

Mid-Columbia Ecosystem Enhancement Project Catalogue

March 2017

Compiled by: Cindy Pearce, Mountain Labyrinths Inc. with Harry van Oort, and Ryan Gill, Coopers Beauschesne; Mandy Kellner, Kingbird Biological Consulting; Will Warnock, Canadian Columbia River Fisheries Commission; Michael Zimmer, Okanagan Nation Alliance; Lucie Thompson, Splatsin Development Corporation; Hailey Ross, Columbia Mountain Institute of Applied Ecology

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders, and Columbia Basin Trust as well as generous in-kind contributions from the project team, community partner organizations and agency staff.

Table of Contents

Background	3
Mid- Columbia Area	3
Hydropower Dams and Reservoirs	4
Information Sources.....	5
Ecological Impacts of Dams and Reservoirs.....	5
General Impacts.....	6
Specific Geographic Impacts.....	7
• Revelstoke Reach/Flats/Drawdown Zone.....	7
• Bridges to Revelstoke Dam	8
• Lake Revelstoke.....	9
Past and Ongoing Projects	9
Potential Projects.....	10
Site Specific Projects	10
Area-wide Projects.....	16
Project Success Factors.....	19
Interested Community Partners	20
Project Location Maps	21

Acknowledgements

The ongoing dedication of the project team members and the community partner organizations to improving ecological conditions in the Mid-Columbia area made this project possible.

Project team members – Harry van Oort and Ryan Gill with Cooper Beauschesne, Mandy Kellner of Kingbird Biological Consulting Inc., Hailey Ross from the Columbia Mountain Institute, Lucie Thompson from the Splatsin Development Corporation, Michael Zimmer from the Okanagan Nation Alliance and Will Warnock with Canadian Columbia River Inter-Tribal Fisheries Commission

Community partner organizations - Columbia Shuswap Invasive Species Society, North Columbia Environmental Society and Revelstoke Rod and Gun Club.

Background

The construction and operation of hydropower dams have highly modified the natural environments in the mid-Columbia River region between Shelter Bay and the Mica dam where this catalogue is focused. There have been permanent changes to a substantial area of upland, riparian, wetland and aquatic ecosystems, with impacts to fish and wildlife habitats. Other human activities including mining, railroads, logging, road networks and recreation use also impact fish and wildlife habitats in this area.

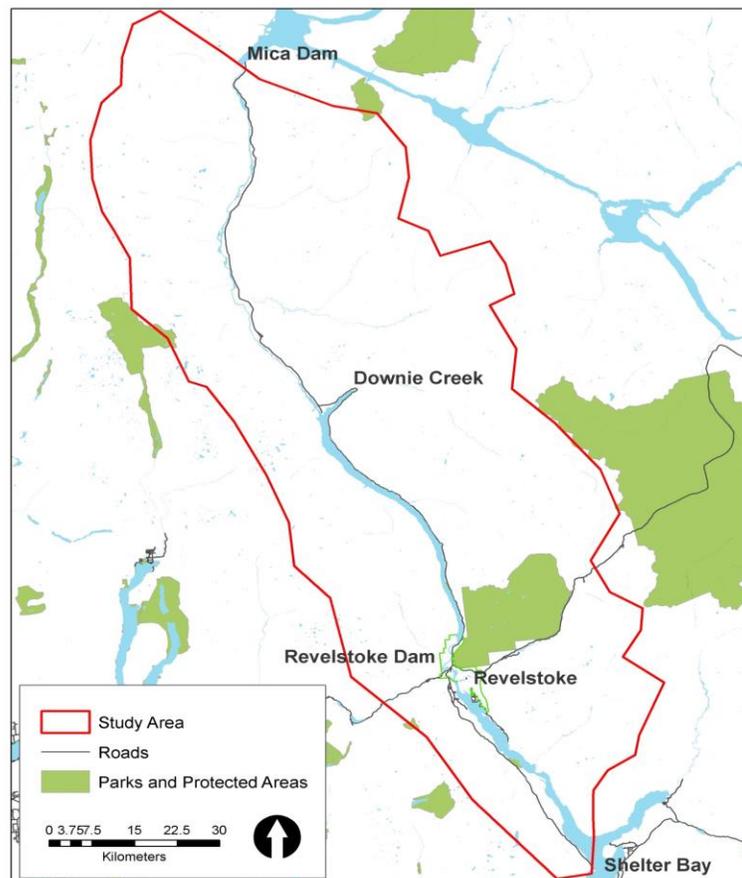
Community groups and the general public in the Revelstoke area as well as First Nations that include this area in their traditional territory are supportive of on-site stewardship, conservation and restoration projects in this area to improve ecosystem function and habitats. Funding is available for these projects from the Columbia Fish and Wildlife Compensation Program, Columbia Basin Trust and other sources however few proposals for this area are received by these potential funders.

There are over 80 publicly available scientific reports that have been completed in the last 25 years that describe the environmental impacts of reservoirs and hydropower operations in this area, with some suggesting potential ecosystem projects and priorities. However, much of this information is not readily available to or understood by non-technical readers. As well, interested groups do not have relationships in place to partner on projects. These barriers have slowed the development of on-site projects. This catalogue aims to reduce these barriers by compiling the scientific information and local perspectives on potential projects to enhance access to this information and facilitate funding applications for ecosystem enhancement projects over time.

The catalogue provides site-specific, hands-on projects that community groups, First Nations, agencies, consultants and others might have the capacity to implement; it does not include existing or potential government lead processes such as recreation use or forest harvesting planning and enforcement; habitat protection decisions; or angling regulations, as these are beyond the jurisdiction of these groups to implement.

Mid- Columbia Area

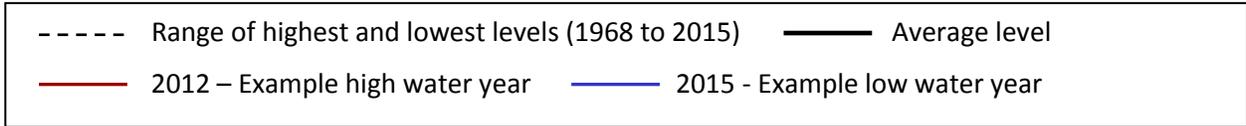
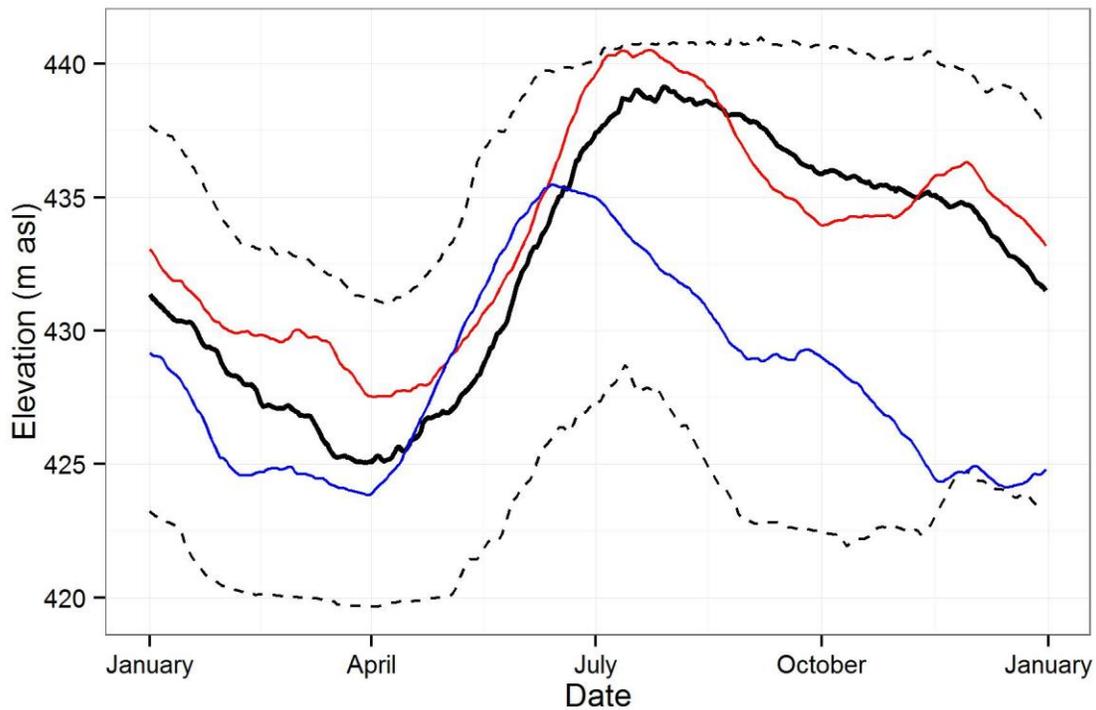
This catalogue covers the area from Shelter Bay to Mica dam, as shown in the map on the right.



Hydropower Dams and Reservoirs

The Hugh Keenleyside dam was built in 1968. This dam created the Arrow Lakes Reservoir upstream of the dam which raised the level of the two natural Arrow Lakes, and extended the extent of ponded waters to 230 kilometers from near Castlegar (downstream) to Revelstoke (upstream). This reservoir was created to store water to reduce flooding of downstream communities and for release to the U.S. under the Columbia River Treaty and other agreements for flood control, power production and, more recently, fish management. This results in water level fluctuations of 12 metres (40 feet) during most years, on average, with sometimes significant differences in water levels from year to year, as shown in the graph below.

Arrow Lakes Reservoir Annual Water Level Fluctuations



The Revelstoke Dam, located just upstream of the City, was completed in 1984 with four turbines. Hydropower is produced at this dam to meet electricity demands during the highest daily and seasonal 'peak' periods. Lake Revelstoke reservoir is 130 kilometres long, ending at Mica Dam. This reservoir stores water for release during peak electricity demand periods. Water levels are relatively stable, only normally fluctuating within 1.5 metres (five feet), although the water license allows for much greater fluctuation.

The Mica dam was completed in 1973, creating the Kinbasket Reservoir, which begins north of Golden and continues 216 kilometres north to Valemount. This dam is the key headwaters storage dam under the Columbia River Treaty and an important hydropower generator for B.C. Together the Revelstoke and Kinbasket dams generate almost half of the hydropower produced by BC Hydro.

Water is released from Mica Dam into Lake Revelstoke based on flood control and hydropower needs as well as the requirements of the Treaty and other agreements.

Dam operations must meet a number of legal requirements including provincial water licenses for each dam and the Columbia River Treaty as well as other agreements such as for non-treaty water storage with the U.S. These requirements and provincial hydropower generation needs result in seasonal and daily water flows and reservoir levels that must be accounted for in any ecosystem enhancement projects in this area.

Information Sources

This project was initiated by collecting a listing of relevant documents that describe the environmental impacts of reservoirs and hydropower operations in this area, with some suggesting potential ecosystem projects and priorities. Over 80 publicly available reports completed in the last 25 years were identified. Project resources did not allow for review of earlier literature.

The project team scanned a short list of these documents, including original research, project reports and strategic action plans to identify potential projects for this catalogue. An Annotated Bibliography of these documents was compiled and is available on the [project webpage](#). The complete list of documents is available from the project lead.

The team found the following sources to be most important during this review:

- [Dam Footprint Impact Summary BC Hydro Dams in the Columbia Basin \(2011\)](#)
- [Fish and Wildlife Compensation Program Columbia Region Action Plans](#)
- [Columbia River Water Use Plan](#)
- [Revelstoke Flow Management Plan](#)

The draft catalogue was reviewed by technical specialists in agencies and community groups and was posted on the project webpage hosted by the Columbia Mountains Institute for Applied Ecology, with an invitation for public input through an on-line survey and interviews. Input from the, technical specialists, survey and interviews were added to the catalogue which was reviewed during a workshop and field trip in early September 2016. Opportunities for private land conservation were discussed during a community meeting in December with representatives from the Kootenay Conservation Program.

Substantial follow-up with technical specialists occurred after the workshop to verify new information. During this review it was found that recommendations in scanned reports for removal of fish passage barriers and addition of large woody debris to streams to enhance fisheries habitat are no longer supported based on more recent understanding about effective fisheries enhancement practices in the steep, flash-prone conditions in local streams.

Ecological Impacts of Dams and Reservoirs

There are a number of common initial ecological impacts resulting from dam and reservoir construction (known as 'footprint' impacts) as well as ongoing ecological impacts from the changes in water flows and reservoir levels resulting from dam operations (known as 'operational' impacts). Some of these impacts have occurred throughout the mid-Columbia area, while others are specific to smaller, well-defined geographic areas. The section below provides a brief overview of the

general ecological impacts throughout the Mid-Columbia area, followed by summaries of the specific impacts in three geographic areas – the Revelstoke Reach (also known as 'the flats' or 'the drawdown zone'); above the CPR and Highway 1 bridges to the Revelstoke dam; and Lake Revelstoke. Where appropriate, specific impacts were considered for significant high quality ecological components, including bull trout, white sturgeon, mountain caribou, painted turtles and great blue herons as well as localized (endemic) west slope cutthroat trout in the Akolkolex River and Kirkup Creek.

General Impacts

A widespread early impact in Canada from hydropower development on the Columbia River happened in 1942 when fish migration, including annual salmon runs, was blocked by the construction of the Grand Coulee dam in the U.S., just below the Canada/US border. Before this barrier was created, salmon had historically spawned and then died along the main-stem of the Columbia River and in some tributaries, thus fertilizing local ecosystems with rich ocean-based nutrients. This nutrient flow was stopped by this barrier. The migratory pathways of resident fish species (e.g., bull and rainbow trout) were also blocked by this early and substantial dam.

Before the Canadian dams were built in the 1960s through the 1980s the ecology of the local area was changed by the rail line, roads and extensive farming in the flat lands south of Revelstoke as well as roads, logging and mining in the upland areas.

The subsequent construction and operation of the three dams in Canada have caused four general ecological impacts within the reservoirs in the mid-Columbia area:

1. **Reduced nutrient flows** - The much slower water flows within each reservoir allows nutrients to settle out, enriching that specific reservoir ecosystem, however these nutrients are no longer transported downstream to enrich lower ecosystems as in the past.
2. **Altered primary biological productivity** – Reduced nutrient flows and changes in water depth, temperature and other conditions within each reservoir alters the ecological processes that define the basic level of biological productivity in each reservoir.
3. **Much reduced fish spawning habitats** – Spawning habitats are critical to fish populations. White sturgeon, now an endangered species, spawns in habitats within the main riverbed. Kokanee, bull trout (also an endangered species), rainbow trout (including the rare yellowfin variety), burbot, whitefish and a variety of minnow, sucker and sculpin species spawn in tributaries with appropriate conditions. Dams blocked fish movement to spawning habitats, reservoirs flooded many of these habitats and the remaining habitat can be impacted by fluctuating water levels and soil/gravel deposits that block fish access.
4. **Diminished riparian and wetland habitats** – These biologically rich ecosystems along the original riverbed are now flooded and subjected to continuously fluctuating water levels. These areas were critical habitats for wildlife and fish, including salmon historically. The loss of these habitats has altered fish and wildlife populations.

Many of these impacts were examined during the [Columbia River Water Use Plan](#), which was implemented in 2007, and are now being further examined in a series of studies directed by this plan.

An additional impact that is often referenced locally is warming of local, low elevation climates due to the heat trapped in and released from the new reservoirs. Scientists have not been able to confirm this impact because the reservoirs were created at a time while the climate was warming regionally and globally.

Specific Geographic Impacts

- **Revelstoke Reach/Flats/Drawdown Zone**

Shelter Bay is located along what was formerly the northern shore of Upper Arrow Lake. Before the reservoir was filled the Columbia River flowed freely through the wide, rich valley bottom area between the lake and the City of Revelstoke. This area is now known as 'Revelstoke Reach' or locally as 'the flats' or the drawdown zone.

Historically many fish bearing streams flowed into the river and the diversity of wetland, riparian and forested habitats supported a variety of wildlife. First Nations spent time on this land fishing, hunting, gathering and conducting cultural and spiritual activities in this abundant and spectacular landscape. Beginning in the late 1800s, Europeans settled many farms and small communities, attracted by the rich soils.

The creation of the Arrow Lakes Reservoir had a very large impact on the ecological processes in the valley. Several thousands of hectares of productive, diverse wetland and upland habitats were cleared and flooded. In addition, over thirteen hundred hectares of settled lands were flooded. The aquatic ecosystems in the area were also disrupted.

These areas continue to be impacted by ongoing hydro operations. In most years during the winter when the reservoir level is low, the valley floor along the river channel is not flooded and the river flows within its original channel. Exposed soils can be wind-eroded though extensive grass plantations have stabilized soils in the higher elevations of the reservoir drawdown zone.

As spring run-off is stored in the Arrow Lakes reservoir, water levels rise and the valley is flooded, beginning at the lowest elevations and often rising to near the maximum permitted level – or 'full pool' – typically reached in mid-summer. This flooding brings a pulse of nutrients to the area. High water levels result in wave action which causes erosion and soil loss in some areas. Over the late summer, fall and winter the reservoir level declines as the stored water is released until the river flows again within its original channel.

Although much of this area is often flooded annually, it retains some ecological functions. The timing and duration of flooding defines what type of vegetation can survive within this area, with simple plant communities of sedges at the lowest elevations where vegetation can survive, and more complex vegetation communities including herbs, shrubs and trees at the very highest elevations. Fall rye, a non-native species, was seeded in many parts of this area to stabilize exposed soils. Reed canarygrass and sedges now dominate ecosystems that are frequently flooded. The increasing complex habitats at higher elevations where flooding is less frequent support a growing diversity of wildlife, including migratory birds and species at risk such as the western painted turtle. While the distribution of wildlife in this area is largely shaped by the habitats that develop based on water levels, wildlife can also be directly affected by the timing and duration of changes in water levels – for example, some bird species nest in areas that are not flooded in the early spring, but are flooded later in the spring, leading to poor reproductive success.

This area also includes many wetland features that despite frequent flooding continue to be of great regional importance for the western painted turtle, aquatic mammals such as beavers and a high diversity of wetland birds, especially when the reservoir is drawn down. Seasonal flooding of these wetlands through ongoing operations commonly submerges many of these wetlands, often making them temporarily unavailable to wildlife.

There are concerns that unmanaged recreational uses on the flats can damage fragile vegetation and disturb wildlife.

Fluctuating water levels and erosion also change aquatic ecosystems within the river and tributary streams. This results in loss, fragmentation and degradation of aquatic habitats, leading to population fragmentation and declines for some fish and other species. The recent decline in kokanee populations is a specific concern. Of special note, this area provides very isolated, known spawning habitat for white sturgeon and thus is designated as part of the Arrow Lakes target area for sturgeon recovery in B.C. Stocking of yearling sturgeon and ongoing monitoring juvenile movement and growth occur in support of sturgeon recovery. Alternatively, some fish species may benefit from these changes.

When the Arrow Lakes Reservoir water levels are relatively low during seasonal drawdown and in dry years, the upper areas of the Revelstoke Reach also experience hydropeaking impacts, which are discussed below.

- **Bridges to Revelstoke Dam**

There is a relatively short stretch of river upstream of the Trans-Canada Highway and railway bridges in Revelstoke to the Revelstoke Dam that is essentially free-flowing, though water levels fluctuate greatly almost daily based on the operations at the Revelstoke Dam. Water flows through this dam change often twice a day to produce electricity during peak demand periods (“hydropeaking”). Flows may also be increased to move stored water from Kinbasket Reservoir behind Mica Dam into the Arrow Lakes Reservoir. The level and timing of high and low flows, the rate of the increase and reduction in flow (‘ramp’ rate), and the duration of changed flows can impact ecosystems. These impacts include erosion and aquatic and shoreline habitat degradation as well as reduced food web productivity due to rapid nutrient flushing, with concurrent impacts on fish productivity, and increased risk of fish stranding.

Before 2010, there was no minimum flow requirement for the Revelstoke Dam. An outcome of the Columbia Water Use Plan was to establish a required minimum flow which must be met at all times. In 2010 a fifth turbine was activated at this dam, and a proposed sixth turbine is under environmental review. As each turbine is added, more water will flow through the dam to meet peak electricity demands, with increasing concerns about the ecological impacts of these ‘hydropeaking’ operations. When the fifth turbine was activated, maximum flows increased by about 30%, and the sixth turbine may further increase maximum flows by approximately 25%. Several studies are underway as part of the Revelstoke Flow Management Plan to monitor the ecological effects of the minimum flow and new hydropeaking operations with the fifth turbine.

Beyond the impacts on habitats, within this area fish passage upstream is blocked by the dam, and downstream movement is limited by fish losses within the turbines (entrainment).

- **Lake Revelstoke**

Almost 11,500 hectares of primarily upland ecosystems, floodplains and streams were flooded by the creation of Lake Revelstoke when the Revelstoke Dam first became operational. Loss of complex river habitats in the main-stem of the Columbia River, and changes to tributary streams both affected biological productivity and fish communities. The historically rich river environment, with a complexity of aquatic habitats including rapids, deep pools and shallow slack water, was replaced by a simpler lake environment. Lake Revelstoke has very low productivity in part due to the short time that water stays in the reservoir (water residence time). This low productivity limits the populations of key fish species such as kokanee, bull trout and rainbow trout. Fish populations are further impacted by losses through entrainment at Mica Dam, although it is suggested that this entrainment may enhance food sources for some downstream populations.

The majority of the productive valley bottom cottonwood and coniferous riparian areas as well as forested wetlands were flooded when Lake Revelstoke was created, reducing the historical complexity of the terrestrial habitats in this area and removing high value habitat for species that rely on these ecosystems. Portions of the upland ecosystems were important seasonal habitat for mountain caribou, which is now a species at risk.

Because Lake Revelstoke normally only fluctuates within a 1.5 metre (five feet) range the ongoing ecological impacts of water level fluctuations are much less than those experienced in the Arrow Lakes Reservoir.

Past and Ongoing Projects

Many projects have been completed in the past and several are ongoing to enhance ecosystem function in the Mid-Columbia area. These projects have been led by provincial agencies, BC Hydro and community groups such as the Rod and Gun Club and the North Columbia Environmental Society and were funded by a variety of sources. Past projects include:

- fisheries enhancement at Akolkolex River, Birch Creek, Martha Creek and Moses Creek;
- floating turtle platform in Montana Bay;
- duck nest boxes at Cartier Bay, Montana Slough and Big Eddy;
- Airport Marsh outflow erosion control; and
- Cartier Bay berm stabilization.

Unfortunately the majority of the fish enhancement projects have not been monitored, while the other projects do have ongoing monitoring, if only informally.

Ongoing projects are listed below with relevant websites or contacts. These projects are not included in the catalogue:

- mountain caribou recovery including [rearing in the wild](#);
- [white sturgeon recovery](#);
- Bridge Creek kokanee educational spawning channel maintenance – contact: [Revelstoke Rod and Gun Club](#);
- invasive species community pulls and restoration projects with partners along the Greenbelt, Big Eddy dyke and other locations – contact: [Columbia Shuswap Invasive Species Society](#);

- Downie slough vegetation planting – contact: [Kingbird Biological Consulting](#), and
- turtle loafing logs in airport marsh – contact: Alan Peatt, Okanagan Nation Alliance (250) 707-0095

Potential Projects

The projects in this catalogue include actions for areas that are directly impacted by the hydropower system (i.e. removing barriers to fish passage that develop in streams within a reservoir) as well as actions in areas that were not directly impacted by the hydropower system to offset the impacts (i.e. removing barriers to fish passage in streams beyond the reservoirs to increase functioning fish habitat in the area).

Site Specific Projects

Potential projects for specific sites are listed in the table below, in roughly geographic order from south to north.

Note to readers: Each project has been assigned a Project Number. The location of the projects that have a specific location is shown using the ID number in the sub-area maps starting on page 21.

Revelstoke Reach/Drawdown Zone	
Project Number	Project details
1	<p>Revelstoke Reach - Fish stranding monitoring/retrieval</p> <p><i>Source</i> – Public suggestion</p> <p><i>Location/land ownership</i> – Throughout drawdown zone, particularly 12 mile flats, Highway 1 bridge, and possibly Walter Hardman outflow and Arrowhead/Crown and BC Hydro</p> <p><i>Environmental values to be enhanced</i> – Reduce impacts on fish populations from predation and increased mortality due to fluctuating water levels.</p> <p><i>Actions</i> – Set up fish stranding report line and response mechanism</p> <p><i>Notes</i> – See CLBMON -53 - Middle Columbia River Juvenile Fish Stranding Assessment</p>
2	<p>Revelstoke Reach – Invasive fish species monitoring</p> <p><i>Source</i> – Jeff Burrows 250 354-6928 jeff.a.burrows@gov.bc.ca</p> <p><i>GPS location/land ownership</i> – Shelter Bay to Revelstoke dam/mixed ownership</p> <p><i>Environmental values to be enhanced</i> – Native fish species</p> <p><i>Actions</i> – Survey appropriate habitats for presence of invasive species including yellow perch (known to be in the wetlands by the Revelstoke airport and have been noted throughout the Revelstoke Reach), northern pike, walleye and small mouth bass. Educate fishers to watch for and report invasive species. Implement appropriate suppression and/or eradication techniques when invasive species are found.</p>

3	<p>Revelstoke Reach – BC Hydro duck box monitoring and maintenance</p> <p><i>Source</i> – Margo Sadler margo.sadler@bchydro.com (604) 528-3102</p> <p><i>Location/land ownership</i> – Cartier Bay, Montana slough, Big Eddy/BC Hydro lands</p> <p><i>Environmental values to be enhanced</i> – duck nesting habitat</p> <p><i>Actions</i> – Regular monitoring of existing box use by species and repairs as required</p> <p><i>Notes</i> – Establishing additional boxes is not recommended on BC Hydro lands as needs are being met by existing boxes</p>
4	<p>Revelstoke Reach - Bat box establishment, monitoring and maintenance</p> <p><i>Source</i> – Margo Sadler margo.sadler@bchydro.com (604) 528-3102</p> <p><i>Location/land ownership</i> – Revelstoke Reach/Crown (and private?) land</p> <p><i>Environmental values to be enhanced</i> – Bat habitat</p> <p><i>Actions</i> – Research being completed to decide on best configuration. Boxes should be established after this research is completed.</p> <p><i>Notes</i> – Researchers – Mandy Kellner myotis@telus.net (250) 837-0820 Cori Lausen Clausen@wcs.org</p>
5	<p>Revelstoke Reach - Riparian and wetland habitat mapping and monitor</p> <p><i>Source</i> – FWCP, Riparian and Wetland Action Plan, 2014</p> <p><i>Location/land ownership</i> – Revelstoke to Shelter Bay/mixed ownership</p> <p><i>Environmental values to be enhanced</i> – Riparian and wetland habitats</p> <p><i>Actions</i> – Inventory, map, and monitor abundance and seral stage distribution of riparian habitat and wetland habitat</p> <p><i>Notes</i> – Map cottonwood, aspen, cedar, etc.</p>
6	<p>Revelstoke Reach - Wetland climate change baseline condition</p> <p><i>Source</i> – FWCP (Riparian and Wetland Action Plan) 2014</p> <p><i>Location/land ownership</i> – Revelstoke to Shelter Bay/mixed ownership</p> <p><i>Environmental values to be enhanced</i> – Wetland habitats</p> <p><i>Actions</i> – Determine a ‘reference condition’ for wetland and riparian areas as a baseline to measure impacts of climate change</p> <p><i>Notes</i> – None</p>

7	<p>Revelstoke Reach – Sharing learnings from drawdown zone projects</p> <p><i>Source</i> – Margo Sadler margo.sadler@bchydro.com (604) 528-3102</p> <p><i>Location/land ownership</i> – Revelstoke Reach/BC Hydro and Crown lands</p> <p><i>Environmental values to be enhanced</i> – Wetland habitats</p> <p><i>Actions</i> – Education session to share learnings from recent projects.</p> <p><i>Notes</i> – BC Hydro is interested in partnering on this possibility. Could be linked to recommendation in FWCP (Riparian and Wetland Action Plan) 2014 to compile and assess the effectiveness of completed restoration projects, to determine future direction</p>
	<p>Revelstoke Reach - Riparian/wetland information collaboration and sharing</p> <p><i>Source</i> – FWCP (Riparian and Wetland Action Plan) 2014</p> <p><i>Location/land ownership</i> – Revelstoke to Shelter Bay/mixed ownership</p> <p><i>Environmental values to be enhanced</i> – Riparian wetland habitats</p> <p><i>Actions</i> – Coordinate the collaboration and sharing of scientific information relating ecological processes and monitoring of them</p> <p><i>Notes</i> – Could be linked to the project to share learnings about drawdown zone projects</p>
8	<p>Alkolkolex –Side channel operations/maintenance</p> <p><i>Source</i> – Cory Legebokow cory.legebokow@gov.bc.ca (250) 837-7711</p> <p><i>Location/land ownership</i> – Standfast Creek and 26 km/Crown land</p> <p><i>Environmental values to be enhanced</i> – endemic west slope cutthroat trout</p> <p><i>Actions</i> – Standfast Cr. annual valve operations (shut off pre-freshet/opened mid-July) and maintenance if gravel is plugging the pipe; remove log jam at 26 km side channel; on-site checks after annual freshet and major storm events</p> <p><i>Notes</i> – Rod and Gun Club interested in taking over; Cory available to provide background and coaching</p>
9	<p>Alkolkolex –River Guardians</p> <p><i>Source</i> – Karen Bray karen.bray@bchydro.bc.ca</p> <p><i>Location/land ownership</i> – Akoloklex River/Crown land</p> <p><i>Environmental values to be enhanced</i> – Endemic west slope cutthroat trout and other fish species.</p> <p><i>Actions</i> – Collecting and providing important fisheries management data, particularly related to the catch and release fishery, as well as providing information and assistance to anglers.</p> <p><i>Notes</i> – None</p>

10	<p>Alkolkolex west slope cutthroat trout habitat enhancement planning and actions</p> <p><i>Source</i> – FWCP (Streams Action Plan) 2012</p> <p><i>GPS location/land ownership</i> – Alkolkolex River/Crown land</p> <p><i>Environmental values to be enhanced</i> – Cutthroat trout habitat</p> <p><i>Actions</i> – Development of regional plan for future enhancement, conduct actions identified in plan, conduct habitat complexing to create pools</p> <p><i>Notes</i> – None</p>
11	<p>Alkolkolex fertilization for resident salmonids</p> <p><i>Source</i> – Moody et al. 2007, p129.</p> <p><i>GPS location/land ownership</i> – Alkolkolex River, no exact location</p> <p><i>Environmental values to be enhanced</i> – Production and quality of salmonids</p> <p><i>Actions</i> – Apply slow-release P fertilizer</p> <p><i>Notes</i> – Ensure coordination with other planning and actions on the Alkolkolex; concerns about purpose and sustainability.</p>
12	<p>McKay Creek oxbow restoration</p> <p><i>Source</i> – Corey Legebokow corey.legebokow@gov.bc.ca (250) 837-7711</p> <p><i>GPS location/land ownership</i> – McKay Cr. outfall into reservoir/ownership unknown</p> <p><i>Environmental values to be enhanced</i> – Wetland development/waterfowl habitat</p> <p><i>Actions</i> – Mouth of McKay Creek was redirected to reduce flooding potential on private land; feasibility study to replace natural channel to the north into the empty oxbow which connects to the Columbia</p> <p><i>Notes</i> – Similar to Site 16 in CLBWORKS-29A Arrow Lakes Reservoir: Wildlife Physical Works Feasibility Study; potential impacts to adjacent private lands.</p>
13	<p>Montana Slough and Cartier Bay floating turtle platforms</p> <p><i>Source</i> – Wood and Hawkes 2015.</p> <p><i>GPS location/land ownership</i> – 50.949005, -118.168781/Crown land, CSRD and BC Hydro</p> <p><i>Environmental values to be enhanced</i> – Endangered western painted turtle basking habitat</p> <p><i>Actions</i> – Install anchored floating islands in known turtle area</p> <p><i>Notes</i> – There is already one floating platform in Montana Bay; no documented use by turtles yet. Larger Cartier Bay platforms considered and rejected by BC Hydro though the reasons for rejection – concerns about permanent anchoring and the potential to create navigational hazards - are questioned by others. Project planning underway for platforms in Airport Marsh.</p>

14	<p>Heron rookery protection</p> <p><i>Source</i> – Workshop suggestion; Ryan Gill rgill@cooperbeauchesne.com</p> <p><i>Location/land ownership</i> – Catherwood Road; Begbie Falls/ Crown and private lands</p> <p><i>Environmental values to be enhanced</i> – Heron nesting habitats</p> <p><i>Actions</i> – Land owner education and conservation actions</p> <p><i>Notes</i> – See <u><i>Great Blue Heron and Bald Eagle Inventory and Stewardship in the Columbia Basin (2007-2008)</i></u>; <u><i>Wanted-Great Blue Heron Breeding Sightings (2016)</i></u></p>
15	<p>Airport Marsh nesting habitat enhancement</p> <p><i>Source</i> – van Oort and Cooper 2015, Bird and van Oort 2015</p> <p><i>Location/land ownership</i> – Airport Marsh/City of Revelstoke, CSRD- Revelstoke Airport, BC Hydro, Crown land</p> <p><i>Environmental values to be enhanced</i> – Protection of regionally-important nesting habitat for numerous species of birds</p> <p><i>Actions</i> – Prevent inundation of Airport Marsh, perhaps by dyking</p> <p><i>Notes</i> – Many species that nest here were identified as having high or very high impact from dam creation (Utzig and Schmidt 2011). Splatsin Development Corporation has a small project in 2016 to investigate dyking.</p>
16	<p>Turtle basking logs – Williamson Lake and other locations</p> <p><i>Source</i> – Public suggestion</p> <p><i>Location/land ownership</i> – Williamson Lake</p> <p><i>Environmental values to be enhanced</i> – Endangered western painted turtle basking habitat</p> <p><i>Actions</i> – Install anchored floating logs</p> <p><i>Notes</i> – Concerns about human use near swimming areas in Williamson Lake</p>
17	<p>Red Devil Hill/Airport Marsh/Airport and Flying Club area turtle habitat enhancement</p> <p><i>Source</i> – Wood and Hawkes 2015, Maltby 2000</p> <p><i>Location/land ownership</i>: Red Devil Hill, Airport Marsh/Crown land, Ministry of Highways, City of Revelstoke</p> <p><i>Environmental values to be enhanced</i> – Endangered western painted turtle habitat</p> <p><i>Actions</i> – Cut down encroaching trees on the downhill side of the road to reduce shade and return soil temperatures to levels that meet the needs for turtle nesting; establish turtle nesting logs.</p> <p><i>Notes</i> – Okanagan Nation Alliance project in 2016. Concerns from City about road stability not resolved.</p>

Revelstoke Reach/Drawdown Zone to Revelstoke dam	
18	<p>Public dumping clean-up and education</p> <p><i>Source</i>– Workshop suggestion</p> <p><i>Location/land ownership</i> – Westside Road especially/Crown land mainly</p> <p><i>Environmental values to be enhanced</i> – General ecological conditions</p> <p><i>Actions</i> – Education on ecological impacts of random dumping; clean-up and post common dumping sites</p> <p><i>Notes</i> – None</p>
19	<p>Bird nest box establishment, monitoring and maintenance</p> <p><i>Source</i> – Mandy Kellner myotis@telus.net (250) 837-0820</p> <p><i>Location/land ownership</i> – South of Cartier Bay and north of the bridges/Crown and private lands</p> <p><i>Environmental values to be enhanced</i> – Bird nesting habitat</p> <p><i>Actions</i> – Establishment and regular monitoring of box use by species and repairs as required</p> <p><i>Notes</i> – Although boxes are well-distributed across BC Hydro lands, opportunities for enhancement of nesting habitat exist at other sites such as south of Cartier Bay, the small wetlands along Westside Road, the Golf Course, or along the Jordan River.</p>
20	<p>Motherwell Channel</p> <p><i>Source</i> – Workshop participants; Cindy Pearce cindypearce@telus.net</p> <p><i>Location/land ownership</i> – Just upstream from Highway 1 bridge/ownership unknown</p> <p><i>Environmental values to be enhanced</i> - Wetland habitat</p> <p><i>Actions</i> – Re-establish natural flows and habitats</p> <p><i>Notes</i>: Workshop idea has not been well developed.</p>
Lake Revelstoke	
21	<p>Lakeside camping use impacts</p> <p><i>Source</i>– Workshop suggestion</p> <p><i>Location/land ownership</i> – East side of Lake Revelstoke/Crown land</p> <p><i>Environmental values to be enhanced</i> –General ecological conditions</p> <p><i>Actions</i> – Conduct a survey of human waste disposal and wildfire prevention practices to identify opportunities to minimize negative impacts.</p> <p><i>Notes</i> – BC Hydro interested in partnering. BC Wildfire Services fire wardens may be helpful in implementing.</p>

22	<p>Lake Revelstoke creel and visitor use survey</p> <p><i>Source</i> – Karen Bray, BC Hydro karen.bray@bchydro.bc.ca</p> <p><i>Location/land ownership</i> – Lake Revelstoke</p> <p><i>Environmental values to be enhanced</i> – Fisheries species</p> <p><i>Actions</i> – Conduct a creel survey to assess the sport fishery, collect biological data on fish species in the reservoir and compare results against the baseline established in the 2000-2001 survey.</p> <p><i>Notes</i> – See Lake Revelstoke Reservoir Winter Creel Survey 2000-2001</p>
23	<p>Big Bend Wetland Enhancement</p> <p><i>Source</i> - Giles Shearing gilesshearing@live.ca; Angela Korsa angela.korsa@bchydro.com</p> <p><i>Location/land ownership</i> – North of CMH Monashee Lodge/BC Hydro and Crown</p> <p><i>Environmental values to be enhanced</i> - Western toad habitat</p> <p><i>Actions</i> – Require further discussion to clarify actions.</p> <p><i>Notes:</i> This site was reviewed years ago by BC Hydro and FWCP staff and agreement was reached not to proceed with any actions at that time. There continues to be interest in this project.</p>

Area-wide Projects

Potential projects that were suggested throughout the Mid-Columbia area, without specific locations, are listed below. Projects that have substantial background information are listed in the table. More general projects are listed in point form below the table.

24	<p>Monitor and treat aquatic and terrestrial invasive species/ develop a response plan</p> <p><i>Source</i> – FWCP (Large Lakes and Upland/Dryland Action Plans) 2012, FWCP (Riparian and Wetland Action Plan) 2014</p> <p><i>Location/land ownership</i> – Arrow and Revelstoke Reservoirs</p> <p><i>Environmental values to be enhanced</i> – Riparian, wetland, upland, and dryland habitats</p> <p><i>Actions</i> – Monitor invasive species in riparian and wetland habitats to determine impacts; monitor and treat aquatic invasive species in wetland and riparian areas and adjacent to conservation properties or other ecologically significant areas ; monitor responses to treatment, develop a response plan</p> <p><i>Notes</i> – The Columbia Shuswap Invasive Species Society - http://columbiashuswapinvasives.org/ is actively partnering to address priority invasive species. . The information about invasive species changes rapidly; readers are encouraged to check the provincial map display of invasive species sightings at http://maps.gov.bc.ca/ess/hm/iapp/.</p>
----	---

25	<p>Conserve and/or re-establish low elevation cottonwood/deciduous forests</p> <p><i>Source</i> – Workshop suggestion; Cindy Pearce cindypearce@telus.net</p> <p><i>Location/land ownership</i> – Williamson Lake, Illecillewaet River, Big Eddy dike, Goldstream River/BC Hydro, Crown, City and some private lands</p> <p><i>Environmental values to be enhanced</i> – Ecosystem characteristics and species habitats in these fragmented ecosystems</p> <p><i>Actions</i> – Feasibility study to identify potential enhancement and restoration areas and actions; private land owner education about conservation options</p> <p><i>Notes</i> – Potential to learn about private land conservation tools from Kootenay Conservation Program. Should be linked to recommended actions in FWCP (Upland/Dryland Action Plan) 2012, FWCP (Riparian and Wetland Action Plan) 2014 to identify priority areas with high conservation value in the Revelstoke to Shelter Bay area, including connectivity.</p>
26	<p>Private land conservation opportunities</p> <p><i>Source</i> – Workshop suggestion Cindy Pearce cindypearce@telus.net</p> <p><i>Location/land ownership</i> – Low elevation private lands</p> <p><i>Environmental values to be enhanced</i> – Ecosystem characteristics and species habitats to mitigate footprint and operations impacts of the dams</p> <p><i>Actions</i> – Feasibility study to identify potential enhancement and restoration areas and actions; private land owner education about conservation options</p> <p><i>Notes</i> – Potential to learn about private land conservation tools from Kootenay Conservation Program. Should be linked to recommended actions in FWCP (Upland/Dryland Action Plan) 2012, FWCP (Riparian and Wetland Action Plan) 2014 to identify priority areas with high conservation value in the Revelstoke to Shelter Bay area, including connectivity.</p>
27	<p>Map Common Nighthawk distribution and nests</p> <p><i>Source</i> – Manley 2008</p> <p><i>Location/land ownership</i> – Mid -Columbia region</p> <p><i>Environmental values to be enhanced</i> – Common Nighthawks</p> <p><i>Actions</i> – Promotion of a reporting system and compilation of public reports of nighthawks</p> <p><i>Notes</i> – Should be compatible with/ expand on work done southern parts of the Columbia Basin and detailed in Manley 2008.</p>

28	<p>Fish disease education/monitoring</p> <p><i>Source</i> – Jeff Burrows 250 354-6928 jeff.a.burrows@gov.bc.ca</p> <p><i>Location/land ownership</i> – Shelter Bay to Mica dam</p> <p><i>Environmental values to be enhanced</i> – Native fish species – whirling disease has infected trout in waterways in and around Banff National Park, including the Bow River</p> <p><i>Actions</i> – Education about the importance of cleaning and drying boats, fishing gear, waders, etc. when moving from one location to another</p> <p><i>Notes</i> – None</p>
----	---

During the literature scan, in the public input survey and at the workshop, general suggestions were offered about potential projects without a specific location or extensive details. These projects are listed below.

1. **Review past projects** - To identify actions needed to restore/maintain/enhance benefits derived from previous work in the area and to learn from these past initiatives. Referenced in FWCP (Riparian and Wetland Action Plan) 2014 for riparian and wetland habitats in the Revelstoke Reach.
2. **Fisheries enhancement**– See [Fish Migration Passage Monitoring and Final Report - CLBMON 32](#).

Note: Fish passage enhancement at Drimmie Creek is recommended in this report. This site was visited during this project and there was agreement that this was not needed at this time.

Possible projects include:

- kokanee/bull trout/rainbow spawning location survey to identify priority streams for enhancement;
- culvert replacement to facilitate fish passage;
- kokanee restoration in tributaries (e.g. egg planting); and
- education and washing stations for decontaminating boats/equipment for invasive species.

3. **Wetland and terrestrial habitats** – See [Arrow Reservoir Wildlife Management Plan](#).

Note: BC Hydro does not have plans to complete any new wildlife enhancement projects under the Water Use Plan at this time.

Relevant references: Moody et al. 2007, p137-139; Hawkes and Eng 2012; FWCP (Riparian and Wetlands Action Plan) 2014.

Possible projects include:

- turtle nesting site development and management;
- western toad habitat protection;
- protection of eagle and osprey nesting poles;

- planting and fertilizing grasslands and willows to expand the range of these habitats (Keefer Ecological Services 2010); and
- decommissioning road access or restricting road access.

Project Success Factors

Ecosystem enhancement projects can be complex and challenging in the ecological, jurisdictional and resource management operational conditions in the Mid-Columbia area. The following is a list of factors that project proponents are encouraged to carefully consider when considering and planning projects.

General ecology, fish and wildlife management factors

- Addresses needs of existing fish and wildlife populations before fostering expanded populations
- Minimizes existing invasive species and avoids potential future introduction of invasive species
- Removal of natural barriers to fish passage will be difficult to justify given high natural stream flows and unpredictable implications of changing streambeds
- Longevity of benefits

Water management factors

- Water license maximum and minimum levels
- Range of historical seasonal reservoir water levels and daily water levels below/above Revelstoke dam with current and potential future peaking operations
- Historical stream flows

Jurisdictional/legal factors

- Land ownership, particularly BC Hydro properties and requirements for projects on BC Hydro properties
- City of Revelstoke and Columbia Shuswap Regional District legal requirements/perspectives
- Provincial legislation and permitting requirements particularly for in-stream work below the high water mark – many riparian areas fall into this zone
- Whether regulation of human uses will adequately protect the expected ecosystem benefits

Project management factors

- Impact and success evaluation
- Maintenance plans, costs, responsibilities, funding sources

Interested Community Partners

Governments/Agencies

BC Forest, Lands and Natural Resource Operations Cory Legebokow cory.legebokow@gov.bc.ca	City of Revelstoke Penny Page-Brittin pbrittin@telus.net
BC Hydro Aquatic projects - Karen Bray karen.bray@bchydro.bc.ca Wildlife projects - Margo Sadler margo.sadler@bchydro.com	

First Nations

Canadian Columbia River Inter-Tribal Fisheries Commission Will Warnock wwarnock@ccrffc.org	Splatsin First Nation Lucie Thomson lucie.thomson@splatsindc.com
Okanagan Nation Alliance Aquatic projects – Michael Zimmer mzimmer@syilx.org Wildlife projects – Al Peatt apeatt@syilx.org	

Community groups

North Columbia Environmental Society Brian Gadbois bmgad@telus.net	Revelstoke Rod and Gun Club Kim Doebert kdoebert@hotmail.com
Columbia-Shuswap Invasive Species Society Robyn Hooper info@columbiashuswapinvasives.org	

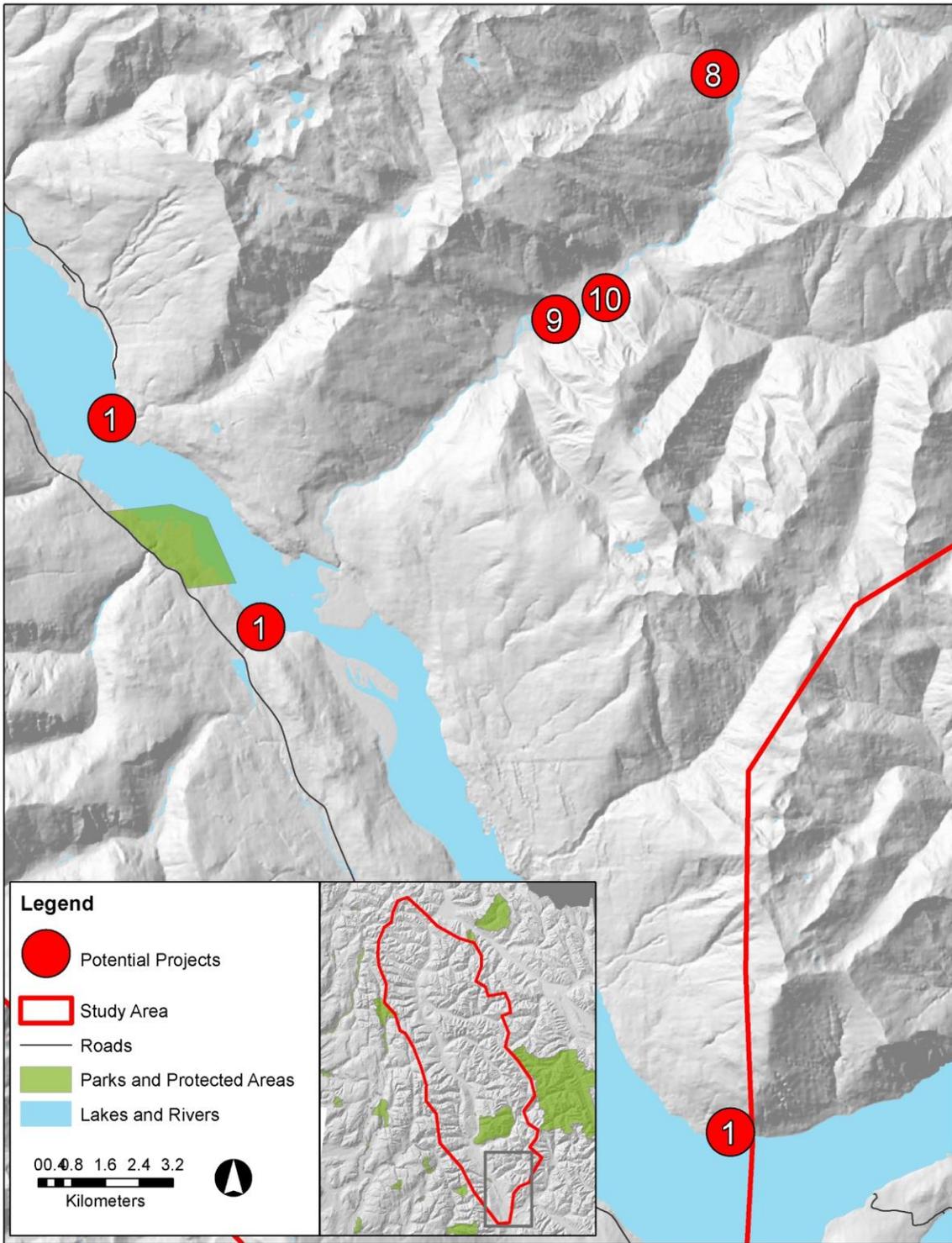
Technical specialists

Cooper Beauschesne Ryan Gill rgill@cooperbeauchesne.com	Columbia Mountains Institute Hailey Ross office@cmiae.org
Francis Maltby flm@telus.net	Giles Shearing gilesshearing@live.ca
Kingbird Biological Consultants Mandy Kellner myotis@telus.net	

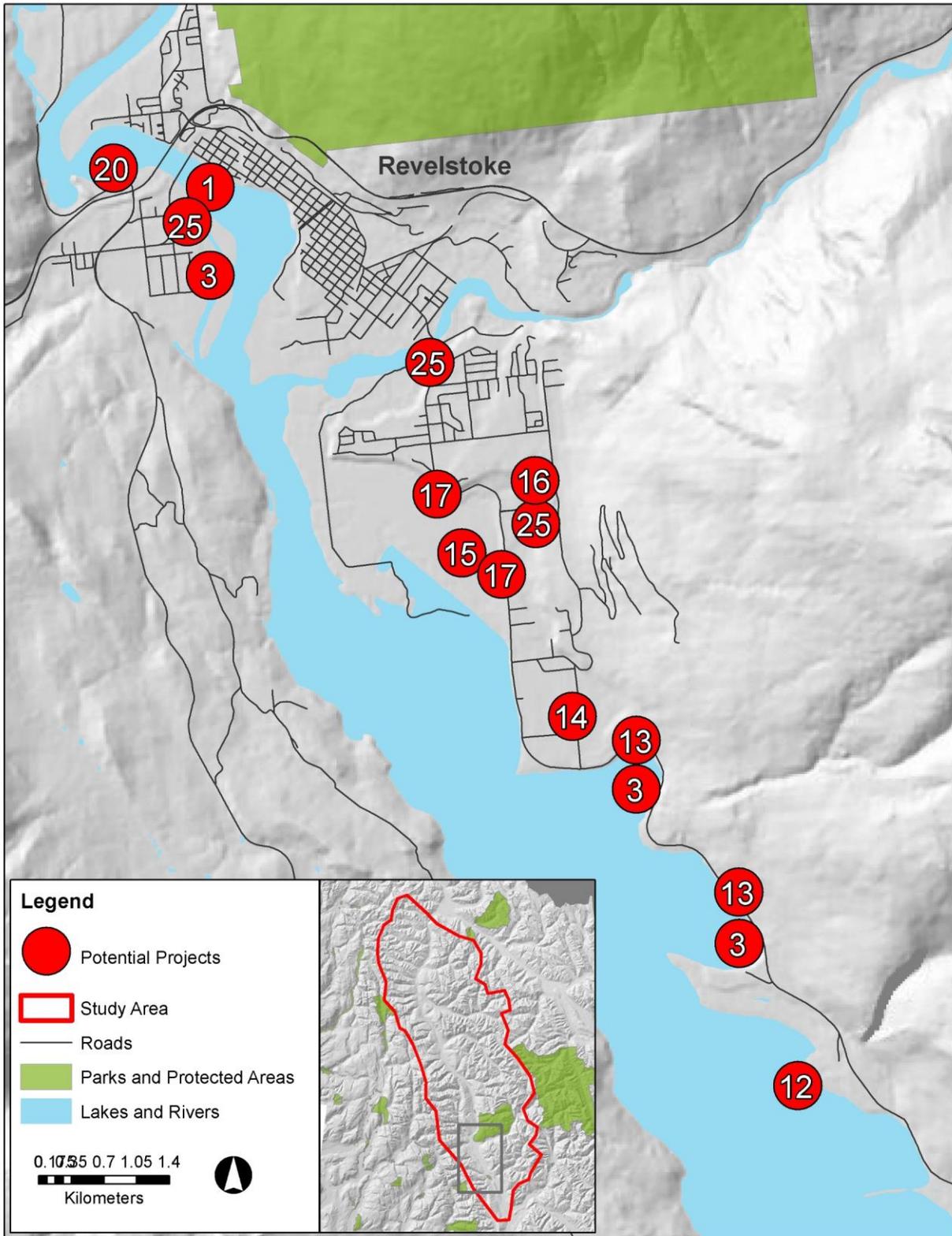
Project Lead - Mountain Labyrinths Inc. Cindy Pearce cindypearce@telus.net

Project Location Maps

Southern Portion of Revelstoke Reach



Northern Portion of Revelstoke Reach



Mica Dam to North of Downie Loop

(Note: No projects identified between Downie Loop and Revelstoke Dam)

