EVALUATION OF THE PIPELINES AND ASSOCIATED WATERCOURSE CROSSINGS FISHERIES SELF-ASSESSMENT TOOL

Context

The *Fisheries Act* was amended in 2012 to include new provisions for fisheries protection which came into force in 2013. The amended Act focuses on protection of threats to the fisheries and the habitat that supports them, while setting clear standards and guidelines for routine projects.

The Canadian Energy Pipelines Association (CEPA), in partnership with the Canadian Association of Petroleum Producers (CAPP) and the Canadian Gas Association (CGA), are revising existing Pipeline Associated Watercourse Crossings guidance (PAWC) to better align with the Fisheries Protection Program's (FPP's) new regulatory requirements and self-assessment approach. DFO's online self-assessment process outlines criteria that guide project proponents on how to determine whether a project requires a review by DFO. The Watercourse Crossings guidelines consists of a Fisheries Self-Assessment Tool (FSAT) to assist pipeline industry proponents in determining which crossings require DFO review, and which crossings do not, provided specific avoidance and mitigation measures are followed. The FSAT is designed to guide proponents to consider the types of impacts pipeline crossings may cause, measures that can be taken to identify, avoid and mitigate potential project-related effects, and prescribe measures and mitigation efforts to avoid causing serious harm to fish. Where serious harm to fish cannot be avoided or mitigated, the FSAT guides the proponent to submit for crossing-specific review or authorization, as required. A companion document has been produced to provide a literature review documenting potential effects, potential mitigation measures and to identify knowledge gaps.

These Watercourse Crossings guidelines are the first national industry-lead guidelines developed under the new FPP. Ensuring that the approach used, and the guidance provided, is science/evidence-based will allow FPP to standardize an approach for guidelines development going forward.

The objectives of this national peer review were to:

1. Determine if all potential effects of summarized activities were identified.
2. Determine if the potential effects identified in the above present a risk of causing serious harm to fish (in terms of timing, duration, intensity, as well as other potential effects).
3. Evaluate if the best practice methods proposed are likely to avoid or mitigate impacts.
4. Identify any uncertainties or limitations and identify actions to address the uncertainties and limitations, including identification of knowledge gaps.

The review found that the potential effects on fish and fish habitats from watercourse crossings were identified. Establishing the magnitude of the effects, and the efficacy of mitigation measures was hampered by a lack of monitoring data; consequently, the assessment relied extensively on professional judgment.

This Science Response Report results from the November 2-3, 2016 Science Response Process on the Evaluation of the Pipelines and Associated Watercourse Crossings Fisheries Self-Assessment Tool.

Background

A list of acronyms and definitions can be found at the end of this document.

Major energy pipeline projects will cross many watercourses that range from small ephemeral streams to large rivers. There can be hundreds of such crossings associated with a single project. At most pipeline crossing sites a temporary vehicle crossing is also required for the movement of equipment. There are a variety of methods for installing pipelines across watercourses and for constructing temporary vehicle crossings that vary in their potential risk to fish and fish habitat (Lévesque and Dubé 2007). FSAT is a tool to assess those risks to determine an appropriate regulatory approach.

The FSAT triages pipeline and vehicle crossing methods by the risk of serious harm associated with each method. If the crossing is in CRA fish habitat and SARA species are not present the basic classification used in FSAT is shown in Table 1:

Table 1. Classification of stream crossing methods by potential for serious harm, as identified in 2.2.1 of the FSAT.

(a) Methods deemed to avoid Serious Harm

Watercourse Crossing	Method
Pipeline	• Trenchless crossing (Horizontal Directional Drilling (HDD) and variants) • Frozen or dry channel trenching or excavation
Vehicle Crossing	• Clear span Bridge • Snow or ice bridge

(b) Methods that have potential for Serious Harm

Crossing Category	Method
Pipeline	• Wet trenching or excavation • Isolated trenching (Flume, dam/pump)
Vehicle Crossing	• Non-clear span bridge • Culvert • Log fill • Ford (wet crossing)

Crossings that propose the use of methods in part (b) of Table 1 are then subject to a Serious Harm Risk Assessment, which makes use of DFO's Pathways of Effects models to evaluate the potential for residual effects when avoidance and mitigation measures are put in place.

Guidance for the evaluation of the potential for serious harm is provided by the Fisheries Protection Policy Statement (DFO 2013) that suggests proponents should identify all potential impacts, estimate the duration, scale and intensity of the impact, and nature of the affected fish and fish habitat to permit an overall assessment of the residual impact.

Analysis and Response

FSAT

There are additional considerations when SARA species are present; this analysis does not consider impacts to SARA species.

Although it was considered that trenchless crossings will avoid serious harm (Table 1), failures may occur that can result in drilling fluid or sediment releases to the watercourse. More information is needed to assess that risk.

Avoidance and mitigation measures (defined in the Appendix) can reduce or eliminate impacts. In this analysis avoidance and mitigation measures are considered separately, consistent with the hierarchy of preference for avoidance measures over mitigation (DFO 2013).

Pathways of Effects and the Identification of Potential Impacts

There are a number of ways the installation of pipelines and the construction of temporary vehicle crossings can affect fish and fish habitat. The FSAT uses DFO's pathways of effects (PoE) to structure the analysis of impacts that can potentially occur during a watercourse crossing. Table 2 shows the endpoints of the relevant pathways identified by the Canadian Energy Pipeline Association (CEPA 2016)[1].

Table 2. List of PoE endpoints considered by FSAT to have potential for residual impacts for pipeline crossing and temporary vehicle crossings.

PoE Endpoint	Most significant mechanisms	Risk to fish and fish habitat
Change in sediment concentration	In-channel construction, frac-out, long term erosion	Habitat quality, fish stress, feeding, food production, barrier to migration
Change in habitat structure and cover	Right of Way (ROW) clearing, in-channel construction, bank erosion, channel widening	Reduction in cover, habitat complexity, shade, instream habitat quality
Change in access to habitat	Coffer dams, weirs, temporary vehicle crossings	Interruption of movements or migration
Direct mortality	In channel machinery, blasting, stranding	Loss of individuals
Change in food supply	Riparian removal, sediment, loss of stream flow	Decrease in habitat quality, growth opportunity
Change in temperature	Removal of riparian at ROW	Effects on development rate or growth
Change in nutrient concentration	Riparian removal or maintenance	Loss of stream productivity

[1] Canadian Energy Pipeline Association. 2016. Review of the Pipeline Associated Water Crossings 5th Edition Fisheries Self Assessment tool. Unpublished document for CSAS review, dated July 18 2016. Prepared by Stantec Consulting Ltd, Calgary.

PoE Endpoint	Most significant mechanisms	Risk to fish and fish habitat
Change in baseflow and hydrodynamics	Sudden decreases in flow during installation of dams, weirs, reductions in flow, change in hydraulic conditions	Stranding, suboptimal habitat conditions, reduced passage
Change in contaminant concentration	Leakages/spills of hydrocarbons or other toxic substances	Stress/mortality (fish or food organisms)

Loss of wetted area (i.e., infilling) can result in a loss of fisheries productivity (DFO 2014a) but is not a PoE endpoint as there are no mitigation measures that can reduce loss. It is not included in FSAT. It is expected that pipeline watercourse crossings that would result in a loss of wetted area would be evaluated by a separate process from FSAT.

The potential for changes in oxygen concentration resulting from disruption of beaver dams, or alteration in groundwater flows was noted as an endpoint that was not included in FSAT. Commentary on this stressor was included under the baseflow section.

Otherwise it was concluded the list of endpoints considered by FSAT was comprehensive.

Evaluation of Individual Endpoints

The following sections contain a more detailed evaluation of the potential of each stressor or endpoint to cause serious harm. A brief description of the stressor in the context of pipeline and vehicle crossings is provided, followed by a summary of avoidance and mitigation measures as proposed by CEPA (2015[2], 2016[1]). Then the residual impact after implementation of avoidance and mitigation measures is assessed. Where possible, quantitative information on the intensity, duration, and spatial scale of the impact (DFO 2013a) was extracted from CEPA (2016)[1], supporting information, and other literature.

Change in Sediment Concentration

Stream sediments (inorganic and organic) become entrained in the water column during construction activity in a wetted channel due to streambank disturbance, operation of machines for the excavation and backfilling of the pipeline trench or construction of a temporary vehicle crossing, and during the installation and removal of equipment.

Longer term sediment release can occur if the streambank disturbance results in destabilization of the stream banks and ongoing erosion.

Releases of drilling fluids into the stream channel from trenchless methods can occur as these fluids are under pressure and can escape through porous or fractured material between the tunnel and the streambed.

Avoidance and mitigation

Construction-related sediment releases can only be fully avoided by the use of successful Horizontal Directional Drilling (HDD) crossings and clear span bridges.

[2] Canadian Energy Pipeline Association. 2015. Pipelines and associated water crossings fisheries self-assessment tool. Unpublished draft, 4th edition. Prepared by Stantec Consulting Ltd.

Realignment away from steep and unstable banks may mitigate short and long-term sediment entrainment resulting from erosion from the right of way (Castro *et al.* 2015).

CEPA (2015)[2] list a variety of mitigation measures that can be implemented during construction and some of these have been demonstrated to be helpful in reducing sediment releases. For example, isolation methods have been shown to reduce suspended sediment values relative to open trenching (Reid *et al.* 2008). Many measures for sediment control are standard for works near water (DFO 2013b) although direct evidence for their efficacy was not assessed.

No information was provided to permit the evaluation of mitigation measures for HDD drilling mud releases.

Long-term bank erosion can be mitigated by attention to siting to avoid steep and unstable banks, measures to encourage bank stabilization after completion of the crossing. A technical basis exists for these measures (e.g., Skidmore *et al.* 2011), however, no information on the efficacy in the context of pipeline crossing sites was reviewed.

Potential for serious harm

Sediment in the water column is usually measured as total suspended sediment (TSS, $mg \cdot L^{-1}$) estimated from water samples, or from calibrated turbidity measurements. The Canadian Council of Ministries of the Environment (CCME 2002) guidelines for the protection of aquatic life are a maximum increase over background of 25 $mg \cdot L^{-1}$ for short term exposures (24 hours or less) and 5 $mg \cdot L^{-1}$ for longer exposures for rivers with “clear” (<250 $mg \cdot L^{-1}$) water, and not more than a 10% increase for rivers with background levels > 250 $mg \cdot L^{-1}$

No recent data on suspended sediment levels from pipeline crossings were made available, therefore inferences about risk are based on studies up to the early 2000s (Reid *et al.* 2008).

The magnitude and duration of sediment releases from open-cut pipeline methods during construction depends on the method employed (Figure 1, Table 3). For instance, non-isolated trench crossings result in the highest suspended sediment levels downstream of the crossing sites but the duration of construction is short. Isolated trench methods take longer to implement, but the sediment releases are lower. Observed TSS values for isolated crossings are generally within or near CCME guidelines of 25 $mg \cdot L^{-1}$ over background for <24h; higher values occur when difficulties or failures take place. The proportion of cases that exceed the guidelines for the historical dataset is shown in Table 3.

Greater experience with isolated crossing methods since the collection of these data has probably lead to improvements in methods and lowered sediment levels. It was also noted that fewer open cut crossing cuts are now performed due to the development of isolated methods.

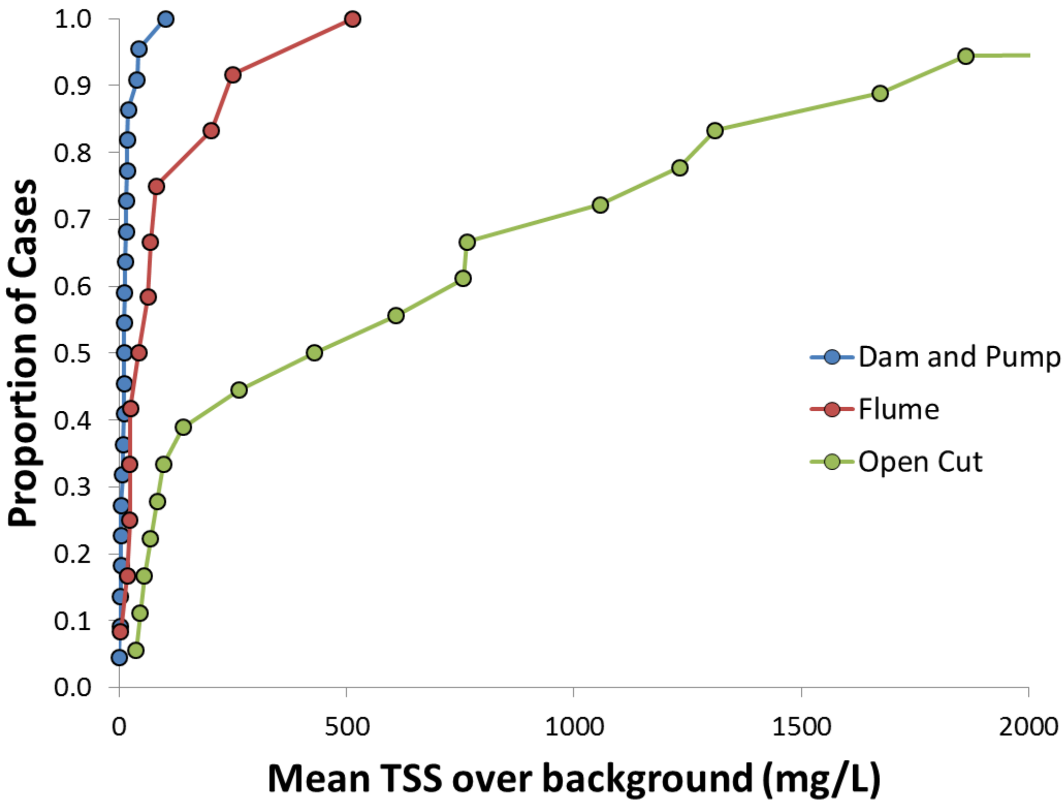

Figure 1. Cumulative probability plots for mean TSS levels during pipeline installation for three crossing methods. One open cut value of >13,000 mg/L is not shown. Each datapoint represents a crossing site. Data from Reid et al. (2008), and S. Reid (unpublished).

Table 3. Summary statistics from pipeline crossing monitoring data in Fig. 1. Median TSS is the median of the mean increase in TSS levels over background measured during the construction phase, 80th percentile is based on mean site values. Last column is the proportion of sites where the mean TSS exceeds the CCME guideline of 25 $mg \cdot L^{-1}$.

Method (N)	**Median TSS ($mg \cdot L^{-1}$)**	**80th ($mg \cdot L^{-1}$)**	**Duration (h)**	**P (mean TSS > 25$mg \cdot L^{-1}$)**
Open Cut (22)	519	1279	14	1.0
Isolated: Flume (12)	53	179	64	0.58
Isolated: Dam/Pump (23)	12	18	38	0.13

These TSS data are drawn from sampling sites less than 100m downstream of the crossing site and few data are available on the spatial extent of elevated sediment levels. Young and Mackie (1991) found elevated TSS values 450m downstream of a single crossing location, however, Reid et al. (2002a) found TSS levels declined by 90% 500m downstream from another crossing site. It can be expected the size of the area affected by entrained sediment will depend on stream size, gradient, discharge and the size of the entrained material (Burge *et al.* 2014). Construction-related sediment releases usually decline rapidly to background levels after the cessation of instream activity (Reid and Anderson 1999; Reid *et al.* 2002b).

Information on the extent and scale of sediment entrainment from bank erosion is sparse. Martz and Campbell (1980) noted a 36% increase in total sediment loads 4 months after the installation of a pipeline in a particularly unstable setting in northern Alberta.

Older summaries of rates of HDD failures suggest the incursion of drilling mud into the overlying watercourse is not an uncommon observation with rates varying from 8 to 43% of sites (CAPP, CEPA & CGA 2012, Appendix B[3]). No data are presented by CEPA (2016)[1] on the extent of the impact of released mud on stream TSS levels, so the potential for serious harm cannot be evaluated.

Some sediment entrained during construction will settle on the streambed, particularly in low velocity areas. This effect appears to be short-lived for construction-related sediment releases as bed sediments are usually mobilized at high flows (i.e., freshet), restoring both habitat and biota within one or two years (Reid and Anderson 1999). It can be expected that the degree of restoration will depend on hydraulic conditions; in particular deep pools may require larger, less frequent floods to mobilize deposited sediments. More significant local effects may occur if sediments are entrained from destabilized stream banks as a continuous supply of sediment can be expected to degrade habitat conditions.

The ecological effects of increased suspended sediment levels depend on the increase in concentration, and the time of exposure, as well as the spatial extent of the sediment release. Other important factors are the background suspended sediment levels, the sensitivity of species present, the timing of the release relative to important life history stages or ecological events.

Newcombe and Jensen (1996) developed a severity of effects (SEV) model for fish exposed to elevated suspended sediment levels, based on the magnitude and duration of the event. Application of these models to the data in Table 3 show that most construction-related sediment release are likely to cause sub-lethal effects to fish, to varying degrees. For example, for juvenile salmonids application of the exposure and concentration data in Table 2 results in SEV scores of 4.7-6; these correspond to effects ranging from loss of feeding opportunities to increased measures of stress that may lead to short-term reductions in abundance. More significant effects may be expected for the few cases with sharply elevated TSS levels (i.e., >1000 $mg \cdot L^{-1}$). Predictions from the model are corroborated with observations of fish behaviour, physiology and abundance (Reid *et al.* 2008).

Sedimentation of the streambed can cause decreases in invertebrate diversity and abundance, and render the stream less suitable for spawning or rearing when streambed complexity serves as cover. Most of the available evidence suggests these effects can be short-lived as deposited sediments are flushed away during high flow events and both physical conditions and invertebrate populations recover to pre-construction levels (CEPA 2016[1]).

Change in Structure and Cover

To gain access to the watercourse riparian vegetation is usually removed as part of right of way (ROW) clearing. The width of a typical ROW is not identified by CEPA but values of 30-50 m may be appropriate. The area of disturbance at the water's edge can be much less, being limited to the pipeline and vehicle crossing sites. For trenched crossings, streambanks are

[3] Canadian Association of Petroleum Producers, Canadian Energy Pipeline Association and Canadian Gas Association. 2012. Pipeline Associated Watercourse Crossings, 4th edition. Prepared by TERA Environmental Consultants. Calgary, AB.

disturbed by the excavation of the trench, vehicle crossings, and by the movement of machines and materials at the worksite. Streambank cover features may be altered by construction. Structure and cover elements associated with the streambed at the crossing site may also be disturbed during the construction of the pipeline trench.

Loss of habitat structure and cover can also occur if streambank disturbance results in widening and shallowing of the river channel, and promotes lateral migration of the channel (Reid and Anderson 1999). This is more likely to occur at locations where the banks are unstable, if the channel consists largely of alluvial material, and if streamflow extremes occur (Castro *et al.* 2015).

Effects on temperature, food supply and nutrients are dealt with in subsequent sections.

Avoidance and mitigation measures

Some changes to structure and cover can be avoided by ROW re-alignment. Castro *et al.* (2015) outline a risk-based evaluation protocol based on detailed technical analysis (Skidmore *et al*. 2011) that identifies the attributes likely to contribute to long-term degradation of stream habitats resulting from riparian and channel disturbances from a trenched crossing. Re-alignment to avoid trenching through important habitat features (spawning beds, pools and significant cover) will reduce impacts. Similarly, situating crossings in locations with previously degraded riparian zones avoids impacts to functioning riparian habitat.

CEPA (2015[2], 2016[1]) identifies the streamside and stream channel stabilization and rehabilitation measures, including the replacement of removed large wood and other structure from the construction area that can mitigate losses in structure and cover at the crossing site. No evidence is presented on the efficacy of these measures, although they are considered best available measures appropriate for mitigating potential impacts (DFO 2013b). In some cases, there may be opportunities for habitat enhancements though the placement of cover or structure features.

Riparian planting and other measures can limit erosion and loss of habitat complexity (Polvi *et al.* 2014). In forested regions there are likely limits in the extent of regrowth of trees and large woody vegetation as access to the crossing will be needed for maintenance or repairs. This can have long-term effects at a local scale on the supply of large wood to the channel. Recreational vehicle and livestock access may be risk factors that prevent recovery of riparian areas once the ROW is established. Thus some types of riparian habitats will not recover to their undisturbed state, nor will some of the functions (organic nutrients, invertebrates, shade, large wood recruitment) recover to pre-construction levels.

Potential for serious harm

Appropriate choice of crossing site can potentially reduce risks due to bank and channel instability. Rehabilitation of the streambank and channel should minimize the loss of structure and cover in the wetted channel. Some localized loss of riparian habitat and associated habitat function can be expected, especially in forested regions.

Change in Access to Habitat

Fish access to habitats can be restricted and barriers to movements can result from dams and weirs used for isolated trenching methods. Fish undergo a variety of movements to complete their life cycle and failure to complete these movements will lead to a loss of productivity. For example, temporary road crossings, and in particular, ice bridges which may fail to melt adequately in the spring, could block the upstream passage of spring spawners that have very early spawning runs. Improper culvert placements can block movements or migrations, as can instream structures such as bridge footings, if they create hydraulic conditions that prevent upstream passage.

Downstream migrations of juveniles and spawners may be affected by dam and pump operations if they are installed for prolonged periods.

Avoidance and mitigation measures

Trenchless crossings and clear span bridges avoid potential impacts. For situations where species have discrete movement or migration times the use of timing windows can avoid impact. Attention to design criteria for culverts and bridges can be successful avoidance strategies for vehicle crossings. Temporary vehicle crossings are intended to be in place for the duration of the crossing construction (normally less than 2 weeks); design criteria and evaluation is expected to be more stringent and complex if the crossings are to remain in place for longer.

Mitigation consists of minimizing the time that fish are blocked from passing the crossing site. Potential for contingency plans (trap and haul schemes) may need to be considered. Ensuring that ice and snow bridges will melt out in a timely fashion will minimize risk.

Potential for serious harm

Blockages that are lengthy (weeks) at critical times could cause serious harm by preventing fish from completing their life cycle. The use of timing windows to avoid impacts on upstream spawning runs is essential in these cases and should also be considered for known periods of downstream migrations. Short term blockages associated with isolation crossing methods and temporary vehicle crossings are not likely to prevent fish from completing their life cycle. However, greater risks are likely if temporary crossings or works remain in place for longer time periods.

Mortality

Mortality can occur in a variety of ways, from crushing by equipment and vehicles, blasting, stranding, impingement and entrainment in pumps. The potential release of hypoxic water from beaver dam clearing is a potential risk.

Avoidance and mitigation

Avoidance is possible with trenchless methods and clear span vehicle crossings. Realignment of crossings away from spawning and high quality nursery habitats will decrease mortality of vulnerable life stages.

Various mitigation measures including removal of fish from the crossing site, measures to reduce blasting impacts, use of fish screens on pump intakes and methods to maintain flow will minimize but not eliminate all sources of mortality. Timing windows may have utility in reducing mortality in some locations. Methods to displace fish from the construction area (bubble screens, noise) may reduce exposure.

Potential for serious harm

No estimates of the magnitude of mortality caused by pipeline or vehicle crossings are available.

Most of the avoidance and mitigation measures for mortality are listed DFOs Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013b) suggesting that their successful implementation will reduce risk.

Change in Food Supply

Suspended sediment releases from construction are usually associated with sort-term increases in invertebrate drift that can potentially increase food supply for drift feeding fish. That sediment will ultimately settle in the stream bed, and can cause a decline in the abundance and quality of invertebrates that are food for many stream-dwelling fish. Those effects are short in duration (less than one year) as deposited sediment will become resuspended during ensuing spate or freshet flows (Reid and Anderson 1999). In forested areas loss of terrestrial insects that drop from trees can be expected with the clearing of the right of way. In some locations clearing of riparian forest results in an increase in light penetration to the stream bed that can stimulate primary and secondary production. A reduction in food supply can be expected if cover and habitat complexity is reduced along the streambank or at the crossing site.

Avoidance and mitigation

These effects are avoided using trenchless crossings or clear span bridges. Mitigation measures include minimizing the extent of streambank disturbance, realignment to prevent destabilization of erodible banks and streambed, bank stabilization, replacement or enhancement of structure and cover and replanting vegetation in the ROW. Information on the condition of the “managed” right of way would be useful in terms of height and nature of riparian vegetation in order to consider the long-term loss of riparian function.

Potential for serious harm

Some decrease in fisheries productivity may result from a loss of food supply immediately after construction due to sediment deposition and riparian alteration, however due to the localized and temporary nature of the change the impacts are expected to be small.

Net long-term effects are difficult to predict and will be site specific, but not likely to cause a meaningful decrease in productivity unless long-term erosion of banks is triggered resulting in continuous sediment releases.

Change in Temperature

Changes in stream temperature are likely in small streams with extensive riparian shading (i.e., forest cover) when the ROW is cleared (Chamberlin *et al.* 1991). This could include warming in the summer, and cooling in winter.

Trenching and associated activities have the potential to disrupt groundwater sources. Groundwater-rich areas are often important as spawning or overwintering areas and can moderate temperature extremes in the stream.

Avoidance and mitigation

Changes in temperature can be avoiding by relocating the ROW to areas where the existing riparian zone is not forested. Similarly, identification of groundwater areas prior to construction can be used to minimize disruptions.

Long term changes in temperature can be mitigated somewhat by the revegetation of the ROW. The extent will depend on the managed condition of the ROW relative to the undisturbed state.

Potential for serious harm

Herunter *et al.* (2003) estimated summer temperature increases from right of way clearing ranged from 0.2 to 1.3°C per 100 m of riparian removed in northern boreal forest streams. Thus only a small change in temperature is likely given the typical width of a pipeline crossing right of way. The magnitude of the temperature change will depend on the local climate, orientation and aspect of the stream, and the discharge and water depth. Impacts of riparian clearing in temperature-sensitive streams will be more critical.

Change in Nutrients

Increases in nutrient inputs may result from riparian disturbances and runoff at the crossing site in a manner similar to that observed for forestry impacts can be expected (Chamberlain *et al.* 1991).

Avoidance and mitigation

Measures to promote recovery of disturbed areas in the ROW and decrease runoff into the watercourse will minimize long-term changes in nutrient inputs.

Potential for serious harm

The potential for serious harm from this pathway appears small but no direct information is available. For much of Canada, aquatic productivity is nutrient limited and a small increase in nutrients may increase fisheries productivity.

Change in Baseflow and Hydrodynamics

Abrupt changes in flow and water depth can occur during the installation and removal of dams, weirs and other equipment in the stream could lead to stranding of fish. Water abstraction may be required for hydrostatic testing, drilling fluids or ice bridge creation and could reduce habitat quantity and quality. Ice dams resulting from ice or snow roads or infrastructure can cause channel erosion during freshet, or loss of habitat quality downstream due to restrictions in flow.

Suboptimal hydraulic conditions can occur as a result of alteration of banks, channel form, or construction of instream works such as footings. These will result in localized loss of habitat quality.

Removal or breaching of beaver dams during the winter months has the potential to introduce anoxic water into the stream.

Avoidance and mitigation

Consistent with previous guidance (DFO 2013c) water removals of less than 10% of the instantaneous flow when flows are greater than 30% of mean annual flow will avoid risk. Water removals during low flow periods may pose greater risk.

Risks associated with infrastructure can be avoided with design.

Construction practices and mitigation measures outlined by CEPA should reduce risk associated with sudden streamflow reductions. Monitoring water quality and oxygen levels in beaver ponds will assist in avoiding harmful water releases.

Potential for serious harm

Localized mortality due to stranding is possible at construction site. No information is available on the likely extent of this risk. Other risks are likely to be avoided or mitigated as described above.

Change in Contaminant Concentrations

Spills of hydrocarbons from machinery operating in channel and releases of some types of drilling fluids are potential stressors. Section 36 of the *Fisheries Act* prohibits the introduction of deleterious substances in waters frequented by fish and thus is not part of considerations of serious harm under section 35. No information is provided on the toxicity of modern-day drilling fluid although it is reported to be benign.

Potential for mitigation measures to avoid serious harm

Standard measures to prevent harmful fluids from machinery reaching the watercourse are available and are described by CEPA (2015[2], 2016[1]) and DFO (2013b).

Potential for serious harm

There is potential for mortality, stress and reduction in habitat quality if quantities and toxicities are sufficient.

Uncertainties and Knowledge Gaps

The assessment of the potential for serious harm involves analysis of the intensity, extent and duration of impacts of the activity to fish and fish habitat, and the sensitivity of fish and habitats that are exposed to those risks. Taking an evidence-based approach requires the collection and summary of data, and appropriate modelling or analytical tools.

Unfortunately, the impact of pipeline crossings on riparian and aquatic habitats has not been the subject of research in recent years. For some endpoints this evaluation largely relied on published literature collected 20 to 40 years ago and may not reflect the use of modern technologies and practises. For other endpoints no empirical information was available. The lack of recent environmental monitoring data is a significant knowledge gap.

Recent information on the failure rate of HDD and other trenchless methods, and TSS levels that result from leakage of drilling fluids was not made available and that prevented an evaluation of risk.

The impacts of blasting and other sources of construction-related mortality on stream fish is not well understood and is a research need.

Documented efficacy of mitigation measures is limited. The efficacy of instream construction-related measures can be inferred from TSS data. Longer-term assessment of bank and riparian areas, and the channel bed at the crossing site is required to determine if mitigation measures are effective. Undoubtedly, significant experiential knowledge exists within individuals working on the ground, but it is difficult to formalize that knowledge in guidance documents without data from a structured monitoring program.

Proliferation of pipeline and other rights of way, as well as other disturbances will contribute to cumulative effects on riparian and aquatic ecosystems. Although these are acknowledged, no specific advice on how cumulative effects can be assessed was generated.

Conclusions

1. This analysis finds that CEPA has identified the pathways most likely to cause impacts to fish and fish habitat, and has identified a reasonable set of avoidance and mitigation measures to minimize risk. The generation of suspended sediment, and the changes to structure and cover, and habitat quality resulting from channel instability at the crossing site are the most likely pathways that could result in a determination of serious harm.
2. For some pathways case studies were available to evaluate risk, but in most cases expert assessment and experience was used, due to a lack of relevant data.
3. Some of the most significant risks to fish and fish habitat can be avoided entirely, or mitigated significantly through an analysis of suitability of the proposed crossing site. A

number of science-based processes have been developed to evaluate place-based risks (e.g. DFO 2014b; Castro *et al.* 2015). Inclusion of a process for evaluating proposed crossing sites for risks of bank erosion, instability and channel changes would permit an assessment of these risks, and consideration of measures to avoid them. This analysis should also consider habitat features and fish use at the crossing site to avoid exposing particularly valuable or vulnerable habitats and life stages to risk.

4. The risk assessment process is appropriate for temporary vehicle crossings designed to facilitate pipeline installation, but is not designed for permanent crossings.
5. Suspended sediment generated from trenched crossings was evaluated, but monitoring data were over 20 years old and may not reflect recent technological and procedural advances. The historical data suggests isolated trenched crossings can mitigate sediment releases with flume crossings posing greater risk than dam/pump methods. Improper execution of procedures does occur and can result in TSS levels that could have physiological or behavioral effects to fish exposed to sediment.
6. CEPA guidance notes that the assessment of risk of serious harm will also be based on the fish and fish habitat present at, or immediately downstream of the crossing site. The guidance will benefit from a more detailed description of how that assessment will be conducted.
7. Although this analysis examines individual stressors, the greatest risks occur in situations where multiple stressors occur as a result of pipeline and vehicle crossings. For example, a combination of sedimentation of the streambed, bank erosion and channel widening can be expected to create lasting impacts on fisheries productivity, particularly if the receiving habitats and fish species are vulnerable to those stressors. The assessment of serious harm needs to consider the combined effects of all risks.
8. To reduce uncertainty about the effects of pipeline and associated watercourse crossings on fish and fish habitat future work should include both field-directed studies and the analysis of existing environmental monitoring data from recently completed projects.

Contributors

Name	Affiliation
Mike Bradford	DFO Science, Pacific Region
Jason Hwang	DFO Ecosystem Management, Pacific Region
Sophie Foster	DFO Science, National Capital Region
Lauren Ellis	DFO Science, National Capital Region – Rapporteur
Melanie Boivin	DFO Fisheries Protection Program, National Capital Region
Neil Mochnacz	DFO Science, Central & Arctic Region
Alain Guitard	DFO Fisheries Protection Program, Quebec Region
Fernand Savoie	DFO Fisheries Protection Program, Gulf Region
Daniel Caissie	DFO Science, Gulf Region
Keith Clarke	DFO Science, Newfoundland & Labrador Region
Lucas Warner	Stantec, Calgary, Alberta
Doug Chiperzak	Stantec, Calgary, Alberta
Scott Reid	Ontario Ministry of Natural Resources and Forestry
Kurt McAllister	National Energy Board, Calgary, Alberta
Sherry Nugent	TransCanada, Calgary, Alberta

Approved by

Arran McPherson
Director General, Ecosystems and Oceans Science
Fisheries and Oceans Canada National Capital Region

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Sources of Information

This Science Response Report results from the Science Response Process of November 2-3, 2016 on the Evaluation of the Pipelines and Associated Watercourse Crossings Fisheries Self-Assessment Tool.

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Appendix: List of Terms and Abbreviations

Avoidance: measures to completely prevent adverse impacts to fish and fish habitat.

Baseflow: In the context of PoE's, baseflow refers to all components of a stream's flow regime.

CCME: Canadian Council for Ministers of the Environment.

Dam and pump: Isolated trench crossing that use temporary dams to isolate the crossing site and pumps to pass streamflow.

Dry trenched crossings: Non-isolated trenched crossings conducted at a location or time of year when no water is flowing.

Flume: Isolated trench crossing that uses a dam and flume system to isolate the crossing site and pass streamflow during construction.

Frac-out: accidental release of drilling fluids into the watercourse from HDD or other trenchless methods.

HDD: Horizontal directional drilling, a trenchless crossing method.

Hydrodynamics: a Pathways of Effect (PoE) endpoint that refers to local hydraulic conditions that can impact habitat conditions or fish passage

Hydrostatic testing: the use of pressurized water to test the integrity of the pipeline. Testing requires water to be taken from a nearby lake or stream.

Mitigation: measures to reduce the spatial scale, duration, or intensity of adverse effects to fish and fish habitat that cannot be completely avoided.

Non-isolated trench crossings: pipeline crossings that use a trench in the streambed; measures to isolate the crossing site from surrounding waters are not used.

PoE: Pathways of effects. Cause-effect diagrams that identify pathways by which activities in or near water could affect fish and fish habitat.

ROW: Right of way; the land cleared and used for pipeline and associated roadways.

Serious harm: Defined in the *Fisheries Act* (2015) as "is the death of fish or any permanent alteration to, or destruction of, fish habitat".

Timing window: Time interval to minimize risk to fish and fish habitat from when works in or near water. Windows vary by region and species present.

Trenchless crossing methods: Pipeline crossing methods that use various forms of tunnelling or boring to allow the pipe to cross under the watercourse. Riparian removal and trenching of the watercourse is not required.

TSS: Total suspended solids, the organic and inorganic non-filterable component of a water sample. Usually reported as $mg \cdot L^{-1}$.

Turbidity: A measure of the transmission of light through water. Turbidity can be used as a surrogate for suspended solids however the relation between the 2 measures is system-specific and must be calibrated.

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Telephone: 613-990-0293
E-Mail: csas-sccs@dfo-mpo.gc.ca
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