

**Fish Passage Strategic Approach:
Protocol for Prioritizing Sites for Fish Passage Remediation**



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Prepared by:

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Executive Summary

This document describes the fish passage ‘**Strategic Approach**’ protocol for remediating crossings that are a barrier to fish passage. The objective of the Strategic Approach is to ensure that the greatest opportunities to restore access to high quality fish habitat are pursued with available resources and funding. A primary goal has been to shift from addressing “one-off” problem sites, to a strategic prioritized approach based on a holistic understanding of the impact of fish passage problems on a watershed scale, across the province.

Healthy fish populations require unrestricted access to the greatest amount of freshwater habitat possible. Historical and more recent research confirm that impediments to fish passage continues to negatively impact fish populations, and that there is a need to restore access to freshwater habitat by remediating substandard road crossings throughout British Columbia (BC).

The direct benefit of restoring fish passage at the intersection of streams and lineal developments such as roads and railways include:

- Restoring access to significant areas of currently isolated fish habitat;
- Improving the diversity, viability and resilience of the native fish species in BC, which are currently under pressure from a myriad of factors (such as loss of connectivity by problematic culverts, loss of habitat, climate change, pollution, over-harvesting);
- Improving aboriginal, recreational and commercial fisheries;
- Improving road crossing safety and resilience to storm-events associated with climate change;
- Supporting government initiatives and commitments that relate to fish passage and the ensuing benefits derived from the program such as BC jobs;
- Building partnerships and environmental stewardship; and,
- Meeting legal obligations under federal and provincial legislation.

The Fish Passage program resulted from high-level direction from [provincial government commitments](#) provided by the Ministry of Forests and the Ministry of Environment executive in 2007. The inter-agency [Fish Passage Technical Working Group](#) was formed to coordinate and focus on advancing fish passage-related work done by government (provincial and federal) in BC.

Through the use of fish passage assessment data collected and stored in the Provincial Stream Crossing Information System (PSCIS), the Technical Working Group informs government of investment opportunities in fish passage remediation. Government considers this information in making funding decisions.

The Fish Passage Strategic Approach protocol involves a four-phase process:

Phase 1: Fish Passage Assessment

The purpose of Phase 1 is to select priority watersheds with high fish values from throughout the Province and conduct comprehensive field assessments of all fish stream crossings in those watersheds. The results from these watershed-based field assessments are then entered into the Provincial Stream Crossing Inventory System (PSCIS). Results

in PSCIS are utilized to identify priority fish passage remediation projects as well as expand on informing on scope and scale of fish passage problems across BC.

Phase 2: Habitat Confirmation

The purpose of Phase 2 is to confirm the quantity and quality of habitat to be gained at selected high-priority sites prior to expending efforts and limited resources in remediation (which is the significant effort and cost part of remediation works). High-priority sites are selected based on the data and the associated maps, photos and reports collected in Phase 1, combined with Geographic Information System (GIS) habitat modeling. Confirmation of the habitat that would be gained at a site involves reviewing existing reports and habitat mapping for the area as well as undertaking a site visit to walk the stream and document the type (spawning, rearing, etc.), quantity and quality of habitat that will be re-connected. Once again, the collected data and habitat assessment report are entered into PSCIS.

Phase 3: Design

The purpose of Phase 3 is to complete site plans and designs at priority crossings which have had high value fish habitat confirmed in Phase 2. This involves: (i) a review of habitat confirmation reports, consultations with First Nations and others, and (ii) the preparation of a site plan and conceptual crossing design, in conformance to ministry standards, to re-establish fish passage to access isolated fish habitat by either replacing the structure that is a barrier to fish, or through removing and deactivating the structure impeding fish passage. Resulting design information and drawings are uploaded into PSCIS.

Phase 4: Remediation

The purpose of Phase 4 is to implement remediation stream crossing designs, developed in Phase 3, to reconnect fish habitat. This is the most expensive phase and involves identifying a delivery agent who would be responsible for remediation project implementation including planning and delivery of pre-construction, construction and post-construction steps. Resulting as-built record documentation, including record drawings, and project report information are uploaded into PSCIS.

Partnerships and Collaboration

The Fish Passage Technical Working Group seeks partnerships with other government and non-government organizations in the remediation of barriers to fish passage.

Quality Assurance and Continuous Improvement

The Fish Passage Technical Working Group conducts quality assurance inspections of activities under each of the four phases of the Strategic Approach in an effort to continuously improve the approach.

Communications and Outreach

The Fish Passage Technical Working Group endeavors to outreach and communicate with other organizations and individuals, including staff and contractors who are involved in delivering various phases of the Strategic Approach, about the Approach's benefits.

Questions? Partnership Interests?

At the end of the document, contact information is provided for any follow-up questions that you may have, or if you organization is interested in a partnership.

Acknowledgements

The Fish Passage Technical Working Group (FPTWG) that prepared this document consists of the following individuals and organizations:

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This document updates [the 2009 *The Strategic Approach: Protocol for Planning and Prioritizing Culverted Sites for Fish Passage Assessment and Remediation*](#) based on about five years of experience. The 2009 document was prepared by the BC Ministry of Environment with the support of the Fish Passage Technical Working Group that existed at that time:

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Introduction

Importance of Fish to BC

Native fish are an integral part of BC's culture, heritage and economy. Salmon have sustained aboriginal people for centuries and have supported commercial and recreational fisheries since the 1830s.

[BC Stats](#) estimated in 2011 that BC's fisheries sector generated \$503 million in the province's gross domestic product (GDP) with revenues reaching \$1.4 billion; this activity supported 10 800 jobs. The fisheries sector includes capture (commercial) fishery, fish and seafood processing, and sport fishing. Although fisheries sector revenues have varied since 1990, revenues from salmon-related capture fishery have declined significantly from \$253 million in 1990 to \$46 million in 2011. Loss and alteration of freshwater habitat is one contributing factor to declining salmon-related capture fishery revenues.

Other economic studies have been undertaken such as Fisheries and Oceans Canada's periodic surveys of [recreational fishing in Canada](#), and the Freshwater Fisheries Society of BC [2013 BC Freshwater Sport Fishing Economic Impact Report](#).

Opportunities to Restore Fish Passage

Healthy anadromous and resident fish populations require access to freshwater habitat. Fish passage failure at road crossings constitutes a major, if not *the* major, loss of freshwater habitat by both migratory and resident fish populations in British Columbia (Northcote and Hartman, 2004¹; [GAO, 2001](#)). A 2009 [Forest Practices Board report](#) highlighted the need to remove barriers to fish passage at fish stream crossings. Culverts can be barriers to fish passage due to primarily to: (i) turbulence and increased velocity; (ii) no streambed substrate and low flow issues; and (iii) perched culverts.

Recent research ([Mount and Thompson, 2013](#)) suggests there are huge opportunities to restore access to freshwater habitat by remediating substandard road crossings throughout British Columbia (BC). Current estimates based on over 10 years of data collection indicate that there are currently over 170 000 closed bottom culverts that impede fish passage. According to the most recent habitat modeling, over 70% of these failed crossings have more than one kilometre of isolated habitat upstream while over 30% have more than five kilometres of isolated upstream habitat.

¹ Northcote, T. G. and G. F. Hartman. 2004. Fishes and Forestry Worldwide Watershed Interactions and Management



Photo: A culvert with a significant outlet drop (leap barrier, smooth bottom and that constricts the natural channel (velocity barrier)

Objective of this Strategic Approach

The ‘Strategic Approach’ to remediating crossings that are a barrier to fish passage is intended to ensure the best opportunities to restore access to high quality fish habitat are provided with available investment funding. The Strategic Approach involves a four-phase process: (i) fish passage assessment; (ii) habitat confirmation; (iii) design; and (iv) remediation. The protocol also identifies the pertinent standards that need to be followed.

Reasons for Restoring Fish Passage

Alignment with Government Initiatives/Direction

- [BC Jobs Plan](#): considerable community-based job opportunities arise from fish passage remediation work, and improved road crossings reduces ‘down time’ for business.
- *Cumulative effects assessment and management (CEAM)*: an enhanced program can address or offset cumulative effects associated with stream crossings that impede fish passage.
- [Marine Planning Partnership \(MaPP\)](#): improving access to fish habitat can complement and strengthen the collaborative partnership the Province and coastal First Nations have built with the MaPP initiative.
- [FLNR and MOE Ministers’ 2010 response to Forest Practices Board report on fish passage](#): “...we are committed to continuing the remediation of priority crossings.”

- *Public-Private Partnerships (P3s)*: enhanced provincial investment in fish passage provides opportunity to expand existing partnerships with community groups and other levels of government.
- *FLNR and MOE Service Plans*: the Fish Passage program supports several goals, objectives and strategies in both ministry's Service Plans.
- *Fisheries and Ocean Canada's Recreational Fisheries Conservation Partnership Program*: to restore, rebuild and rehabilitate recreational fisheries habitat.

Socio-economic benefits

- *Commercial and recreational fishery benefits*: with associated job opportunities and benefits to the economy of local communities and First Nations.
- *Certification*: use of the Strategic Approach and associated implementation of fish passage restoration activities can benefit land managers as they pursue environmental certification and work to ensure they maintain the social license to operate in BC's natural resource sector.
- *Public safety*: remediating defective crossing structures that impede fish passage improves public and industrial road use safety.
- *Climate change adaptation*: a [US Forest Service study](#) has demonstrated that structures that constitute fish-friendly stream crossings (open arch, with streambed simulation) are more flood-resilient and have lower risk of failure in extreme weather events; undersized structures can cause millions of dollars in damage from storm events, which are expected to be more frequent and intense with climate change.

Biodiversity (environmental) benefits

- *Ecosystem restoration*: fish-stream crossing remediations restore access by fish to their natural habitat and help ensure aquatic connectivity [for other species such as freshwater mussels](#).
- *Climate change adaptation*: with increased opportunities to access their natural habitat (i.e., to facilitate migration as habitat shifts), fish are better able to adapt to a changing climate.

Alignment with legal requirements

- *Federal Fisheries Act*: it is an offense under the Act for the owner or occupier of an obstruction across or in any stream to not provide for free passage of fish.
- *Provincial legislation (Forest and Range Practices Act - FRPA, Water Act, Oil and Gas Activities Act)*: under these acts, regulated activities must not have a material adverse effect on fish passage in a fish stream. The *Water Sustainability Act*, intended to replace the *Water Act*, also has provisions for fish passage.
- *Aboriginal rights*: the [courts](#) (see p. 3 in linked document) have told governments that Aboriginal rights are practices, customs or traditions integral to a distinctive culture of First Nation such as hunting and fishing.

Fish Passage Technical Working Group

The [Fish Passage Technical Working Group](#) was formed in 2007, based from high-level direction from [provincial government commitments](#), to coordinate and advance fish passage-related work done by government (provincial and federal) in BC. Technical working group activities include preparation of the revised [2012 Fish-Stream Crossing Guidebook](#), and prioritizing investments in [fish passage remediation under the Land](#)

[Based Investment Strategy](#) (LBIS). The Technical Working Group prepared a [Progress Report](#) in 2012. The Technical Working Group informs government of investment opportunities in fish passage remediation. Government considers this information in making funding decisions.

Background

Through the period 2000 to 2006, Fisheries and Oceans Canada and the Government of BC examined a number of historic and recent stream crossings. Fisheries and Oceans Canada conducted an [audit](#) examining compliance with their no-net-loss policy at stream crossings. The audit found that fish passage associated with closed-bottom culverts was a problem. This audit and [other projects](#) raised awareness of fish passage problems at road crossings in BC. As a result many more sites were brought to the attention of government resulting in increased pressure to remediate problem structures. It became evident that dealing with problem structures on a case-by-case basis, rather than prioritizing structures on a watershed basis, resulted in inefficient allocation of limited restoration dollars.

The “Strategic Approach” was first developed in 2008 to create a defensible process around the identification and prioritization of fish passage problems in BC. This 2014 update to the “Strategic Approach” reflects refinements in the process in the intervening years.

The Ministry of Transportation and Infrastructure (MTI) recently joined the Fish Passage Technical Working Group (TWG) in 2012. The approach for remediating public road crossings that are barriers to fish passage are sometimes different than what are described in this Strategic Approach with respect to standards, consultations and delivery model. As part of the TWG, MTI shares information and expertise that will result in improvements to fish passage processes.



Phase 1: Fish Passage Assessment

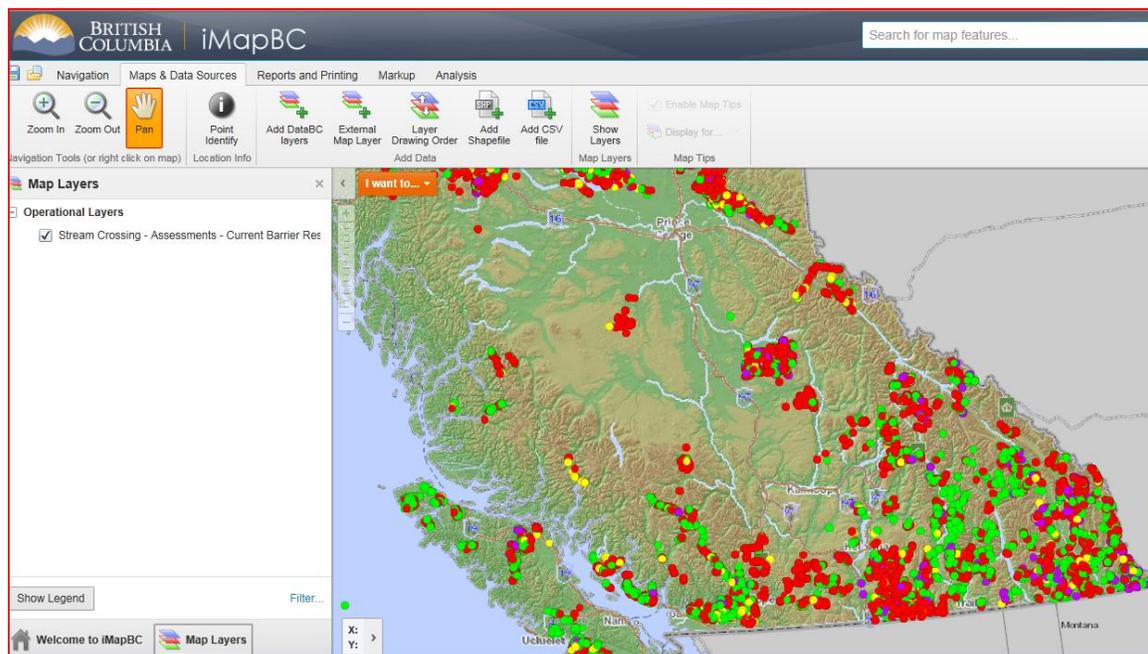
The purpose of [Phase 1](#) is to conduct field assessments in priority watersheds to identify sites that impede fish passage.

Select Watersheds for Assessments

The Fish Passage Technical Working Group [selects watersheds for fish passage assessment](#) based on three considerations along with local knowledge:

1. Watersheds with known presence of species at risk or important salmon populations (i.e. Fisheries Value)
2. Watersheds with little or no previous fish passage assessments conducted
3. [Fisheries Sensitive Watersheds](#)

The [Provincial Stream Crossing Inventory System](#) (PSCIS) is where the information in each of the four phases of the Strategic Approach is spatially stored and accessible for review on iMapBC. The PSCIS data system can be accessed on iMap to determine which watersheds already have fish passage assessment information and to review existing site data and reports.



Watershed-based Field Assessments

Fish passage assessments are undertaken in a systematic, watershed-based process following the 2011 protocol entitled [Field Assessment for Determining Fish Passage Status of Closed Bottom Structures](#). All data collected must be submitted in PSCIS consistent with the [PSCIS Assessment Form](#) regarding field data submission.

The objective is to complete a systematic assessment of all closed-bottom structures (independent of land ownership, tenure, or date of installation) on fish streams within a priority watershed, and to identify the location and basic information of open-bottom structures on fish streams. Phase 1 field assessments are intended to be limited with data

being collected only at the crossing (e.g., there is no need to walk up- or down-stream to assess habitat quality and quantity to potential barriers – as this is done in Phase 2).

To determine whether a culvert is a barrier or potential barrier to fish passage, five key indicators are measured in the field assessments: (i) embeddedness; (ii) outlet drop; (iii) stream width ratio; (iv) culvert slope; and (v) culvert length.

By having complete assessment data for closed-bottom structures on fish streams within priority watersheds, members of the FPTWG or other resource professionals can make better decisions regarding which problem structures should be fixed first. With the data assembled and available spatially in a GIS, resource professionals can combine these assessment results with observed and modeled aquatic habitat layers to determine: (a) structure(s) that, if remediated, would provide the greatest amount of habitat gain; and (b) which other structures need to be fixed at the same time in order to achieve that gain. Basic questions of land ownership, tenure, and funding sources can also be examined at this time. Once preliminary priorities have been set, the crossings can be reviewed in greater detail under Phase 2 ('habitat confirmation').

Currently the Fish Passage Technical Working Group directs funding under the [Land Based Investment Strategy](#) (LBIS) to BC Timber Sales (BCTS) Business Areas or resource districts, who then (as delivery agents) hire qualified contractors to undertake Phase 1 fish passage assessments. The contractors are responsible for entering all assessment data, photos, maps and reports into PSCIS. The Fish Passage Technical Working Group has prepared [on-line training resources](#), [Field Work Guidance](#), and [Project Deliverables](#) to assist those undertaking fish passage assessments.

The potential exists for other organizations, such as local government and local streamkeeper groups, to take on an assessment project, enter the data in PSCIS, and set priorities that facilitate restoration activities.

Completing systematic *watershed* assessments for fish passage has an important benefit: it moves decision makers away from making decisions about single crossings on a case-by-case basis, thereby enabling decisions that consider all fish passage issues within the watershed. In situations where a decision maker is presented with a single problem crossing, two questions should be answered: Is this a priority watershed? Do I have existing assessment data or can I collect assessment data for other crossings in the watershed to put this crossing in context? If the answer to both questions is 'yes', the process would first involve assembling or collecting assessment data, then checking to see if the single problem crossing is a priority in the watershed or if other structures need to be fixed at the same time to restore fish passage.

Phase 2: Habitat Confirmation

The purpose of [Phase 2](#) is to confirm whether problem crossings identified in Phase 1 are actual barriers to fish passage, then (for the problem crossings) assess the type, quantity and quality of fish habitat to be gained as a result of remediation.

Select High Priority Crossings for Habitat Confirmations

The first step in Phase 2 is to select priority crossings for habitat confirmation field work. Each assessment project should be supported by a summary report that will include the assessors recommended priority sites for habitat confirmations. These assessment reports, along with examination of the data stored in PSCIS, will form the basis of a list of sites for habitat confirmation. The individual or team carrying out the habitat confirmation should then check other habitat information (e.g. other reports stored in EcoCat, Fish Wizard, habitat modeling) and contact local experts in the provincial and federal government to gain knowledge about fish habitat and passage barrier concerns. For example, in some cases, local fisheries experts may want to maintain a fish passage barrier to separate fish populations (e.g. so a non-native fishery does not impact an upstream native species at risk). Local experts include fisheries and habitat/ecosystems staff with the Ministry of Environment, Fisheries and Oceans Canada, and/or Ministry of Forests, Land and Natural Resource Operations.

A pre-field assessment entitled [Checklist for Habitat Confirmation](#) has been prepared to help assessors identify sites *not* suitable for a Phase 2 site visit. If any of the following four conditions are found while conducting the background review, the site is unsuitable for rehabilitation and, hence, no need for a site visit:

- Site is non-fish habitat based on fish inventory or fish habitat modeling (above a barrier or steep section);
- Site is non-fish bearing based on evidence found in past reports;
- Plans are in place to permanently deactivate the road; or,
- Numerous downstream crossings would need to be fixed first to realize the habitat gain at the site.

Site Visit and Habitat Confirmation Report

The objective of the site visit is to determine, for crossings that are barriers to fish passage, the habitat quality and quantity to be gained by remediation (consistent with [Criteria for Selecting Stream Crossing Sites for Remediation](#)). Site visits will help assessors identify problem crossings that are the best candidates for remediation planning and delivery (in Phases 3 and 4).

As outlined in the [Checklist for Habitat Confirmation](#), the background research and the habitat confirmation site visit lead to a report that documents:

- Site location, photos and maps;
- Findings from background review;
- Stream characteristics at crossing;
- Stream characteristics upstream (e.g. value and length of habitat to be gained if remediation work were undertaken); this step requires walking up the stream;

- Stream characteristics downstream (e.g. confirming no downstream barriers); and
- Conclusions: an overall assessment of habitat type, quality and quantity; species present if known; and, overall value of rehabilitating stream crossing (e.g. high, moderate, low or nil).

As with each phase of the Strategic Approach, assessors or their contractors are required to enter site visit information and the habitat confirmation report in the [Provincial Stream Crossing Inventory System](#) (PSCIS).

Phase 3: Design

The purpose of [Phase 3](#) is to commission a site plan and design at priority crossings identified in Phase 2.

Review Habitat Confirmation Reports

As a first step, review Phase 2 habitat confirmation reports to identify high priority sites for remediation where a site plan and design are needed, consistent with [Criteria for Selecting Stream Crossing Sites for Remediation](#).

Consultations

Since Phase 3 is intended to support the actual remediation of a crossing that is a barrier to fish passage, consult with First Nations, and communicate with district and regional engineering staff within the Ministry of Forests, Lands and Natural Resource Operations. First Nations consultation should be consistent with [LBI First Nations Information Sharing Guidelines](#).

Site Plan and Design

Following consultations, prepare a site plan and conceptual design consistent with [Fish Passage Activity Engineering Standards](#), [Fish-Stream Crossing Guidebook](#), and other documents as appropriate (e.g. [Bridge Design Standards, Manuals & Guideline Documents](#)). Qualified persons who undertake this work must adhere to Professional Practice Guidelines (e.g. for [Forest Sector Crossings](#)).

Three key outcomes of Phase 3 are:

- District manager approval of the site plan and design (which is required);
- A cost estimate for remediating the crossing; and,
- General arrangement drawings and maps (consistent with the [PSCIS Remediation Design Proposal Form](#)) uploaded into PSCIS.

Phase 4: Remediation

The purpose of [Phase 4](#) is to remediate the stream crossing and reconnect fish habitat primarily by either replacing the structure that is a barrier to fish passage, or removing and deactivating the crossing if the road is no longer needed. There may be other approaches based on an evaluation of the problem crossing.

Pre-construction:

- Confirm the budget for construction (replacement or deactivation);
- Confirm delivery agent (e.g. BC Timber Sales, FLNR operations staff in region or district, Ministry of Transportation and Infrastructure, other);
- Acquire crossing structure and/or other needed construction material;
- Hire suitable contractor for construction, and an environmental monitor as needed; and,
- Notify appropriate agencies of intended work, and obtain approvals as required.

Construction:

- Move crossing structure and/or needed construction material to the site and complete the construction work;
- Obtain independent professional sign-off, and submit as-constructed photos and record (as-built) drawings to PSCIS consistent with the [PSCIS Remediation Result Form](#)

Post-Construction:

- Conduct a post-construction inspection of the construction site to verify that the work was done correctly and that the crossing is no longer a barrier to fish passage.

All activities in Phase 4 need to be consistent with [Fish Passage Activity Engineering Standards](#), [Fish-Stream Crossing Guidebook](#), and other documents as appropriate (e.g. [Bridge Design Standards, Manuals & Guideline Documents](#)). Qualified persons who undertake this work must adhere to Professional Practice Guidelines (e.g. for [Forest Sector Crossings](#)).

Partnerships and Collaboration

The Fish Passage Technical Working Group seeks partnerships and collaboration with other government and non-government organizations in the remediation of barriers to fish passage, ideally within the framework of this Strategic Approach.

With the support and assistance of the [Pacific Salmon Foundation](#), the Technical Working Group has been able to leverage its funding from the BC's Land Based Investment Strategy (LBIS) to access partnership funding from the federal [Recreational Fisheries Conservation Partnership Program](#) (RPCPP) administered by Fisheries and Oceans Canada. One major remediation project was completed based on this partnership in 2013/14, and five major remediation projects are underway in 2014/15.

There is also a partnership project in 2014/15 with BC Hydro's [Fish and Wildlife Compensation Program](#) (FWCP) that will be carried out by the [Society for Ecological Restoration in North Central British Columbia](#) (SERNbc).

The Fish Passage Technical Working Group is actively outreaching to find additional partners, and if your organization is interested, please contact us (see below) us. A couple of potential partnership examples provided below.

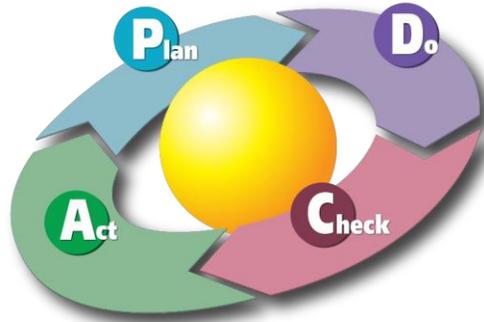
For example, a major project proponent may be interested in mitigation or compensation opportunities related to fish or fish passage. They can access the about 15 000 fish passage crossing assessments in the PSCIS data base to determine which ones in their 'area of interest' are likely best candidates for habitat confirmations (Phase 2), site plans/designs (Phase 3) so that the best remediation projects can be identified. The Strategic Approach provides the framework for identifying the best 'shovel-ready' projects. We encourage all partners or users of the data base to enter their data in PSCIS so that crossings inspected in the field by one organizations are not inspected for the same reason by another organization.

Another example is local government accessing fish passage assessments in PSCIS on municipal roads, and then prioritizing problem crossings for habitat confirmations (Phase 2), design (Phase 3), and remediation (Phase 4) to help ensure their investments provide the best returns for fish and local residents. If no assessments occur in areas of interest, it may be possible to partner with local government so that a watershed-based assessment of fish passage barriers is undertaken. Local government are also encouraged to submit data they do collect in PSCIS – as it is intended to serve a wide range of organizations.

There may be instances where, outside of the framework of the Strategic Approach, an organization is aware of a significant barrier to fish passage in a high value fish-stream and simply approaches the Technical Working Group for support and assistance. These situations will be considered on a case-by-case basis in the context of planned activities under the Strategic Approach and available funding.

Quality Assurance and Continuous Improvement

The Fish Passage Technical Working Group conducts quality assurance inspections of completed activities under each of the four Phases of the Strategic Approach in an effort to continuously improve the approach. The Technical Working Group is guided by the iterative four-stage Plan-Do-Check-Act management method (also known as the [Deming cycle](#)) used in business for the control and continuous improvement of processes and products. The stages in each successive cycle are:



Stage 1: Plan. Plan (pre-field work) the intended assessment, habitat confirmation, design, or remediation work.

Stage 2: Do. Carry out the assessment, habitat confirmation, design, or remediation work in the field and report in PSCIS.

Stage 3: Check. Monitor to determine if the intended desired outcomes for each phase in Strategic Approach have materialized (e.g. effectiveness evaluation of assessment, habitat confirmation, design, or remediation work).

Stage 4: Act. If the desired outcomes are not being realized, assess the root causes and take corrective actions. Determine where to apply changes to improve the process.



Photo: Examining field passage restoration projects in the field in order to improve processes and practices.

Outreach and Communication

The Fish Passage Technical Working Group endeavors to communicate and collaborate with other organizations and individuals, including staff and contractors who are involved in delivering various phases of this Strategic Approach, so they are aware of the benefits of following this approach. This includes presentations at conferences and workshops, meetings and conference calls, and e-mails and phone calls.

Questions? Partnership interests?

If you are interested in learning more about this Strategic Approach, or have any questions about it, please contact one of the following Fish Passage Technical Working Group members:

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