sampling began in Creston on July 21, 2014 to coincide with optimum surveying times for *P. crispus* and *M. spicatum* (Duncan, 2011). At the onset of this project, British Columbia had not yet adopted a protocol for the sampling of aquatic invasive plants. Aquatic invasive plant surveys were carried out following a modified version of the State of Montana's Aquatic Plant Survey and Sample Collection Protocol as outlined in Appendix B of the document "Montana's Statewide Strategic Plan for Aquatic Invasive Plant Management and Resource Protection" (Duncan, 2011). The Montana protocol was used at the recommendation of Val Miller, Invasive Plant Officer for the MFLNRO. A rough draft of British Columbia's protocol was obtained in late August and was followed for the remainder of the project. At all sampling sites a thatched (hard) rake head attached to 30m of rope was deployed into the water and retrieved bringing a sample of macrophytes with it if present. GPS coordinates were recorded as well as substrate type, site description (boat launch, marina, beach, etc.), presence/absence of AIS, presence/absence of native vegetation and any pertinent site specific comments. At sites where AIS were present, density and distribution were recorded in accordance with IAPP standards and entered into the provincial database. Native plants were identified using a dichotomous key and non-dichotomous methods (Warrington, 1980). Sampling methods differed slightly depending on the type of waterbody being sampled following a separate protocol for large lakes and rivers and one for small to medium sized lakes. All gear including paddles, were decontaminated by soaking in a 5% solution of bleach for 30 minutes before being deployed to a waterbody. Watercraft were sprayed with bleach, wiped down and allowed to dry.

LARGE LAKES AND RIVERS

In October of 2010, AIS surveys were conducted on Kootenay and Slocan Lakes and the Kootenay and Columbia Rivers and the data was entered into IAPP. Where possible these same sites were visited in 2014, in order to observe and record changes in known existing AIS infestations and to discover new AIS locations. At each site rake throws were conducted 100m in each direction along the shoreline (where possible), from the initial access point at 25m intervals. The shoreline was scanned for the presence of riparian invasive vegetation such as yellow flag iris, purple loosestrife, etc. or fragments of submerged AIS. Trout Lake was surveyed with the use of a boat provided by the Columbia Shuswap Regional District for the day. Areas of high risk for the establishment of AIS such as boat launches, private docks and inflow and outflow of creeks were visited. A secchi depth of 9.2m was recorded allowing for visual observation to the outer extent of macrophyte beds encountered. A rake was deployed in order to confirm the identity of observed vegetation around the dock and boat launch areas.

In addition to these targeted surveys, CKIPC Program Technician Matt Chilakos and Summer Student Matt Fraser conducted a thorough survey of the Kootenay River Bird Marsh area (by foot from land) and the Slocan Pool (by canoe) and the Pend D'Oreille River (by canoe). All sites were identified with GPS coordinates and data collected as per IAPP standards (https://www.for.gov.bc.ca/hra/plants/RefGuide.htm) and entered into IAPP. These additional surveys

and consequent treatments were completed with leveraged funds provided by CBT, FortisBC Electric and MFLNRO.

SMALL AND MEDIUM LAKES

The entire littoral zones of each of the smaller lakes were surveyed with the use of a boat. A small boat with an electric motor and oars was used for Summit, Box and Staubert Lakes. A canoe was used for all other lakes in the study area. The littoral zone was traversed in a zig-zag pattern and was surveyed with a combination of rake throws and visual observations. The shoreline was also scanned for the presence of invasive riparian plants. It was thought that Eurasian milfoil might be present in Summit Lake, so a snorkel survey was employed around the boat launch, campsites and beach area of Summit Lake Provincial Park.

4.2 ZEBRA AND QUAGGA MUSSEL MONITORING

VELIGER MONITORING

Sampling for zebra and quagga mussel (*D.polymorpha and D. rostriformis bugensis*) veligers commenced on July 28, 2014, and concluded on October 10, 2014. Sampling techniques followed the protocol distributed by Matthias Herborg, Aquatic Invasive Species Coordinator, BC Ministry of Environment. The sampling protocol used during the project is provided in Appendix B and as a separate attachment to this document. Any modifications to this protocol that were needed to accommodate inconsistencies in the field were approved by Matthias Herborg. CKIPC employees, project contractors, local stewardship groups and other partners undertook sampling for veligers and adults.

In total, twenty-three sites were sampled; 12 were sampled thrice, one was sampled twice, and 10 were sampled once (see Table 1). Nine of these locations were established as veliger monitoring sites in 2012 – 13 under the *Columbia and Kootenay Sentinel (Calcium and Dressinid Larvae) Monitoring Program* (CKIPC, 2013b). At all sample 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 presence of zebra or quagga mussel veligers.

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

Waterbody	Common site name	Location	Sampled in 2012	Sampled in 2014	Sampling frequency in 2014
Columbia River	Gyro Park boat launch	11 U 448416 E 5438837 N	x	x	3
Columbia River	Old Bridge, Trail	11 U 449030 E 5437859 N	x	x	3
Slocan Lake	New Denver	11 U 472937 E 5536986 N	x	x	3

Waterbody	Common site name	Location	Sampled in 2012	Sampled in 2014	Sampling frequency in 2014
	boat launch				
Slocan Lake	Silverton boat launch	11 U 474012 E 5533607 N	x	x	3
Kootenay Lake	Balfour boat launch	11 U 502978 E 5496721 N	x	x	3
Kootenay Lake	Kokanee Creek Provincial Park boat launch	11 U 491774 E 5495242 N		x	3
Kootenay Lake	Lakeside Park boat launch	11 U 479581 E 5484086 N		x	3
Upper Arrow Lake	Nakusp boat launch	11 U 443099 E 5565193 N	x	x	3
Lower Arrow Lake	Syringa Creek Provincial Park boat launch	11 U 436701 E 5465721 N	x	x	3
Pend D'Oreille River	Buckley campground boat launch	11 U 464006 E 5431944 N	x	x	2
Pend D'Oreille River	Boat launch	11 U 459550 E 5428779 N	x		
Kootenay Lake	Kaslo boat launch	11 U 506664 E 5529470 N	x		
Kootenay Lake	Riondel Marina	11 U 510285 E 5513027 N		x	3
Kootenay Lake	Kuskanook Marina	11 U 524508 E 5460867 N		x	3
Slocan Lake	Slocan boat launch	11 U 465959 E 5513126 N	x	x	3
Upper Little Slocan Lake	Boat launch	11 U 452640 E 5503327 N		x	1
Summit Lake	Three Island Lodge boat launch	11 U 452951 E 5556340 N		x	1
Box Lake	Boat launch	11 U 449084 E 5561866 N		x	1
Nancy Greene Lake	Boat put-in	11 U 431397 E 5456224 N		x	1

Waterbody	Common site name	Location	Sampled in 2012	Sampled in 2014	Sampling frequency in 2014
Rosebud Lake	Boat put-in	11 U 480334 E 5432608 N		x	1
Trout Lake	Boat launch	11 U 462126 E 5610471 N		x	1
Trout Lake	Boat put-in	11 U 480303 E 5595508 N		x	1
Staubert Lake	Boat put-in	11 U 454841 E 5614426 N		x	1
Fish Lake	Boat put-in	11 U 486998 E 5543674 N		x	1
Wilson Lake	Boat launch	11 U 456954 E 5564743 N		x	1

SUBSTRATE MONITORING

A total of five substrates were installed around the region, and monitored monthly from July through October (see Table 2*).* The installation of substrates was dependent on approval from the appropriate authority, public safety, and depth requirements. Sampling techniques followed the protocol distributed by Matthias Herborg, Aquatic Invasive Species Coordinator, BC Ministry of Environment. The sampling protocol used during the project is provided in Appendix C and in a separate attachment to this document. Any modifications to this protocol that were needed to accommodate inconsistencies in the field were approved by Matthias Herborg. Samples were collected from substrates if suspect organisms were seen or if the substrate felt like rough sandpaper, and then examined under a hand lens.

TABLE 2. *LOCATIONS WHERE SUBSTRATES WERE INSTALLED AROUND THE CENTRAL KOOTENAY REGION TO MONITOR FOR ADULT ZEBRA AND QUAGGA MUSSELS, 2014.*

Waterbody	Common site name	Nearest town	Location	Sampler
Kootenay Lake	Riondel Marina	Riondel	11 U 510285 E 5513027 N	Eastshore Freshwater Habitat Society
Kootenay Lake	Lakeside Park boat launch	Nelson	11 U 479604 E 5484070 N	CKIPC
Kootenay Lake	Kuskanook Marina	Creston	11 U 524508 E 5460867 N	CKIPC
Slocan Lake	Slocan boat launch	Slocan	11 U 465959 E 5513126 N	CKIPC

Waterbody	Common site name	Nearest town	Location	Sampler
Columbia River	Gyro Park boat launch	Trail	11 U 448356 E 5439054 N	Teck Metals Ltd.

4.3 LITERATURE REVIEW OF INVASIVE FISH PROJECTS

A thorough review of all fish related projects within the Central Kootenay, Kootenay Boundary and East Kootenay Regional Districts was conducted. Initially, a full review of West Kootenay Environmental Funding Agency websites was completed to determine fish projects that may have been conducted in the region. Projects approved for funding involving invasive fish in the Kootenay region were recorded.

The Columbia Basin Trust, the Fish and Wildlife Compensation Program and the Ministry of Environment provide a search option of archived reports on their websites and the Habitat Conservation Trust Foundation provides lists of projects funded by area in BC. These sources were searched for projects directly or indirectly involving invasive fish using keywords such as “invasive”, “invasive fish” and “fish”. A Google search was also performed using “Kootenays” and the aforementioned keywords.

In addition to searching these websites, emails were sent to industry, stewardship groups, First Nations organizations, environmental consultants and local government fish biologists that conduct research in aquatic issues within the region, requesting information on projects involving invasive fish.

4.4 EXTENSION AND OUTREACH

The Central Kootenay Invasive Plant Committee 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, particularly zebra and quagga mussels, and to promote the province-wide Clean-Drain-Dry program (see Table 3).

TABLE 3. *EXTENSION AND OUTREACH ACTIVITIES FOCUSED ON AQUATIC INVASIVE SPECIES UNDERTAKEN BY THE CENTRAL KOOTENAY INVASIVE PLANT COMMITTEE IN 2014.*

Date	Details	Topic(s) Covered
August 11	Interview: Sport Fishing on the Fly (TV)	Interview at Kokanee Creek Provincial Park; discussed aquatic invasive species (AIS), Clean-Drain-Dry (CDD) program
September 9	Interview: EZ Rock (radio)	Discussed zebra and quagga mussel sampling & provincial program, CDD, and boat wash machine
August 23	Invasive Fishing Derby (Robson)	Disseminated AIS and CDD educational materials
August 26-27	Hosted aquatic invasive species booth: Toadfest	Focus: terrestrial, riparian and aquatic invasive species, CDD, PlantWise (PW), Grow Me Instead (GMI)

Date	Details	Topic(s) Covered
	(Summit Lake)	
August 31	Presentation, field tour: Eastshore Freshwater Habitat Society	Discussed terrestrial, riparian and aquatic invasive species (identification, prevention, management, etc.), CDD; provided zebra/quagga mussel sampling demonstration
September	Media Article	Discussed zebra/quagga mussels and CDD
September 23	Presentation: Columbia Power Corporation, Lunch and Learn	Discussed riparian and aquatic invasive species (identification, prevention, management, etc.), CDD, PW, GMI, Don't Let it Loose
September 29	CKIPC Annual Field Tour (General membership and public), New Denver	Discussed AIS (identification, prevention, management, etc.), CDD, PW, GMI; provided zebra/quagga mussel and aquatic invasive plant sampling demonstration
November 6	Presentation: Columbia Basin Watershed Network members meeting	Discussed AIS (identification, prevention, management, etc.), CDD, zebra/quagga mussel and aquatic invasive plant sampling programs, boat wash machine
January 8, 2015	Presentation: West Kootenay Fly Fishing Club members meeting	Discussed AIS (identification, prevention, management, etc.), zebra/quagga mussel sampling program, CDD, boat wash machine

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, Fish, Erie, Nancy Greene, Wilson, Little Wilson, Sasquatch, Upper Little Slocan, Summit, Staubert, Armstrong or Six Mile Lakes) as a result of this study. Trout and Slocan lakes were also found to be free of invasive plants.

M. spicatum had been reported as being present in Summit Lake. A large patch of milfoil at Summit Lake Provincial Park was identified as a native milfoil*, M. sibricum*. This was a dense monotypic stand with an emergent flower spike close to the shore in an area of high boat traffic and could easily be confused with an invasive species. The following photos demonstrate how similar these species appear and an old sign describing *M. spicatum* may have led to the reports by a concerned citizen (see Figure. 2).

FIGURE 2. *EMERGENT FLOWER SPIKE OF M.SPICATUM (LEFT) AND NATIVE M. SIBRICUM PATCH AT SUMMIT LAKE (RIGHT), 2014.*

Fourteen relatively small patches of yellow flag iris (YFI) were present on the shores of Erie Lake just west of Salmo. 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. In addition, 42 distinct patches of YFI and 47 distinct patches of purple loosestrife on the Kootenay River within the Bird Marsh and Slocan pool area and 23 patches of YFI on the Pend D'Oreille River were inventoried and mechanically treated, with leveraged funding from Columbia Basin Trust, FortisBC Electric and Ministry of Forests, Lands and Natural Resources Operations.

Nymphaea odorata, or fragrant water-lily, was discovered to be growing in one small patch (1m x 2m) in a shallow bay in the north-west section of Nancy Greene Lake. This patch of plants was found growing at the end of a trail leading from a pullout on Hwy 3. *N. odorata* is listed on CKIPC's EDRR (Early Detection-Rapid Response) list as a species not currently present in CKIPC's region. This species has become established in Christina Lake, the next community west of Nancy Greene Provincial Park on Hwy. 3. The site was revisited the following day and plants and rhizomes were removed with support from Terry Anderson, Habitat Officer with the BC Ministry of Environment.

A total of 144 sites were sampled on the Kootenay-Columbia system during the course of this study (FWCP funding portion) (see Figures 3 and 4). Five of these sites from Creston to Riondel were visited twice, once in mid-July and again at the beginning of October. This was done in order to observe changes in plant communities over the course of a season. At three sites where *P. crispus* and *M. spicatum* were both present, density and distribution of *M. spicatum* increased while those of *P. crispus* decreased. In one of these cases *P. crispus* was no longer detected. Of the two sites where only *P. crispus* had been found, density and distribution increased at one site and it was undetected at the other. Densities, distributions and estimated areas for *M. spicatum* and *P. crispus* for all sites as well as a legend for density and distribution codes in IAPP are presented in Appendix D.

For ease of discussion the system has been divided into four reaches: 1) Kootenay River- Creston; the section of the Kootenay River from the US border to Kootenay Lake 2) Kootenay Lake; the main body of the lake 3) West Arm-Lower Kootenay River; from Balfour to Nelson on the West Arm of Kootenay Lake and the Kootenay River from Nelson to Castlegar and 4) Columbia River; Syringa Provincial Park to the US border.

As outlined in the BC Aquatic Plant Survey and Sample Collection Protocol (unpublished), frequency of occurrence for each plant species in a water body was calculated by dividing the number of survey points where the individual species was observed, by the total number of points surveyed for a given water body, then multiplied by 100 to achieve a percent. These results are given in Table 4. It is likely that macrophyte abundance (native and non-native) on the Columbia River is limited due to steep-sided river channels, fluctuating flows and water velocity (NECL, 1992).

TABLE 4. *PERCENT OCCURRENCE OF M. SPICATUM AND P. CRISPUS IN WATERBODIES SAMPLED IN 2014.*

Reach	# Sites sampled	% Occurrence of *M. spicatum*	% Occurrence of *P. crispus*
Kootenay River-Creston	15	46.7	73.3
Kootenay Lake	31	48.4	64.5
West Arm-Kootenay River	42	33.3	28.6
Columbia River	29	13.8	34.5

On comparing the results of this study with those from 2010, it is evident that within the Kootenay-Columbia system *M*. *spicatum* and *P*.*crispus* have expanded their range (see Figures 3, 4, 5 and 6). *P*. *crispus* in particular has spread into regions where *M*. *spicatum* is still not found, such as the northern reaches of Kootenay Lake in Argenta and Lardeau. It has also been observed on the Columbia River upstream from the confluence of the Kootenay River in Robson. *P. crispus* has become established in areas with significant water velocities, while *M. spicatum* has been more successful colonizing backwater channels and bays with low flow rates. Golder Associates, Castlegar (Golder and Poisson, 2013) have anecdotally observed a gradual increase in aquatic vegetation (dominantly *M. spicatum*) in low water velocity areas of the Lower Columbia River for the past seven years.

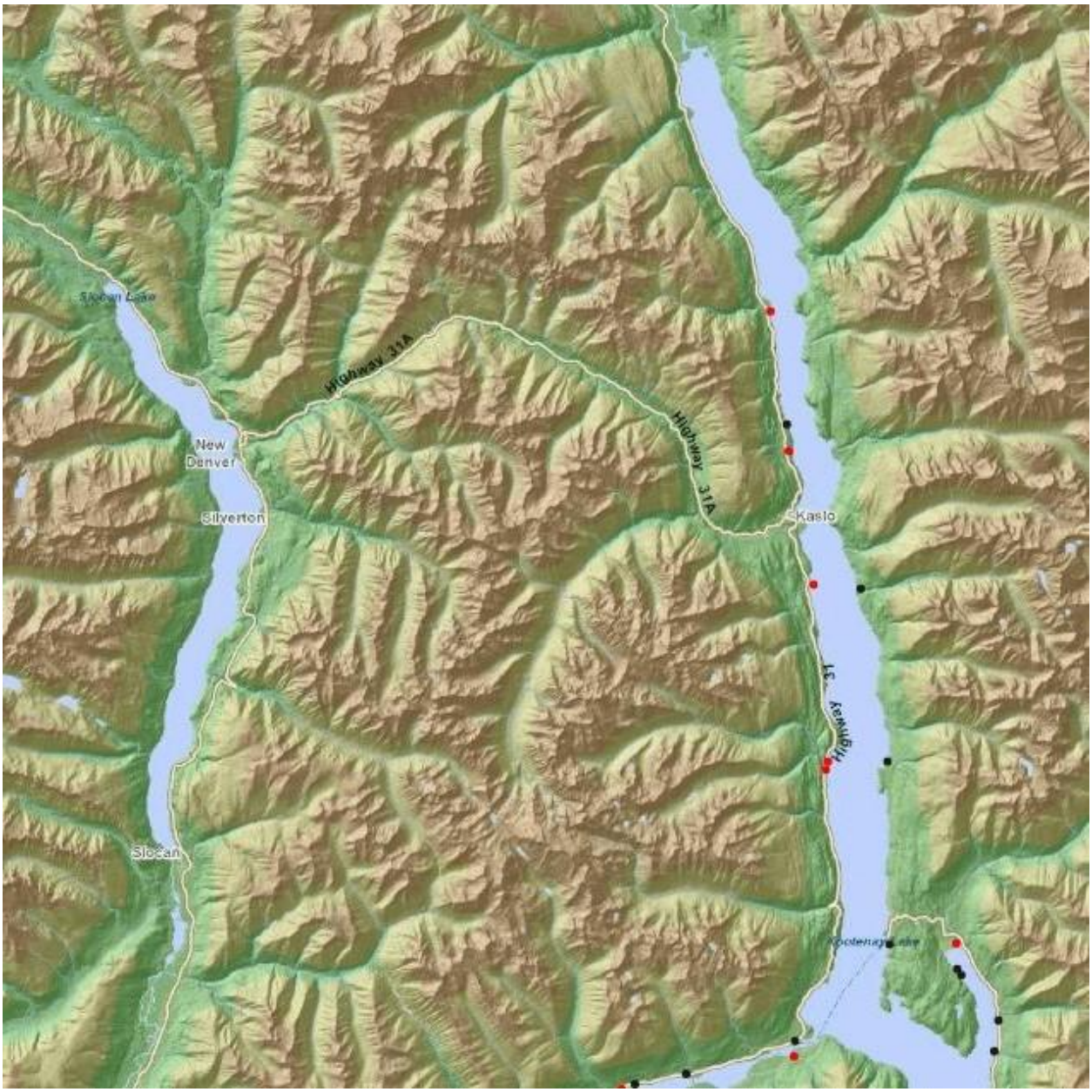

FIGURE 3. *SAMPLING POINTS FROM 2010 INDICATING PRESENCE OF ● M. SPICATUM AND P. CRISPUS, ● M. SPICATUM, ● P. CRISPUS IN THE NORTHERN SECTION OF THE STUDY AREA.*

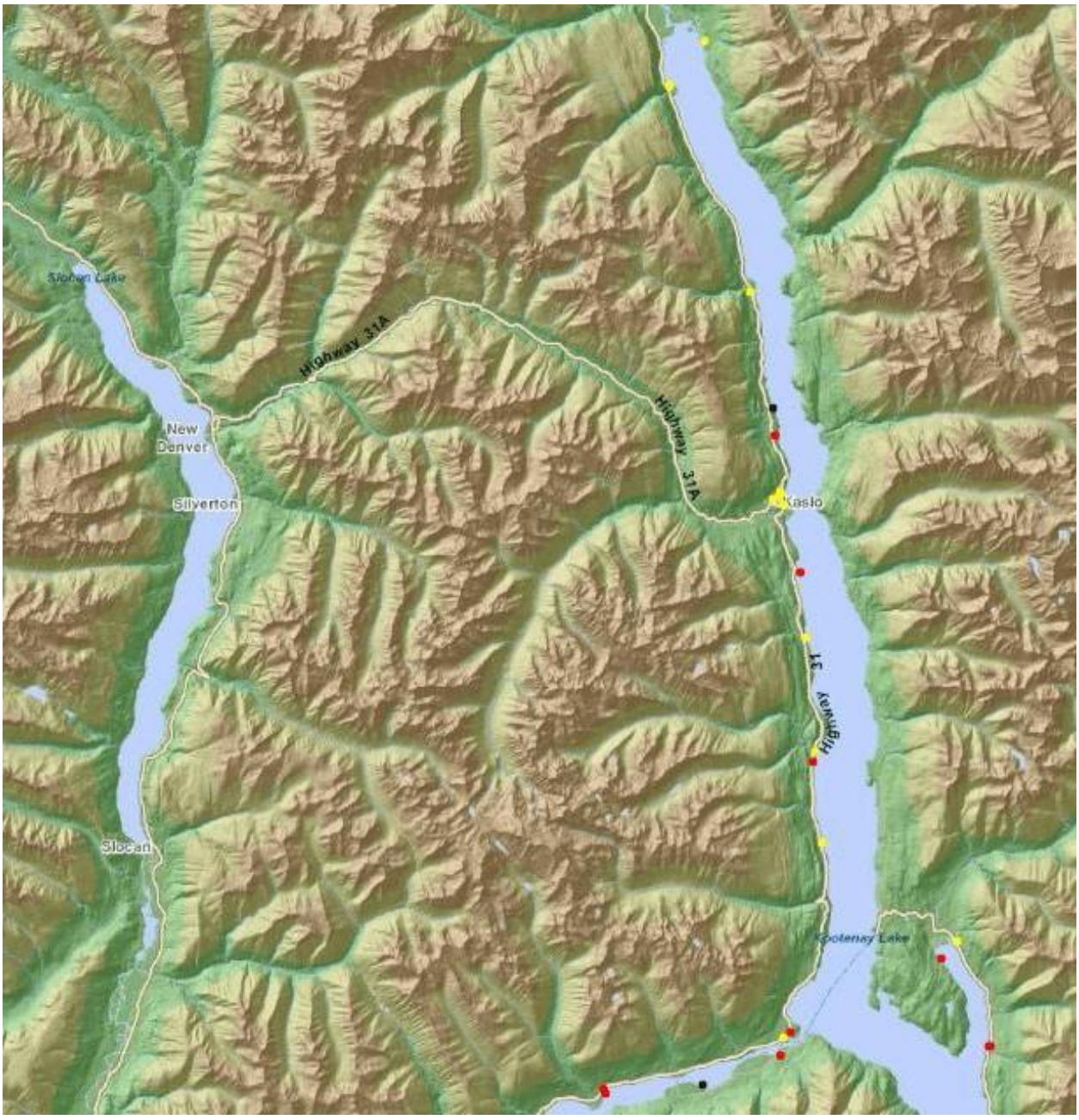

FIGURE 4. *SAMPLING POINTS FROM 2014 INDICATING PRESENCE OF ● M. SPICATUM AND P. CRISPUS, ● M. SPICATUM, ● P. CRISPUS IN THE NORTHERN SECTION OF THE STUDY AREA.*

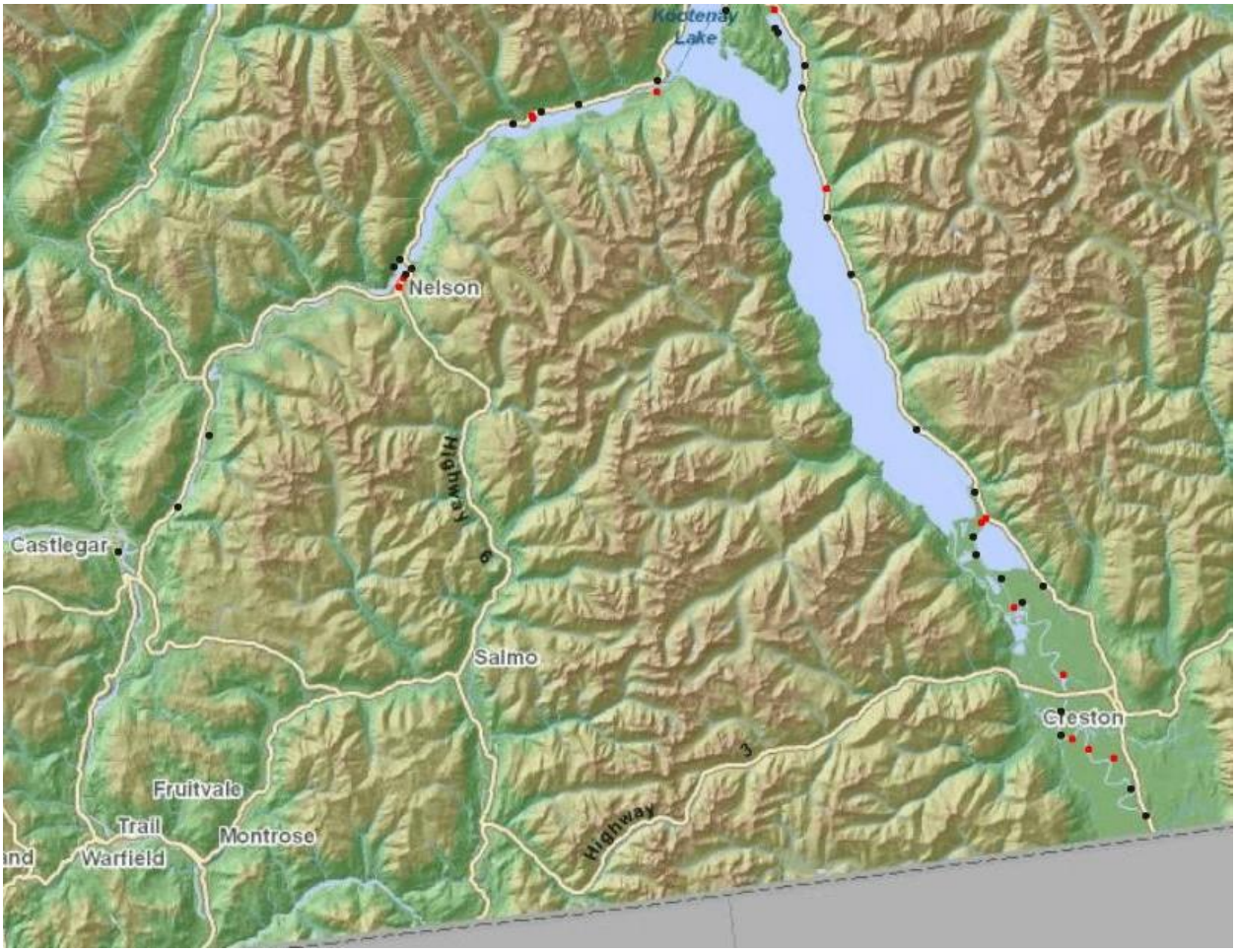

FIGURE 5. *SAMPLING SITES FROM 2010 INDICATING PRESENCE OF ● M. SPICATUM AND P. CRIPSUS, ● M. SPICATUM, ● P. CRISPUS IN THE SOUTHERN SECTION OF THE STUDY AREA.*

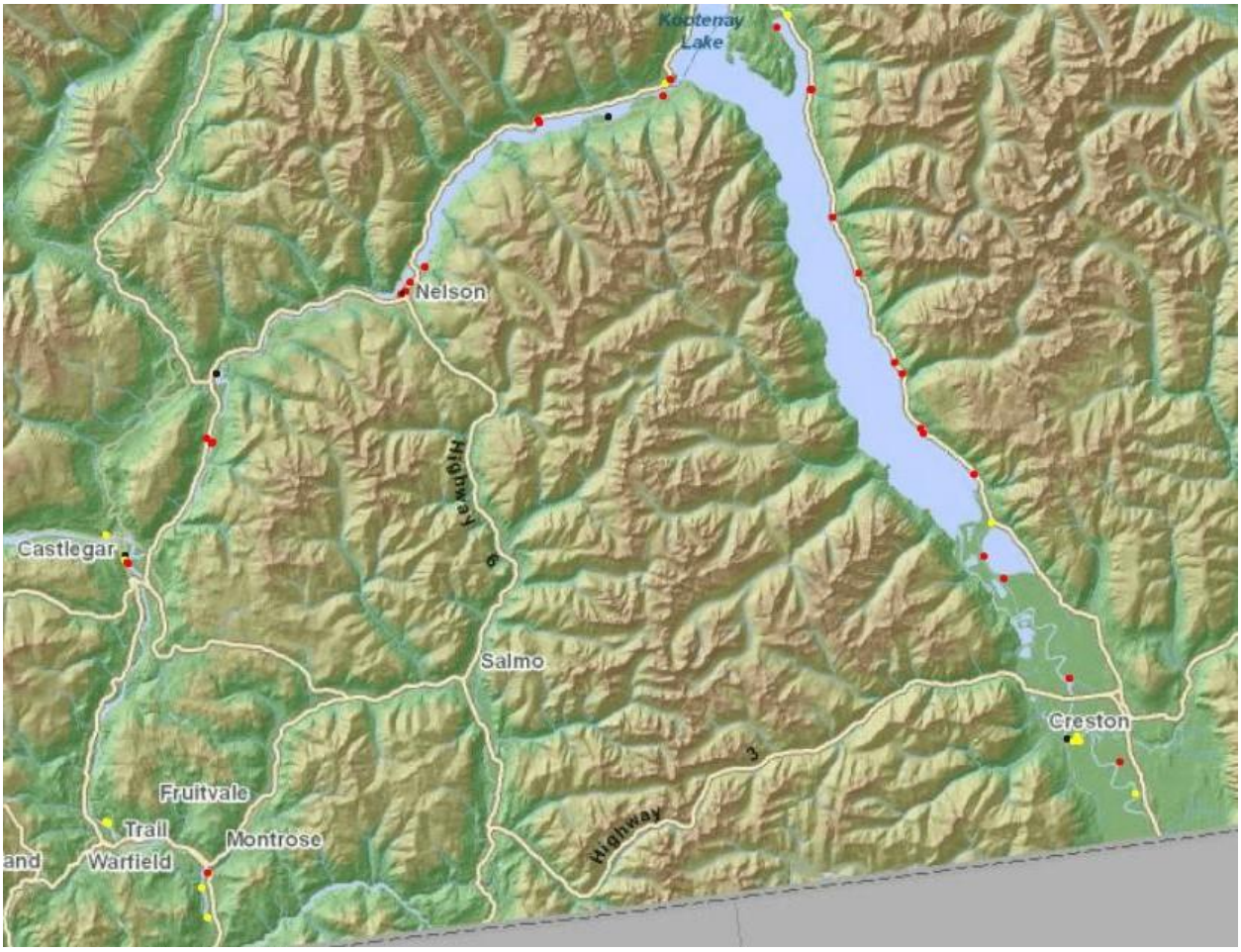

FIGURE 6. *SAMPLING SITES FROM 2014 INDICATING PRESENCE OF ● M. SPICATUM AND P. CRIPSUS, ● M. SPICATUM, ● P. CRISPUS IN THE SOUTHERN SECTION OF THE STUDY AREA.*

5.2 ZEBRA AND QUAGGA MUSSEL MONITORING

No juvenile or adult mussels were detected on any of the submerged substrates. In addition, no Dreissenid mussel veligers were detected in any of the 48 analyzed water samples. One species of native mussel veligers from the family Unionidae was detected in one sample (see Appendix E for detailed results).

5.3 LITERATURE REVIEW OF INVASIVE FISH PROJECTS

After reviewing the literature available, it is apparent that a limited number of projects directly targeting invasive fish have been conducted within the Columbia region of BC

The majority of current efforts have been concentrated on *Esox lucius* (Northern Pike) management. The presence of pike was first discovered during a Lower Columbia River Large River Indexing study. These studies, as well as Middle Columbia River Large River Indexing studies, are performed yearly and have observed and monitored the presence of invasive fish such as pike, walleye, smallmouth bass and others.

Many studies involving genetic hybridization of rainbow and cutthroat (*Oncorhynchus mykiss* and *O. clarkii*) have been carried out in the East Kootenay region since the late 1980's; these studies have resulted in a management plan for Whiteswan Lake's introduced rainbow trout fishery. Of the numerous studies available, three have been referenced in Table 6. For further information on hybridization studies please contact Heather Lamson at the Ministry of Forests, Lands and Natural Resource Operations, Cranbrook.

In addition to the aforementioned studies a variety of random studies and observations have been completed that include but are not limited to the following;

- BC *Hydro's MCR and LCR Large River Indexing* and *Fish Stranding Assessment and Ramping Protocol* studies have documented the presence of invasive and exotic fish in the Columbia River and Arrow Lakes and common carp and brook trout below Hugh Keenleyside and Brilliant dams,
- Columbia Power Corporation is currently investigating predation by invasive fish on sturgeon eggs,
- Studies by the FWCP and CBT assessed predation on northern leopard frogs in Creston by bass, sunfish and brown bullhead, and
- Consultants (Poisson Consulting, Masse Environmental Consultants, Salmo Watershed Streamkeepers Society) have regularly encountered brook trout (*Salvelinus fontinalis*) while conducting electrofishing or snorkel surveys throughout the West Kootenays.

Projects that directly or indirectly involve invasive fish in the Columbia Basin and associated reference documents are listed in Table 6 (Note that detailed references are listed in Section 8.0).

TABLE 5. *SUMMARY OF INVASIVE OR EXOTIC FISH RELATED PROJECTS CONDUCTED IN THE COLUMBIA BASIN.*

Project title or description	Date of project	Area/Location	Funder	Reference
Northern Leopard Frog	2001	Kootenay River, Creston Valley Wildlife Management Area	Fish and Wildlife Compensation Program	Gebhart and Roberge, 2001
Evaluate and implement best options for Northern Pike control in the Ha Ha Creek watershed	2007-2008	East Kootenays	Habitat Conservation Trust Foundation	Davis, 2011
Containment or eradication of Northern Pike in Ha Ha Creek watershed	2008-2009	East Kootenays	Habitat Conservation Trust Foundation	Davis, 2011
Conclusively determine whether Northern Pike were completely eradicated from Ha Ha Creek in 2009 thereby eliminating a donor source for future illegal introductions.	2011-2012	East Kootenays	Habitat Conservation Trust Foundation	Davis, 2011

Project title or description	Date of project	Area/Location	Funder	Reference
A study to investigate management practices that may be applicable to control invasives for the Pend D'Oreille system.	2014-2015	Pend D'Oreille	BC Hydro	In progress
Lower Columbia River Fish Population Indexing (CLBMON-45)	2007-present	Lower Columbia River	BC Hydro	Golder Associates and Poisson Consulting Ltd., 2013
Middle Columbia River Fish Population Indexing (CLBMON-16)	2007-present	Arrow Lakes Reservoir	BC Hydro	Okanagan Nation Alliance et al, 2015
Lower Columbia and Kootenay River Fish Stranding Assessments (CLBMON-42)	2007-present	Lower Columbia and Lower Kootenay River	BC Hydro	Golder Associates, 2014
Sturgeon egg predation study	In progress	Lower Columbia River	Columbia Power Corporation	In progress
Pike inventory and management project: ID, presence/absence, size and age composition, food consumption and decrease population where practical.	2014- possibly 2017 (funding dependent)	Lower Columbia River	Teck Metals Ltd., MFLNRO	In progress
Columbia River Northern Pike Reward Program (for PIT tagged fish returned)	2013-2014	Lower Columbia River	MFLNRO	n/a
Sunfish eradication at a Northern Leopard Frog reintroduction area in south-eastern British Columbia	2014	Bummers Flats, East Kootenays	Columbia Basin Trust Ktunaxa First Nation	Oliver and Ohanjanian, 2014
Whiteswan Lake Provincial Park Fisheries Management Plan	2013	Whiteswan Lake, East Kootenays	MFLNRO	MacPherson and Robertson, 2013
Genetic Hybridization Studies on Westslope Cutthroat and Rainbow Trout in the Upper Kootenay River	1980's-present	Upper Kootenay River and its Tributaries	Various	Bennett, 2007; Rubidge and Taylor, 2005; Rubidge et al., 2001

5.4 EXTENSION AND OUTREACH

By engaging in a variety of outreach methods, such as media, in-person presentations, interactive field tours, etc., the Central Kootenay Invasive Plant Committee was able to disseminate educational resources, increase awareness about AIS and their impacts, provide training for AIS identification and sampling techniques, and promote best practices such as cleaning, draining, and drying water-based recreational equipment.

In-person activities reached upwards of 680 people. A radio interview was broadcast in eight Central/West Kootenay communities and one Kootenay Boundary community. An article was circulated to 20 media sources. An interview for one of North America's longest running fly-fishing TV shows was broadcast in February 2015 on a variety of North American TV networks and the internet.

CKIPC 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

Prevention is the most effective and least costly management tool available in managing aquatic invasive species. Preventative actions can drastically reduce the introduction and spread of aquatic invasive species into waterbodies (Vander Zanden and Olden, 2008; Hanson, 2012; Matthias Herborg pers. comm., December 3, 2014*).* Educating the public on impacts of AIS and promoting programs such as "Clean-Drain-Dry" are key components of a prevention strategy. Idaho's Invasive Species Program has been focused on outreach and education and preventative strategies since 2009, and to date no zebra or quagga mussels have been detected in any Idaho waterbodies despite their presence in neighbouring states (U.S. Geological Survey, 2015). Therefore, it is likely that the education and action oriented Clean-Drain-Dry initiative that has been promoted in the province of BC since 2012 could be a major contributing factor to the absence of zebra and quagga mussels in the region's waterbodies.

Moreover, the effectiveness of education and prevention based programs can be seen in the long-standing boat inspection program in Idaho, which has intercepted 14 mussel-fouled boats destined for BC (ISDA, 2014). In addition, the recently created boat inspection program in Alberta intercepted two mussel-fouled boats (CBC, 2014). Considering the fouled watercraft that have been intercepted by Idaho and Alberta's boat inspection programs, it is reasonable to assume that Washington and Montana's inspection programs have also played an important role in preventing mussel-infested watercraft from entering the province.

It is known that zebra and quagga mussels impact many aspects of aquatic ecosystems, including fish and native mussel populations. In North America, the native freshwater mussels are ecologically significant because they are indicators of ecosystem health, important components of freshwater biodiversity, and a major food source (Williams et al., 1992). Due to the fact that the native mussels life-cycle requires native fish species as hosts, the detection of only one native mussel species during sample analysis could heighten the cause for concern were these region's waterbodies to become infested with invasive mussels.

Working collaboratively with local organizations was a key factor in our ability to have twice as many sites monitored for zebra and quagga mussels as in 2012. Through the continued engagement with previously trained persons involved with local stewardship groups and others, as well as the creation of new partnerships, CKIPC continues to build capacity within the region to support the provincial zebra and quagga mussel monitoring program.

Once introduced into a system, a relatively small window of opportunity is available for preventing the establishment of species such as zebra/quagga mussels or *M. spicatum*. 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. *M. spicatum* 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). Based on a 2013 economic impact report released by the Ministry of Environment, the projected economic losses to BC from AIS are estimated at $21.7 million considering only impacts to hydro generation, recreational use, and water utilities (ISCBC, 2014). 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.

In the Kootenay-Columbia system, the levels of infestation of both *M. spicatum* and *P. crispus* had surpassed an early detection rapid response 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. An influx of plant fragments and turions from Idaho on the Kootenai River into Canada provide a constant source of new material for colonization. *M. spicatum* and *P. crispus* were confirmed to be present in the Idaho section of the Kootenai River from three miles upstream of Bonner's Ferry to the Canadian border in 2007 (Aquatechnex, 2007). As the river turns north downstream from Bonner's Ferry, *M. spicatum* populations expand and begin to dominate the littoral zone (Aquatechnex, 2007). This is undoubtedly the greatest source of new infestations into the Kootenay system. It should be noted that Idaho has enacted an aggressive integrated management plan, incorporating herbicides for AIS, resulting in a reduction in *M. spicatum* by 63% in Lake Pend D'Oreille from 2007 to 2008 (Madsen, 2009). Unfortunately, Madsen also reported an increase in *P. crispus* attributed to its production of turions and resistance to herbicides.

The Canadian portion of the Pend D'Oreille River system has already experienced movement of upstream infestations of yellow flag iris and purple loosestrife. CKIPC and the FWCP summer student program have been mechanically treating yellow flag iris infestations for several years and will continue to collaborate into the future. In addition, CKIPC has been working closely with the Province of BC and our cross-border partners surveying for flowering rush infestation within this system.

The use of mechanical harvesters has been widely employed in BC for the removal of nuisance aquatic plants in the Okanagan, Shuswap and Lower Mainland. With the exception of rototillers or rotovators, these provide temporary control of vegetation by effectively "mowing the lawn" allowing plants to regrow from the remaining base and roots (Woolf, 2009). This is primarily to enhance recreational use and aesthetic appeal of areas of waterbodies. Rotovators will effectively remove root crowns and turions from the sediment, but cause considerable damage to the substrate and increase turbidity. These methods are also non-specific removing native vegetation, invertebrates and possibly fish and

may spread fragments to previously uncolonized areas (Haller, 2009). Currently, with the possible exception of sections of the Kootenay River around Creston, there are no large monotypic stands of AIS warranting these methods. In Creston, *P. crispus* has colonized vast stretches of the littoral zone, however there are still native species present in and surrounding these dense stands. Constraints such as, access, cost of disposal and environmental consequences must be considered. *M. spicatum* has extensively colonized backwater sloughs and complex side channels making access difficult.

Hand or suction removal by SCUBA divers is the most ecologically sensitive method available for controlling macrophytes. Trained divers can remove plants selectively while causing minimal disturbance to the benthic zone. Care is taken to place plant material in mesh bags or guided into a suction hose to limit unintentional spread. A steep littoral zone, as is the case in much of Kootenay Lake, has been shown to facilitate removal of *M. spicatum* by divers (Caswell, 2010). Although costly and time consuming, this method has been used to effectively manage *M. spicatum* in Christina and Champion Lakes. This is also the preferred method in shallow and debris laden sites as well as areas where it is difficult to access and manoeuver with a machine. In Montana a significant decrease (up to 63%) in *M. spicatum* biomass was achieved after three years of hand removal in the Noxon reservoir (Beck 2013). The effectiveness of this treatment on *P. crispus* abundance is currently being evaluated in Flathead Lake and Flathead River in Montana.

The suitable habitats in oligotrophic lakes are usually much smaller and more isolated than those in eutrophic lakes and non-native plants such as *M. spicatum* tend to form isolated beds due to the patchiness of suitable littoral zone habitat (Madsen, 1994). *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). This does not appear to be the case with *P. crispus* as it was observed growing in areas with no other vegetation such as coarse sand bays and in the interstitial spaces of rocks and boulders.

On Kootenay Lake, marinas appear to provide an increase in suitable habitat for *M. spicatum* and *P. crispus.* In general, marinas are sheltered from natural wave action creating artificial backwater areas. The protected nature of marinas can result in high sedimentation rates and therefore increased nutrients are available to plants. The substrate is continuously disturbed allowing for easier colonization by opportunistic non-native species. Once established, plant fragments are easily dispersed into the lake by motorized boats propellers and associated wakes.

In small, localized situations such as marinas and boat launches, benthic barriers have been used to smother or prevent colonization by invasive plants. When a barrier that had been applied on Lake Coeur D'Alene in spring for eight weeks was removed, *M. spicatum* did not regrow, however native macrophytes returned after four weeks (Laitala et al., 2012). These barriers are costly and labour intensive to install and maintain. Plants can regrow in sediment that accumulates on top of the barrier and must be removed.

A combination of these methods with an emphasis on prevention can effectively control and limit the spread of populations of aquatic invasive species. These efforts require a sustained level of commitment and funding as even brief interruptions in support can negate years of past gains (National Invasive Species Council, 2005).

7.0 RECOMMENDATIONS

The inclusion of Provincial mandatory boat inspection stations, similar to those in the states of Washington, Idaho, and Montana, would be an important and effective addition to any AIS prevention program. Since the majority of BC's waterbodies have been assigned a medium-high risk status for introduction and establishment of zebra and quagga mussels, it is essential that annual monitoring 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, and the drastic decline of native mussels further highlight the need for a long-term zebra and quagga mussel monitoring program. Note that since the initial writing of this document, the Ministry of Environment has instituted a provincial boat inspection program. The regional invasive species committees within the Canadian Columbia Basin are working closely with the Province by providing staff support and additional boat wash units for the 2015 season.

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 cleaning, draining, and drying must be ongoing (ISDA, 2014; ISCBC, 2013). In addition, efforts should be made to utilize as many different media types as feasible to reach the widest possible audience. Because of the association between boating and AIS spread, marina operators should be encouraged to remove or control plant material from their waters. In speaking with marina operators and users, it is evident that there is a desire to manage aquatic vegetation, but there are concerns around costs associated with management. Incentives, financial support and guidance should be provided by the province to assist marinas in tackling this problem.

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.

Current infestations of *P. crispus* and *M. spicatum* in the region allow for easy dispersal and spread to other waterbodies. Annual monitoring of priority waterbodies should continue in order to facilitate a rapid response should new infestations be discovered. If left unchecked, these populations will continue to expand in size and range, potentially reducing native plant species diversity and adversely impacting fish and wildlife species. Populations in the Kootenay River around Creston are of particular concern. In some areas *P. crispus* and/or *M. spicatum* communities make up over 90% of plants present in the littoral zone. The Kootenai Tribe in Idaho have raised concerns that infestations of AIS's impacts on water quality and habitat may be adversely affecting populations of white sturgeon in the river (Aquatechnex 2007). Impacts on sturgeon and other red or blue listed species in the region should be assessed, and where warranted 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 populations continue to expand, methods such as rototilling may become feasible.

The existing population of *N. odorata* at Nancy Greene Lake 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.

A number of shallow water habitats on the Columbia River and West Arm of Kootenay Lake have limited invasion by invasive plants. These situations represent localized EDRR situations 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. Similarly, some shallow backwater areas around Creston could be accessed by canoe and plants removed with a rake or similar tool taking care to gather up all fragments. These methods would greatly reduce associated costs.

A survey conducted on the Pend D'Oreille River in Washington state confirmed the presence of flowering rush a few hundred meters upstream of the Boundary Dam (Jen Parsons, Washington State Department of Ecology, personal communications). A survey targeting flowering rush should be undertaken on the Pend D'Oreille in order to limit or halt its spread into the region; the Province of BC is conducting a full survey of 35 high priority species, including flowering rush, in 2015. In addition, CKIPC will continue to work with State partners on controlling infestations and movement of yellow flag iris and purple loosestrife within this system.

The Salmo Watershed Streamkeepers Society have been actively involved in removing yellow flag iris from Erie Lake for a number of years. Cooperation with local stewardship groups will continue to be a valuable asset in managing invasive plants. Workshops, training opportunities and support should be provided to organizations and the public in order to increase management capacity. In addition, the CKIPC is currently in discussion with the cross-border agencies to manage the large yellow flag iris source at the Nelway border ponds and decrease spread into Lake Erie.

In addition to cross-border management of invasive plant species, CKIPC is currently working with cross-border partners, regional stakeholders and the Province on the development of an American Bullfrog Surveillance Framework, as the American Bullfrog has been confirmed in Washington and Idaho adjacent to the Canadian border and the CKIPC 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.

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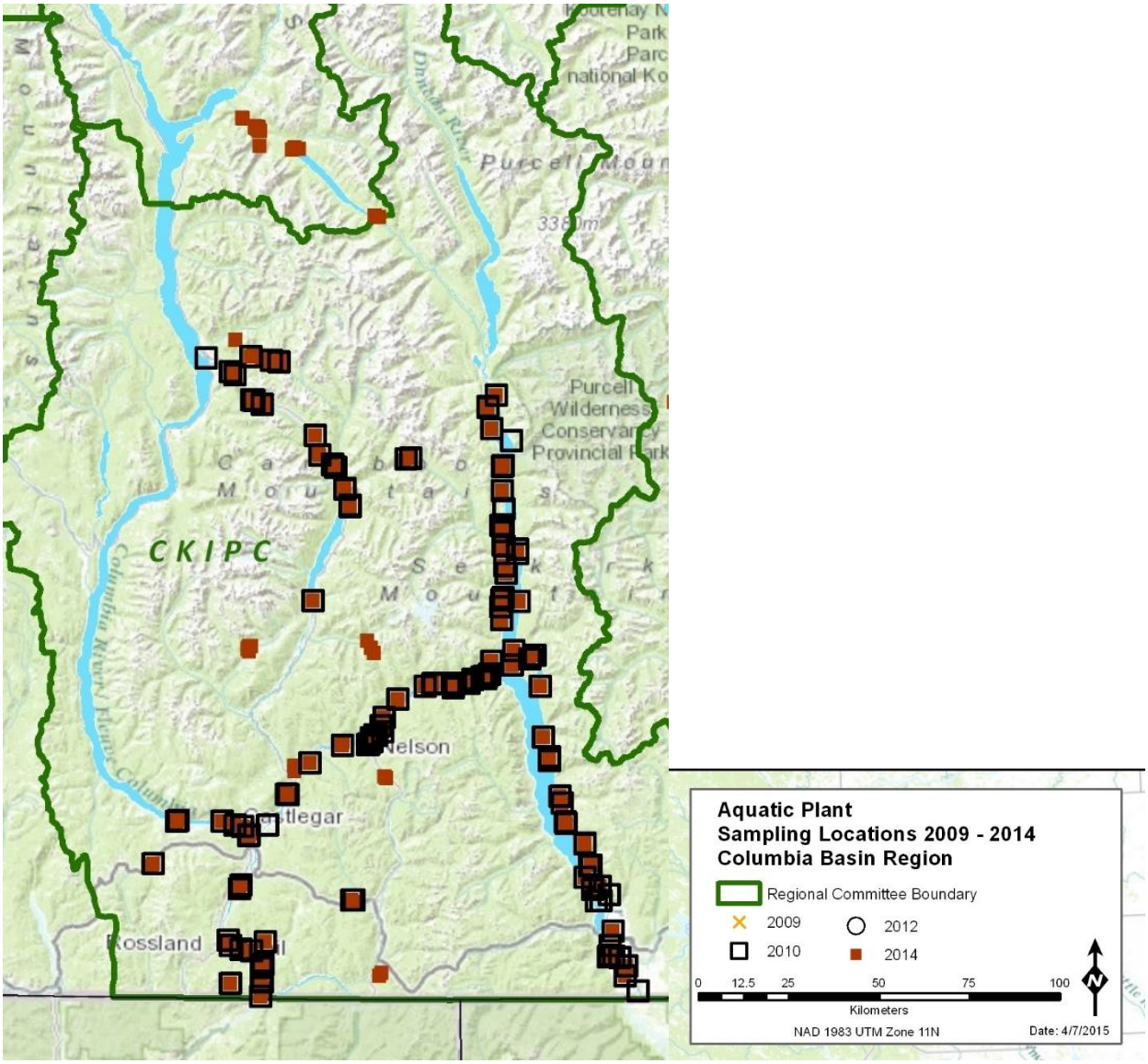
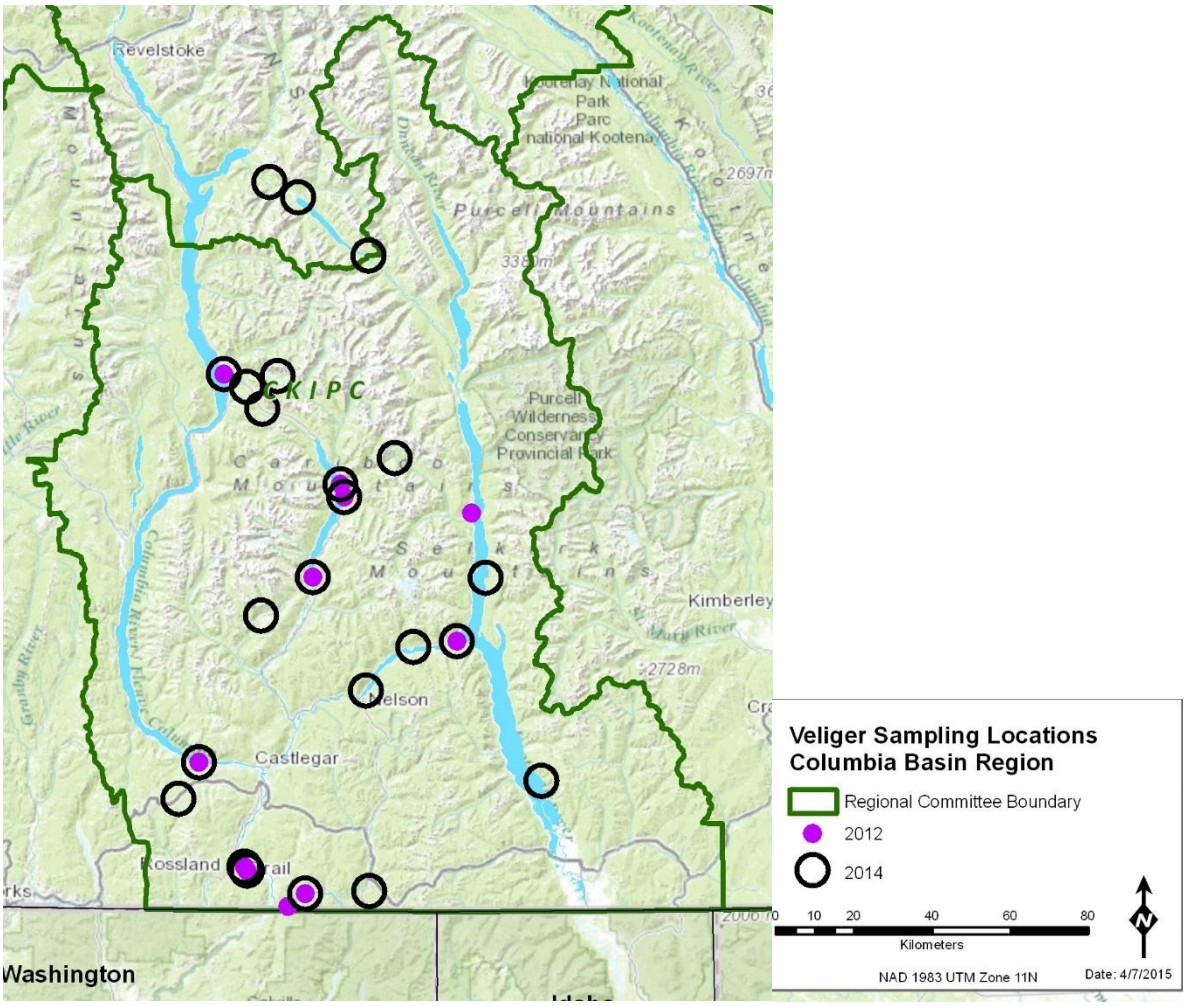
APPENDIX A

Map of sampling points for aquatic invasive plants in the study area for 2009 - 2014.



Map of sampling points for zebra and quagga mussel veligers in the study area for 2012 and 2014.



ZEBRA QUAGGA MUSSEL VELIGER SAMPLING PROTOCOL

Zebra mussel. (Photo credit: Ohio Sea Grant)

Developed by Columbia Basin Volunteer Monitoring Project - modified for Provincial Use

Apr 24, 2014

Zebra & Quagga Mussel Substrate Monitoring

Written by Matthias Herborg, Aquatic Invasive Species Coordinator, BC Ministry of Environment

Adapted from PSU, Steve Wells & USACE, Betsy L. Hull

The majority of lakes and reservoirs in British Columbia have been assigned a medium-high risk status for introduction and establishment of zebra (*Dreissena polymorpha)* and quagga (*Dreissena rostriformis burgensis)* mussels. Monitoring is critical for early detection. Substrate sampling allows widespread low cost and low effort monitoring across the province to make sure no zebra or quagga mussels are found in BC.

Substrate Construction

Substrates shall be constructed as follows (see Figure 1):

- The substrate sampler consists of 17-cm sections of white-colored pvc pipe (5-cm diameter) and black-colored abs pipe (5-cm diameter) with 7-mm diameter holes drilled into pipe.
- Pipe sections are suspended along a rope with pipe located at rope end and then about 3-m up from end.
- A plastic construction mesh (13-mm diameter mesh) is cut into 3-cm wide strips, and the rope is woven through this plastic mesh strip in between the terminal pipe sections and those located 3-m from bottom. Large flat washers are used above and below pipe sections to keep them stable.
- A small (16-oz) concrete anchor is tied to end of rope. The length of rope used depends on water depth of deployment.
- The ideal depth to deploy substrates is 8-m depth keeping the end of substrate off the lake bottom. The secure surface structure to tie the surface end of the rope is the most limiting factor for substrate monitoring; dam booms work best.
- Buoys work well but substrate rope can get tangled with mooring line. Docks and piers are often used, but are then in more shallow waters.
- Keep in mind that any hard surface works. Concrete, bare steel and certain plastics work well. Biofilm is good thing for settlement. Surface roughness or irregularities are good things.

Substrate Locations

At each of the locations one substrate shall be deployed in a manner that will not interfere with boater or swimmer activities. Ideally the substrate would be deployed in a shady area with some water flow and as deep as possible. As boat traffic is an essential part of the spread of aquatic invasive species, it is recommended that substrates be deployed in areas with high boat traffic (e.g. marinas, boat docks, etc.) A physical description and/or GPS coordinates of each monitoring station will be obtained at initial deployment. If possible, it is ideal to get a contact person for each site (the person who will be checking the substrate most often).

APPENDIX D

Density, distribution and estimated area of Curlyleaf Pondweed (P. crispus) at sampling sites on the Kootenay-Columbia system.

Reach	UTM zone	Easting	Northing	Estimated area (ha)	Distribution	Density
Columbia River	11	455309	5435001	0.1050	5	2
Columbia River	11	454891	5434319	0.0045	2	1
Columbia River	11	454874	5431447	0.0001	1	1
Columbia River	11	447835	5440176	0.5000	5	2
Columbia River	11	448338	5430952	0.0001	2	2
Columbia River	11	452518	5463096	0.0375	2	1
Columbia River	11	452390	5462882	0.0001	2	2
Columbia River	11	450888	5464656	0.0030	5	2
Columbia River	11	452394	5462998	0.0030	3	2
Columbia River	11	452387	5462910	0.0020	2	1
Kootenay Lake	11	506669	5513255	1.2000	5	2
Kootenay Lake	11	516899	5478780	1.2000	8	4
Kootenay Lake	11	520338	5465312	0.0050	5	2
Kootenay Lake	11	520276	5465551	0.5000	6	3
Kootenay Lake	11	524516	5460862	0.0400	7	3
Kootenay Lake	11	506877	5513860	0.0500	5	2
Kootenay Lake	11	512620	5500586	1.0000	4	2
Kootenay Lake	11	514925	5494729	0.0200	4	3
Kootenay Lake	11	514925	5494729	0.0200	5	3
Kootenay Lake	11	513701	5501380	0.1000	6	2
Kootenay Lake	11	505480	5557255	0.0120	4	2
Kootenay Lake	11	506833	5529233	0.0300	4	1

Reach	UTM zone	Easting	Northing	Estimated area (ha)	Distribution	Density
Kootenay Lake	11	506718	5529350	0.0300	4	1
Kootenay Lake	11	506433	5529283	0.3000	6	2
Kootenay Lake	11	507260	5520570	0.0001	3	2
Kootenay Lake	11	506711	5529040	0.0025	3	2
Kootenay Lake	11	519106	5471168	0.1500	5	3
Kootenay Lake	11	515441	5483873	0.1625	6	2
Kootenay Lake	11	515441	5483873	0.1625	4	2
Kootenay Lake	11	507126	5524874	0.0250	2	1
Kootenay River-Creston	11	530731	5436826	0.1000	4	2
Kootenay River-Creston	11	530731	5436826	0.1000	8	3
Kootenay River-Creston	11	533086	5432511	0.1000	2	1
Kootenay River-Creston	11	526111	5451048	0.0450	7	2
Kootenay River-Creston	11	526111	5451048	0.0450	2	1
Kootenay River-Creston	11	533434	5434657	0.0400	5	2
Kootenay River-Creston	11	530626	5436983	0.1500	4	2
Kootenay River-Creston	11	525745	5453645	0.0015	1	1
Kootenay River-Creston	11	529724	5436849	0.0075	2	1
Kootenay River-Creston	11	524559	5453722	0.0300	7	2
Kootenay River-Creston	11	530491	5451050	0.2415	4	1
West Arm-Lower Kootenay River	11	502877	5496875	0.0150	2	1
West Arm-Lower Kootenay River	11	491728	5495209	0.0030	3	2
West Arm-Lower Kootenay River	11	491884	5495379	0.0875	5	2
West Arm-Lower Kootenay River	11	502990	5496818	1.0000	5	2
West Arm-Lower Kootenay River	11	460586	5471443	0.0400	2	1
West Arm-Lower Kootenay River	11	477788	5482153	0.0250	5	2

Reach	UTM zone	Easting	Northing	Estimated area (ha)	Distribution	Density
West Arm-Lower Kootenay River	11	479622	5484056	0.0300	2	1
West Arm-Lower Kootenay River	11	506542	5508326	0.0001	3	3
West Arm-Lower Kootenay River	11	460633	5471502	0.0500	2	1
West Arm-Lower Kootenay River	11	460377	5471553	0.0750	4	1
West Arm-Lower Kootenay River	11	478599	5482854	0.0001	1	1
West Arm-Lower Kootenay River	11	477913	5482245	0.0075	3	1

Density, distribution and estimated area of Eurasian Milfoil (Myriophyllum spicatum) at sampling sites on the Kootenay-Columbia system

Reach	UTM Zone	Easting	Northing	Estimated Area (ha)	Distribution	Density
Columbia River	11	452154	5462793	0.0750	2	1
Columbia River	11	452210	5462627	0.1500	4	3
Columbia River	11	452394	5462998	0.0030	2	1
Columbia River	11	452387	5462910	0.0020	4	2
Kootenay Lake	11	506669	5513255	1.2000	4	2
Kootenay Lake	11	516899	5478780	1.2000	2	1
Kootenay Lake	11	520338	5465312	0.0050	4	1
Kootenay Lake	11	520276	5465551	0.5000	6	3
Kootenay Lake	11	520276	5465551	0.0200	4	2
Kootenay Lake	11	524516	5460862	0.0400	7	3
Kootenay Lake	11	524516	5460862	0.6000	6	3
Kootenay Lake	11	512620	5500586	1.0000	5	2
Kootenay Lake	11	514925	5494729	0.0200	2	2
Kootenay Lake	11	514925	5494729	0.0200	2	2
Kootenay Lake	11	506777	5541940	0.2000	6	2
Kootenay Lake	11	519106	5471168	0.1500	5	2
Kootenay Lake	11	515441	5483873	0.1625	2	1
Kootenay Lake	11	515441	5483873	0.1625	3	2
Kootenay Lake	11	507126	5524874	0.0001	2	1
Kootenay River-Creston	11	529647	5436898	0.0600	7	3
Kootenay River-Creston	11	526111	5451048	0.0450	2	1
Kootenay River-Creston	11	526111	5451048	0.0450	6	4
Kootenay River-Creston	11	533434	5434657	0.0400	4	1

Reach	UTM Zone	Easting	Northing	Estimated Area (ha)	Distribution	Density
Kootenay River-Creston	11	524559	5453722	0.0300	4	1
Kootenay River-Creston	11	530491	5451050	0.2415	2	1
Kootenay River-Creston	11	529508	5436660	0.0120	5	2
West Arm-Lower Kootenay River	11	491728	5495209	0.0030	4	2
West Arm-Lower Kootenay River	11	491884	5495379	0.0875	6	2
West Arm-Lower Kootenay River	11	502990	5496818	0.2250	4	1
West Arm-Lower Kootenay River	11	460586	5471443	0.0400	4	2
West Arm-Lower Kootenay River	11	477788	5482153	0.0250	4	2
West Arm-Lower Kootenay River	11	479622	5484056	0.0300	3	2
West Arm-Lower Kootenay River	11	497308	5494847	0.0800	4	2
West Arm-Lower Kootenay River	11	462119	5477656	0.0150	2	1
West Arm-Lower Kootenay River	11	460633	5471502	0.0500	7	4
West Arm-Lower Kootenay River	11	460377	5471553	0.0750	5	1
West Arm-Lower Kootenay River	11	478599	5482854	0.0500	2	1
West Arm-Lower Kootenay River	11	478671	5482828	0.0600	3	2
West Arm-Lower Kootenay River	11	477913	5482245	0.0075	4	2
West Arm-Lower Kootenay River	11	478126	5482425	0.0100	2	1

APPENDIX E

Results of the zebra and quagga mussel veliger monitoring program around the Central Kootenay region in 2014.

Waterbody	Common site name	Date sampled	Zebra/Quagga/Veliger	Others
Upper Arrow Lake	Nakusp boat launch	30.07.2014	-	Ostracoda
Upper Arrow Lake	Nakusp boat launch	26.08.2014	-	-
Upper Arrow Lake	Nakusp boat launch	28.09.2014	-	-
Lower Arrow Lake	Syringa Creek Provincial Park boat launch	05.08.2014	-	-
Lower Arrow Lake	Syringa Creek Provincial Park boat launch	05.09.2014	-	-
Lower Arrow Lake	Syringa Creek Provincial Park boat launch	04.10.2014	-	Ostracoda
Slocan Lake	New Denver boat launch	30.07.2014	-	-
Slocan Lake	New Denver boat launch	30.08.2014	-	-
Slocan Lake	New Denver boat launch	28.09.2014	-	-
Slocan Lake	Slocan boat launch	30.07.2014	-	-
Slocan Lake	Slocan boat launch	30.08.2014	-	Unionidae
Slocan Lake	Slocan boat launch	28.09.2014	-	-
Slocan Lake	Silverton boat launch	12.08.2014	-	-
Slocan Lake	Silverton boat launch	30.08.2014	-	-
Slocan Lake	Silverton boat launch	29.09.2014	-	-
Columbia River	Gyro Park boat launch	30.07.2014	-	-
Columbia River	Gyro Park boat launch	29.08.2014	-	-
Columbia River	Gyro Park boat launch	30.09.2014	-	-
Columbia River	Old Bridge, Trail	30.07.2014	-	-
Columbia River	Old Bridge, Trail	29.08.2014	-	-
Columbia River	Old Bridge, Trail	30.09.2014	-	-
Pend D'Oreille River	Buckley campground boat launch	01.08.2014	-	Ostracoda
Pend D'Oreille River	Buckley campground boat launch	05.09.2014	-	-
Kootenay Lake	Balfour boat launch	28.07.2014	-	-

Waterbody	Common site name	Date sampled	Zebra/Quagga/Veliger	Others
Kootenay Lake	Balfour boat launch	26.08.2014	-	-
Kootenay Lake	Balfour boat launch	22.09.2014	-	-
Kootenay Lake	Riondel Marina	06.08.2014	-	-
Kootenay Lake	Riondel Marina	31.08.2014	-	-
Kootenay Lake	Riondel Marina	10.10.2014	-	Ostracoda
Kootenay Lake	Kuskanook Marina	06.08.2014	-	Ostracoda
Kootenay Lake	Kuskanook Marina	31.08.2014	-	Ostracoda
Kootenay Lake	Kuskanook Marina	10.10.2014	-	Ostracoda
Kootenay Lake	Kokanee Creek Provincial Park boat launch	28.07.2014	-	-
Kootenay Lake	Kokanee Creek Provincial Park boat launch	26.08.2014	-	-
Kootenay Lake	Kokanee Creek Provincial Park boat launch	22.09.2014	-	Ostracoda
Kootenay Lake	Lakeside Park boat launch	28.07.2014	-	Ostracoda
Kootenay Lake	Lakeside Park boat launch	26.08.2014	-	Ostracoda
Kootenay Lake	Lakeside Park boat launch	22.09.2014	-	Ostracoda
Summit Lake	Three Island Lodge boat launch	06.08.2014	-	Ostracoda
Box Lake	Boat launch	07.08.2014	-	Ostracoda
Rosebud Lake	Boat put-in	11.08.2014	-	Ostracoda
Nancy Greene Lake	Boat put-in	12.08.2014	-	-
Fish Lake	Boat put-in	27.08.2014	-	Ostracoda
Trout Lake	Boat put-in	19.08.2014	-	-
Trout Lake	Boat launch	18.08.2014	-	-
Staubert Lake	Boat put-in	20.08.2014	-	Ostracoda
Wilson Lake	Boat launch	19.09.2014	-	-
Upper Little Slocan	Boat launch	02.09.2014	-	-