Fisheries and Oceans Canada
Pêches et Océans Canada

P. O. Box 1871
Inuvik, Northwest Territories
X0E 0T0

Your file Votre référence
02/10-05
Our file Notre référence
10-HCAA-CA6-0006

Environmental Impact Review Board
PO Box 2120
Inuvik, NT
X0E 0T0

Sent via email: **eirb@jointsec.nt.ca**

September 10th, 2012

Dear Mr. Nasogaluak:

Subject: **Fisheries and Oceans Canada Draft Technical Submission for the Inuvik to Tuktoyaktuk Highway.**

Fisheries and Oceans Canada (DFO) is pleased to submit our Draft Technical submission to the Environmental Impact Review Board (EIRB) Panel for the Inuvik to Tuktoyaktuk Highway project. As per the EIRB directive dated August 10th 2012, DFO's submission contains a summary of all issues our department has been tracking throughout the review process and includes a rationale for whether each issue has been satisfactorily addressed, or whether it is (or parts of it are) still unaddressed. DFO has also provided our preliminary conclusions with respect to technical issues that fall under our mandate and will put forward our final conclusions and recommendations as part of our Final Technical submission due on October 9th, 2012.

DFO will require more information, in respect to crossing design details, fish habitat compensation, mitigation measures and monitoring to address the information requirements necessary to make a regulatory decision and issue Authorizations under S.35(2) of the *Fisheries Act* for this project. It is the expectation of DFO that this information will be provided well in advance of any works in or near water.

If you have questions regarding this submission, please contact Sarah Olivier at sarah.olivier@dfo-mpo.gc.ca or by phone at (867) 669-4919.

Sincerely,

Larry Dow
Acting Area Director, Western Arctic Area
Fisheries and Oceans Canada

c.c.: Kelly Burke – DFO
Julie Dahl - DFO
Bev Ross – DFO
Amanda Joynt - DFO

Canada

Fisheries and Oceans Canada | Pêches et Océans Canada

DRAFT TECHNICAL REPORT

Hamlet of Tuktoyaktuk, Town of Inuvik and Government of the Northwest Territories

Inuvik to Tuktoyaktuk Highway Project

Submitted to:
Environmental Impact Review Board
September 10th, 2012

Canada

NON-TECHNICAL SUMMARY

The Department of Fisheries and Oceans (DFO) is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters. The following submission is based upon our departmental mandate under the *Fisheries Act*, specifically related to the management of fish and fish habitat. DFO's primary focus in reviewing proposed developments in and around Canadian fisheries waters is to ensure that the works and undertakings are conducted in such a way that proponents are in compliance with the applicable provisions of the *Fisheries Act*.

On August 10th, 2012, the Environmental Impact Review Board (EIRB) issued direction to parties on the content requirements for this technical submission. As per the EIRB directive, DFO's submission contains a summary of all issues our department has been tracking throughout the review process and includes a rationale for whether each issue has been satisfactorily addressed, or whether it is (or parts of it are) still unaddressed. DFO's final conclusions and recommendations will be submitted following the public hearings. The issues that DFO has been tracking include: watercourse crossings, sedimentation, water withdrawal, Fisheries Management and Harvesting, borrow sites, monitoring, blasting, No Net Loss (NNL) plan as well as cumulative effects assessment. The following is a summary of those issues and the status of DFO's review:

Many aspects related to water crossings have either been unaddressed or partly addressed. Specifically DFO has reviewed summer installations, aggregate and other access roads, crossing selection, and winter fish habitat. The proponent has committed to constructing all crossings during the winter, but has indicated that if summer construction were required that DFO's timing window operation statement would be used. DFO still requires site-specific information related to crossings as well as a detailed habitat assessment in order to determine the extent of impacts and related regulatory information requirements.

There is a potential for fine sediment release into watercourses as a results of project construction, operation and maintenance. Should the proponent construct appropriate crossings, implement appropriate mitigation measures as well as monitor with timely adaptive management measures, there should not be significant impacts to fish and fish habitat. The proponent has committed to developing a sediment and erosion control plan.

Water withdrawals have been partly addressed by the proponents' commitment to use DFO's Protocol for Winter Water withdrawal from ice-covered waterbodies in the Northwest Territories and other relevant guidelines. DFO will still require specific details for each water source including location and quantities being withdrawn.

The proponent has committed to working in cooperation with users to assist in the conservation of fisheries, particularly in terms of signage and ensuring the highway is designed to prevent or discourage overfishing. However it is the proponent's responsibility within the environmental assessment to assess the impacts of the highway on fisheries within the area. This issue has been partly addressed.

The proponent has committed to not developing borrow sites within 50m of any watercourse and not within 1km of the Husky Lakes. DFO will require a commitment to also include a 50m setback from waterbodies. Otherwise, DFO does not have outstanding concerns if the commitments regarding borrow sites are met and a sediment and erosion control plan is developed.

DFO's concerns with blasting have been resolved with the proponent's commitment to using a 50 kPa pressure threshold in and around water. DFO is also waiting for a draft NNL plan as well as an updated cumulative effects assessment.

DFO will continue to work with the proponent and will require more information, in respect to crossing design details, fish habitat compensation, mitigation measures and monitoring to address the information requirements necessary to make a regulatory decision and issue Authorizations under ss.35(2) of the *Fisheries Act*. DFO will not be able to issue a *Fisheries Act* Authorization until such time as all information requirements are satisfactorily met. Therefore, to expedite the regulatory review process, all outstanding information should be submitted as early as possible.

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1.0 ACRONYMS AND DEFINITIONS

Abbreviation	*Definition*
BMP	Best Management Practices
CEA	Cumulative Effects Assessment
CEAA	*Canadian Environmental Assessment Act*
DFO	Department of Fisheries and Oceans
EC	Environment Canada
EIRB	Environmental Impact Review Board
EIS	Environmental Impact Statement
EMP	Environmental Management Plans
FA	*Fisheries Act*
FJMC	Fisheries Joint Management Committee
GNWT	Government of the Northwest Territories
HADD	Harmful alteration, disruption or destruction of fish habitat
IFA	Inuvialuit Final Agreement
ISR	Inuvialuit Settlement Region
ITH	Inuvik to Tuktoyaktuk Highway
kPa	Kilopascal
NNL	No Net Loss – as per the *Policy for the Management of Fish Habitat* (1986)

Term	*Definition*	*Source*
Fish	includes (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine mammals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals;	*Fisheries Act*
Fish Habitat	Means spawning ground and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes;	*Fisheries Act*
Obstruction	means any slide, dam or other obstruction impeding the free passage of fish;	*Fisheries Act*
Developer	Hamlet of Tuktoyaktuk, Town of Inuvik and the Government of Northwest Territories Department of Transportation	

2.0 INTRODUCTION

2.1 Mandate of Fisheries and Oceans Canada

On behalf of the Government of Canada, the Department of Fisheries and Oceans (DFO) is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters.

The Department's guiding legislation includes the *Oceans Act*, which charges the Minister with leading oceans management and providing coast guard and hydrographic services on behalf of the Government of Canada, and the *Fisheries Act*, which confers responsibility to the Minister for the management of fisheries, habitat and aquaculture. The Department is also one of the three responsible authorities under the *Species at Risk Act*.

The *Fisheries Act* provides DFO with its regulatory powers to conserve and protect fish and fish habitat. This is accomplished through the administration of the Habitat Protection and Pollution Prevention provisions and other sections of the *Fisheries Act* which are binding on all levels of government and the public. These include the following sections:

- the prohibition against the harmful alteration, disruption or destruction (HADD) of fish habitat unless authorized by DFO – **section 35**
- the provision of sufficient water flows – **section 22**
- passage of fish around migration barriers – **sections 20 and 21**
- screening of water intakes – **section 30**
- prohibition against the destruction of fish by means other than fishing unless authorized by DFO – **section 32**
- prohibition to deposit deleterious substances unless by regulation – **section 36**

Environment Canada (EC) is responsible for the administration and enforcement of the pollution prevention provisions of the *Fisheries Act* on behalf of DFO (section 34 and sections 36-42).

With respect to fish habitat, the *Policy for the Management of Fish Habitat (*1986*)* (the Policy), and supporting documents such as the *Practitioner's Guide to Risk Management Framework*, provides direction to Habitat Management staff on when and how HADDs can be authorized. The Policy and supporting documents outline the decision framework and criteria to be used when reviewing specific development proposals. Generally, Proponents are to avoid or minimize HADDs to fish habitat through relocation, redesign, and/or mitigation techniques. It is only after these steps are taken that any remaining HADD to fish habitat is considered for authorization by the Minister. If it is determined to be appropriate, the Minister may issue a section 35(2) Authorization for a HADD resulting from the project; the Policy generally requires that fish habitat be created as compensation for the loss incurred as a result of the HADD such that there is a no net loss of fish habitat resulting from the authorized HADD. The Policy and the *Practitioner's Guide to Habitat Compensation* provide further direction in the form of a hierarchy of preferences for deciding upon the level, type and location of compensation works.

2.2 The Scope of the Technical Submission

DFO's Technical Submission focuses on the following sections of the Terms of Reference for the Environmental Impact Statement:

10.1.1 – Impact Assessment on Terrain, Geology, Soils and Permafrost
10.1.4 – Impact Assessment on Water Withdrawal and Water Quality
10.1.6 – Impact Assessment on Fish and Fish Habitat
10.5 – Determination of Significance
11.0 – Cumulative Effects Assessment
12.1 – Mitigation
12.2 – Mitigative and Remedial Measures
13.1 – Environmental Monitoring
13.2 – Compliance Monitoring
13.3 – Environmental Management Plans

2.3 DFO's Role in the Review

DFO is participating in the environmental assessment for the Inuvik to Tuktoyaktuk Highway as a regulator for the construction and operation of highway crossings as well as an expert advisor to the Review Board on potential physical impacts of the development on fish and fish habitat.

DFO is designated as a "government authority competent to authorize the development" as per the Inuvialuit Final Agreement (IFA) and a Responsible Authority under the Canadian Environmental Assessment Act (CEAA).

3.0 PARTY IDENTIFICATION

The following are the names, technical qualifications and full contact information of the DFO technical reviewers for this submission:

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4.0 ISSUE TRACKING

The following is a brief description of each issue DFO has been following throughout the review process and includes a rationale for whether each issue has been satisfactorily addressed, or whether it is (or parts of it are) still unaddressed.

4.1 Issue - Water Crossings

4.1.1 Summer Installations

The proponent has committed to constructing all crossings during the winter. If construction is required in summer, the proponent has stated that "*summer construction will not take place between April 1 and July 15, in accordance with the DFO timing window for spring spawning fish (respecting grayling and northern pike, which are the only large-bodied fish species likely to use Project area streams for spawning)*." and "*Where it is deemed preferable to install culverts in summer, construction will adhere to appropriate guidelines, such as those identified in Dane (1978) and in the DFO Land Development Guidelines for the Protection of Aquatic Habitats, to avoid or minimize the potential for erosion, sedimentation or channel effects*."

Issue Status & Rationale
This issue is partly addressed.

Installing culverts in the open water season requires mitigation to focus on more than just erosion, sedimentation, and channel effects. Open water installation can require site isolation, stream diversion, and other techniques. The impact of summer installation of crossings was not assessed in the Environmental Impact Statement (EIS), and mitigations are not outlined. The DFO Land Development Guidelines are generic and are not specific to permafrost regions.

With regards to summer construction, DFO expects the use of the Timing Windows Operational Statement (Appendix I), with the further recommendation of consultation with DFO and communities with regards to fish migration timing and fish habitat use of streams.

DFO will require that the details for all summer installation, including type of crossing, mitigations, and remaining impacts be provided and be included in the impact assessment on fish and fish habitat.

4.1.2 Aggregate and other Access Roads

The proponent has stated that only winter roads will be used to access aggregate sources.

Issue Status and Rationale
This issue is partly addressed.

The proponent has stated that aggregate and other access roads will only be constructed in the winter season and that no other permanent crossings or roads will be built for the project.

DFO recommends the use of the Ice Bridges and Snow Fills Operational Statement (Appendix I) for the construction and decommissioning of all winter roads associated with the Inuvik-Tuktoyaktuk Highway (ITH) project.

4.1.3 Selection of Crossing Types

The Developer has provided a master update list of crossings on Sept 4th, 2012. The proponent has stated that they "*will consider, at a minimum, stream category when determining the type of structure to be placed at stream crossings*." The proponent has also stated that they will develop and implement a fish and fish habitat protection plan in cooperation with DFO, Fisheries Joint Management Committee (FJMC) and the Tuktoyaktuk-Inuvik Working Group that will include designing appropriate crossing structures based on site conditions.

There is also a commitment by the Developer to conduct consultations (after Public Hearings) with the Inuvik and Tuktoyaktuk Hunter and Trapper Committees, Inuvialuit Game Council, DFO and Transport Canada regarding:
- Selection criteria for crossings;
- Use of waterbodies; and
- Types of vessels.

Issue Status and Rationale
This issue has been partly addressed.It is not clear which criteria from the statements above will be used for the crossing selection.
The fish habitat assessment is not yet complete;
- in the crossing table there are 10 crossings with little or no information.
- DFO notes that some of the crossings are noted in the table to be moved from the original location, which may affect the fish habitat assessment at that location.
- During the technical sessions the proponent committed to consulting with the communities regarding selection criteria for the crossing type to be used on each crossing, with particular emphasis on subsistence harvesting.

To assess the impacts to fish and fish habitat, DFO requires more detail as to the types of mitigation that will be applied at each type of crossing during the construction and operations phase. The 'scenario' description has been discussed at previous meetings, including the technical session.

4.1.4 Winter Fish Habitat

The fish habitat surveys completed to date did not determine winter fish habitat. Annual variations in precipitation, groundwater recharge/discharge and climate will alter the winter habitat characteristics of a watercourse on a seasonal basis. Given the limitations of the proponents' sampling program there are data gaps, particularly with regard to the identification of overwintering habitats.

Issue Status & Rationale
This issue is unaddressed.

There have been no winter surveys to assess overwintering habitat. The proponent has assumed that the majority of the streams freeze to the bottom over the winter and no field assessments have been completed. DFO will expect that the proponent use construction methods that avoid impacts to fish and fish habitat and crossing designs (ex. Clear-span bridges) that preserve the spawning and overwintering habitat at each crossing. DFO recommends that a survey of winter habitat be completed on crossings that have potential for overwintering habitat and are scheduled to be a culvert crossing.

4.1.5 General DFO comments on Water Crossings

DFO has requested that the proponent develop a lessons learned document based on their experience constructing the Tuktoyaktuk to source 177 road, which would include culvert embedding challenges, ensuring fish passage, fish presence in small streams, dealing with beaver dams, dealing with ice in culverts during freshet, riprap management, sediment and erosion control, overflow culverts, planning (including consultation and incorporating subsistence harvesting considerations), communication between proponent, regulators and contractors as well as any other design challenges associated with that road (e.g flow rates, embankment, slumping,)

DFO also requested that the proponent provide "scenarios" describing each type of crossings and associated mitigations.

DFO recommends that once the crossing table has been finalized, that the impacts to fish, fish habitat, and fisheries be assessed and quantified. And finally that the proponent provides stream crossing design criteria, final crossing designs, and site-specific mitigation measures to DFO and other appropriate regulators for review and approval upon completion of the detailed engineering phase and prior to the regulatory phase.

4.2 Issue – Sedimentation

There is a potential for fine sediment release into watercourses as a result of project construction, operation and maintenance. Sediment deposition in water bodies may result in the harmful alteration, disruption or destruction of fish habitat by the smothering of coarse substrate or aquatic vegetation. Sediment deposition can also be directly harmful to fish by affecting their ability to feed and migrate, and may result in egg mortality in the substrate by suffocation.

Stream crossing construction and channel and slope disturbance can lead to the accumulation of unconsolidated sediments or can initiate erosion, slumping or bank failure, all of which may lead to sedimentation impacts in streams.

A summary of the proponent's evaluation of the potential impact of erosion and sediment during construction and operation on fish and fish habitat can be found on page 493 and page 497 in the EIS (May 2011). Several components of the project have the potential to result in erosion and sedimentation effects on fish and fish habitat and these include bridge construction, culvert installation and maintenance, use of heavy equipment, general highway operation and maintenance, and road drainage.

Issue Status & Rationale
This issue has been partly addressed.

The proponent has proposed the use of mitigation measures to reduce physical disturbance and sedimentation impacts on channel morphology and fish habitat. DFO is concerned that the effectiveness of these measures cannot be evaluated because of a lack of detail. However, DFO is aware of the measures to minimize impacts as indicated in the EIS and the August 31st, 2012 commitments table.

The EIS identified the following avoidance or mitigation measures for sediment and erosion impacts:

- construction of highway embankments and abutment during the winter months
- employ erosion and sediment control best management practice (BMP) and guidelines such as DFO clear-span bridge operational statement;

- implement erosion and sediment control BMP and culvert installation guidelines (DFO land Development Guidelines)
- road drainage filtration by natural vegetation
- silt fences installed at each road-stream crossing
- inspect and maintain culverts, as needed, in the spring and fall
- follow DFO's Operational Statement for Culvert Maintenance

The proponent has also committed to developing an Erosion and Sediment Control Plan as well as a Fish and Fish Habitat Protection Plan as part of the Environmental Management Plan (EMP). Additionally in the commitments table, it was also stated that "*Streambank erosion will require temporary stabilization with mates or longer term armoring*" and that "*training will be provided to environmental monitors to identify sources and causes of erosion and sedimentation*".

Prior to construction, the proponent will be required to provide a draft sediment and erosion control plan to regulators and other interested parties. The Government of Northwest Territories department of Transportation, with support from DFO, has been working on a Sediment and Erosion control manual for highway construction projects in the NWT. This document should be finalized prior to the construction of the ITH and would assist in mitigating any potential impacts on fish and fish habitat.

4.3 Issue - Water Withdrawal

The proponent stated that when extracting water from waterbodies for the construction of winter roads, dust suppression and other activities, the DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut (2010) would be used. (Appendix II).

The proponent stated that hydrological assessments will be conducted prior to bridge design to determine suitable span widths and abutment placement, including identification of suitable water withdrawal sources (lakes and streams); bathymetric mapping of proposed water sources; and assessment of allowable withdrawal quantities per source, unique source identification, and water withdrawal volume tracking.

Issue Status & Rationale
This issue has been partly addressed.

In order to adhere to all the conditions within DFO's water withdrawal protocol, site specific information such as bathymetry, locations and quantities of water must be provided. Furthermore, the proponent has stated that they will also be withdrawing water from streams and has stated that it will provide an assessment of allowable withdrawal quantities per source. It should be noted that DFO's Winter Water Withdrawal Protocol does not apply to watercourses. DFO will require the identification of those streams as well as the instantaneous flow rate to assess the potential impacts on fish and fish habitat prior to construction.

The use of fish screens when withdrawing water has not been discussed. DFO will require that fish be protected from entrainment or impingement where water is extracted from fish-bearing waters, including any water withdrawals made using water trucks. DFO has a Freshwater Intake End-of-Pipe Fish Screen Guideline (Appendix III) to assist proponents in the design and installation of fish screens. Fish screen designs must be submitted to DFO for review and approval prior to installation.

DFO will require the proponents to develop water withdrawal plans prior to construction. DFO encourages consultation with aboriginal communities and local resource users in order to ensure that impacts to fisheries are prevented.

4.4 Issue – Fisheries Management and Harvesting

The impact of increased fishing activities along the road route has not been adequately assessed within the EIS.

Issue Status & Rationale
This issue has been partly addressed.

It is the responsibility of DFO and its co-management partners (FJMC, HTCs) to manage fisheries resources along the highway corridor. The proponent has committed to working in cooperation with users to assist in the management of fisheries, particularly in terms of signage and ensuring the highway is designed to prevent or discourage overfishing. However it is the proponent's responsibility within the environmental assessment to assess the potential impacts of the highway on fisheries within the area.

4.5 Issue – Borrow sites

The detailed pit or quarry development plans, which will include site-specific environmental information and reclamation plans for each borrow site, have not yet been provided. The proponent provided a report of geotechnical investigations of proposed borrow sources for ITH project on August 20th, 2012. The final selected borrow sources for the project include Borrow Sources 170, 172, 173/305, 307, 312, 314/325 and 2.45.

Issue Status & Rationale
This issue is satisfactorily addressed.

Mitigation measures to reduce or eliminate potential impacts to fish and fish habitat include: selecting borrow sites that are located away from water bodies (where practical), the use of erosion and sediment control measures during pit operation, and reclamation and re-vegetation of the borrow sites during decommissioning. If properly implemented and used in conjunction with an effective monitoring program, these measures should ensure adequate protection of fish and fish habitat.

In the August 31st, 2012 commitments table, the proponent has indicated that "*borrow sites will not be developed within 50m of any watercourses and 1km of the Husky lakes*". DFO would also like confirmation that the 50m setback also applies to other waterbodies.

The proponent has already committed to developing a Sediment and Erosion control plan for the project, which should include the borrow sites.

4.6 Issue –Monitoring

The EIS requires more details on short (construction-related) and long term monitoring. A well-designed monitoring program is critical to the verification of impact predictions and assessment of the efficacy of mitigation measures.

Issue Status & Rationale
This issue has been partly addressed.

Monitoring for impacts to fish habitat as a result of sedimentation should prioritize early detection and rapid response because minor erosion may quickly become major bank failure in many of the soil conditions found along the proposed Highway.

Monitoring should consist of systems for detection, response and follow-up, and should be adaptive and responsive to field conditions in case first remedial actions are not successful.

The proponent has committed to monitoring culverts in fish bearing streams annually for three years to verify that fish passage is maintained, particularly during migration periods. Long term monitoring may also be required depending on the crossing type and fish use. DFO may also require monitoring as part of our *Fisheries Act* authorizations.

4.7 Issue - Blasting

It was stated in the August 31st, 2012 commitments that "*Should the Developer require the use of explosives, any planned activities will be provided to DFO for review during the construction phase to ensure appropriate best practices are followed.*"

Issue Status & Rationale
This issue has been adequately addressed.

DFO is confident that the use of standard mitigation and monitoring measures as described in our guidelines as well as a lower threshold value for blasting can be effectively employed for the project to mitigate any blasting impacts on fish. Please note, however, DFO will require complete information in this regard in order to assess our regulatory requirements under the Fisheries Act.

Please note that based on NWT-specific monitoring results, DFO recommends the use of a lower threshold values than indicated in the national guidelines to mitigate impacts associated with the use of explosives in or near water (50kPa). Other mitigation should also be employed including using a series of smaller blasts, timing, and fish exclusion measures if necessary. Please refer to the following reference found in Appendix IV :
- **Monitoring Explosive-Based Winter Seismic Exploration in Water Bodies NWT 2000- 2002**. Cott, P., B. Hanna, J. Dahl. Canadian Manuscript Report for Fisheries and Aquatic Sciences 2648. 2003. Discussion on Seismic Exploration in the Northwest Territories 2000–2003.

4.8 Issue – No Net Loss Plan

While the proponent has provided a preliminary estimate of impacted area of fish habitat, complete information related to a plan for achieving no net loss of fish habitat has not yet been provided. Offsetting residual habitat impacts through the application of habitat compensation can meet the guiding principle of DFO's habitat policy and is viewed as a means of mitigating significant adverse environmental effects to fish habitat under CEAA.

Issue Status & Rationale
This issue is partly addressed.

DFO will need information in respect to crossing design details, fish habitat classification, fish habitat compensation, mitigation measures and monitoring to address the information requirements necessary to make a regulatory decision and issue Authorizations under ss.35(2) of the *Fisheries Act*. DFO will not be able to issue a *Fisheries Act* Authorization until such time as all information requirements are satisfactorily met.

To expedite the regulatory review process, all outstanding information should be submitted to DFO as early as possible.

4.9 Issue – Cumulative Effects Assessment

The cumulative effects assessment provided in the Environmental Impact Statement does not fully assess cumulative effects on fish and fish habitat.

Issue Status & Rationale
As stated in the Technical Sessions, the cumulative effects assessment does not provide a quantitative analysis of the cumulative impacts to fish, fisheries, and fish habitat. It also only describes the potential future projects, but does not quantify their potential impact.

DFO recommends completing the cumulative effects assessment, including a quantitative analysis of the impacts to fisheries, fish, and fish habitat. It should be shown how the cumulative effects assessment was completed, what methods were used and what VECs were assessed and how conclusions were arrived at.

Appendix I – DFO Operational Statements

ICE BRIDGES AND SNOW FILLS

Fisheries and Oceans Canada
Northwest Territories Operational Statement

Version 3.0

Ice bridges and snow fills are two methods used for temporary winter access in remote areas. Ice bridges are constructed on larger watercourses that have sufficient stream flow and water depth to prevent the ice bridge from coming into contact with the stream bed or restricting water movement beneath the ice. Snow fills, however, are temporary stream crossings constructed by filling a stream channel with clean compacted snow.

Ice bridge and snow fill crossings provide cost-effective access to remote areas when lakes, rivers and streams are frozen. Since the ground is frozen, ice bridges and snow fills can be built with minimal disturbance to the bed and banks of the watercourse. However, these crossings can still have negative effects on fish and fish habitat. Clearing shoreline and bank vegetation increases the potential for erosion and instability of the banks and can lead to deposition of sediments into fish habitat. There is also potential for blockage of fish passage during spring break-up.

Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat across Canada. Under the *Fisheries Act* no one may carry out a work or undertaking that will cause the harmful alteration, disruption or destruction (HADD) of fish habitat unless it has been authorized by DFO. By following the conditions and measures set out below you will be in compliance with the subsection 35(1) of the *Fisheries Act*.

The purpose of this Operational Statement is to describe the conditions under which it is applicable to your project and the measures to incorporate into your project in order to avoid negative impacts to fish habitat. You may proceed with your ice bridge or snow fill project without a DFO review when you meet the following conditions:

- your planned work is not located in a critical area, as identified in a NWT Community Conservation Plan or other applicable land use plan,
- ice bridges are constructed of clean (ambient) water, ice and snow,
- snow fills are constructed of clean snow, which will not restrict water flow at any time,
- the work does not include realigning the watercourse, dredging, placing fill, or grading or excavating the bed or bank of the watercourse,
- materials such as gravel, rock and loose woody material are NOT used,
- where logs are required for use in stabilizing shoreline approaches, they are clean and securely bound together, and they are removed either before or immediately following the spring freshet,
- the withdrawal of any water will not exceed 10% of the instantaneous flow, in order to maintain existing fish habitat,
- water flow is maintained under the ice, where this naturally occurs,
- this Operational Statement is posted at the work site and is readily available for reference by workers, and
- you incorporate the *Measures to Protect Fish and Fish Habitat when Constructing an Ice Bridge or Snow Fill* listed below in this Operational Statement.

If you cannot meet all of the conditions listed above and cannot incorporate all of the measures listed below then your project may result in the violation of subsection 35(1) of the *Fisheries Act* and you could be subject to enforcement action. In this case, you should contact the DFO office in your area if you wish to obtain DFO's opinion on the possible options you should consider to avoid contravention of the *Fisheries Act*.

You are required to respect all local, municipal, territorial or federal legislation that applies to the work being carried out in relation to this Operational Statement. The activities undertaken in this Operational Statement must also comply with the *Species at Risk Act* (**www.sararegistry.gc.ca**). If you have questions regarding this Operational Statement, please contact the DFO office in your area (see Northwest Territories DFO office list).

We ask that you notify DFO, preferably 10 working days before starting your work by filling out and sending the Northwest Territories Operational Statement notification form (**www.dfo-mpo.gc.ca/regions/central/habitat/os-eo/prov-terr/index_e.htm**) to the DFO office in your area. This information is requested in order to evaluate the effectiveness of the work carried out in relation to this Operational Statement.

Measures to Protect Fish and Fish Habitat when Constructing an Ice Bridge or Snow Fill

1. Use existing trails, winter roads or cut lines wherever possible as access routes to limit unnecessary clearing of additional vegetation and prevent soil compaction.

2. Construct approaches and crossings perpendicular to the watercourse wherever possible.

3. Construct ice bridge and snow fill approaches using clean, compacted snow and ice to a sufficient depth to protect the banks of the lake, river or stream. Clean logs may be used where necessary to stabilize approaches.

4. Where logs are used to stabilize the approaches of an ice bridge or snow fill:

   4.1. The logs are clean and securely bound together so they can be easily removed.
   4.2. No logs or woody debris are to be left within the water body or on the banks or shoreline where they can wash back into the water body.

   Note: The use of material other than ice or snow to construct a temporary crossing over any ice-covered stream is prohibited under section 11 of the *Northwest Territories Fishery Regulations*, unless authorized by a Fishery Officer. Please contact the nearest NWT DFO office.

5. While this Operational Statement does not cover the clearing of riparian vegetation, the removal of select plants may be necessary to accommodate the road. This removal should be kept to a minimum and within the road right-of-way.

6. Install sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect them regularly during the course of construction and decommissioning activities and make all necessary repairs if any damage occurs.

7. Operate machinery on land or on ice and in a manner that minimizes disturbance to the banks of the lake, river or stream.

   7.1. Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks.
   7.2. Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent any deleterious substance from entering the water or spreading onto the ice surface.
   7.3. Keep an emergency spill kit on site in case of fluid leaks or spills from machinery.
   7.4. Restore banks to original condition if any disturbance occurs.

8. If water is being pumped from a lake or river to build up the bridge, follow DFO's *NWT Winter Water Withdrawal Protocol* (available from the DFO offices listed below), and ensure that the intakes are sized and adequately screened to prevent debris blockage and fish mortality (refer to DFO's *Freshwater Intake End-of-Pipe Fish Screen Guideline* (1995) available at **www.dfo-mpo.gc.ca/Library/223669.pdf**).

9. Crossings do not impede water flow at any time of the year.

10. When the crossing season is over and where it is safe to do so, create a v-notch in the centre of the ice bridge to allow it to melt from the centre and also to prevent blocking fish passage, channel erosion and flooding. Compacted snow should be removed from snow fills prior to the spring freshet.

11. Stabilize any waste materials removed from the work site to prevent them from entering the lake, river, or stream. This could include covering spoil piles with biodegradable mats or tarps or planting them with grass or shrubs.

12. Vegetate and stabilize (e.g., cover exposed areas with erosion control blankets or tarps to keep the soil in place and prevent erosion) any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses. Cover such areas with mulch to prevent erosion and to help seeds germinate. If re-vegetation is not possible due to climatic extremes and/or lack of appropriate seed or stock, the site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.

    12.1. Maintain effective sediment and erosion control measures until re-vegetation of disturbed areas is achieved or until such areas have been permanently stabilized by other effective sediment and erosion control measures, in the event that re-vegetation is not possible.

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DFO/2007-1329

TEMPORARY STREAM CROSSING

Fisheries and Oceans Canada
Northwest Territories Operational Statement

Version 1.0

A temporary stream crossing consists of i) a one-time ford in flowing waters, ii) a seasonally dry streambed ford, or iii) a temporary bridge (e.g., Bailey bridge or log stringer bridge). Temporary stream crossings are employed for short term access across a watercourse by construction vehicles when an existing crossing is not available or practical to use. They are not intended for prolonged use (e.g., forest or mining haul roads). The use of temporary bridges or dry fording is preferred over fording in flowing waters due to the reduced risk of damaging the bed and banks of the watercourse and downstream sedimentation caused by vehicles. Separate Operational Statements are available for *Ice Bridges and Snow Fills* used for temporary access during the winter and for non-temporary *Clear Span Bridges*.

The risks to fish and fish habitat associated with temporary stream crossings include the potential for direct harm to stream banks and beds, release of excessive sediments and other deleterious substances (e.g., fuel, oil leaks), loss of riparian habitat and disruption to sensitive fish life stages.

Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat across Canada. Under the *Fisheries Act* no one may carry out a work or undertaking that will cause the harmful alteration, disruption or destruction (HADD) of fish habitat unless it has been authorized by DFO. By following the conditions and measures set out below you will be in compliance with subsection 35(1) of the *Fisheries Act*.

The purpose of this Operational Statement is to describe the conditions under which it is applicable to your project and the measures to incorporate into your project in order to avoid negative impacts to fish habitat. You may proceed with your temporary stream crossing project without a DFO review when you meet the following conditions:

- your planned work is not located in a critical area, as identified in a NWT *Community Conservation Plan*, or other applicable land use plan,
- the bridge is no greater than one lane in width, and no part of its structure is placed within the wetted portion of the stream,
- the work does not include realigning the watercourse,
- for fording in flowing waters and temporary bridges, the channel width at the crossing site is no greater than 5 metres from ordinary high water mark to ordinary high water mark (HWM) (see definition below),
- disturbance to riparian vegetation is minimized,
- the work does not involve dredging, infilling, grading or excavating the bed or bank of the watercourse,
- all crossing materials will be removed prior to the spring freshet, or immediately following project completion if this occurs earlier,
- fording involves a one time event (over and back) and will not occur in areas that are known fish spawning sites,
- the crossing will not result in erosion and sedimentation of the stream, or alteration (e.g., compaction or rutting) of the bed and bank substrates,
- the crossing does not involve installation of a temporary culvert,
- this Operational Statement is posted at the work site and is readily available for reference by workers, and
- you incorporate the *Measures to Protect Fish and Fish Habitat when Carrying Out a Temporary Stream Crossing* listed below.

If you cannot meet all of the conditions listed above and cannot incorporate all of the measures listed below then your project may result in a violation of subsection 35(1) of the *Fisheries Act* and you could be subject to enforcement action. In this case, you should contact the DFO office in your area if you wish to obtain DFO's opinion on the possible options you should consider to avoid contravention of the *Fisheries Act*.

You are required to respect all local, municipal, territorial and federal legislation that applies to the work being carried out in relation to this Operational Statement. The activities undertaken in this Operational Statement must also comply with the *Species at Risk Act* (SARA) (**www.sararegistry.gc.ca**). If you have questions regarding this Operational Statement, please contact the DFO office in your area (see Northwest Territories DFO office list).

We ask that you notify DFO, preferably 10 working days before starting your work, by filling out and sending the Northwest Territories Operational Statement notification form (**www.dfo-mpo.gc.ca/regions/central/habitat/os-eo/prov-terr/index_e.htm**) to the DFO office in your area. This information is requested in order to evaluate the effectiveness of the work carried out in relation to this Operational Statement.

Measures to Protect Fish and Fish Habitat when Carrying Out a Temporary Stream Crossing

1. Use existing trails, roads or cut lines wherever possible, as access routes to avoid disturbance to the riparian vegetation.

2. Locate crossings at straight sections of the stream, perpendicular to the bank, whenever possible. Avoid crossing on meander bends, braided streams, alluvial fans, or any other area that is inherently unstable and may result in the erosion and scouring of the stream bed.

3. While this Operational Statement does not cover the clearing of riparian vegetation, the removal of select plants may be necessary to access the construction site. This removal should be kept to a minimum and within the road or utility right-of-way. When practicable, prune or top the vegetation instead of uprooting.

4. Generally, there are no restrictions on timing for the construction of bridge structures or fording seasonally dry streambeds, as they do not involve in-water work. However, if there are any activities with the potential to disrupt sensitive fish life stages (e.g., fording of the watercourse by machinery) these should adhere to appropriate fisheries timing widows (see the *Northwest Territories In-Water Construction Timing Windows*).

5. Machinery fording a flowing watercourse to bring equipment required for construction to the opposite side is limited to a one-time event (over and back) and is to occur only if an existing crossing at another location is not available or practical to use.

   5.1. If minor rutting is likely to occur, stream bank and bed protection methods (e.g., swamp mats, pads) should be used, provided they do not constrict flows or block fish passage.
   5.2. Grading of the stream banks for the approaches should not occur.
   5.3. If the stream bed and banks are steep and highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation are likely to occur as a result of equipment fording, then a temporary bridge should be used in order to protect these areas.
   5.4. The one-time fording should adhere to fisheries timing windows (see Measure 4).
   5.5. Fording should occur under low flow conditions, and not when flows are elevated due to local rain events or seasonal flooding.

6. Install effective sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect them regularly during the course of construction and make all necessary repairs if any damage occurs.

7. For temporary bridges also employ the following measures:

   7.1. Use only clean materials (e.g., rock or coarse gravel fill, wood, or steel) for approaches to the bridge (i.e., not sand, clay or organic soil) and install in a manner that avoids erosion and sedimentation.
   7.2. Design temporary bridges to accommodate any expected high flows of the watercourse during the construction period.
   7.3. Restore the bank and substrate to pre-construction condition.
   7.4. Completely remove all materials used in the construction of the temporary bridge from the watercourse following the equipment crossing, and stabilize and re-vegetate the banks.

8. Operate machinery in a manner that minimizes disturbance to the watercourse bed and banks.

   8.1. Protect entrances at machinery access points (e.g., using swamp mats) and establish single site entry and exit.
   8.2. Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks.
   8.3. Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent deleterious substances from entering the water.
   8.4. Keep an emergency spill kit on site in case of fluid leaks or spills from machinery.
   8.5. Spills of oil, fuel or other deleterious material, whether near or directly into a water body, should be reported immediately to the NWT/Nunavut 24-hour Spill Report Line at (867) 920-8130, as per existing reporting protocols.

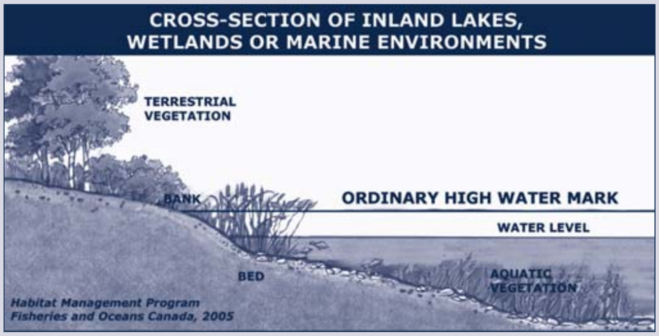
9. Stabilize any waste materials removed from the work site, above the HWM, to prevent them from entering any watercourse. This could include covering spoil piles with biodegradable mats or tarps or planting them with preferably native grass or shrubs.

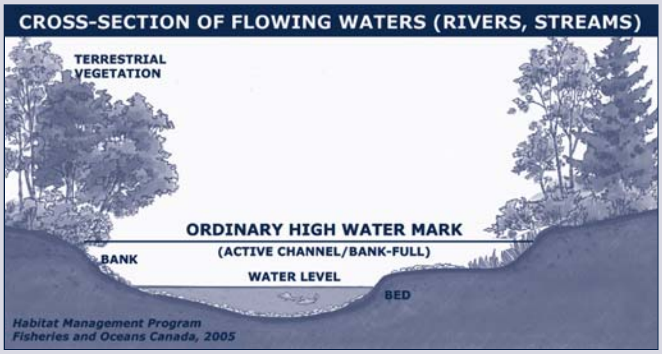
10. Vegetate any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses and cover such areas with mulch to prevent soil erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring. If re-vegetation is not possible due to climatic extremes and/or lack of appropriate seed or stock, the site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.

    10.1. Maintain effective sediment and erosion control measures until re-vegetation of disturbed areas is achieved or until such areas have been permanently stabilized by other effective sediment and erosion control measures, in the event that re-vegetation is not possible.

Definition:

Ordinary high water mark (HWM) - The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams) this refers to the “active channel/bank-full level” which is often the 1:2 year flood flow return level. In inland lakes, wetlands or marine environments it refers to those parts of the water body bed and banks that are frequently flooded by water so as to leave a mark on the land and where the natural vegetation changes from predominately aquatic vegetation to terrestrial vegetation (excepting water tolerant species). For reservoirs this refers to normal high operating levels (Full Supply Level).





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DFO/2007-1329

CLEAR-SPAN BRIDGES

Fisheries and Oceans Canada
Northwest Territories Operational Statement

Version 3.0

This Operational Statement applies to the construction of small-scale bridge structures that completely span a watercourse without altering the stream bed or bank, and that are a maximum of two lanes wide. The bridge structure (including bridge approaches, abutments, footings, and armouring) is built entirely above the ordinary high water mark (HWM) (see definition below). A clear-span bridge is preferred to structures that are placed within the stream bed and therefore result in loss of fish habitat or alteration of natural channel processes.

Clear-span bridge construction has the potential to negatively affect riparian habitat. Riparian vegetation occurs adjacent to the watercourse and directly contributes to fish habitat by providing shade, cover and areas for spawning and food production. Only the vegetation required to accommodate operational and safety concerns for the crossing structure and approaches, within the right-of-way, should be removed. Stormwater run-off and the use of machinery can introduce deleterious substances to the water body and result in erosion and sedimentation.

Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat across Canada. Under the *Fisheries Act* no one may carry out a work or undertaking that will cause the harmful alteration, disruption or destruction (HADD) of fish habitat unless it has been authorized by DFO. By following the conditions and measures set out below you will be in compliance with subsection 35(1) of the *Fisheries Act*.

The purpose of this Operational Statement is to describe the conditions under which it is applicable to your project and the measures to incorporate into your project in order to avoid negative impacts to fish habitat and maintain passage of fish. You may proceed with your clear-span bridge project without a DFO review when you meet the following conditions:

- your planned work is not located in a critical area, as identified in a NWT Community Conservation Plan or other applicable land use plan,
- the bridge is placed entirely above the HWM,
- the bridge is not located on meander bends, braided streams, alluvial fans, active flood plains, or any other area that is inherently unstable and may result in the alteration of natural steam functions or erosion and scouring of the bridge structure,
- the bridge is no greater than two lanes in width and does not encroach on the natural channel width by the placement of abutments, footings or rock armouring below the HWM,
- the work does not include realigning the watercourse,
- there is no alteration of the stream bed or banks or infilling of the channel,
- this Operational Statement is posted at the work site and is readily available for reference by workers, and
- you incorporate the *Measures to Protect Fish and Fish Habitat when Constructing Clear-Span Bridges* listed below in this Operational Statement.

If you cannot meet all of the conditions listed above and cannot incorporate all of the measures listed below then your project may result in a violation of subsection 35(1) of the *Fisheries Act* and you could be subject to enforcement action. In this case, you should contact the DFO office in your area if you wish to obtain DFO's opinion on the possible options you should consider to avoid contravention of the *Fisheries Act*.

You are required to respect all local, municipal, territorial or federal legislation that applies to the work being carried out in relation to this Operational Statement. The activities undertaken in this Operational Statement must also comply with the *Species at Risk Act* (**www.sararegistry.gc.ca**). If you have questions regarding this Operational Statement, please contact the DFO office in your area (see Northwest Territories DFO office list).

We ask that you notify DFO, preferably 10 working days before starting your work by filling out and sending the Northwest Territories Operational Statement notification form (**www.dfo-mpo.gc.ca/regions/central/habitat/os-eo/prov-terr/index_e.htm**) to the DFO office in your area. This information is requested in order to evaluate the effectiveness of the work carried out in relation to this Operational Statement.

Measures to Protect Fish and Fish Habitat when Constructing Clear-Span Bridges

1. Use existing trails, roads, or cut lines wherever possible to avoid disturbance to the riparian vegetation.

2. While this Operational Statement does not apply to the clearing of riparian vegetation, the removal of select plants within the road right-of-way (ROW) may be required to meet operational and/or safety concerns for the crossing

structure and the approaches. This removal should be kept to a minimum and within the road or utility right-of-way. When practicable, prune or top the vegetation instead of uprooting.

3. Design and construct approaches so that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.

4. Design the bridge so that stormwater runoff from the bridge deck, side slopes and approaches is directed into a retention pond or vegetated area to remove suspended solids, dissipate velocity and prevent sediment and other deleterious substances from entering the watercourse.

5. Generally there are no restrictions on timing for the construction of clear-span structures as they do not involve in-water work. However, if there are any activities with the potential to disrupt sensitive fish life stages (e.g., crossing of watercourse by machinery), these should adhere to appropriate fisheries timing windows (see the *Northwest Territories In-Water Construction Timing Windows*) or alternatively, carry out the project when the waterbody is frozen to the bottom or is dry.

6. Machinery fording the watercourse to bring equipment required for construction to the opposite side is limited to a one-time event (over and back) and should occur only if an existing crossing at another location is not available or practical to use. A *Temporary Stream Crossing* Operational Statement is also available.

- **6.1.** If minor rutting is likely to occur, stream bank and bed protection methods (e.g., swamp mats, pads) should be used provided they do not constrict flows or block fish passage.
- **6.2.** Grading of the stream banks for the approaches should not occur.
- **6.3.** If the stream bed and banks are steep and highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation are likely to occur as a result of equipment fording, then a temporary crossing structure or other practice should be used to protect these areas.
- **6.4.** The one-time fording should adhere to fisheries timing windows (see Measure 5).
- **6.5.** Fording should occur under low flow conditions and not when flows are elevated due to local rain events or seasonal flooding.

7. Install effective sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect them regularly during the course of construction and make all necessary repairs if any damage occurs.

8. Operate machinery on land (above the HWM) and in a manner that minimizes disturbance to the banks of the watercourse.

- **8.1.** Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks.
- **8.2.** Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent any deleterious substance from entering the water.
- **8.3.** Keep an emergency spill kit on site in case of fluid leaks or spills from machinery.
- **8.4.** Restore banks to original condition if any disturbance occurs.

9. Use measures to prevent deleterious substances such as new concrete (i.e., it is pre-cast, cured and dried before use near the watercourse), grout, paint, ditch sediment and preservatives from entering the watercourse.

10. Stabilize any waste materials removed from the work site to prevent them from entering the watercourse. This could include covering spoil piles with biodegradable mats or tarps or planting them with preferably native grass or shrubs.

11. Vegetate any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses and cover such areas with mulch to prevent erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring. If re-vegetation is not possible due to climatic extremes and/or lack of appropriate seed or stock, the site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.

- **11.1.** Maintain effective sediment and erosion control measures until re-vegetation of disturbed areas is achieved or until such areas have been permanently stabilized by other effective sediment and erosion control measures, in the event that re-vegetation is not possible.

Definition:

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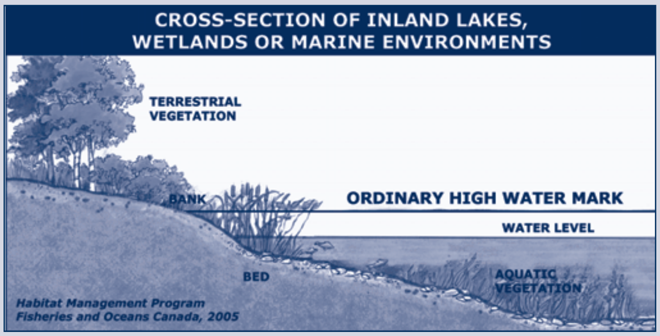

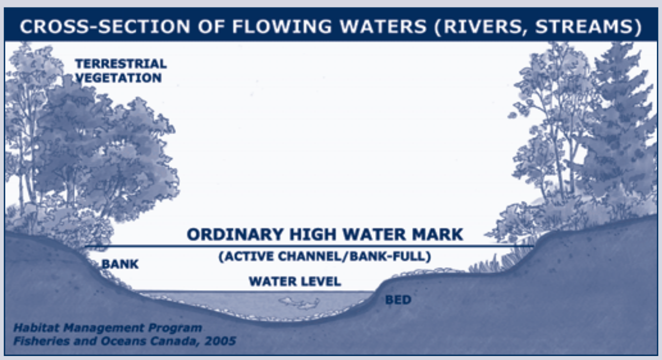

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DFO/2007-1329

TIMING WINDOWS

Fisheries and Oceans Canada
Northwest Territories Operational Statement

Version 3.0

NORTHWEST TERRITORIES IN-WATER CONSTRUCTION TIMING WINDOWS FOR THE PROTECTION OF FISH AND FISH HABITAT

Restricted activity timing windows have been identified for Northwest Territories lakes, rivers and streams to protect fish during spawning and incubation periods when spawning fish, eggs and fry are vulnerable to disturbance or sediment. During these periods, no in-water or shoreline work is allowed except under site-or project-specific review and with the implementation of protective measures. Restricted activity periods are determined on a case by case basis according to the species of fish in the water body, whether those fish spawn in the spring, summer, fall or winter, and where the water body is located.

Timing windows are just one of many measures used to protect fish and fish habitat when carrying out a work or undertaking in or around water. Be sure to follow all of the measures outlined in the Operational Statements to avoid negative impacts to fish habitat.

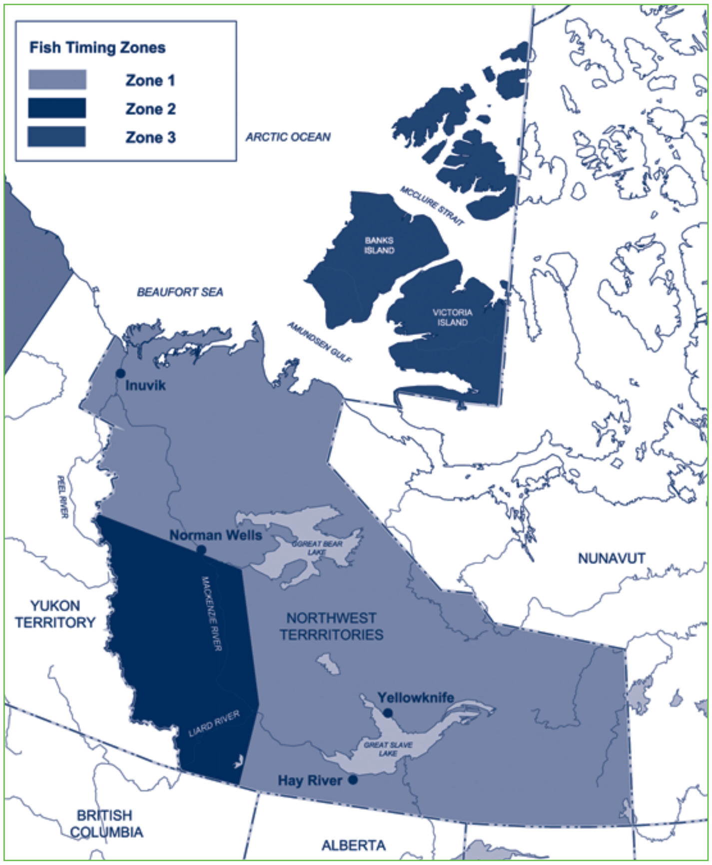

Figure 1:
Fish Timing Zones for the Northwest Territories.

How To Determine Timing Windows

1. Determine the fish species living in the water body where you wish to do work. Consult with local organizations such as hunters and trappers committees, Renewable Resource Councils or your local Fisheries and Oceans Canada (DFO) office.

2. Determine if the fish living in the water body spawn in the spring, summer, fall or winter according to Table 1. There may be one or more spawning types in any given water body. For most water bodies in the NWT there are at least two spawning types. The spawning windows for multiple species should be observed.

3. Determine if the water body is in Zone 1, 2 or 3 according to Figure 1.

4. Using Tables 2 and 3, determine the in-water work timing restrictions according to the location of a water body (Zone 1, 2 or 3) and the type (spring/summer, fall or winter) of spawning fish. During these periods, in-water work (below the ordinary high water mark) is not permitted without site or project-specific review by DFO.

Table 1:
General Range of Spawning Times in Northwest Territories.

FALL SPAWNERS		
Species	**Range of Spawning Timing**	**Incubation/Hatch Time**
Lake Whitefish	Mid-September to mid-October	Late winter-early spring
Broad Whitefish	November	April-May
Round Whitefish	October-November	April-May (123-140 days)
Least Cisco	Late September to early October	May or June (break-up)
Arctic Cisco	Mid-September to early October	Spring under ice
Lake Cisco	September to November	Spring
Inconnu	Late September to early October	Spring
Lake Trout	Mid to late August	May-June
Bull Trout	Mid-August to October	Spring (around break-up)
Dolly Varden Char	September to early October (Rat River - August 15 to late September)	8 months (May or June)
Arctic Char	Late September to early October	April
Chum Salmon	September to October	122-173 days

SPRING/SUMMER SPAWNERS		
Species	**Range of Spawning Timing**	**Incubation/Hatch Time**
Arctic Grayling	Mid-May to early June	8-32 days
Northern Pike	Early May to mid-June	Approximately 2 weeks
Walleye	April-June	4-34 days
Yellow Perch	March-July	8-20 days
Goldeye	Early May to early July	Approximately 2 weeks
Rainbow Smelt	April-May	About 29 days
Longnose Sucker	June	Approximately 2 weeks
White Sucker	June	Approximately 2 weeks

WINTER SPAWNERS		
Species	**Range of Spawning Timing**	**Incubation/Hatch Time**
Burbot	December to mid-January	30 days to 3 months

Table 2:
Timing Windows when In-water Activities are NOT Permitted, by Type of Spawning.

Zone	Spring/Summer	Fall	Winter
NWT Zone 1	April 1 to July 15	September 15[1, 2] to June 30	December 1 to April 15
NWT (SW corner) Zone 2	April 1 to July 15	August 15 to June 30	December 1 to April 15
NWT offshore islands Zone 3	n/a	September 15[1] to June 30	n/a

NOTES: 1. For lakes with spawning Lake Trout populations, the timing window begins earlier, starting August 15.
2. Dolly Varden in the Rat River begin spawning in mid-August and therefore the fall window for this system should be August 15 to June 30.

Timing Windows for Water bodies Where All Spawning Types are Present or Fish Species NOT Known:
If all spawning types are present, or if you don't know which species are in the water body, then Table 3 can be followed.

Table 3:
Fish Timing Windows using All Spawning Types.

Zone	When In-water Activity Not Permitted	When In-water Activity May Occur
NWT Zone 1	September 15 to July 15[1, 2]	July 16 to September 14[3]
NWT Zone 2	August 15 to July 15	July 16 to August 14
NWT Zone 3	September 15 to June 30[1]	July 1 to September 14

NOTES: [1] For lakes with spawning Lake Trout populations, the timing window begins earlier, starting August 15.
[2] Dolly Varden in the Rat River begin spawning in mid-August and therefore the fall window for this system should be August 15 to June 30.
[3] For the Rat River and for lakes with spawning Lake Trout populations, the timing window when in-water activities may occur is July 16 to August 14.

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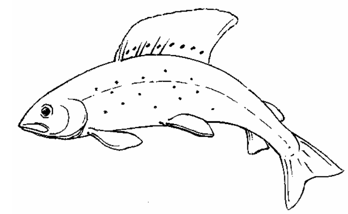
DFO/2007-1329

Appendix II – DFO Winter Water Withdrawal Protocol



DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut

Rationale

In the Northwest Territories and Nunavut, winter activities such as access road construction, exploratory drilling and camp operations often require large amounts of water. Excessive amounts of water withdrawn from ice-covered waterbodies can impact fish through oxygen depletion, loss of over-wintering habitat and/or reductions in littoral habitat. The potential for such negative impacts to over-wintering fish and fish habitat has made winter water withdrawal a critical issue for Fisheries and Oceans Canada (DFO) in the Northwest Territories and Nunavut. To mitigate impacts to fish from water withdrawal from ice-covered waterbodies, and to provide standardized guidance to water users, including volume limits for certain water source types, DFO has developed this protocol in conjunction with industry and other regulators.

For the purposes of this protocol, a **waterbody** is defined as any water-filled basin that is potential fish habitat. A waterbody is defined by the ordinary high water mark of the basin, and excludes connecting watercourses.

This protocol will **not** apply to the following:

- Any waterbody that is exempted by DFO (e.g. Great Bear Lake, Great Slave Lake, Gordon Lake, and others as and when determined by DFO), and;
- Any waterbody from which less than $100m^3$ is to be withdrawn over the course of one ice-covered period.

In order to establish a winter water withdrawal limit for a given waterbody, the following criteria must be adhered to:

1. In one ice-covered season, total water withdrawal from a single waterbody is not to exceed 10% of the available water volume calculated using the appropriate maximum expected ice thickness provided in Table 1.
2. In cases where there are multiple users withdrawing water from a single waterbody, the total combined withdrawal volume is not to exceed 10% of the available water volume calculated using the appropriate maximum expected ice thickness provided in Table 1. Therefore, consistent and coordinated water source identification is essential.
3. Only waterbodies with maximum depths that are ≥1.5m than their corresponding maximum expected ice thickness should be considered for water withdrawal (Table 1). Waterbodies with less than 1.5m of free water beneath the maximum ice are considered to be particularly vulnerable to the effects of water withdrawal.
4. Any waterbody with a maximum expected ice thickness that is greater than, or equal to, its maximum depth (as determined from a bathymetric survey) is exempt from the 10% maximum withdrawal limit (Table 1).

To further mitigate the impacts of water withdrawal, water is to be removed from deep areas of waterbodies (>2m below the ice surface) wherever feasible, to avoid the removal of oxygenated surface waters that are critical to over-wintering fish. The littoral zone should be avoided as a water withdrawal location. Water intakes should also be properly screened with fine mesh of 2.54 mm (1/10") and have moderate intake velocities to prevent the entrainment of fish. Please refer to the *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO, 1995) which is available upon request, or at the following internet address: www.dfo-mpo.gc.ca/Library/223669.pdf.

In order to determine the maximum water withdrawal volume from an ice-covered waterbody, and thereby conform to this protocol, the following information must be provided to DFO for review and concurrence prior to program commencement.

Water Source Identification

1. Proposed water sources, access routes, and crossing locations clearly identified on a map, with geographical coordinates (latitude/longitude and/or UTMs) included.
2. Any watercourse connectivity (permanently flowing and/or seasonal) between the proposed water source and any other waterbody or watercourse.

3. Aerial photos or satellite imagery of the water sources.
4. Estimated total water withdrawal requirement for work or activity and estimated total water withdrawal per water source (in m^3).

Bathymetric Survey Results

1. <u>For all waterbodies</u>: One longitudinal transect, connecting the two farthest shorelines, is to be conducted regardless of waterbody size. Note: a longitudinal transect may be straight or curved in order to accommodate the shape of a lake (see Figure 1).
2. <u>For waterbodies equal to or less than 1 km in length</u>: a minimum of one longitudinal transect and two perpendicular transects are to be conducted. Perpendicular transects should be evenly spaced on the longest longitudinal transect, dividing the lake into thirds (Figure 1).
3. <u>For lakes greater than 1 km in length</u>: a minimum of one longitudinal transect is to be conducted. Perpendicular transects (minimum of 2) should be evenly spaced on the longest longitudinal transect at maximum intervals of 500 m.
4. Additional transects should be run as required to include irregularities in waterbody shape such as fingers or bays (Figure 1).
5. All longitudinal and perpendicular transects are to be conducted using an accurate, continuous depth sounding methodology, such as open water echo sounding or ground penetrating radar (GPR), that provides a continuous depth recording from one shore to the farthest opposing shore (Figure 1). Any alternative technology should be reviewed by DFO prior to implementing for bathymetric surveys.

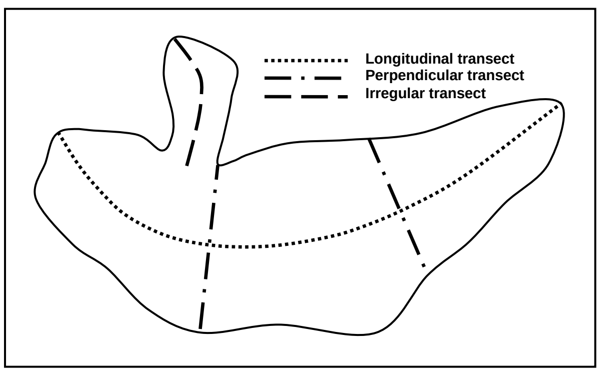


Figure 1. Minimum transect layout for a lake that is less than 1 km in length, with an irregularity.

Volume Calculations

1. Document the methods used to calculate surface area. If aerial photos or satellite imagery were used, provide the date (day/month/year) taken, as surface area may change depending on the time of year. If maps were used, provide the year that they were surveyed.
2. Detail the methods used to determine the total volume of free water, incorporating the relevant bathymetric information.
3. Calculate the available water volume under the ice using the appropriate maximum expected ice thickness, i.e. *Total Volume* $_{lake}$ – *Ice Volume* $_{max\ thickness}$ = *Available Water Volume* (see Table 1 for maximum ice thickness).
4. For programs where ice-chipping is used, the total ice volume to be removed from the waterbody should be converted to total liquid volume and incorporated into the estimate of total water withdrawal requirement per water source.

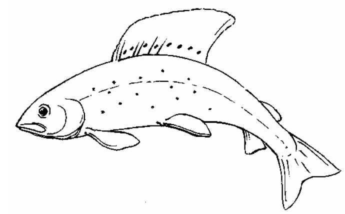


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Table 1. Maximum expected ice thickness, and corresponding water depth requirements, for different regions in the Northwest Territories.

Area	Maximum Expected Ice Thickness (m)	Minimum Waterbody depth Required for 10% Water Withdrawal (m)
Above the Tree Line	2.0	≥3.5
Below the Tree Line - North of Fort Simpson	1.5	≥3.0
Deh Cho –South of Fort Simpson	1.0	≥2.5

A brief project summary report documenting and confirming total water volume used per water source and corresponding dates should be submitted to DFO within 60 days of project completion. Information should be provided in the following format (this information would also be useful as part of the project description):

Lake ID	number and/or name
Coordinates	latitude and longitude and/or UTM coordinates
Surface area	in ha
Total Lake Volume	in m^3
Under Ice Volume	in m^3 (based on max ice thickness for region)
Max expected ice thickness value used	in m
Calculated 10% Withdrawal volume	in m^3
Total required water volume extracted	in m^3
Aerial photographs of waterbody	PDF format
Bathymetric Map(s) of waterbody	PDF format

Any requests deviating from the above must be submitted to DFO and will be addressed on a site-specific basis.

Beaver and Muskrat

Many species of animals are highly sensitive to water fluctuations. In areas where beaver and muskrat may occur, the appropriate agencies or organizations should be consulted to determine if harmful effects will result from your activities, and whether these effects can be successfully mitigated through modifications to your plans including best management practices.

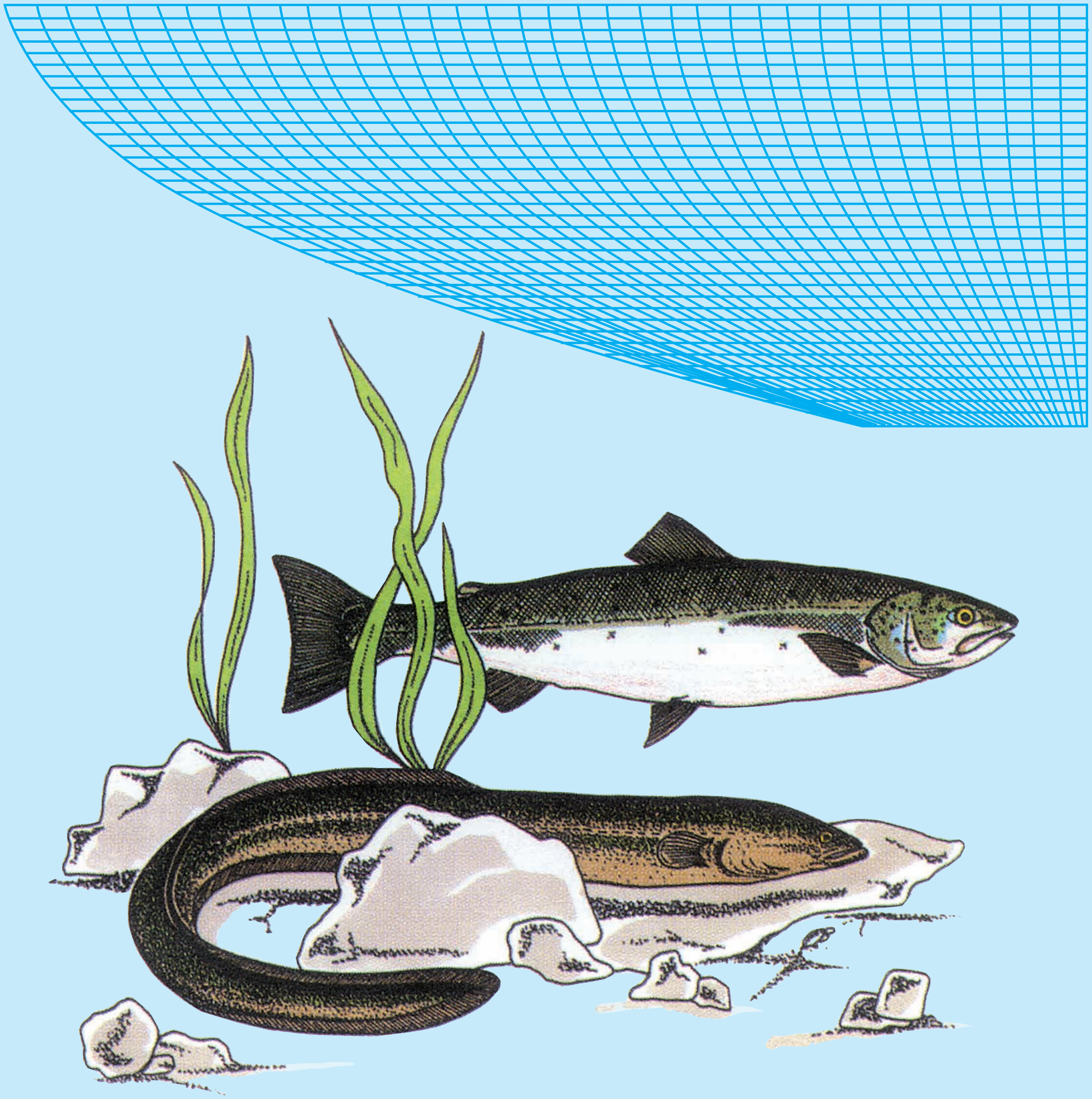
Please note that adherence to this protocol does not release the proponent of the responsibility for obtaining any permits, licenses or authorizations that may be required.

For more information contact DFO at (867) 669-4915.

Appendix III – DFO's Freshwater Intake End-of-Pipe Fish Screen Guidelines

Department of Fisheries and Oceans

Freshwater Intake End-of-Pipe Fish Screen Guideline



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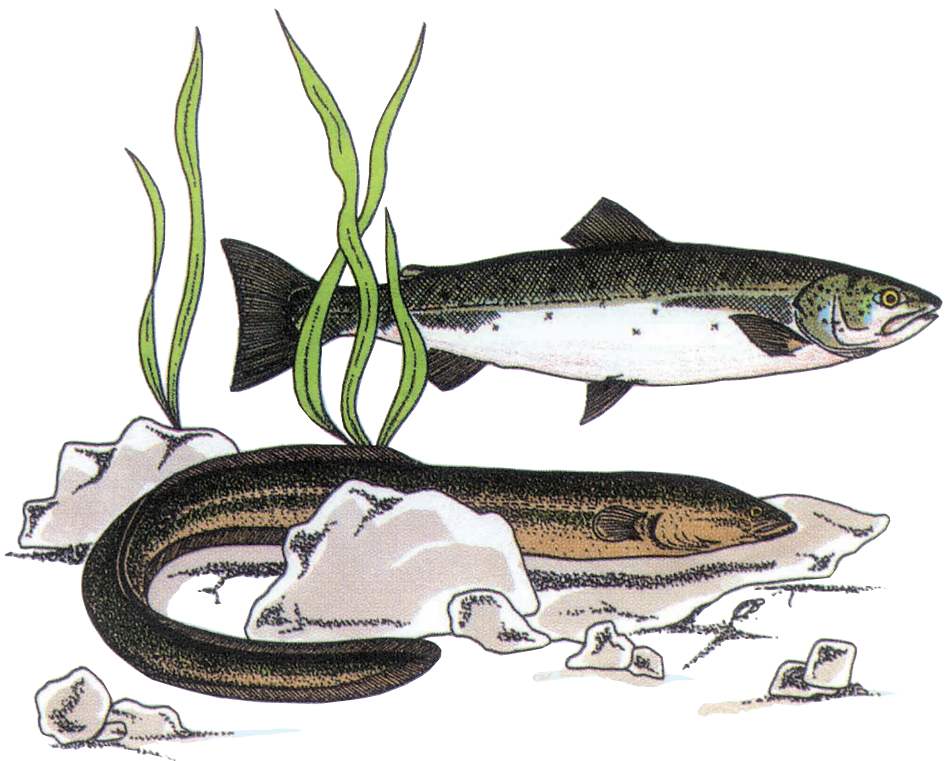
Department of Fisheries and Oceans

Freshwater Intake End-of-Pipe Fish Screen Guideline



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1.0 Introduction

The Department of Fisheries and Oceans (DFO) has prepared the **Freshwater Intake End-of-Pipe Fish Screen Guideline** to assist proponents in the design and installation of fish screens lfor the protection of anadromous and resident fish where freshwater is extracted from fish-bearing waters. This guideline will also assist regulatory agencies in the review of fish screen proposals.

A requirement for fish screening is stated under Section 30 of the *Fisheries Act*, where every water intake, ditch, channel, or canal in Canada constructed or adapted for conducting water from any Canadian fisheries waters must provide for a fish guard or a screen, covering, or netting over the entrance or intake so as to prevent the passage of fish into such water intake, ditch, channel or canal. Other sections of the *Fisheries Act*, or other Federal, Provincial, or Municipal Legislation and Policy may also apply to associated water extraction activities. Proponents are advised to contact the appropriate regulatory agencies regarding approvals or permits.

2.0 Guideline Objective

The objective of the guideline is to provide a National standard-of-practice and guidance for end-of-pipe fish screens at freshwater intakes to prevent potential losses of fish due to entrainment or impingement. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. The severity of the impact on the fisheries resource and habitat depends on the abundance, distribution, size, swimming ability, and behaviour of the organisms in the vicinity of the intake, as well as, water velocity, flow and depth, intake design, screen mesh size, installation and construction procedures and other physical factors.

The **Freshwater Intake End-of-Pipe Fish Screen Guideline** deals exclusively with the sizing and design of fixed screens that are often placed at the end of a pipe used to extract water up to 0.125 m^3/s, or 125 litres per second (L/s) (i.e., 2000 US gallons per minute (US gpm)). The guideline is intended for use in addressing fish screens for small permanent and temporary withdrawals for irrigation, construction, small municipal and private water supplies, etc. It is *not* intended for application to hydroelectric or canal screen designs; however, such proposals can be considered by regulatory agencies on a site-specific basis. The guideline focuses on the technical aspects of intake screens and the protection of fish rather than on policy, legislation, or environmental assessment processes and their application. This guideline has been developed to provide protection of freshwater fish with a minimum fork length of 25 mm (approximately 1 inch) since most eggs and fish larvae remain in bottom substrates until they reach the fry stage (i.e., 25 mm fork length). Other designs, in addition to intake screens, may be appropiate to address fish and fish habitat protection associated with water withdrawals. Such proposed designs should be addressed with the appropriate regulatory agencies on a site-specific basis.

3.0

Information Requirements for Evaluation of Intake Screens

Information that should be provided to facilitate evaluation of an end-of-pipe intake screen design intended for fish protection during a freshwater withdrawal is highlighted below. Types of information requirements that may also be applicable to the water intake project as a whole are identified in Appendix A.

- fish presence, species, and possible fish size or fish habitat conditions at the project site
- rate or ranges of rates of withdrawal from the watercourse
- screen open and effective areas
- physical screen open parameters with respect to the intake and the watercourse
- screen material, method of installation and supporting structures
- screen maintenance, cleaning, or other special requirements

4.0

Design, Installation, & Maintenance of Freshwater Intake End-of-Pipe Fish Screens

The appropriate design of a fish screen is largely dependent upon the species and the size of fish requiring protection. Appropriate installation and maintenance/cleaning of the screen are also important in keeping approach velocities low and ensuring satisfactory operation of the screen. For the purposes of this guideline, emphasis is placed on the protection of freshwater fish with a minimum fork length of 25 mm from entrainment and impingement due to water extraction activities. Depending upon site-specific circumstances, a case may be made whereby the minimum fork length size of fish to be protected is greater than 25 mm. In this instance, the fish screen criteria for open screen area (Table 2 and Figure 1) and screen mesh size (2.54 mm) presented here do not apply. Fish screen criteria and guidance for the protection of fish larger than 25 mm is provided by Katopodis (1992).

The following sections address the appropriate design of fixed freshwater intake end-of-pipe fish screens for the protection of fish with a minimum fork length of 25 mm. Guidance on installation, cleaning, and maintenance is provided. Common types of intake screens and associated intakes are also presented. Appendix B presents a sample calculation utilizing the guideline to determine the appropriate end-of-pipe intake screen size for the protection of freshwater fish.

4. 1 Fish Screen Criteria

To protect fish from impingement or entrainment, the approach velocity (i.e., the water velocity into, or perpendicular to, the face of an intake screen) should not exceed certain values based on the swimming mode (i.e., subcarangiform or anguilliform) of the fish present in the watercourse. The subcarangiform group includes fish that swim like a trout or salmon, and move through the water by undulating the posterior third to half of their bodies. The anguilliform group includes fish that swim like an eel, and move through the water by undulating most or all of their body. Table 1 presents the swimming modes of most common fish species in Canada. Contact DFO or provincial fisheries agencies regarding fish species that are not included in Table 1.

Envelope curves for approach velocities were developed for each swimming mode corresponding to a minimum fork length of 25 mm and a maximum endurance time of 10 minutes (the time the fish is in front of the face of the screen before it can elude it). To satisfy approach velocities of approximately 0.11 m/s and 0.038 m/s for the subcarangiform and anguilliform groups respectively, curves indicating the required open screen areas, based on fish swimming performance data, including fish species and size (Katopodis, 1990) and related to flows/extractions, were developed. Table 2 presents the required open screen area, in both metric and non-metric units, for end-of-pipe intake screens with a capacity up to 125 L/s (2000 US gpm). The open screen area is the area of all open spaces on the screen available for the free flow of water. The same information is presented graphically in Figure 1.

Table 1
Summary of Common Fish Species and Swimming Modes

SUBCARANGIFORM SWIMMING MODE

Common Name	Scientific Name
Alewife (Gaspereau)	*Alosa pseudoharengus*
Arctic Char	*Salvelinus alpinus*
Arctic Grayling	*Thymallus arcticus*
Atlantic Salmon	*Salmo salar*
Broad Whitefish	*Coregonus nasus*
Brook Trout	*Salvelinus fontinalis*
Brown Trout	*Salmo trutta*
Carp	*Cyprinus carpio*
Channel Catfish	*Ictalurus punctatus*
Chinook Salmon	*Oncorhynchus tshawytscha*
Chum Salmon	*Oncorhynchus keta*
Cisco	*Coregonus artedii*
Coho Salmon	*Oncorhynchus kisutch*
Cutthroat Trout	*Oncorhynchus clarki clarki*
Dolly Varden	*Salvelinus malma*
Goldeye	*Hiodon alosoides*
Green Sturgeon	*Acipenser medirostris*
Inconnu	*Stenodus leucichthys*
Kokanee	*Oncorhynchus nerka*
Lake Sturgeon	*Acipenser fulvescens*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Largemouth Bass	*Micropterus salmoides*
Longnose Sucker	*Catostomus catostomus*
Mooneye	*Hiodon tergisus*
Mountain Whitefish	*Prosopium williamsoni*
Ouananiche	*Salmo salar ouananiche*
Pink Salmon	*Oncorhynchus gorbuscha*
Rainbow Smelt	*Osmerus mordax*
Rainbow Trout	*Oncorhynchus mykiss*
Sauger	*Stizostedion canadense*
Smallmouth Bass	*Micropterus dolomieui*
Sockeye Salmon	*Oncorhynchus nerka*
Walleye	*Stizostedio vitreum*
White Bass	*Morone chrysops*
White Perch	*Morone americana*
White Sturgeon	*Acipenser transmontanus*
White Sucker	*Catostomus commersoni*
Yellow Perch	*Perca flavescens*

ANGUILLIFORM SWIMMING MODE

Common Name	Scientific Name
American Eel	*Anguilla rostrata*
Burbot	*Lota lota*
Sea Lamprey	*Petromyzon marinus*

Note: The few data points available for Northern Pike *(Esox lucius)* are close to the anguilliform group.

4.2 Design of Fixed End-of-Pipe Fish Screens

Once the required open area has been found from Table 2 or Figure 1, the effective screen area must be calculated. It is the area occupied by the open spaces (i.e., open screen area) and the screen material available for the free flow of water. The effective screen area should be provided at the intake location and is determined as follows:

$$\text{Effective Screen Area } (m^2 \text{ or } ft^2) = \frac{\text{Open Screen Area (Table 2)}}{\left(\frac{\text{\% Open Area (Table 3)}}{100}\right)}$$

It should be noted that if the percent (%) open screen area is maximized, then the effective screen area required for a given flow is minimized. The narrowest dimension of any opening on the screen is referred to as the design opening, regardless of opening shape. The maximum design opening for a fish of 25 mm fork length is estimated at 2.54 mm (0.10 inches). Guidance on screen openings and materials is presented below.

- The screen openings may be round, square, rectangular, or any combination thereof, but should not have any protrusions that could injure fish.
- Screen materials may include brass, bronze, aluminum, monel metal, galvanized or stainless steel, and plastics. The screen material should be resistant to corrosion and UV light.
- Note: clogging due to corrosion is minimized with the use of stainless steel.
- Welded wedge wire screens offer reduced debris clogging and increased open area and screen stiffness, in comparison to round wire mesh and punch plate.

Table 3 presents several common types of screening material that meet the requirements of wire diameter, clear opening width and percent open area,

The dimensions of the fish screen can be calculated after the correct shape, configuration, location, and method of installation have been determined. This will usually be determined after a site investigation and a review of these guidelines. Included in Figure 2 are common screen shapes and the associated

Table 2

Open Screen Area Required for End-of-Pipe Water Intakes

Metric Units

Flow (L/s)	Subcarangiform (m^2)	Anguilliform (m^2)
1	0.01	0.03
5	0.05	0.13
6	0.06	0.16
8	0.07	0.21
10	0.09	0.26
12	0.11	0.31
14	0.13	0.37
15	0.14	0.39
16	0.15	0.42
18	0.17	0.47
20	0.18	0.52
22	0.20	0.58
24	0.22	0.63
25	0.23	0.65
26	0.24	0.68
28	0.26	0.73
30	0.28	0.79
32	0.30	0.84
34	0.31	0.89
35	0.32	0.92
36	0.33	0.94
38	0.35	0.99
40	0.37	1.05
45	0.42	1.18
50	0.46	1.31
55	0.51	1.44
60	0.55	1.57
65	0.60	1.70
70	0.65	1.83
75	0.69	1.96
80	0.74	2.09
85	0.78	2.23
90	0.83	2.36
95	0.88	2.49
100	0.92	2.62
110	1.02	2.88
120	1.11	3.14
125	1.16	3.30

Non-Metric Units

Flow (US gpm)	Subcarangiform (ft^2)	Anguilliform (ft^2)
10	0.1	0.2
50	0.3	0.9
100	0.6	1.8
150	0.9	2.7
200	1.3	3.6
250	1.6	4.5
300	1.9	5.4
350	2.2	6.2
400	2.5	7.1
450	2.8	8.0
500	3.2	8.9
550	3.5	9.8
600	3.8	10.7
650	4.1	11.6
700	4.4	12.5
750	4.7	13.4
800	5.0	14.3
850	5.4	15.2
900	5.7	16.0
950	6.0	16.9
1000	6.3	17.8
1050	6.6	18.7
1100	6.9	19.6
1150	7.2	20.5
1200	7.6	21.4
1250	7.9	22.3
1300	8.2	23.2
1350	8.5	24.1
1400	8.8	25.0
1450	9.1	25.8
1500	9.4	26.7
1550	9.8	27.6
1600	10.1	28.5
1650	10.4	29.4
1700	10.7	30.3
1750	11.0	31.2
1800	11.3	32.1
1850	11.6	33.0
1900	12.0	33.9
1950	12.3	34.8
2000	12.6	35.7

Table 3

Examples of Sereen Material

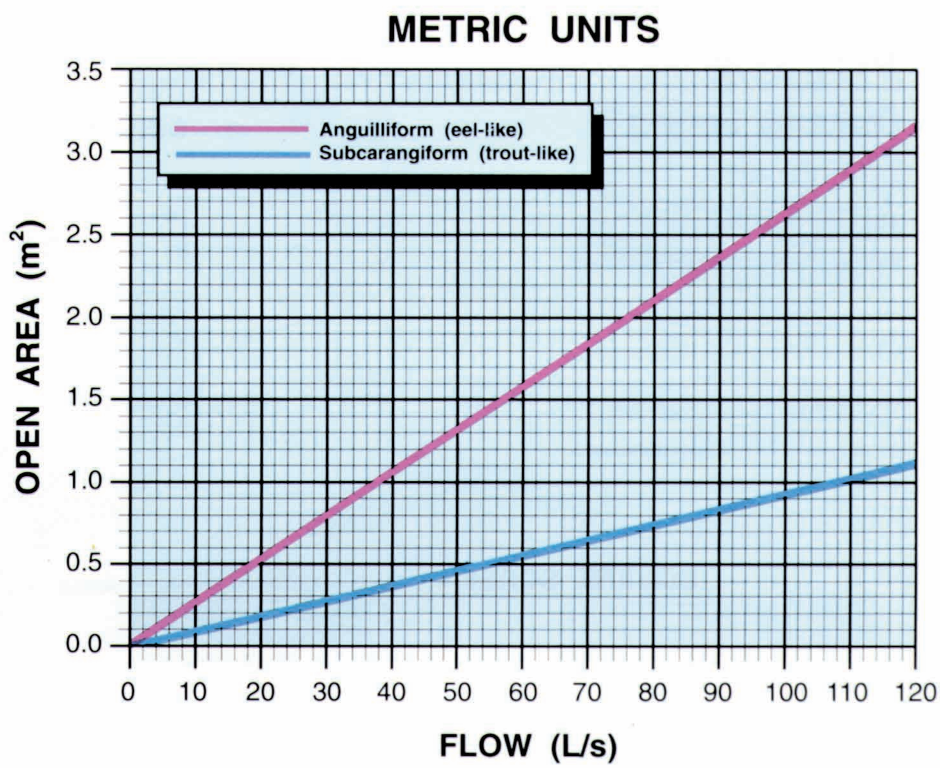
Material	Wire Thickness	Opening Width	% Open Area
8x 8 Stainless Steel Alloy Mesh	0.711 mm (0.028")	2.44 mm (0.096")	60
#7 Mesh Wire Cloth	1.025mm (0.041")	2.54 mm (0.100")	51
#8 Mesh Wire Cloth	0.875 mm (0.035")	2.25 mm (0.089")	52
#8 Mesh Wire Cloth	0.700mm (0.028")	2.54 mm (0.100")	62
#60 Wedge Wire Screen	1.50mm (0.059")	2.54 mm (0.100")	63
#45Wedge Wire Screen	1.10mm (0.080")	2.54 mm (0.100")	69

dimensions and area formulae. These are just examples of the many shapes and sizes in which fish screens can be fabricated. Screens are instream structures and, as such, should have sufficient strength and durability, and be capable of withstanding any potential large forces and impacts. Figure 3, 4, and 5 illustrate some of the various configurations, applications, and screen material types of end-of-pipe fish screens.

4.3 Installation

- Screens should be located in areas and depths of water with low concentrations of fish throughout the year.
- Screens should be located away from natural or man-made structures that may attract fish that are migrating, spawning, or in rearing habitat.
- The screen face should be oriented in the same direction as the flow.
- Ensure openings in the guides and seals are less than the opening criteria to make "fish tight".
- Screens should be located a minimum of 300 mm (12 in.) above the bottom of the watercourse to prevent entrainment of sediment and aquatic organisms associated with the bottom area.
- Structural support should be provided to the screen panels to prevent sagging and collapse of the screen.
- Large cylindrical and box-type screens should have a manifold installed in them to ensure even water velocity distribution across the screen surface. The ends of the structure should be made out of solid materials and the end of the manifold capped.
- Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody material, leaves, algae mats, etc.). A 150 mm (6 in.) spacing between bars is typical.

Figure 1
Open Screen Area for End-of-Pipe Water Intake Flow



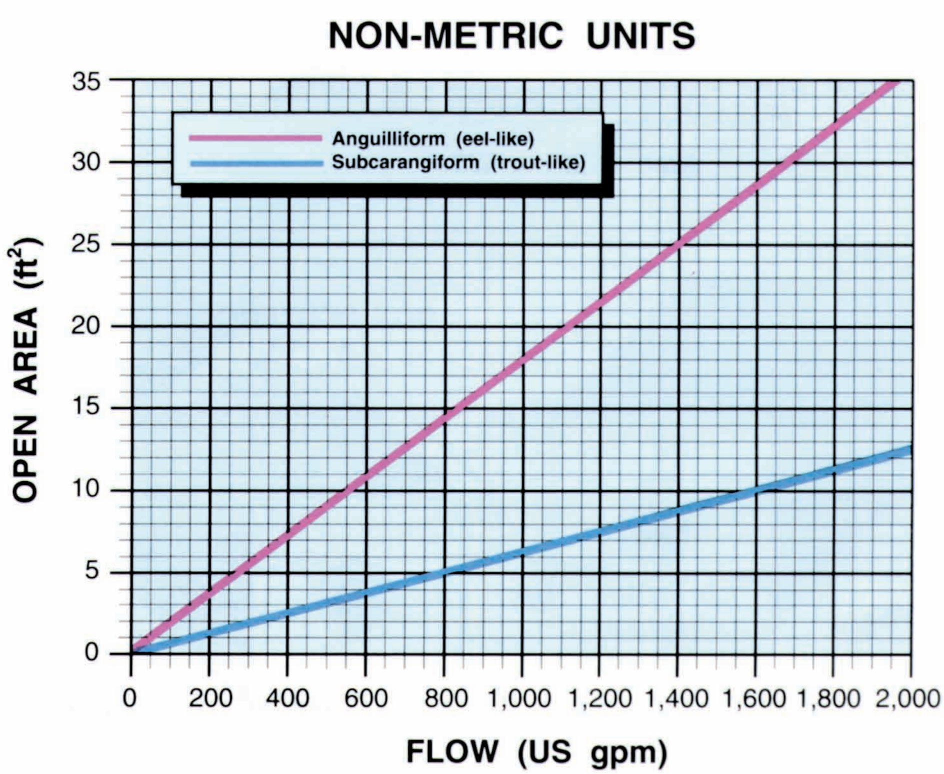


Figure 2
Common Screen Shapes and Area Formulae

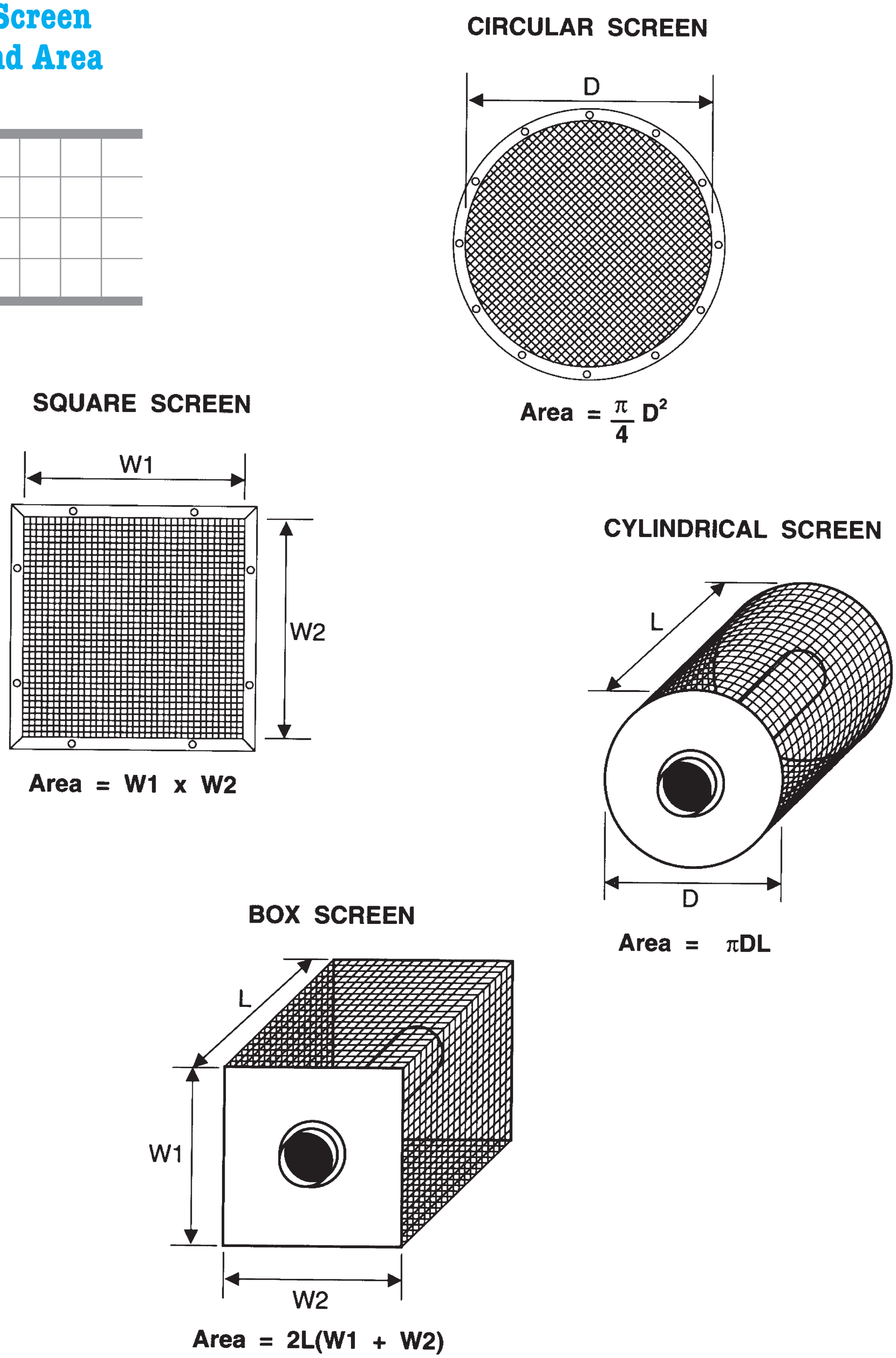


Figure 3
Typical Applications and Features of End-of-Pipe Screens

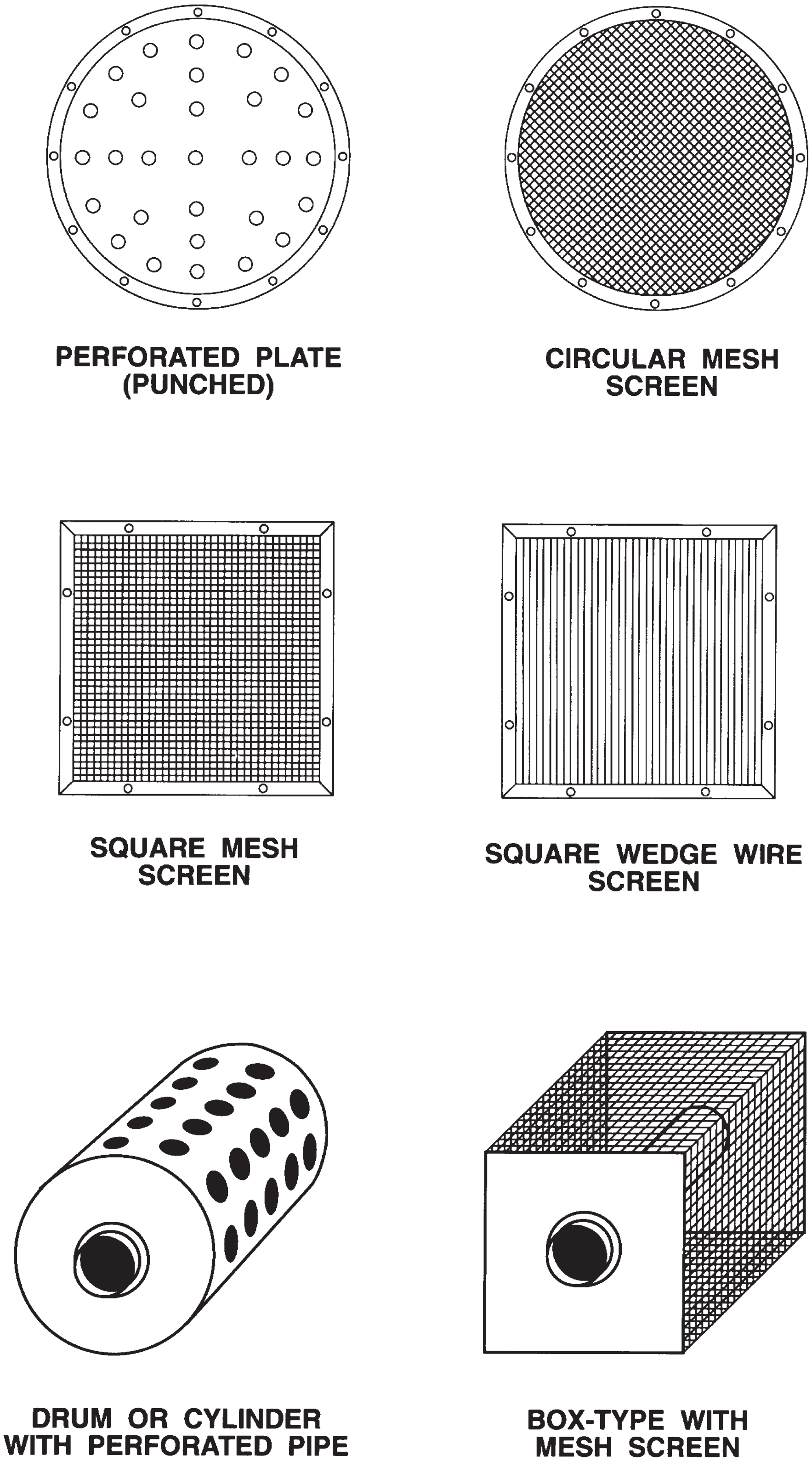
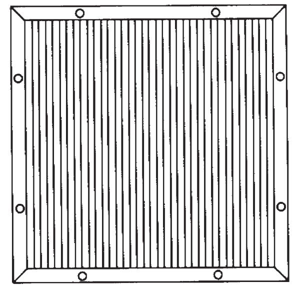
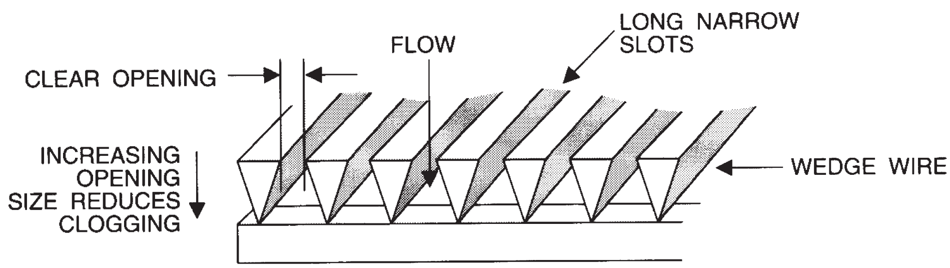


Figure 4

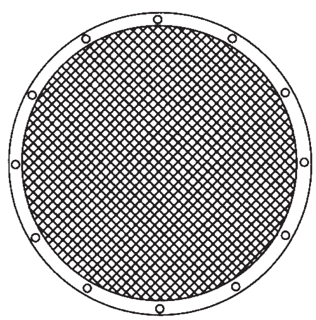
Examples of Typical Screen and Material Types



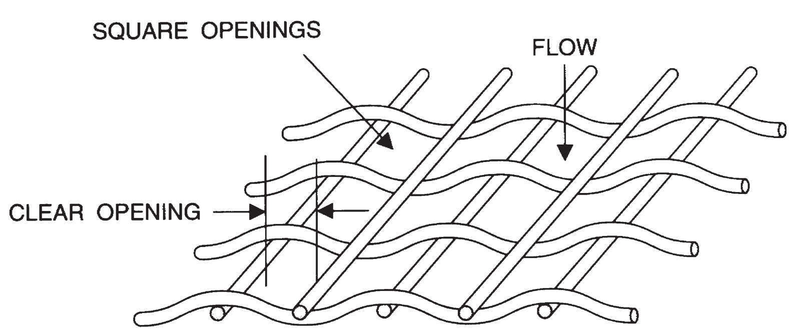
SQUARE WEDGE WIRE SCREEN



WEDGE WIRE PROFILE

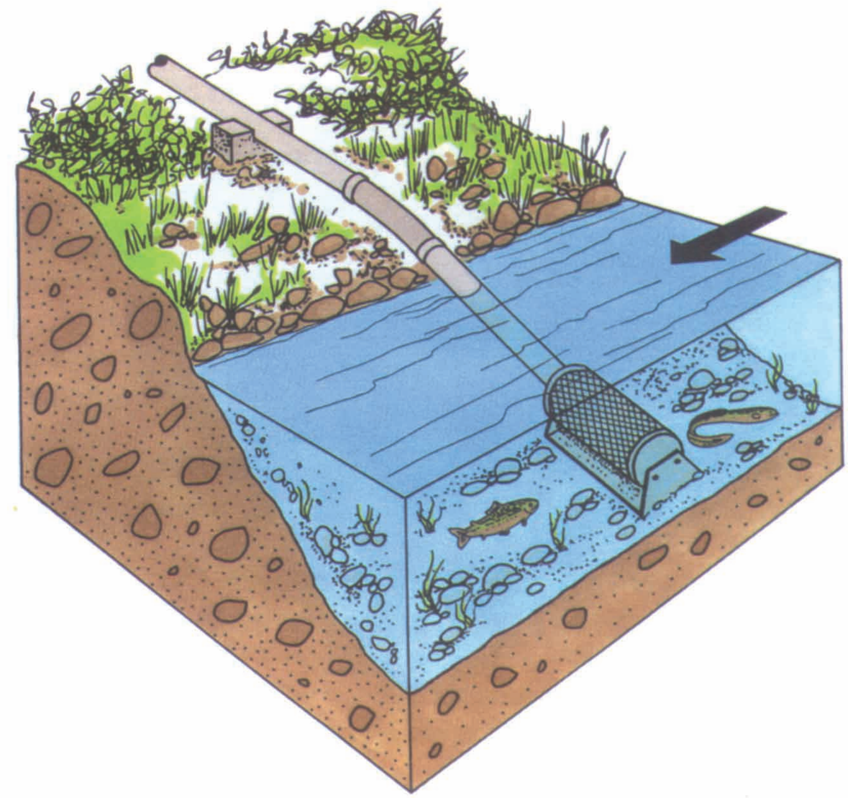


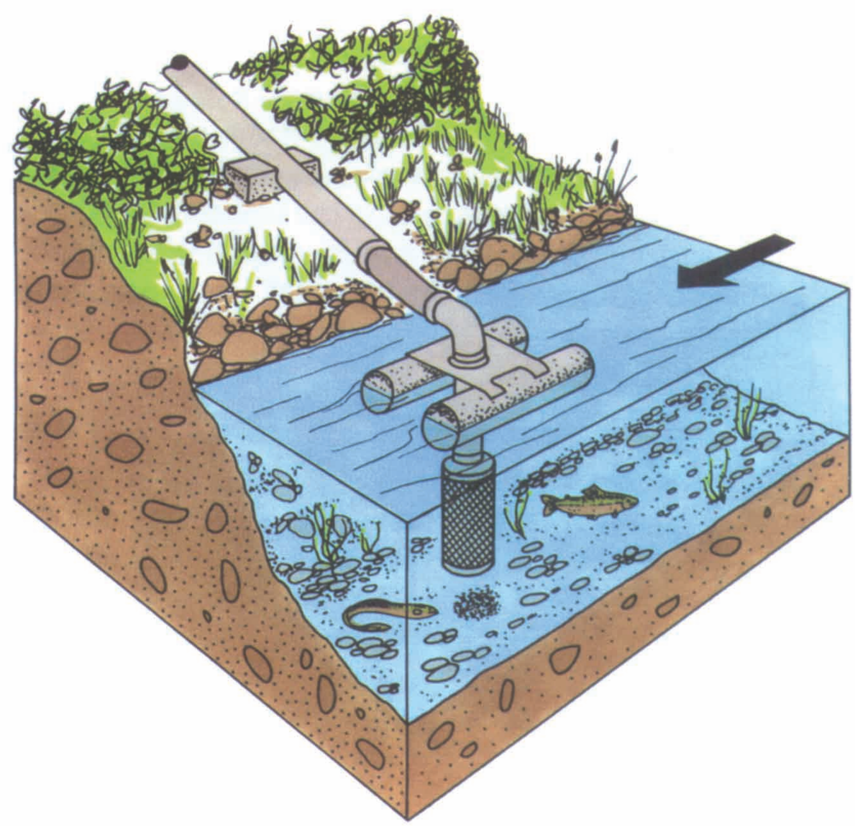
CIRCULAR MESH SCREEN

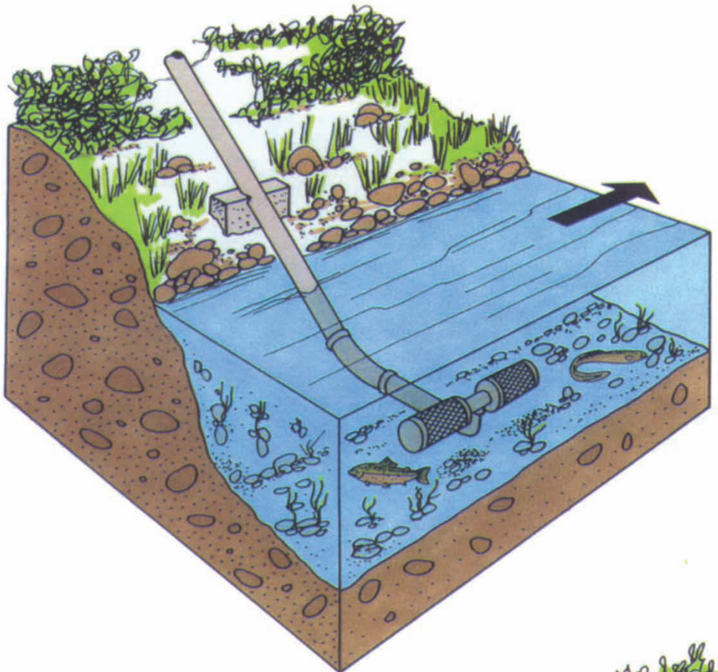


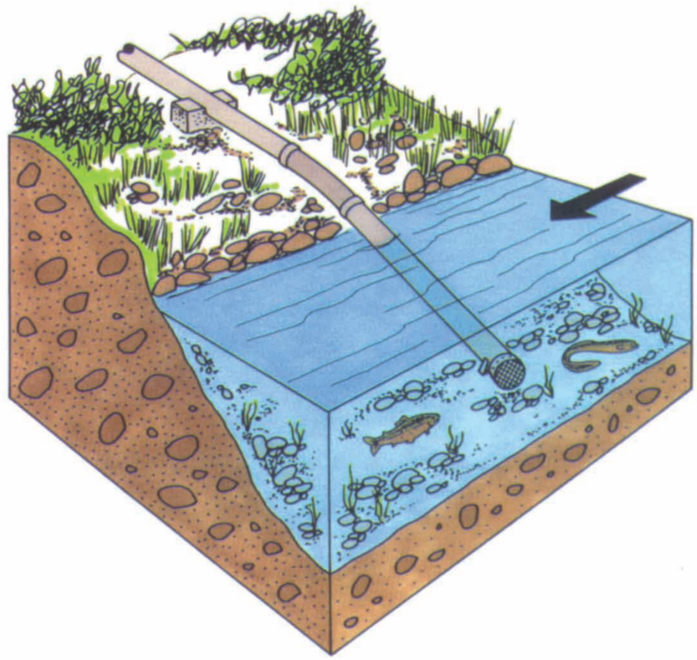
WOVEN WIRE MESH PROFILE

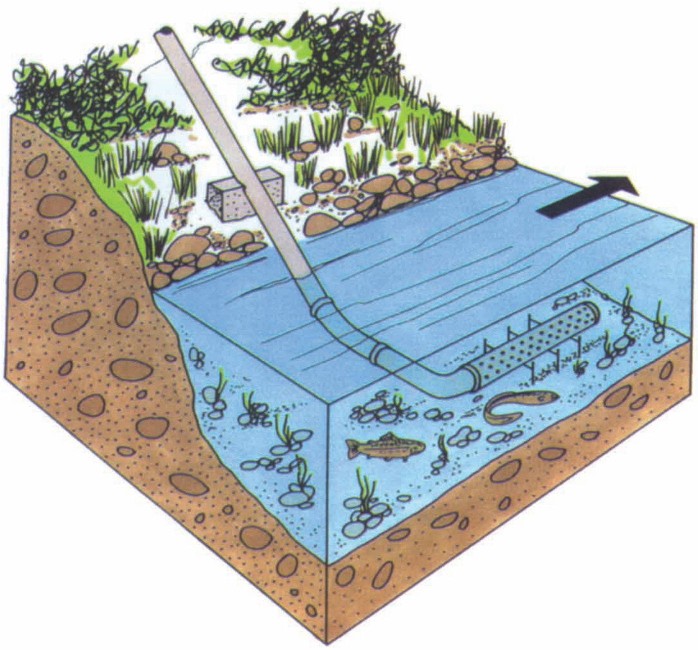
Figure 5
Examples of Typical Installations of End-of-Pipe Screen











4.4 Cleaning and Maintenance

- Provision should be made for the removal, inspection, and cleaning of screens.
- Ensure regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish.
- Pumps should be shut down when fish screens are removed for inspection and cleaning.
- Screens may be cleaned by methods such as air or water, backwashing, removal and pressure washing or scrubbing.
- Under certain site-specific winter conditions, it may be appropriate to remove screens to prevent screen damage.
- Flexible suction pipe may be used instead of solid, fixed piping for ease of screen removal and cleaning.
- Pump suction pressure can be measured to assess the need for screen cleaning.

To facilitate intake screen cleaning/maintenance, design and installation features such as orientation of the screen (e.g., in a cove) or variation in mesh shape (i.e., square wire/bars versus round wire/bars), etc. may be considered for regularly cleaned screens. For screens that will not be cleaned regularly, provision of considerably more open screen area (e.g., four times more) than determined from Table 2/Figure 1 may be considered. Such design/installation features should be addressed with the appropriate regulatory agencies on a site-specific basis.

Appendix C presents a list of units of conversion.

For more information on the appropriate design of freshwater intake end-of-pipe fish screens, contact the nearest DFO office. In addition, a list of DFO Regional contacts is presented in Appendix D. Other appropriate regulatory agencies should also be contacted.

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Glossary

Anadromous: Fish species that migrate from the sea to freshwater systems in order to spawn.

Anguilliform: The type of swimming mode for fish that swim like an eel, and move through the water by undulating most or all of their body.

Effective Screen Area: The area occupied by the open spaces (i.e., open screen area) and screen material available for the free flow of water.

Entrainment: Occurs when a fish is drawn into a water intake and cannot escape.

Fork Length: The straight line distance measured from the tip of the nose to the fork of the tail of a fish.

Impingement: Occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.

Open Screen Area: The area of all open spaces on the screen available for the free flow of water.

Subcarangiform: The type of swimming mode for fish that swim like trout or salmon, and move through the water by undulating the posterior third to half of their body.

Appendix A
Information Requirements

Appendix A Information Requirements

Types of information requirements that may be applicable to a freshwater intake proposal are highlighted below. While this listing is not intended to be all inclusive, it indicates information that may be necessary to enable regulatory agencies to review a water intake and fish screen proposal. The information highlighted below considers Section 30 and other sections of the *Fisheries Act* .These information requirements may also address other Federal, Provincial, and Municipal legislation and policies.

General and Site Information

- gazette or common name of the watercourse
- location of the watercourse
- type of watercourse (e.g., pond or stream)
- type of water intake
- other activities associated with the development or construction of the intake/screen structure

Biophysical Information

- fish presence, species, and possible fish size or fish habitat conditions at the protect site
- physical description of the watercourse at the intake site, including channel width and depth, direction and velocity of water currents, variations in wafer levels, sediment transport processes, lateral or channel grade movement, debris loading, etc.
- location and position of the intake within the watercourse, including dimensions, alignment, depth in the water column, wetted area, etc.
- description of the site features and characteristics, including site access

Water Use Information

- purpose of water withdrawal

- average rate, or ranges of rates, of withdrawal from the watercourse
- duration and lime of withdrawal
- estimates of ranges of flow (i.e., daily, weekly, monthly) in the watercourse during times of withdrawal with dates and times of year (with particular consideration to periods of low flow)
- expected effects of withdrawal on existing watercourse (e.g., drawdown, downstream dewatering, etc)
- description of structures or activities associated with the development of the intake
- whether the application is for a new intake, or re-development or upgrading of an existing structure

Other Information

- site plans/sketches indicating intake site and location (detailed on 1:50,000 topographic map)
- photographs/video of the site are often useful

Fish Screen Information

- screen open and effective areas
- physical screen parameters with respect to the intake and the watercourse
- screen material, method of installation and supporting structures
- screen maintenance, cleaning or other special requirements

Appendix B
Sample Calculation

A proponent wishes to withdraw water at a rate of 0.075 m^3/s from a nearby pond. The pond supports populations of brown trout, brook trout, and American eel. The intake is proposed to be cylindrical with the ends solid and #60 wedge wire screen around the cylinder.

What size must the intake screen be to satisfy the guideline requirements?

There are 4 steps to finding the answer:

1. Determine the fish swimming mode.
2. Determine the open screen area.
3. Determine the effective screen area.
4. Determine the dimensions necessary to produce the effective screen area.

1. Fish Swimming Mode

The fish swimming mode is found from Table 1. Brook trout and brown trout are listed as subcarangiform swimmers, while the American eel is an anguilliform swimmer.

2. Open Screen Area

Table 2 lists the required open screen area for both subcarangiform and anguilliform swimmers under flows up to 125 L/s (2000 US gpm). To use the table, if is necessary first to convert the flow from cubic metres per second to litres per second.

$$0.075 \frac{m^3}{s} \times \frac{1000 \text{ L}}{1 \text{ m}^3} = 75 \frac{L}{s}$$

For a flow of 75 L/s, Table 2 indicates that the open screen area must be:

- 0.69 m^2 for subcarangiform swimmers, and
- 1.96 m^2 for anguilliform swimmers.

The higher number (1.96 m^2) is the more stringent requirement, therefore, it is used in the calculation of effective screen area,

3. Effective Screen Area

The screen material in this case is # 60 Wedge Wire. A review of Table 3 indicates that the % Open Area for this material is 63%, With this value and the previously determined area from Step 2, the following formula is used to determine the Effective Screen Area.

$$\text{Effective Screen Area} = \frac{\text{Open Screen Area}}{\left(\frac{\text{\% Open Area}}{100}\right)}$$

$$= \frac{1.96\ m^2}{\left(\frac{63}{100}\right)}$$

$$= 3.111\ m^2$$

4. Dimensions of Intake Screen

Figure 2 lists several common screen shapes and their respective area formulae. For a cylindrical screen where the ends are solid and screening is around the cylinder, the following formula applies:

$$\text{Area} = \pi DL$$

The unknown dimensions are diameter (D) and length (L). These dimensions are determined by choosing a value for one and solving the equation for the other.

If the diameter is 0.600 m, then the length follows as:

$$\text{Area} = \pi DL$$

$$3.111\ m^2 = (0.600\ m)L$$

$$3.111\ m^2 = (1.885\ m)L$$

$$L = \frac{3.111\ m^2}{1.885\ m}$$

$$L = 1.65\ m$$

A 0.600 m diameter, 1.65 m long cylindrical screen would meet the design requirements. It should be noted that the dimensions given are representative of the screening area only; they do not include any screen that may be blocked by framing, etc. By comparison, if the pond only supported trout (subcarangiform), a 0.600 m diameter, 0.58 m long cylindrical screen would meet the design requirements.

Appendix C
Units of Conversion

To Convert	Into	Multiply By
cubic feet per second	cubic metres per second	0.0283
cubic feet per second	litres per second	28.3
cubic feet per second	US gallons per minute	448.9
cubic metres per second	cubic feet per second	35.3
cubic metres per second	US gallons per minute	15850
litres per second	cubic feet per second	0.0353
litres per second	cubic feet per minute	2.12
litres per second	cubic metres per second	0.001
litres per second	US gallons per minute	15.85
square metre	square foot	10.76
square metre	square inch	1550
square foot	square metre	0.0929
US gallons per minute	litres per second	0.0631
US gallons per minute	cubic feet per second	0.00223
US gallons per minute	Imperial gallons per minute	0.833
Imperial gallons per minute	litres per second	0.0758

Appendix D
DFO Regional Contacts

NEWFOUNDLAND REGION	Habitat Management Division P.O. Box 5667 St. John's NF A1C 5X1 Tel: 709-772-6157 Fax: 709-772-5562
GULF REGION	Habitat Management Division P.O. Box 5030 Moncton NB E1C 9B6 Tel: 506-851-6252 Fax: 506-851-6579
SCOTIA-FUNDY REGION	Habitat Management Division P.O. Box 550 Halifax NS B3J 2S7 Tel: 902-426-6027 Fax: 902-426-1489
QUEBEC REGION	Fish Habitat Management P.O. Box 15550 Quebec QC G1K 7Y7 Tel: 418-648-4092 Fax: 418-648-7777
CENTRAL & ARCTIC REGION	Habitat Management 501 University Crescent Winnipeg MB R3T 2N6 Tel: 204-983-5181 Fax: 204-984-2404
PACIFIC REGION	Habitat Management 555 W. Hastings St. Vancouver BC V6B 5G3 Tel: 604-666-6566 Fax: 604-666-7907

Local DFO offices should be contacted. Other appropriate regulatory agencies should also be contacted.

Appendix IV - Monitoring Explosive-Based Winter Seismic Exploration in Water Bodies NWT 2000- 2002. Cott, P., B. Hanna, J. Dahl. 2003.

Offshore Oil and Gas Environmental Effects Monitoring

Approaches and Technologies

Edited by Shelley L. Armsworthy, Peter J. Cranford, and Kenneth Lee

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Monitoring Explosive-Based Winter Seismic Exploration in Waterbodies, NWT 2000–2002

Cott, P. (cottp@dfo-mpo.gc.ca) and B. Hanna (Department of Fisheries and Oceans, Yellowknife, NWT, Canada)

ABSTRACT: During the winter of 2000/2001, there was a resurgence of oil and gas exploration in the Mackenzie Delta area of the Northwest Territories. Explosives were the primary energy source for seismic exploration crossing waterbodies not frozen to the bottom. Industry initially followed burial depths outlined in the Department of Fisheries and Oceans, *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* (the Guidelines), when setting charges under waterbodies. The instantaneous pressure change (IPC) in the water column resulting from charge detonation was monitored and revealed that many charges produced IPC higher than DFO's 100 kPa threshold guideline for the protection of fish. DFO required additional monitoring and subsequently determined that 50% of the remaining charges monitored and recorded (n = 429) exceeded 100 kPa. As a result, DFO outlined a series of requirements for 2001/2002 winter seismic exploration programs. These included program-specific testing of charge size/burial depth combinations prior to initiating production

seismic programs over waterbodies. The test results indicated that 10 of 11 explosive-based seismic programs required increased burial depths for production shot holes; up to five-times the distance outlined in the Guidelines in order to not exceed the 100 kPa threshold. Despite using greatly increased burial depths for a given charge size in most cases, approximately 1 of 12 charges monitored and recorded (n = 507) still exceeded 100 kPa. Although the reasons for high IPC are not fully understood, it is clear that the IPC from the use of explosives in waters potentially bearing fish is not entirely predictable. Due to the potential negative impacts on fish, DFO no longer authorizes explosive-based seismic exploration programs under waterbodies not frozen to the bottom in the NWT.

INTRODUCTION

It has been well documented that the use of explosives in aquatic environments has the potential to negatively impact fish by rupturing the swim bladder and/or damaging other internal organs (Falk and Lawrence, 1973; Teleki and Chamberlain, 1978; Wright, 1982; Alaska Department of Fish and Game, 1991; CAPP, unpublished); hence, the Department of Fisheries and Oceans developed the *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* (hereafter the Guidelines). The Guidelines recommend burial depths for given charge sizes for certain generalized substrate types. These charge size/burial depth combinations were intended to keep peak pressures of the Instantaneous Pressure Change (IPC) in the water column below a critical threshold of 100 kPa, a level believed to cause fish injury or death. The killing of fish by any means other than fishing is prohibited under Section 32 of the *Fisheries Act* unless authorized by the Department of Fisheries and Oceans (Government of Canada, 1985).

Alaska has many similarities to the Northwest Territories (NWT) in both environment and types of hydrocarbon exploration and development. Current mitigation for seismic exploration in Alaska prohibits the use of explosives in fish-bearing waters, and charges cannot be set under or near fish-bearing waters if the explosive produces IPC values greater than 2.5 pounds per square inch (17.2 kPa) unless the waterbody and its substrates are solidly frozen (Alaska Department of Natural Resources, 2003). The last explosive-based seismic program near waterbodies approved in Alaska was in the late 1980s, however it was never conducted as the company withdrew the application (A. Ott, Alaska Department of Fish and Game, pers. comm.).

In 2000, seismic exploration and exploratory drilling programs re-commenced in the NWT at a scale not seen since the 1970s and early 1980s. Seismic exploration projects were conducted throughout the Mackenzie Delta and surrounding area within the Inuvialuit Settlement Region (ISR), using both dynamite and vibrator energy sources. Over 11,000 km of 2-D and 3-D seismic lines were surveyed (Cott et al., 2003; Fig. 1).

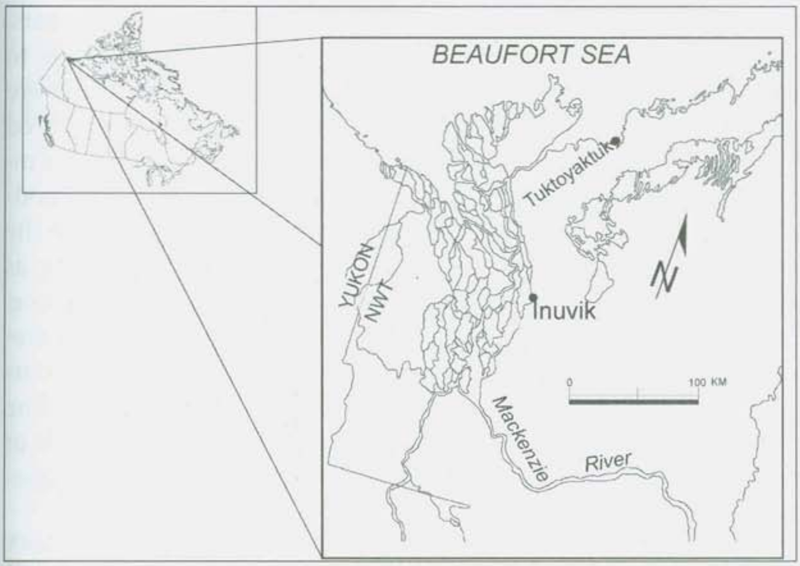

FIGURE 1. The Mackenzie Delta and surrounding area within the Inuvialuit Settlement Region, NWT where Instantaneous Pressure Change monitoring of explosive-based winter seismic programs 2000/2001 and 2001/2002 was conducted.

Most of the seismic exploration conducted under waterbodies not frozen to the bottom (including lakes, delta channels, and the near-shore Beaufort Sea) used dynamite as the energy source. Burial depths outlined within the Guidelines were followed when shooting under waterbodies not frozen to the bottom. In the winter of 2000/2001, industry experienced problems maintaining the desired depth of buried charges, particularly when using a Vibra-ram® (seismic drilling equipment using a vibrating rod designed to deploy explosive charges in soft substrates). Concerned with exceeding the instantaneous pressure change (IPC) threshold, industry voluntarily implemented an IPC monitoring program and notified DFO that in many cases, IPC was exceeding 100 kPa. This experience prompted DFO to increase requirements, such as extensive IPC monitoring, for seismic programs proposed for the following winter season.

MATERIALS AND METHODS

Monitoring of IPC was conducted in 2000/2001 and 2001/2002 during winter seismic exploration in the NWT. In both years, seismographs equipped with hydrophones were used to measure IPC. The most frequently used seismographs were the BlastMate™ and MiniMate™ series units manufactured by Instantel®. These units are portable and capable of a sampling rate greater than 16,000 s^{-1} (up to 65,536 s^{-1} on some models; Instantel, 2001). The sampling rate for units was set to the highest possible frequency in order to ensure a reading as close to the true peak pressure as possible (AquaScience, 2001a; R. Cyr, Explotech, pers. comm.). The waveform frequency of dynamite is very high, with peak pressure occurring within 1/1000th of a second of detonation. The hydrophones used in the monitoring program are capable of recording IPC in the water-column up to 346 kPa (AquaScience, 2001a).

Monitoring for IPC was conducted using three hydrophones placed under the ice in the water column; each suspended approximately 15 cm above the bottom. Hydrophones set during the 2000/2001 monitoring were placed above the shot hole (0 m), 5 m, and 15 m laterally away from the shot hole, measuring from the initial auger hole on the ice surface where the charge was loaded (AquaScience, 2001b). The reason for the placement of three hydrophones at different distances from the charge was to determine the rate of energy attenuation and potential area of exposure of IPC to fish.

For monitoring in the winter of 2001/2002, a minimum sampling frequency of 16,000 s^{-1} per hydrophone was specified. In addition, there was a change made in the hydrophone placement requirements. The three hydrophones were now placed directly over the shot hole (burial depth plus 0 m), burial depth plus 5 m, and burial depth plus 10 m. Trigonometry was used to calculate the appropriate lateral distance on the ice surface. This method enabled standardized hydrophone placement laterally from the shot hole regardless of the burial depth achieved (Fig. 2).

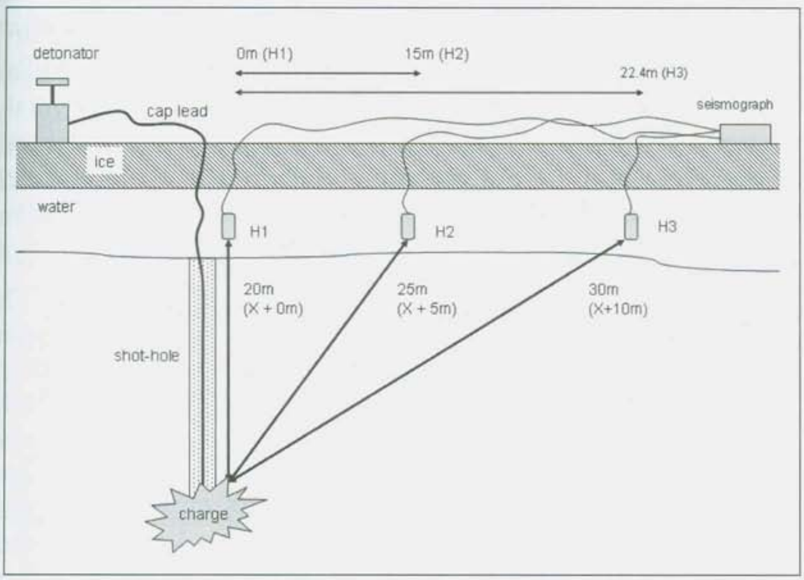

FIGURE 2. Hydrophone placement for instantaneous pressure change (IPC) monitoring using a 20 m burial depth example. Hydrophone 1 (HP1) is placed directly above the shot-hole to monitor burial depth of 20 m, HP2 is placed 15 m laterally from shot-hole to monitor burial depth + 5 m and HP3 is placed at 22.4 m laterally from shot-hole to monitor burial depth + 10 m.

It should be noted that pre- and post drilling, and pre- and post detonation water quality monitoring for turbidity, suspended solids and dissolved oxygen, and long-term water quality monitoring of waterbodies exposed to seismic activity was also conducted (Cott et al., 2003).

RESULTS AND DISCUSSION

Since it was not feasible to leave potentially shallow buried charges un-detonated due to safety concerns, DFO issued authorizations under section 32 of the *Fisheries Act* to allow for the completion of seismic programs experiencing high IPC values in the winter of 2000/2001. The authorizations stipulated monitoring 20% of the un-detonated charges remaining under waterbodies. Determination of charge burial depth was based on the amount of cap lead on the ice surface (i.e. burial depth of charge = total cap lead used – (ice depth + water depth + remaining cap lead on the ice surface)).

Of the 436 charges monitored and recorded for IPC in 2000/2001, 50.0% exceeded 100 kPa and 74.6% exceeded 50 kPa directly above the shot-hole (Table 1; Fig. 3). After several unsuccessful attempts were made to rectify the shortcomings of the Vibra-ram®, DFO recommended that it no longer be used when conducting seismic activities under waterbodies

TABLE 1. Summary of instantaneous pressure change data (IPC) data from monitoring explosive-based seismic exploration, by hydrophone (H) in the Mackenzie Delta area, NWT, 2000–2002. *Reasons for "no record" include an iced hydrophone, IPC value below the trigger setting on the monitoring equipment (< 5 kPa), or an undetonated charge.

IPC (kPa)	H-1 recorded and monitored % (n)	H-1 monitored % (n)	H-2 monitored % (n)	H-3 monitored % (n)
Winter 2000/ 2001	(n = 429)		(n total = 436)	
> 100	50.0 (214)	49.1 (214)	25.2 (110)	13.1 (57)
100 - 50	24.7 (106)	24.3 (106)	10.1 (44)	2.3 (10)
< 50	25.4 (109)	25.0 (109)	36.0 (157)	33.5 (146)
*no record	N/A	1.6 (7)	28.7 (125)	51.1 (223)
Winter 2001/2002	(n = 507)		(n total = 626)	
> 100	8.7 (44)	7.0 (44)	2.6 (16)	1.1 (7)
100 - 50	7.1 (36)	5.8 (36)	3.3 (21)	1.6 (10)
< 50	84.2 (427)	68.2 (427)	70.3 (440)	68.7 (430)
* no record	N/A	19.0 (119)	23.8 (149)	28.6 (179)

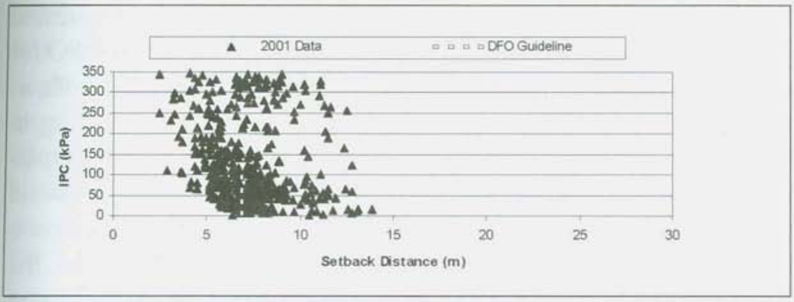

FIGURE 3. Instantaneous pressure change (IPC) values (kPa) versus burial depth (m) for 2.0 kg charges recorded directly above the shot-hole with hydrophone 1 for waterbodies not frozen to the bottom in the Mackenzie Delta area, NWT (January–April 2001).

not frozen to the bottom in the NWT. However, a great deal of variation in IPC values between program areas suggested that the reasons for excessive pressures were not limited to equipment problems or inadequate burial depths (Cott et al., 2003).

It should also be noted that a summer, open-water seismic test program using explosives on Parson's Lake, NWT, resulted in IPCs over 100 kPa and confirmed fish kills (Golder Associates Limited, 2000). This included charges buried to depths recommended in the Guidelines, indicating that the problem with high IPC values is not limited to winter conditions.

As a result of the previous year's experience, DFO outlined new requirements for conducting and monitoring seismic programs in the NWT. These requirements included the use of drilling technology proven to be effective in northern environments under winter conditions, proven mitigation to minimize the exposure of fish to critical IPC thresholds, contingency plans in place for unexpected events such as shallow buried charges, an assessment of alternative seismic exploration methods, IPC monitoring, long-term aquatic monitoring, and baseline studies on certain waterbodies likely to be encountered in the program areas (Cott et al., 2003). Also, it appeared that the Guidelines were being used too prescriptively, and that adjustments were required to account for site-specific conditions.

By the fall of 2001, industry had not presented the requested contingency plans and proven mitigation methods to DFO for review. As a result of these deficiencies, DFO issued a follow-up letter stipulating that charges should not exceed 2 kg in size, and that a conservative charge size/burial depth combination of 2 kg/15 m was being implemented in order to avoid exceeding the 100 kPa threshold. This charge size/setback combination is approximately double what is outlined in the Guidelines when using the rock substrate value (Wright and Hopky, 1998). As rock offers the most conservative value in the Guidelines, it was thought that that this precautionary approach would assist in providing an additional margin of safety to avoid or reduce impacts to fish.

Some proponents felt the 15 m minimum burial depth was too conservative, and that acceptable IPC values could be achieved with shallower depths. As such, a request was made to conduct field tests to demonstrate that shallower burial depths could achieve low IPC. DFO agreed to allow testing, and under *Fisheries Act* authorizations outlined IPC monitoring requirements for both tests and subsequent production seismic operations. The *DFO Western Arctic Area 2001/2002 Protocol for Monitoring the Use of Dynamite in Waterbodies not Frozen to the Bottom* was developed to assist proponents in developing monitoring programs, and to ensure consistency between seismic projects. The protocol was distributed to industry in February 2002. To take into account likely variations in subsurface geology, program-specific tests were used to determine appropriate combinations for individual program areas. Charge size/burial depth combinations for full production seismic exploration would be determined, pending the outcome of each program's test. The charge size/burial depth combinations using the rock substrate values outlined within the Guidelines would act as the minimum to begin testing.

Upon conclusion of the test programs, the burial depth for production seismic exploration on 10 out of the 11 programs had to be increased beyond double the Guideline levels, in some cases up to five times deeper (e.g. 24 m burial depth for 2 kg charge) in order to maintain IPC at levels that were consistently below 100 kPa. Also, through monitoring of production seismic operations, it was determined that the burial depths had to be increased for some programs as they encroached on different waterbodies in their program areas. During one program, the IPC on several charges surpassed 100 kPa in one lake after achieving safe IPC over much of their program area. In this case, the program was suspended by DFO until additional testing was conducted and a revised and acceptable charge size/burial depth combination was determined.

Despite the burial depths equal to, or in most cases, well beyond those outlined in the Guidelines, 8.7% of detonations monitored and recorded still produced IPCs in excess of 100 kPa, and 15.8% exceeded 50 kPa (n = 507) (Table 1; Fig. 4). The majority of charges used in production seismic were 2 kg, although other charge sizes were used experimentally and in limited production shooting.

Data derived from seismograph units that measured at frequencies of 16,000 s^{-1} and 65,000 s^{-1} were analysed together. This was acceptable as measurements taken at a frequency of 16,000 s^{-1} may be an under-representation of peak pressure. A higher sampling rate can more accurately delineate the peak pressure (R. Cyr, Explotech, pers. comm.; AquaScience, 2001a). Studies have indicated that seismograph units sampling at the

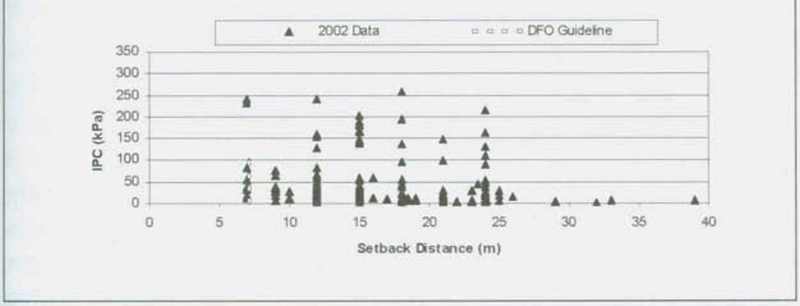

FIGURE 4. Instantaneous pressure change (IPC) values (kPa) versus burial depth (m) for 2.0 kg charges recorded directly above the shot-hole with hydrophone 1 for waterbodies not frozen to the bottom in the Mackenzie Delta area, NWT (January–April 2002).

higher frequencies record IPC values up to 25% higher than those sampling at lower frequencies, e.g. 65,000 s^{-1} versus 16,000 s^{-1} (Instantel, 2003; Explotech, unpublished data; T. Linton, Texas A and M University, unpublished data). If this is indicative of the differences between the two sampling rates it implies that the data sampled at 16,000 s^{-1} may be a gross underestimation of IPC peak pressure.

IPC was highly variable from waterbody to waterbody and within waterbodies even when the substrate appeared similar (similarity based on drillers' logs). This variability has been noted in other studies (T. Linton, Texas A and M University, unpublished data), and is possibly due to variations of the substrata, which further complicates the process of making accurate IPC predictions when applying the general substrate category values listed in the Guidelines (Cott et al., 2003).

No dead fish were observed in lakes by government regulators or industry during post-program site inspections. Due to the time between the seismic activity and ice melt (> 2 months), observed fish mortality was not anticipated as scavengers would have consumed any dead fish. Also, small-bodied fish are most susceptible to impacts from high IPC and would be very difficult to observe during aerial reconnaissance (Alaska Department of Fish and Game, 1991). Even during open water conditions, less than 50% of pressure-killed fish may actually be observed, due to injured fish swimming out of the immediate area prior to expiring or initially sinking to the bottom and surfacing at a later date (Teleki and Chamberlain, 1978).

Water quality monitoring from pre- and post drilling and pre- and post blasting showed that dissolved oxygen and turbidity exhibited a short-lived temporal and spatial increase (< 3 meters, < 10 minutes), or no change at all. The rapid settling of suspended sediments was observed with spot surveys using underwater video. Preliminary results from long-term monitoring suggest that seismic operations using explosive charges set several meters below the substrate of a waterbody do not adversely alter selected water quality parameters such as dissolved oxygen and turbidity. Similar findings were reported from water quality monitoring of the seismic operations during open-water conditions at Parsons Lake (Golder Associates Limited, 2000) and during underwater construction blasting in Lake Erie (Teleki and Chamberlain, 1978).

As a result of the data collected through the monitoring programs in 2000 to 2002, DFO released a position statement on February 14, 2003 that explosive-based seismic exploration in areas of waterbodies not frozen to the bottom in the NWT will not be authorized by DFO (Cott et al., 2003).

Lessons Learned

It became obvious that there were many potential reasons for the unpredictability of IPC values when conducting exploration under areas of waterbodies not frozen to the bottom. Differences were noted between program areas, within program areas, and between sequential shot holes under individual waterbodies. Possible reasons for high and/or unpredictable IPCs may include differences in substrate type, substrata, ice thickness, water depth, as well as equipment failure, human error, and subjectivity regarding substrate type on the part of drilling operators when working with different types of equipment. Most of these variables are difficult to predict or control in the field, and many are also a challenge to measure.

Conducting tests to determine acceptable charge size/burial depth combinations prior to initiating production seismic programs proved to be a prudent decision. The mean IPC level for production seismic exploration was approximately 43% lower than what was recorded during the testing phase as a result of using site-specific burial depth/charge size combinations determined for each production area. This was a successful example of adaptive management. If explosive-based seismic exploration programs under waterbodies are proposed elsewhere in Canada, it is imperative that project-specific testing to determine safe charge size/burial depth combinations be conducted to ensure that the potential for negative impacts to fish and fish habitat is minimized as much as possible.

A more conservative threshold of < 50 kPa should be utilized, rather than the 100 kPa in the Guidelines, which is essentially an LD_{50} where mortality of 50% of fish species exposed to that IPC would be expected (Wright and Hopky, 1998; D. Wright, DFO, pers. comm.). The < 50 kPa threshold should be used until such time that further research determines the correct threshold necessary to protect all life stages of fish. A lower threshold is also supported based on the results of IPC monitoring required by DFO biologists in the Pacific Region on a pile-driving operation after fish kills were observed. The IPC responsible for the fish kills were < 65 kPa (C. Salomi, DFO, pers. comm.; Cott et al., 2003). This would be closer to the guidelines used in Alaska; an area that has had much more experience with seismic exploration than the NWT.

Based on the results of short term and long term monitoring for dissolved oxygen (DO) and turbidity, the disturbance associated with deploying and detonating charges is thought to be negligible, and is not anticipated to have any adverse impact on fish and fish habitat in the Mackenzie Delta area.

Methods that were used to confirm burial depth of charges included keeping track of the number of drill stem sections and the total amount of cap-lead used. These methods are not precise and are subject to error such as slack cap-lead frozen under the ice giving an overestimation of burial depth. It is essential that a method to accurately measure and confirm burial depth be developed.

It is likely beneficial to allow time to elapse between charge burial and detonation. This is commonly referred to as "sleep time". If the detonation of a charge is delayed, the shot-hole has the opportunity to collapse on itself and re-consolidate; depending on substrate, the amount of energy escaping up the shot-hole may be reduced (R. Prudholm, Conoco, pers. comm.). The length of sleep time would be dependent on the type of substrate and its consolidation properties. The collapse of a shot-hole immediately upon drill stem removal was observed by using underwater video. Reducing the amount of energy transmitted up the shot-hole into the water column has the potential to lower the IPC value, likely minimizing impacts to fish. However, prolonged sleep time does not negate the need for adequate charge burial depth. Some extremely high IPCs (> 200 kPa) resulted from charges that "slept" for over a month.

Some of the most difficult variables to control are human error and subjectivity. In some cases, this relates directly to the equipment type being used by the individual operator. For instance, the operator's "feel" for what substrate is being encountered can be influenced by how powerful or heavy the particular drill is, and how the equipment is handled by different individuals. In one instance, an operator determined that consolidated material had been reached after going through 3 m of water. When this was checked by the person monitoring IPC, the water depth was actually 13 m. Mistakes happen. This is why it is imperative to develop and have on site mitigation that can minimize the effects of high IPC. Also, it is important that monitoring results are clear regarding "no-record" events. To accurately interpret data, the reason for "no-record" events must be established, distinguishing those that occur because the IPC is below recordable levels from those that are due to equipment or charge failure.

With all other variables being equal, deeper burial depths are an effective mitigation measure against high IPC. Unfortunately, all of the other variables are never equal, making it impossible to predict IPC strictly from a charge size/burial depth combination. The only completely effective mitigation measure currently available is to avoid conducting explosive-based seismic operations under fish bearing waters.

CONCLUSIONS

Monitoring of seismic programs in the ISR was conducted in a stepwise, exploratory fashion and yielded a significant amount of new information for management purposes. We now recognize that explosive-induced IPCs are very difficult to predict with any accuracy in waterbodies, and that the charge size/burial depth combinations suggested in the DFO *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* may not provide the required level of protection to fish.

The following recommendations are based on lessons learned during seismic exploration monitoring in the winter seasons of 2000/2001 and 2001/2002.

General Recommendations and Areas for Further Study

1. Seismic exploration should not be conducted under waterbodies not frozen to the bottom in the NWT due to the unpredictability of IPC and absence of proven mitigation to suppress the negative effects of a detonated charge.
2. The existing Guidelines should be re-investigated using data obtained from modern monitoring equipment that is the current industry standard.
3. Guidelines should be used as intended, as "guidelines", and be adjusted to site-specific conditions accordingly, not applied as mitigation.
4. Additional research should be conducted to determine what the exact IPC threshold should be to offer protection for all affected life stages of fish species likely to be impacted.
5. Ice profiling on waterbodies should be used as a tool to determine the extent of bottom-fast ice. If the bottom-fast ice zones are determined, it may be possible to infill/undershoot the non-bottom fast portions without large gaps being left in the seismic data, while providing the necessary protection for over wintering fish and incubating eggs. Also, when the bottom fast ice zone of a lake is accurately delineated, it allows the use of vibrator-based energy sources.
6. The results of a recent fish deterrent study in the Mackenzie Delta area of the NWT demonstrated that the deterrents tested in winter conditions did not successfully move fish out of a designated area, and therefore should not be used as mitigation (Racca et al., 2004). Further investigation with other fish deterrent options is needed.

Recommendations for Project Requirements and Monitoring of Explosive-based Seismic Exploration Programs in Fish-bearing Waters

Steps need to be taken to minimize human error as much as possible.

1. Equipment must be proven to be appropriate for the operating environment. The use of new technology, as it becomes available, is encouraged, but it must be tested to ensure it can operate as intended in the environment selected (e.g. Canada's Western Arctic in winter conditions) before it is used for the full seismic program. This applies to all equipment from drill rigs to dissolved oxygen probes.
2. Proven mitigation to minimize the impact on fish from the effects of high IPC should be available on site in the event that an unforeseen event occurs, such as a shallow buried charge. Currently no such mitigation has been proven to be effective in the NWT.
3. For any explosive-based seismic program, a protocol must be developed that clearly indicates what is expected, how monitoring is to be conducted, what and how information is to be recorded, and when the results are to be submitted. The protocol should be designed well in advance of the proposed seismic exploration program, and be a joint effort between industry and regulators. Maintaining effective communication with the people conducting the field monitoring is essential.
4. Initial testing should be conducted to determine site-specific charge size/burial depth combinations.
5. Charge burial depth must be accurately measured and confirmed.
6. Substrate type must be carefully recorded. Drill logs completed at the end of the day do not provide an accurate assessment.

7. A maximum threshold of < 50kPa should be set for testing and production seismic operations.
8. Two hydrophones should be utilized for monitoring each shot hole as a contingency to minimize "no-record" events. However, if "no-record" events do occur, the reasons should be well documented (e.g. charge not detonating). See point 4 above. Additional hydrophones radiating from the shot hole could be used if monitoring IPC attenuation is desired.
9. Monitoring equipment should be capable of monitoring at the highest frequency available; currently 65,000 s^{-1} is standard. Also, the hydrophones must be compatible with the monitoring equipment being used.
10. A pre-determined number of production holes should be monitored to confirm the adequacy of site-specific charge size/burial depth combinations for the entire project area. Shot holes should be monitored sequentially rather than monitoring a certain number of charges after everything else has been detonated. They should also be distributed in a manner that ensures the shot holes monitored sufficiently represent the variation found within the program area.
11. When designing a program to monitor activities of industry, it is important that the requirements be practical and considers the technical and environmental conditions in which industry is bound to operate. Involving industry in the development of such monitoring programs is a good way to ensure that the requirements set forth are actually feasible. It is important to have all monitoring requirements clearly defined to ensure consistency and compliance, and to avoid the intent of the requirement from being misinterpreted. From the authors' experiences, fostering good and cooperative working relationships with industry, other government agencies, and co-management partners are essential ingredients in having successful monitoring programs that assist in the effective management and protection of NWT's fisheries resources.

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