Kootenay Riparian Invasive Plant Control (COL-F24-W-3840)

Prepared for: Fish & Wildlife Compensation Program

Prepared by: Khaylish Fraser, Aquatics Program Coordinator, CKISS;

Erin Bates, Executive Director, CKISS;

Kalenna Olynyk, Field Program Manager, CKISS

Prepared with financial support of the Fish & Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and Public Stakeholders

31-Mar-2024

Executive Summary

Numerous infestations of the invasive riparian plants yellow flag iris (*Iris pseudacorus*) and purple loosestrife (*Lythrum salicaria*) are threatening the riparian ecosystem along the shoreline of Kootenay Lake's West Arm and down Kootenay River to Brilliant Dam. The Central Kootenay Invasive Species Society, with the support of several agencies, organizations, and First Nations has implemented an invasive riparian plant control project in this area to improve riparian ecosystem function and protect high value conservation areas. This project is in alignment with the habitat-based action of preventing and controlling invasive species, under the *Columbia Region: Rivers & Riparian Areas Action Plan*, action COLRRA.ECO.HB.10.01 Prevention and control of invasive species-P1, and the *Columbia Region: Reservoirs & Large Lakes Action Plan*, action COLRLL.ECO.HB.13.01 Prevention & control of invasive species in Kootenay, Arrow, Pend d'Oreille, Koocanusa-P1.

Plant surveys found *I. pseudacorus* and *L. salicaria* present over an estimated 149,509 m^2 and 149,704 m^2, respectively. Biological control agent surveys found black-margined loosestrife beetle (*Galerucella calmariensis*), at two sites. Mechanical control was used to remove 376 m^2 of *I. pseudacorus* and 727 m^2 of *L. salicaria*, while 1,370 m^2 of *L. salicaria* was deadheaded. Where biological control agents were present, plants were left untreated to encourage establishment of the agent's population to contribute to ongoing control efforts. An ecological restoration consultant was employed to assess treated sites and provide recommendations, and one site was determined to be appropriate for restoration. Following suggestions put forth by the ecological restoration consultant in years one and two of this project, five treated sites received replacement planting with 173 native plants. To increase awareness of the negative impacts of invasive riparian plants and promote long term stewardship among local residents, education and outreach at various public and targeted events, as well as through traditional and social media platforms reached upwards of 156,500 people.

Surveys should continue in future project years to detect new incursions and fill any remaining inventory gaps within the project area. Mechanical treatment should continue as needed and where feasible. Treated sites should be monitored for several years following initial plant removal with follow-up removal as required. Once the Provincial biocontrol collection and dispersal policy is finalized, collection and release of agents should commence as soon as possible on applicable sites. Restoration should commence as recommended: immediate planting after *L. salicaria* removal on a trial basis at select site(s), while overall, replacement planting after all individuals have been removed and the seedbank has been addressed. Human activities are the primary vector for invasive species introduction and spread so education to increase public awareness and change the behaviours that are responsible for spreading invasive species should continue.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1. Introduction

Invasive species cause major losses in biodiversity and ecosystem function globally (Green & Grosholz, 2021). Invasive species are non-native plants and animals that become well established because natural predators or controls are absent in the areas into which they are introduced (Central Kootenay Invasive Species Society, n.d.); they can spread quickly and have the ability to out compete native species, impacting fragile ecosystems, species at risk, and water quality (Environment Canada, 2004). Invasive plants can impart costly ecological, social, and economic impacts on local and global scales (Lockwood, Hoopes, & Marchetti, 2013; Ricciardi, Hoopes, Marchetti, & Lockwood, 2013).

Numerous infestations of yellow flag iris (*Iris pseudacorus*) and purple loosestrife (*Lythrum salicaria*) are threatening the riparian ecosystem along the shoreline of the West Arm of Kootenay Lake and down the Kootenay River to Brilliant Dam. *I. pseudacorus* is known to change the hydrology, ecosystem complexity and function of an area, reducing habitat suitability for native plant and animal species (Pathikonda, Ackleh, Hasenstein, & Mopper, 2009). Similarly, *L. salicaria* has been shown to alter the structure, function, and productivity of wetland habitats where it has negative impacts on waterfowl and fish populations (Thompson, Stuckey, & Thompson, 1987).

Under year three of this project, which was initiated by the Central Kootenay Invasive Species Society (CKISS) in 2021, it was proposed to continue implementing a multi-year plan for control of *I. pseudacorus* and *L. salicaria* including mechanical and biological control treatments; assessment and restoration of impacted sites; and monitoring to ensure long term success.

2. Goals and Objectives

The goal of this project is to improve riparian ecosystem function in the Kootenay Lake and River system, protect high value conservation areas, and increase awareness and long-term stewardship among local residents.

The objectives of this project are as follows:

- Inventory of upstream target plant seed source areas;
- Removal of target riparian plants;
- Dispersal of biological control agents;
- Assessment, restoration, and monitoring of treated sites; and,
- Landowner and public outreach.

This project is in alignment with the habitat-based action of preventing and controlling invasive species, under the *Columbia Region: Rivers & Riparian Areas Action Plan*, action COLRRA.ECO.HB.10.01 Prevention and control of invasive species-P1, and the *Columbia Region: Reservoirs & Large Lakes Action Plan*, action COLRLL.ECO.HB.13.01 Prevention & control of invasive species in Kootenay, Arrow, Pend d'Oreille, Koocanusa-P1.

3. Study Area

The study area for this project was within the CKISS' operational area (Figure 1). During year three of this multi-year project, activities focused on the West Arm of Kootenay Lake and the Kootenay River to the Brilliant Dam, where possible (Figure 2).

Figure 1. Map of Central Kootenay Invasive Species Society's Operation Area.

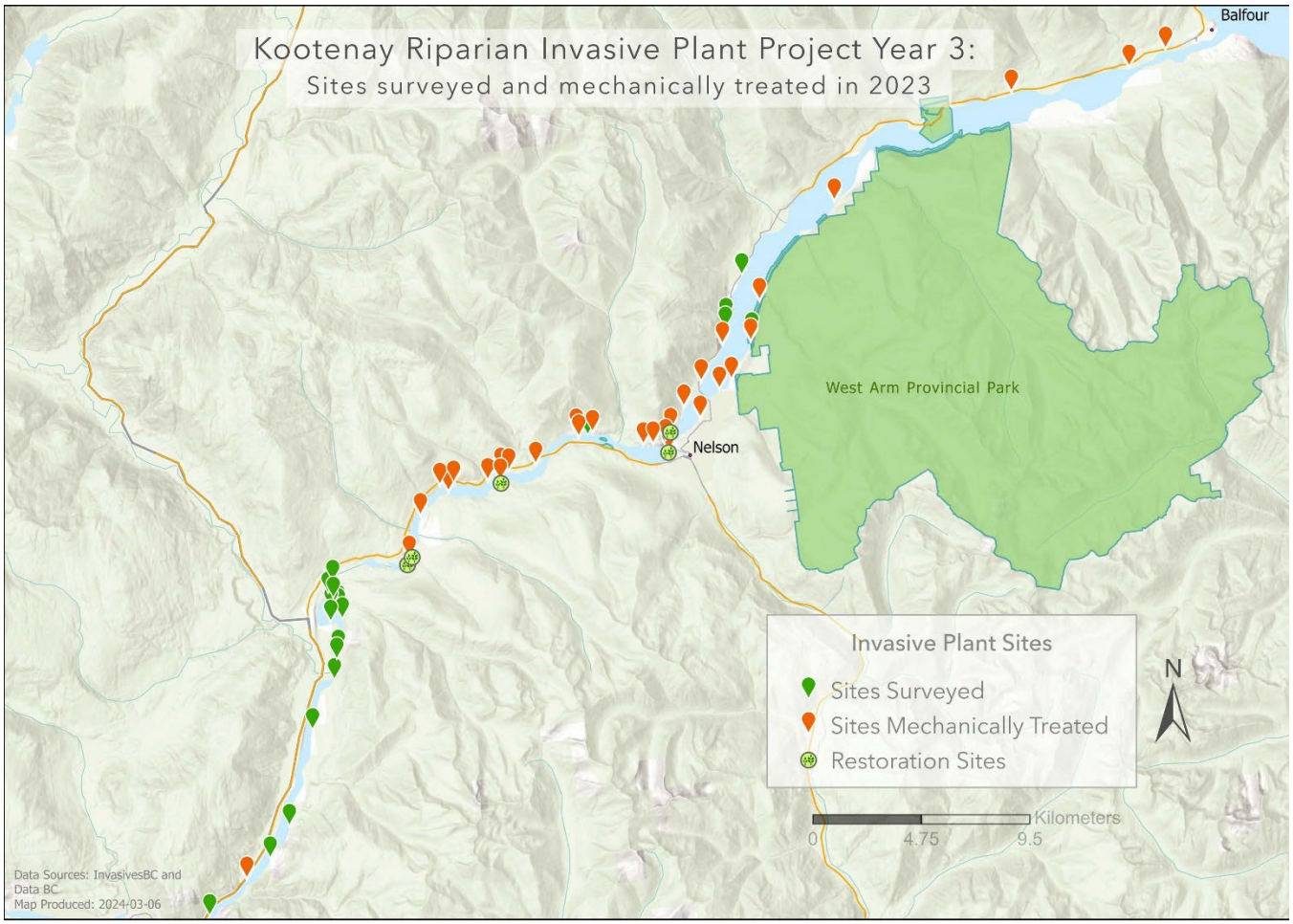

Figure 2. Kootenay Lake and River survey and treatment area, Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area, 2023.

4. Methods

4.1 Instream Works and Archaeological Permitting

Two notices of instream work for invasive species removal were completed and submitted to FrontCounter BC on May 26, 2023 and were approved on June 2, 2023. Multiple notices were submitted as there is a limit of twenty work sites per application. The Ministry of Forests Regional Habitat Officer who approves permitting reviewed the possible work sites to identify any overlap with fish redds.

A BC archaeological information request form was submitted to, and approved by, the Ministry of Forests Archaeology Branch on April 5, 2023. Archaeological and heritage site data within 100 metres of the existing shoreline of the Kootenay River upstream of the Brilliant Dam up to and including the

West Arm of Kootenay Lake was requested. The services of an Eligible Consulting Archaeologist were retained for the purposes of completing an Archaeological Overview Assessment (AOA), a Heritage Inspection Permit (HIP), and if necessary, a Site Alteration Permit (SAP).

4.2 Invasive Riparian Plant and Biological Control Agent Surveys

Invasive plant and biological control (biocontrol) agent surveys were conducted in accordance with the InvasivesBC Reference Guide[1]. For the priority invasive riparian plant species *I. pseudacorus* and *L. salicaria*, sites that were scheduled to receive treatment were resurveyed prior to treatment commencing: when a site that was treated in a previous year also was treated in a subsequent year, the width and length of the area infested with plants, as well as the plants density and distribution were monitored prior to treatment commencing. Crews opportunistically inventoried new sites while traveling throughout the project area to access treatment sites, as well, planned inventories began in the Brilliant Headpond (Kootenay River between the South Slocan Generation Station and the Brilliant Dam) this year. Biocontrol agent surveys for the black-margined loosestrife beetle (*Galerucella calmariensis*) and the golden loosestrife beetle (*G. pusilla*) were conducted on the plant species *L. salicaria,* when accessible.

4.3 Invasive Riparian Plant and Biocontrol Agent Data

Invasive plant survey and biocontrol agent data were collected in a digital format using mobile devices and spatial data collection software. All data were uploaded to the new Ministry of Forests InvasivesBC (IBC) database. In addition to standardized data collection, site information relating to access, safety, and appropriate control methods (e.g. hand pulling, digging, benthic barriers, etc.) was identified during surveys to assist with current and future management plans.

4.4 Invasive Riparian Plant Control

Manual control measures (e.g. digging, hand pulling, deadheading) were used to remove *I. pseudacorus* and *L. salicaria* between July 17 and September 30, 2023. Control methods followed

[1] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/invasivesbc-resources/invasivesbc_guidance_document.pdf

current Best Management Practices[2,3] for removal, disposal, and prevention of spread. All treatment also was conducted in accordance with stipulations identified in the approved stream work application authorization letters provided by the Regional Habitat Officer. The rhizomes of *I. pseudacorus* and roots of *L. salicaria* were dug up, wherever feasible, to reduce regrowth of the plants. When digging was not possible due to site characteristics (e.g. rocky areas), plants were hand pulled or deadheaded. All cut or dug plant material was bagged, removed from site and disposed of in a landfill. Special care was taken to minimize soil disturbance, root fragmentation, erosion, and accidental seed spread. All treatment data were uploaded to the IBC database.

4.5 Treated Sites Restoration Review

Following site disturbance from invasive plant removal, and in line with Best Management Practices, sites were assessed to determine if restoration of treated sites was warranted and feasible and would be beneficial for the ecosystem. An ecological restoration consultant was employed to assess treated sites and provide recommendations for restoration. Assessment of treated sites occurred on October 16, 2023.

4.6 Education and Outreach

Human activities are the primary vector for invasive species introduction and spread therefore various educational outreach events were provided to target audiences and the general public to increase awareness of invasive riparian plants and the threats they pose to native biodiversity and species at risk. Species-specific information was disseminated in combination with PlantWise messaging, an international program that uses community-based social marketing to influence human behaviour. CKISS also maintained an active online presence, using their website, Facebook, Instagram, and e-newsletters to engage with members of the public.

[2] http://www.metrovancouver.org/services/regional-planning/PlanningPublications/YellowFlagIrisBMP.pdf

[3] http://www.metrovancouver.org/services/regional-planning/PlanningPublications/PurpleLoosestrifeBMP.pdf

5. Results and Outcomes

5.1 Instream Works and Archaeological Permitting

Approved works were restricted to sites identified on the notice applications and approved mechanical treatment methods were pulling, digging, and barriers. All invasive plant material removed during treatments was required to be removed from site and transported to an appropriate disposal facility. The Ministry of Forests Regional Habitat Officer identified overlap between possible treatment sites and fish redds at six sites; works were approved at these locations but within a reduced time frame. All works were subject to stipulations identified in the stream work application authorization letters, and this and all other documents pertinent to the works were kept at each work site (e.g. application, Kootenay-Boundary Water Sustainability Regulation Notification Terms and Conditions).

A shapefile set identifying 221 archaeology/heritage sites within the area of interest was received from the B.C. Archaeology Branch and then overlaid on the proposed project area using ArcGIS to identify any overlap between archaeological or heritage sites and possible treatment sites. Four sites known to have one or both of the target species present had a partial overlap with known archaeological sites; therefore, only the portions of these sites that did not overlap received treatment. Any sites that fully overlapped known archaeological sites were not proposed for treatment on the notice applications. Further, all field staff were familiarized with, and kept present on site, the *Chance Find Procedures for Archaeological Material* document provided by the Ministry of Forests. This document provided information on how to manage for potential archaeological material discoveries while undertaking treatment activities, and assisted field crews in the identification of archaeological remains and the procedures to follow if a discovery was made. During the course of the treatment efforts, no archaeological material discoveries were made. The AOA written by the archaeologist will be used in future to determine treatment sites that do not conflict with archaeology sites, and the HIP and SAP will be used if needed, under the guidance of an archaeologist.

Several heritage sites were identified within the project area, for all of which the City of Nelson is the governing body. Following communication with the appropriate City of Nelson department (Development Services), approval was given to proceed with manual removal of target plants as the heritage status of a property does not restrict the removal of invasive species.

5.2 Invasive Riparian Plant and Biocontrol Surveys and Data

Plant surveys were conducted prior to treatment at known sites to monitor for reduced invasive plant density. At ten sites where follow-up treatments were planned, one or both of the target species were not detected. Surveys for *L. salicaria* and *I. pseudacorus* were conducted at 59 sites, and one or both of these species were detected at 53 sites (Figure 3). A comparison of estimated area in which *L. salicaria* and *I. pseudacorus* have been detected in all three project years is shown in Table 1. Planned inventories in the Brilliant Headpond found *I. pseudacorus* to be present across an estimated 10,437 m^2.

Table 1. Comparison of estimated area in which purple loosestrife (*Lythrum salicaria*) and yellow flag iris (*Iris pseudacorus*) have been detected in all three years of the Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area.

	2021	2022	2023
L. salicaria	180,863 m^2	187,952 m^2	149,704 m^2
I. pseudacorus	7,231 m^2	146,030 m^2	149,509 m^2
No. sites surveyed	62	53	59

Biocontrol agent surveys were conducted at 23 sites, with *G. calmariensis* being detected at two sites. A comparison of biocontrol surveys in all three project years is shown in Table 2.

Table 2. Comparison of biological control agent survey results in all three years of the Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area. Target survey species are black-margined loosestrife beetle (*Galerucella calmariensis*) and the golden loosestrife beetle (*G. pusilla*).

	2021	2022	2023
G. calmariensis	Evidence of agents found 9 times; *G. calmariensis* confirmed 1 time	1	2
G. pusilla	0	0	0
No. sites surveyed	24	36	23

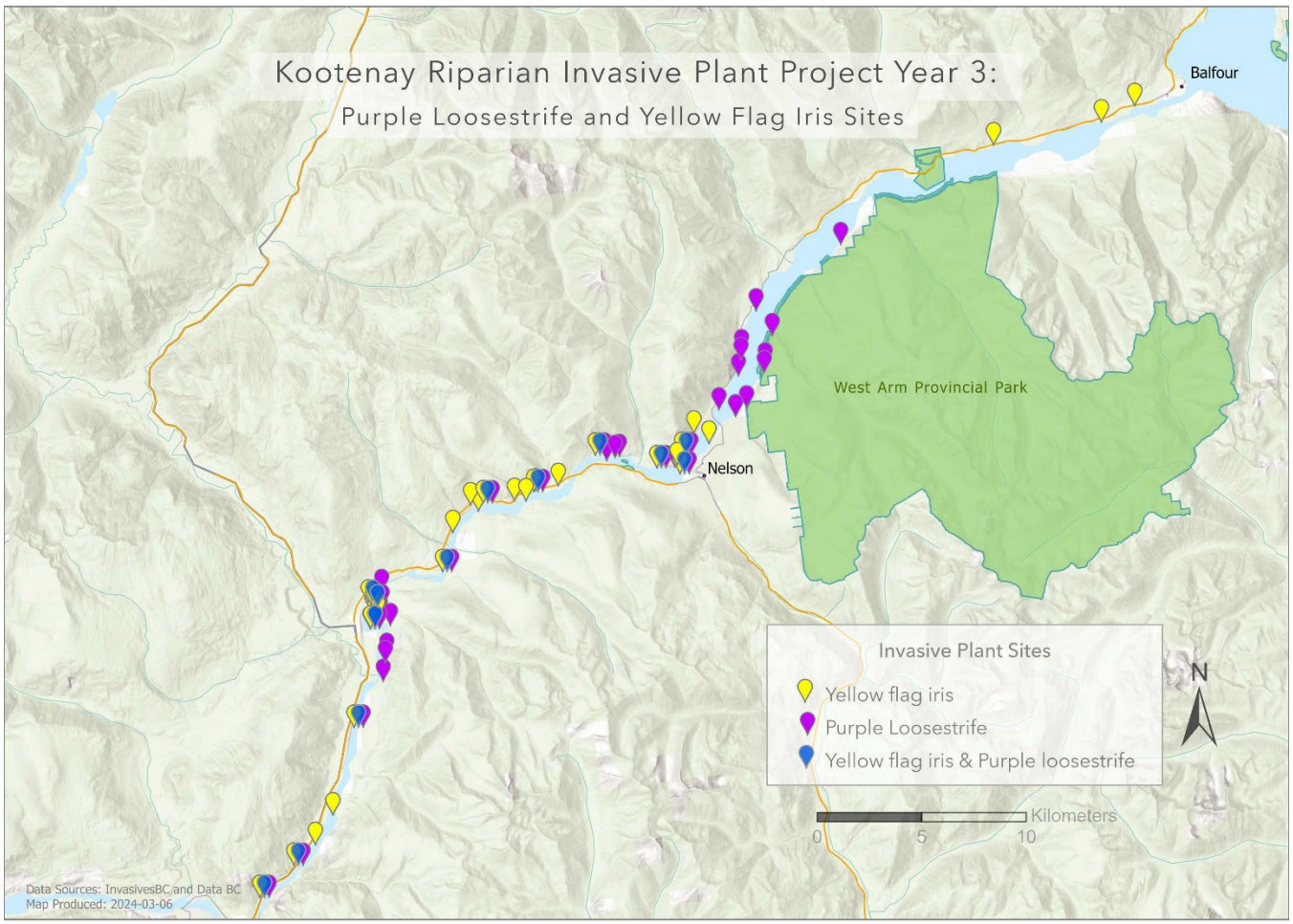

Figure 3. Sites where purple loosestrife or yellow flag iris are present in Kootenay Lake and River, Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area, 2023.

5.3 Invasive Riparian Plant Control

Mechanical control measures, such as digging or hand pulling, were used to remove 376 m^2 of *I. pseudacorus* at 20 sites, 727 m^2 of *L. salicaria* at 12 sites, and 1,370 m^2 of *L. salicaria* was deadheaded at three sites. A total of 3,445 kg of invasive plant material was removed. Sites where full treatment was not completed was due to the high number of plants and/or difficulty of removal in certain environments; staff resources were not sufficient to remove all plants. Where biocontrol agents were present, plants were intentionally left untreated to encourage continued establishment of the agent's population to contribute to ongoing control efforts.

5.4 Treated Sites Restoration Review and Actions

An ecological restoration consultant was employed to assess treated sites and provide recommendations. The detailed assessment is provided in a separate report titled *Kootenay Riparian Invasive Plant Removal Site Restoration Recommendations Year 3* (Appendix A[4]). In summary, eight treated sites were assessed for restoration potential, and one site was determined to be appropriate for restoration (Table 3). The most appropriate restoration technique was determined to be replacement planting with native plants.

Table 3. Invasive plant treatment site recommended for restoration under the Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area, 2023.

Site ID	Plants Treated	Habitat Type	Dominant Species	Plant #	Plant Size	Comment
359993	PL/YFI	Riparian/ Foreshore	red osier dogwood, black hawthorn, alder, rose, reed canary grass	50	2 or 5 gallon	Teck property downstream of old Taghum bridge including small island and shoreline. Many YFI present along shoreline to be treated in future years. **Replace YFI sites with potted stock during/after removal.** Good candidate restoration site due to minimal disturbance and browse, existing cover, moisture. If not planted disturbances will likely be colonized by reed canary grass and other weeds. **Continue mechanical treatment of PL to reduce seedbank and consider biocontrol.**

Suitable restoration site(s) are those that have the highest potential for successful establishment of planted vegetation over the long term. The following site factors were assessed to determine if restoration was warranted and feasible: level of disturbance, existing native vegetation, re-invasion risk, maintenance, elevation, substrate, and browse. These factors are described in Table 4.

Table 4. Site factors used to determine successful restoration of sites where riparian invasive plants were removed under the Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area, 2023.

Site Factors	Restoration Candidate	Not Suitable for Restoration
Level of disturbance	exposed soil areas caused by control activities; minimal anthropogenic disturbance	no disturbance observed from control activities; ongoing anthropogenic disturbance present

[4] Original PDF document provided by consultant has been converted to JPEG to preserve formatting and inserted into this MS Word document.

Site Factors	Restoration Candidate	Not Suitable for Restoration
Existing native vegetation	native vegetation either young or not well developed and needs help to regenerate	native vegetation well developed and will regenerate naturally
Re-invasion risk	root systems fully removed, planting would help prevent reinvasion from seedbank, invasive species present nearby that could reinvade site	root systems not fully removed during control; seed bank would counteract restoration efforts
Maintenance	high potential for success with no maintenance (shady slope aspect, cover from existing vegetation to retain moisture); no irrigation, browse protection required	Low potential for success with no maintenance (hot, dry, exposed sites); requires irrigation and/or browse protection
Elevation	appropriate to accommodate growth (along or above normal HWM for shrub/tree species, higher portion of littoral zone for sedges/rushes)	not appropriate to accommodate growth (site inundated too many months per season)
Substrate	appropriate to accommodate growth (consists of soil/silt/mixed sand)	not appropriate to accommodate growth (pure sand, cobble, boulder, bedrock)
Browse	minimal browse present	high levels of browse present

Following the suggestions put forth by the ecological restoration consultant in years one and two of this project, five treated sites received replacement planting with 173 native plants. Table 5 identifies the number and types of plants used.

Table 5. Native species planted at suitable restoration sites where riparian invasive plants were removed under the Kootenay Riparian Invasive Plant Control Project, CKISS Operational Area, 2023.

Site ID Number	Common snowberry (*Symphoricarpos albus*)	Bebbs willow (*Salix bebbiana*)	Red osier dogwood (*Cornus sericea*)	Mountain alder (*Alnus incana*)	Nootka rose (*Rosa nutkana*)	*Carex* spp.
206926		1				47
359935	4		2	2	2	46
359953						2
359981		2	1	2	4	

Site ID Number	Common snowberry (*Symphoricarpos albus*)	Bebbs willow (*Salix bebbiana*)	Red osier dogwood (*Cornus sericea*)	Mountain alder (*Alnus incana*)	Nootka rose (*Rosa nutkana*)	*Carex* spp.
360004			1	2		55

5.5 Education and Outreach

Awareness of invasive riparian plants and the ecological threats they pose was raised through the delivery of the PlantWise campaign message at various public and targeted events (Table 6), as well as through traditional and social media platforms (Table 7). Through these efforts, up to 7,810 people received information through in-person/interactive events, and an estimated 148,753 through media activities. The local community also was engaged through CKISS' citizen science projects on iNaturalist to help track invasive species in the region. iNaturalist is a crowdsourced citizen science platform where people can record and share their observations of living things, and this has been useful as an education and early detection tool. FWCP's contribution was recognized at all relevant events and media opportunities.

Table 6. Invasive species focused education and outreach activities conducted by the Central Kootenay Invasive Species Society, 2023.

Activity Type	Activity Number	No. ppl. reached directly	No. ppl. reached indirectly
Community Weed Pull	5	124	-
Educational Outreach Booth	18	1,544	5,359
Presentation	3	62	0
Restoration Event	2	77	-
Webinar	1	75	152
Workshop	5	69	60
Field Trip	10	286	2
PlantWise and species specific resources distributed = 408			

Table 7. Invasive species focused traditional and social media delivered by the Central Kootenay Invasive Species Society, 2023.

Media Platform	Number of Posts/Spots	Like/Views/Hits/Followers
Facebook	5	994 followers; post reach 1,275
Instagram	6	642 followers; post reach 953
Website Blog	1	35,285 visits to the CKISS website
CKISS n'Tell E-newsletter	1	1,010 subscribers
Online or Print Article	2	Estimated reach 110,230
iNaturalist public reports	-	9 yellow flag iris; 10 purple loosestrife

6. Discussion

Plant survey results showed *L. salicaria* abundance was reduced, which is the expected result following two years of treatment effort. However, this species still was found to be present across an estimated 149,704 m^2, and it's biological control agents still are present in low numbers. Biocontrol agent surveys were conducted at 23 sites and agents were found only at two sites. Further, of the two species of agents known to be released in the area in the past, only one species was found. *Galerucella calmariensis* and *G. pusilla* are reported to be mobile and disperse in search of new plant sites and second generation beetles are reported to be more prone to dispersal than those that overwinter and emerge in spring (first generation) (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, n.d.). However, this may not be the case locally given the low number of agents detected. The literature states that egg-laying is heaviest when air temperatures are above 25°C, reducing when temperatures lower to 20°C for *G. calmariensis,* and for *G. pusilla*, low (not defined) temperatures strongly affect oviposition. Upon review of the past ten years of air temperature data (No Author, n.d.), as a reference point for reproductive success, the monthly average temperature ranges have been as follows: June 14.5 – 20.6 °C; July 19.7 – 24.2 °C; and August 19.5 – 22.2 °C. Therefore, it is possible that regional temperatures in the project area may not be adequate to facilitate maximum reproduction for the biocontrol agents that are released in this part of the province, which may be a primary reason for low population densities. It also is of interest to note that *G. pusilla* has not been detected during any project years because the two *Galerucella* species provide different benefits to *L. salicaria* control. *G. calmariensis* feeds on early plant growth, causing the plants to send out new

shoots that then coincide with *G. pusilla* feeding requirements. Additionally, the two species prefer different densities of plants, and therefore, should feed on a wider range of plants in an infestation.

The release of more biocontrol agents, and their use as a primary control method on suitable *L. salicaria* sites was to be incorporated into this project in 2022 and 2023. In October 2021, the Province's Biocontrol Specialist announced that biocontrol agents would be available for collection and dispersal by non-government agencies on *L. salicaria* sites starting in 2022. This control method was previously restricted to requests submitted to the Ministry of Forests each year and resourcing shortages meant that it was effectively unavailable for most sites. Unfortunately, this method of control has not been incorporated into the project because the Province has yet to finalize the biocontrol collection and dispersal policy and the timeline for this is unknown.

Surveys on *I. pseudacorus* detected an increase in area covered. This likely is due to the lower portion of the project area (Brilliant Headpond) being surveyed for the first time since 2018, at which time, *I. pseudacorus* already was found across an estimated 6,774 m^2. As expected, the downstream transport of reproductive plant material present upstream, both in and outside of the project area, is leading to increasing infestations in the Brilliant Headpond. As such, surveys and treatments have been focused on the upper portions of the project area in years one and two of this project.

Control methods continued to consist of mechanical methods, the primary methods being hand pulling, digging, and seed head removal. Deadheading *L. salicaria* plants was increased this year on sites where plants were found in high distribution and/or density, and/or where substrate made other control methods unfeasible. In the absence of collection and release of biocontrol agents, deadheading is being utilized to reduce possible seed production and limit spread.

One of the treated sites was determined to be appropriate for restoration efforts with the most appropriate restoration technique being replacement planting with native plants. Sites were deemed to be suitable candidates for restoration when treatment disturbance was evident; anthropogenic disturbance was minimal; native vegetation needed help to regenerate; root systems and seedbanks were fully removed; no irrigation nor browse protection would be required; elevation and substrate were appropriate to accommodate growth; and evidence of browse activity was minimal.

Similar to the recommendations provided in years one and two of this project, revegetation is known to be most effective when it is implemented after treatment is complete (all individuals have been removed and the seedbank has been addressed). However, this also needs to be balanced with the possibility of non-native plants further colonizing disturbed areas if not replanted with native species. Therefore, five previously treated sites received replacement planting with 173 native plants.

7. Recommendations

It is recommended that alternate treatment methods for *L. salicaria* be explored in addition to mechanical control methods, or in place of, where terrain or site size prevents effective digging/pulling/deadheading. The primary alternate treatment recommendation is to source and distribute substantial quantities of both biological control agents used in this area that are known to attack *L. salicaria.* When treatments are made with small numbers of beetles released, small populations usually will continue, therefore large releases perform best, and thus are recommended. If less than ideal air temperatures could be a limiting factor on reproduction, population density should be monitored annually, at minimum, as adult life expectancy is approximately eight – ten weeks, and new agents released as needed. When the Provincial biocontrol collection and dispersal policy is finalized, both *G. calmariensis* and *G. pusilla* should be sourced and released. By combining the two *Galerucella* species, benefits are gained due to their different feeding habits. Collection and release of agents should commence as soon as possible on applicable sites and continue into future project years as needed, as determined by follow-up monitoring.

Mechanical treatment should continue to be conducted annually as needed (e.g. new sites, follow-up control of previously treated sites), where feasible, on both *L. salicaria* and *I. pseudacorus*. Focusing more resources on treatment of *I. pseudacorus* where infestations are extensive is recommended. For *I. pseudacorus* sites where neither benthic barrier nor digging methods may be suitable, removal of seed heads should be conducted. All treated sites should be monitored for several years following initial plant removal with follow-up removal as required as there will be ongoing germination and re-establishment from the seedbank as well as from root or rhizome fragments.

Functional eradication is a management technique focused on suppressing invader populations below levels that cause unacceptable ecological effects within high-priority locations when eradication of an invasive species is unfeasible. For both of the target plant species in this project it is recommended that this management technique be given consideration as it may assist in identifying management targets or criteria to evaluate what level of control is sufficient to mitigate ecological impacts of *L. salicaria* and *I. pseudacorus* in high-priority management areas.

For site(s) that are considered to be appropriate for restoration, it is recommended that larger potted stock native plants be used to infill the area(s) where *I. pseudacorus* is removed, while smaller plants such as plugs are more suitable for infilling where *L. salicaria* is removed. Planting native plugs immediately after removal of *L. salicaria* is recommended on a trial basis at select site(s), while overall,

replacement planting is recommended after treatment is complete (all individuals have been removed and the seedbank has been addressed).

Some infested sites exist on private property and given that human activities are the primary vector for invasive species introduction and spread, an important component to the success of this project would be to continue providing education to increase public awareness and change the behaviours that are responsible for spreading invasive species. A variety of outreach activities and media directed at specific target audiences and the general public should continue so as to raise awareness about invasive species and promote the PlantWise program. Further, direct communication with landowner(s) whose property contains target species within the project area should continue in order to coordinate access and treatments.

8. Acknowledgements

CKISS acknowledges that we are privileged to live and work in the unceded territories of the Ktunaxa, Syilx, Secwépemc, and Sinixt First Nations.

The CKISS would like to gratefully acknowledge the following organizations and representatives for lending their assistance, expertise, cash or in-kind support to the success of the project:

- Okanagan Nation Alliance
- Ktunaxa Nation Council
- Nature Trust of B.C.
- FortisBC
- Columbia Basin Trust
- Teck Metals Ltd.
- Fish & Wildlife Compensation Program
- City of Nelson
- BC Hydro
- Columbia Power

Title page photo credit: CKISS

9. Literature Cited

Central Kootenay Invasive Species Society. (n.d.). What are invasive species? Retrieved from Central Kootenay Invasive Species Society: https://ckiss.ca/species/what-are-invasive-species/

Environment Canada. (2004, September). Government of Canada Publications. Retrieved 2022, from Government of Canada: https://publications.gc.ca/site/eng/home.html

Green, S. J., & Grosholz, E. D. (2021). *Functional eradication as a framework for invasive species control*. Frontiers in Ecology and the Environment, 19(2), 98–107.

Lockwood, J. L., Hoopes, M. F., & Marchetti, M. P. (2013). Invasion Ecology. Chichester, England: Wiley-Blackwell. Retrieved 2022, from https://www.esf.edu/efb/parry/502-18lecture_summaries/Lockwood_etal_pp1-30.pdf

Ministry of Forests, Lands, Natural Resource Operations and Rural Development. (n.d.). Agents & Plants. Retrieved 2022, from Government of B.C.: https://testwww.for.gov.bc.ca/hra/Plants/plants/purple-loosestrife.htm

No Author. (n.d.). British Columbia - Weather Conditions and Forecast by Locations. Retrieved 2022, from Government of Canada: https://weather.gc.ca/forecast/canada/index_e.html?id=bc

Pathikonda, S., Ackleh, A. S., Hasenstein, K. H., & Mopper, S. (2009). *Invasion, Disturbance, and Competition: Modeling the Fate of Coastal Plant Populations.* Conservation Biology, 23(1), 164-173. doi: https://doi.org/10.1111/j.1523-1739.2008.01073.x

Ricciardi, A., Hoopes, M. F., Marchetti, M. P., & Lockwood, J. L. (2013). *Progress toward understanding the ecological impacts of nonnative species*. Ecological Monographs, 83(3), 263-282. doi: https://doi.org/10.1890/13-0183.1

Thompson, D. Q., Stuckey, R. L., & Thompson, E. B. (1987). Spread, Impact, and Control of Purple Loosestrife (Lythrum salicaria) in North American Wetlands. Jamestown, U.S.A.: U.S. Fish and Wildlife Service. Retrieved 2022, from http://stoppinginvasives.com/dotAsset/670d2f92-cd0c-41ab-9955-7204f1a9a192.pdf

10. Appendix A: Kootenay Riparian Invasive Plant Removal Site Restoration Recommendations Year 3

Central Kootenay Invasive Species Society
Suite 19 - 622 Front St
Nelson, B.C., V1L - 4B7

January 2, 2024

Attn: Khaylish Fraser

Re: Kootenay Riparian Invasive Plant Removal Site Restoration Recommendations Year 3

Masse Environmental was retained by the Central Kootenay Invasive Species Society (CKISS) to identify sites that require restoration following removal of yellow flag iris (*Iris pseudacorus*; YFI) and purple loosestrife (*Lythrum salicaria*, PL) in year 3 of the Riparian Restoration project. The goal of the project is to improve riparian ecosystem function, protect high-value conservation areas, and increase awareness and long-term stewardship among local residents.

The scope of work was to assess CKISS treatment sites along the Kootenay River and West Arm of Kootenay Lake where yellow flag iris and purple loosestrife were mechanically removed and determine if they require restoration based on the level of disturbance caused by the treatment. For sites that were determined to require restoration, recommendations are provided. This letter provides the results of the assessment and associated recommendations for restoration.

Methods

Field surveys were conducted on October 16 by Lisa Pavelich P.Ag. of Masse Environmental and Khaylish Fraser of CKISS, at eight treatment sites where yellow flag iris and/or purple loosestrife were removed by digging and hand pulling during the 2023 field season. Sites were accessed by boat or traversed on foot to assess site conditions and identify the need for restoration post treatment. Multiple factors were considered to determine if restoration is warranted and feasible (Table 1).

Table 1. Site factors for successful restoration.

Site Factors	Restoration Candidate	Not Suitable for Restoration
Level of disturbance	exposed soil areas caused by control activities; minimal anthropogenic disturbance	no disturbance observed from control activities; ongoing anthropogenic disturbance present
Existing native vegetation	native vegetation either young or not well developed and needs help to regenerate	native vegetation well developed and will regenerate naturally
Re-invasion risk	root systems fully removed, planting would help prevent reinvasion from seedbank, invasive species present nearby that could reinvade site	root systems not fully removed during control; seed bank would counteract restoration efforts
Maintenance	high potential for success with no maintenance (shady slope aspect, cover from existing vegetation to retain moisture); no irrigation, browse protection required	Low potential for success with no maintenance (hot, dry, exposed sites); requires irrigation and/or browse protection
Elevation	appropriate to accommodate growth (along or above normal HWM for shrub/tree species, higher portion of littoral zone for sedges/rushes)	not appropriate to accommodate growth (site inundated too many months per season)
Substrate	appropriate to accommodate growth (consists of soil/silt/mixed sand)	not appropriate to accommodate growth (pure sand, cobble, boulder, bedrock)
Browse	minimal browse present	high levels of browse present

Results

Of the eight sites assessed, one was determined to require restoration (Attachment 1). No other treatment sites met the factors for successful restoration; however, a few purple loosestrife treatment sites were identified that would benefit from continued mechanical treatment and potentially the introduction of biocontrol. The individual site and associated recommendations for restoration are summarized in Table 2 and specific restoration techniques are described for each target species below.

Table 2. Treatment sites recommended for restoration.

Site ID	CKISS Treatment	Habitat Type	Dominant Species	Plant #	Plant Size	Comment
359993	PL/YFI	Riparian/ Foreshore	red osier dogwood, black hawthorn, alder, rose, reed canary grass	50	2 or 5 gallon	Teck property downstream of old Taghum bridge including small island and shoreline. Many YFI present along shoreline to be treated in future years. **Replace YFI sites with potted stock during/after removal.** Good candidate restoration site due to minimal disturbance and browse, existing cover, moisture. If not planted disturbances will likely be colonized by reed canary grass and other weeds. **Continue mechanical treatment of PL to reduce seedbank and consider biocontrol.**

Yellow flag iris

The most effective restoration technique for yellow flag iris treatment sites, where appropriate, was determined to be replacement planting with native plants. The removal of invasive plants such as yellow flag iris sometimes creates large, disturbed areas (up to $1m^2$) from excavation of the root system. Native plants can be planted in the depression where the invasive plant was removed to revegetate the area, prevent other invasive species from colonizing and improve the habitat along the shoreline. In this case, larger potted stock native plants are best suited to infill the area and compete with surrounding vegetation. Appropriate replacement species should align with the habitat and dominant species present on site, however a full list of potential replacement species is provided in Table 3.

Purple loosestrife

The most effective restoration technique for purple loosestrife control sites was determined to be continued mechanical treatment combined with the introduction of biocontrol. This is because on many occasions loosestrife was found to be growing within both foreshore and riparian habitats where well-established native vegetation occurs preventing the need for replacement planting where suitable vegetation already exists. Biocontrol may provide a more effective method for long term control in this circumstance and reduce the need for repeated mechanical treatments.

In some situations, replacement planting may also be appropriate to help jump start natural succession following treatment. Replacement planting creates direct competition with purple loosestrife ingrowth and makes the site more resistant to future invasions (Warne 2016[1]). It is best known to be effective when revegetation is implemented after treatment is complete. For the purpose of this project however it would be worthwhile exploring if it would also be effective when implemented during treatment to prevent repeated site visits and disturbance of the seedbank. Any soil disturbance by pulling or digging can bring thousands of seeds to the surface (Warne 2016[1]). Since purple loosestrife has a smaller root system than yellow flag iris and leaves largely undetectable disturbance following removal, it might be effective to install smaller plants such as plugs in the same hole the weed is being removed from. A trial could be conducted at Site 206926 (2022) or Site 359993 (2023) to determine the effectiveness of this technique in helping to prevent reinvasion. If successful it would provide a cost-effective control option, specifically in the foreshore environment when replaced with sedges and rushes where appropriate substrate exists. The site would need to be monitored to document the effectiveness of the trial and some maintenance should be expected to conduct spot treatments for additional mechanical removal.

A list of native species appropriate for replacement planting along Kootenay Lake and the Kootenay River is provided in Table 3.

Another restoration technique that could be used following purple loosestrife treatment is seeding. Seeding with an annual cover crop or native plant mix over the disturbed area, immediately following treatment, may help prevent the establishment of undesirable vegetation or new invasive species (Warne 2016[1]). This technique may be particularly useful on sites with coarse (cobble/boulder) substrate, where roots were difficult to remove, in tandem with biocontrol. Further background review is required to fully explore the viability of this option given the seasonal inundation of these sites, identify appropriate species, and source certified weed free seeds.

[1] Warne, A. 2016. Purple Loosestrife (*Lythrum salicaria*) Best Management Practices in Ontario. Ontario Invasive Plant Council, Peterborough ON.

Table 3. Plant species suitable for restoration along the shoreline of Kootenay Lake and Kootenay River.

Common Name	Latin name
Tall Shrubs	
Sitka willow	*Salix sitchensis*
Bebbs willow	*Salix bebbiana*
Narrow leaf willow	*Salix exigua*
Red osier dogwood	*Cornus sericea*
Mountain alder	*Alnus incana*
Nootka rose	*Rosa nutkana*
Woods rose	*Rosa woodsii*
Black hawthorn	*Crataegus douglasii*
Low shrubs	
Common snowberry	*Symphoricarpos albus*
Pink spirea	*Spirea douglasii*
Grasses	
Bluejoint reedgrass	*Calamagrostis canadensis*
Tufted hairgrass	*Deschampsia cespitosa*
Sedges	
Slender-beaked sedge	*Carex athrostachya*
Columbia sedge	*Carex aperta*
Water sedge	*Carex aquatilis*
Inflated sedge	*Carex exsiccata*
Sitka sedge	*Carex sitchensis*
Kellogg's sedge	*Carex lenticuclaris*
Beaked sedge	*Carex utriculata*

Closure

I trust the information contained herein meets your current requirements. If you have any questions or comments, please contact the undersigned.

Sincerely,

Lisa Pavelich, PAg
Masse Environmental Consultants
E: lisa@masse-env.com

Attachment 1

Results of Field Assessment

Site ID	Treated Species	Habitat Type	Dominant Species	Substrate	Restoration Candidate	# Plants	Plant Size	Comment	Photo	
206923	PL	Riparian/ Foreshore	red-osier dogwood, alder, sedge, grass, forbs	sand, cobble	N			Shoreline below Bealby Point Road partially treated. Many individuals remain along edge of riparian and in cobble substrate along foreshore. Not currently a good candidate for restoration due to abundant seedbank present. **Once site is fully treated and seedbank depleted would be good candidate for collecting and planting cuttings of red osier dogwood.**		
359941	YFI	Riparian	alder, black cottonwood, red osier dogwood, western red cedar, grass, equisetum	sand	N			Partial private property south of Balfour ferry landing. No site disturbance identified. **Recommend landowner education.**		
359942	YFI	Riparian	none	cobble	N			Site consists of rock groyne at edge of private property where one clump YFI was removed. Not a candidate for restoration due to no disturbance identified, lack of plantable substrate and low likelihood of recolonization.		
359945	YFI	Riparian	willow, sedge, grass, forbes, equisetum, skunk cabbage	sand, soil	N			Offshore inlet where watercourse enters lake through culvert. One disturbance site identified surrounded by native vegetation which will quickly recolonize the site. Existing individuals identified in willow thicket will not require replanting after removal due to dense canopy of vegetation present. **Investigate possible upstream seed source.**		
359985	YFI	Riparian	alder, snowberry, willow, black hawthorn, sedge	cobble, boulder	N			Private property at the bottom of Kays Road with mix of domestic and native well established riparian vegetation along shoreline. Not a good candidate for restoration due to abundant beaver activity, rocky substrate and steep bank. **Recommend landowner education to monitor and remove future individuals.**		

Site ID	Treated Species	Habitat Type	Dominant Species	Substrate	Restoration Candidate	# Plants	Plant Size	Comment	Photo	
359993	PL/YFI	Riparian/ Foreshore	red osier dogwood, black hawthorn, alder, rose, reed canary grass	sand, cobble	Y	50	2-5 gallon	Teck property downstream of old Taghum bridge including small island and shoreline. Many YFI present along shoreline to be treated in future years. **Replace YFI sites with potted stock during/after removal.** Good candidate restoration site due to minimal disturbance and browse, existing cover, moisture. If not planted disturbances will likely be colonized by reed canary grass. **Continue mechanical treatment of PL to reduce seedbank and consider biocontrol.**		
359995	PL/YFI	Riparian	grass	mixed sand, cobble	N			Site is primarily private property, a portion of which is owned by Teck. Extensive disturbance along shoreline from unrestricted grazing of sheep. **Recommend landowner education and consider fencing and planting riparian area. Continue mechanical treatment to reduce seedbank and consider biocontrol.**		
359996	PL	Foreshore	grass	boulder, bedrock	N			Site underwater at time of survey, therefore site has low potential for restoration success based on inundation period and substrate.