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TECHNICAL REPORT

Canadian Zinc Corporation
Prairie Creek Mine Project

Submitted to:
Mackenzie Valley Environmental Impact Review Board
June 3rd, 2011

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Canada

PLAIN LANGUAGE 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. DFO is participating in the environmental assessment for the Canadian Zinc Corporation (CZN) Prairie Creek Mine as a regulator for the construction, operation and decommissioning of an exfiltration outfall trench as well as an expert advisor to the Review Board on potential physical impacts of the development on fish and fish habitat. The following technical comments and recommendations are 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 the proponents are in compliance with the applicable provisions of the *Fisheries Act*. DFO's technical review of the Prairie Creek Mine Project proposal is divided into three main categories: Effluent Outfall, Winter Access Road and Other (monitoring and closure and reclamation). The following is a summary of DFO's conclusion and recommendation for Prairie Creek Mine.

DFO has stated throughout the environmental assessment that we would not consider authorizing a specific outfall option until downstream impacts have been adequately assessed and considered as part of the selection criteria for the outfall design. DFO has outstanding concerns related to the construction, operation and decommissioning of the proposed double-piped exfiltration trench including potential impacts due to sedimentation at the site of discharge, changes in flow and temperature regimes in Prairie Creek and possible avoidance and impediments to passage of Bull Trout and Mountain Whitefish to access the upper reaches of Prairie Creek. DFO also requires that appropriate mitigation measures be implemented to ensure protection of fish and fish habitat downstream of the effluent outfall include monitoring to ensure fish passage.

For the Winter Access Road, DFO is recommending that CZN follow our operational statements for temporary crossings, span structures, ice bridges and snow fills (see Appendix I of this document) to ensure that proper mitigation measures are implemented to reduce impacts at stream crossings to fish and fish habitat. DFO is also recommending that CZN develop a comprehensive sediment and erosion control plan for the road and crossings. CZN has provided preliminary information about locations and quantities of water for the construction and maintenance of the winter road and has also committed to using DFO's "Protocol for Winter Water withdrawals from Ice-covered waterbodies" (see Appendix II). CZN is also proposing to use streams and rivers as water sources but has not gathered any baseline information. DFO still has uncertainties on the potential impacts to overwintering fish in these rivers and would require that CZN provide the appropriate information prior to withdrawing water from any watercourse. DFO is also recommending, and CZN has already committed to, ensuring that aggregate will not be taken from within the high water mark of river and/or streams.

Finally, DFO is recommending that CZN develop an Aquatic Effects Monitoring Program to monitor and detect potential changes in Prairie Creek due to the mining activities. The AEMP should be within an adaptive management framework, which would include thresholds to determine when adaptive management action is required. DFO requires information on how the proponent plans to restore fish and fish habitat at the site during closure and reclamation.

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1.0 INTRODUCTION

1.1 Background

The Canadian Zinc Corporation (CZN) is proposing to develop an underground mine and milling complex located approximately 90 kilometres northwest of Nahanni Butte and within the Nahanni National Park Reserve of Canada. The proposed development includes winter road and highway transportation of concentrate from the lead-zinc mine by truck to the railhead in Fort Nelson, British Columbia.

The Department of Fisheries and Oceans (DFO) has completed its technical review of the proposed development, taking into consideration the information supplied by the CZN through their correspondence with DFO, their Developer's Assessment Report (DAR), Technical sessions and other pertinent documents submitted to the Mackenzie Valley Environmental Impact Review Board (MVEIRB). DFO is submitting the following comments for the environmental assessment of the Prairie Creek Mine Proposal.

1.2 Mandate

On behalf of the Government of Canada, 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.

DFO is a national and international leader in marine safety and in the management of oceans and freshwater resources. Departmental activities and presence on Canadian waters help to ensure the safe movement of people and goods. As a sustainable development department, DFO will integrate environment, economic and social perspectives to ensure Canada's oceans and freshwater resources benefit this generation and those to come.

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 is 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.

2.0 TECHNICAL COMMENTS – EFFLUENT OUTFALL

DFO has identified the requirement for one (1) *Fisheries Act* authorization for a HADD resulting from the construction and operation of a double-piped exfiltration trench effluent outfall. The recommendations made in this section including any other provisions considered appropriate by DFO, would be included within the conditions of our authorization.

2.1 Construction of Exfiltration Trench Outfall

2.1.1 Document Reviewed

- Developer's Assessment Report (DAR), March 2010 :
  - Section 6.16 (p.102; 208; 216-217),
  - Section 8 (p.257)
  - Section 10 (p.307)
- IR Response (Round 1) to DFO_03:
  - Appendix K – "*Conceptual design for mine site outfall to Prairie Creek*", Northwest Hydraulic Consultants, September 9 2010
- Technical Session October 6-8th 2010:
  - Undertaking #3, 4
  - "*Prairie Creek Mine, Outfall Designs – Preliminary Construction Details, Draft*" by Northwest Hydraulic Consultants, October 5th 2010.
  - "*Prairie Creek Mine, Outfall Performance – Downstream Mixing Analysis, Draft*", Northwest Hydraulic Consultants, October 6 2010.
- IR Response (Round 2) to DFO_2-4:
  - Appendix E – "*Hydraulic Design Details for Exfiltration Trench Outfall to Prairie Creek REVIEW DRAFT*", Northwest Hydraulic Consultants, December 22, 2010
  - Appendix L – "*Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT*", Northwest Hydraulic Consultants, February 11th 2011
  - Appendix Q – "*Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT*", Golder Associates, February 2011
- Technical Session April 12th, 2011:
  - Appendix A - "*Response to Commitments 1, 2, 7, and 8 from April 12, 2011, Technical Meeting*", Canadian Zinc Corporation, May 8 2011

2.1.2 Proponent's Assessment and Conclusions

CZN submitted their DAR in March 2010, where it was proposed that a diffuser, located on the bed of Prairie Creek, would be used to discharge treated mine water. The diffuser was argued to be a best management practice because "*it promotes complete mixing with receiving water and should avoid impacts associated with non-mixed, 'neat' solutions*". CZN also proposed to use a 'timing window' for discharge based on seasonal flows in Prairie Creek. As part of DFO's first round of Information Requests (IR) (DFO_03) we indicated that further information was required including conceptual designs, baseline habitat assessment within the area of influence from the construction and operation of the diffuser and mitigation measures to reduce mobilization of sediment. DFO also wanted CZN to assess potential downstream impacts to fish and fish habitat due to possible changes to flows, sedimentation and/or other factors that could degrade downstream habitat. Following the proposed

diffuser option, CZN has changed the design for the effluent outfall a number of times. Table 1 below summarizes the changes in effluent outfall design as well as the information requested by DFO during the various stages of the EA.

Table 1: Progression of the Diffuser Design and Information Provided

Design	Document/ Date	Information Provided	Information Requested
Diffuser – on the bed of Prairie Creek	DAR, March 2010	- A diffuser would be used to discharge water; complete mixing of effluent with receiving waters would be achieved. - To be installed in a deep, singular channel. - Summer discharge to be 12 000L/s - Winter discharge to be 350 L/s	- Location and conceptual design - Fish habitat assessment - Methods of installation and mitigation measures - Assessment of downstream impacts o Flow regime o Degradation of downstream fish habitat o Mobilization of sediment **Requested July 2, 2010**
Simple Pipe Outlet – located on the left bank of Prairie Creek	Information Request Round 1 Reponses **September 2010;** Appendix K	- Four alternatives presented - Locations shown on figures; GPS locations not provided - excavation through left bank - armouring the trench with light riprap -silt fencing would be used for sediment control - minimal maintenance - larger IDZ	- provision of rationale for the proposed simple pipe outlet, including consideration of how downstream impacts will be reduced - provision of conceptual designs, details on construction and installation methods, mitigation measures - provision of detailed habitat assessment **Requested Oct 29th, 2010**
Exfiltration Trench – single pipe	Information Request Round 2 Reponses **March 2011;** Appendix E, L and Q	- proposed an exfiltration trench; 12 m would extend into the thalweg and 8m contain perforations to diffuse treated discharge water - Provided some design specifications (trench ~ 15m long, 4.6m wide, 1.2m deep during construction) - provided isolation considerations - model of effluent plume	Technical sessions were held on April 12th to address outstanding concerns; however at technical sessions a new design was verbally proposed. Concerns raised: - fish passage - change in thermal regime - change in flows in the IDZ and downstream - effects to downstream overwintering habitat
Exfiltration Trench – double pipe	2nd Technical Sessions **April 12, 2011**	- Verbally proposed installing two pipes, one longer for higher flows and one shorter for lower flows to provide for passage of migrating fish species.	
Exfiltration Trench – double pipe	Appendix A, Response to Commitments 1,2,7 & 8 **April 28th, 2011**	2 exfiltration pipes have been designed for companies in Alberta. One had serious start up issues. Success of structures has not been followed up, but Northwest Hydraulics Consultants assumes clients are satisfied as they have not been contacted.	

2.1.3 DFO's Conclusions and Recommendations

The construction of double-piped exfiltration trench will require a *Fisheries Act* Authorization for a HADD. In Appendix Q it states that" impacts from the installation of the exfiltration trench are not expected because the site is not important or critical fish habitat", however, on page 3 of that same report, it also states that Mountain Whitefish and Slimy Sculpin possibly use the area for spawning and rearing habitat. Despite CZN's commitment to using "best practices", DFO still has outstanding concerns associated with the double-pipe exfiltration trench.

DFO has also stated, throughout the environmental assessment process, that an authorization for the proposed outfall and associated works would not be considered until the downstream impacts have been adequately assessed. Despite the changes to the designs, DFO has not been provided with additional information to show that downstream impacts have been considered.

Recommendation #1: Should the project proceed, DFO recommends that CZN provide a detailed fish habitat assessment and appropriate mitigation measures for the construction of the double-piped exfiltration trench to ensure adverse impacts to fish and fish habitat are avoided.

2.2 Operation of Exfiltration Trench Outfall

2.2.1 Document Reviewed

- Developer's Assessment Report (DAR), March 2010 :
  - Section 4.7, p. 101-106
- IR Response (Round 1) to DFO_11:
  - A revised version of Table 5 from the DAR Addendum, 'Impact Significance Matrix – Fish and Aquatic Habitat'
- IR Response (Round 2) to DFO_2-3 :
  - Appendix Q – "*Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT*", Golder Associates, February 2011
- Technical Session April 12th, 2011:
  - Appendix H - "*Additional Water Quality Issues (Memo 5)*", Hatfield Consultants, May 9 2011
  - Revised Appendix B – "*Mixing analysis for exfiltration trench outfall to Prairie Creek – UPDATED"* May 11, 2011

2.2.2 Proponent's Assessment and Conclusions

CZN has indicated in the revised Table 5, provided on page 60 of the Round 1 IR Responses, that the impacts to fish and fish habitat from the discharge of effluent will be "moderate**".** However, little in the way of assessment of downstream impacts to fish and fish habitat or potential mitigation measures have been provided.

In DFO's information requests (DFO_2-3), we ask that CZN provide information on effects to the downstream ecosystem, including impacts to fish and fish habitat and the potential for fish behaviour to change as a result of the discharge. This information was not provided in the September 2010 or March 2011 IR Responses.

During the April 12, 2011 technical session, additional concerns were raised based on the information received in the March 2011 including the potential impacts to a migratory corridor, thermal changes, changes in flow and effects to downstream over-wintering habitat. Limited information with respect to these potential effects of the project has not been provided to DFO.

2.2.3 DFO's Conclusions and Recommendations

DFO does not have enough information to make a determination of potential impacts from the operation of the exfiltration system on fish and fish habitat. Some of the outstanding information includes:

- Sedimentation at the site of discharge;
- Change in flow and temperature regimes in Prairie Creek;
- Potential impacts to fish passage and overwintering habitat.

In considering the potential risk to fish and fish habitat DFO gave particular consideration to Bull Trout. Bull Trout are considered a species that "may be at risk" by the Government of the Northwest Territories (Species 2011) and are known to be sensitive to disturbance (Mochnacz 2002; Post 2002; Reist 2002). We also know that based on information provided by the proponent in the DAR (i.e Beak 1981; Mochnacz 2001) as well as in a preliminary habitat assessment provide in Appendix Q (Second round IR), that Prairie Creek is an important migratory route for Bull Trout to spawn in Funeral Creek and that it is possible spawning and rearing habitat for Mountain Whitefish and Slimy Sculpin. Preliminary data from DFO's on-going research in Prairie Creek and Funeral Creek also confirms that there is movement of Bull Trout between Prairie and Funeral Creeks, and that it is possible that Bull Trout use Prairie Creek for overwintering. For these reasons, DFO believes that Prairie Creek is important habitat for Bull Trout, Mountain Whitefish and Slimy Sculpin.

<u>Importance of Thermal Regime</u>

Water temperature and the presence of groundwater are critical habitat characteristics that determine migration, spawning, incubation periods and rearing of Bull Trout (Post 2002). Bull Trout are found in pristine, cold, high gradient, headwater mountain streams (Evans 2002; Mochnacz 2002), and exhibit a preference for a narrow range of habitat niches (Mochnacz 2002). Bull Trout are sensitive to thermal regimes (Selong 2001; Dunham 2003), and temperature has been demonstrated to strongly influence the distribution of Bull Trout (Dunham 2003). Typically Bull Trout inhabit streams where the water temperatures are less than 18C (Evans 2002), and are found in the highest densities where water temperatures are less than or equal to 12-13C (Post 2002). Spawning in the South Nahanni watershed has been observed when the water temperature is between 6-9C (Mochnacz 2002). Experiments have shown that Bull Trout do not survive in water temperatures of 22C for 60 days. Groundwater upwellings have been strongly correlated to spawning locations, likely reducing the fluctuations in water temperature and ice formation (Post 2002). Juveniles have been found in areas where the groundwater temperature was 6.1C or less (Gamett 2002). Reist 2002, suggested that climate change resulting in an increase in water temperature, will likely have a direct negative effect on the Bull Trout populations in the South Nahanni watershed. Groundwater presence in Funeral Creek is highly likely and provides rearing habitat for incubating eggs to juvenile Bull Trout (Mochnacz 2001). Moderating any change to the existing thermal regime will be critical to the continued use of Prairie Creek and migration to Funeral Creek by Bull Trout.

DFO has outstanding concerns about the potential impacts of water temperature from the exfiltration system on the Bull Trout. CZN has provided limited information about the expected temperature changes in Prairie Creek and the potential to impact Bull Trout and other fish. Appendix H (commitments to April 2011 technical session) indicates that during the summer, temperature in the water storage pond will increase a few degrees above the water temperature of Prairie Creek and that it is not expected to have effects downstream of the Initial Dilution Zone (IDZ). However, a temperature increase within the IDZ is not discussed, how temperatures were determined downstream were not provided, and temperature differentials between the water storage pond, the water treatment process and Prairie Creek are not provided, but assumed by the proponent to be only five degrees apart. There is uncertainty regarding the prediction of downstream temperature changes outside of the IDZ and potential effects to the aquatic ecosystem in Prairie Creek, particularly Bull Trout.

Importance of safeguarding migratory habitat

CZN has provided modeling for vertical and transverse mixing, most recently in the revised Appendix B provided on May 11, 2011. Considering the criteria outlined by the Canadian Council of Ministers of the Environment of what is required of an Initial Dilution Zone (IDZ) including two regarding fish passage:

- *A zone of passage for migrating aquatic organisms must be maintained;*
- *Mixing zones should not unduly attract aquatic life or wildlife, thereby causing increased exposure to Contaminants of potential concern;*

CZN has not demonstrated how the exfiltration pipes will meet these criteria, particularly how a passage will be maintained for migrating Bull Trout and Mountain Whitefish. At the April 12, 2011 technical session, CZN proposed a second, shorter pipe to provide for passage during low flows, however the modeling that has been provided on May 8th, 2011, suggests that the effluent will be dispersed across the width of the channel. CZN has not demonstrated that the exfiltration system will not interrupt fish migrations.

Recommendation #2: DFO recommends that fish passage be maintained at all times of the year and that specific parameters be monitored to ensure fish passage such as temperature, flow, and total suspended solids.

3.0 TECHNICAL COMMENTS – WINTER ACCESS ROAD

3.1 Water Crossings and Portions of the Road along Watercourses

3.1.1 Documents Reviewed

- DAR, March 2010:
  - Sec.6.21, pg 224; pg 227; p. 292-293
- Technical Session October 6-8th 2010:
  - Undertaking 12, 17
- IR Response (Round 1) to DFO_02
  - Appendix E – "*Road Construction and Fish Habitat*" CZN, Sept 2010
- IR Response (Round 2) to DFO_2-5; 2-7:
  - Main report "*Prairie Creek Mine Responses to Second Round of Information Request*", CZN March 2011, p.47-48
- Technical Session April 12th, 2011 Commitments
- May 8th commitments table

3.1.2 Proponent's Assessment and Conclusions

Fish Habitat Assessment

CZN has identified that there will be a number of crossings required for the winter access road. Information on the streams to be crossed by the alternative routes for the winter access road were provided; 28 streams were assessed, 24 from the air, in a helicopter, and 4 in-stream. Streams that were assessed in-stream were electro-fished (Appendix 14, pg.2).

Crossings

CZN proposed the use of temporary culverts and ford crossings (DAR, p. 47, 230, 291, 293, 303). After discussions with DFO, CZN has committed to using our Operational Statements associated with snow and ice crossings, temporary crossings, and clear spans (see Appendix 1). Temporary culverts and ford crossings are no longer proposed (IR Round 1 response, Appendix E, p. 2).

Three temporary clear span bridges will be installed at Polje Creek, Sundog Creek and Funeral Creek (DAR, p. 300, 301). CZN has committed that abutments of the spans will be constructed outside of the high water mark (IR Round 1 response, Appendix E, p. 2).

CZN has committed to the following to minimize the potential impacts to fish and fish habitat (DAR, p. 292-293):

- *minimize disturbance to stream banks and riparian areas at stream crossings*
- *remove temporary crossing structures and snow-fills at breakup to avoid blockage and erosion*
- *conduct a stable road bed adjacent to creeks and provide for runoff control to minimize dispersal of sediment during precipitation events; and*
- *promote re-vegetation of riparian areas to further reduce the potential for sedimentation*

Additional commitments were made as of May 8, 2011 to further reduce the potential for impacts to fish and fish habitat (April 12, 2011 Progress Report regarding commitments to provide information, Table 2). These commitments have been considered in our assessment below.

3.1.3 DFO's Conclusions and Recommendations

Fish Habitat Assessment

It is DFO's opinion that the fisheries assessment that was done on the 28 stream crossings is insufficient to determine fish absence/presence. Four of 28 streams were assessed in-stream; the remaining 24 were assessed from a helicopter. The habitat assessment seemed to be weighted heavily towards presence of over-wintering habitat. Ephemeral, or intermittent, streams can provide important spawning habitat for a number of fish species, such as Northern Pike, and should not be discounted as important fish habitat. Assessments of fish habitat should consider all life stages required for spawning, incubation of eggs, rearing, feeding, over-wintering and migratory habitat. Requirements at each stage must be considered when assessing fish habitat.

Based on the information provided, DFO is assuming that fish use all streams crossed by the winter access road throughout their life histories. This includes headwater streams that may be crossed, that provide flow, nutrients, potential food sources, and help regulate water temperature.

Crossings

To protect the beds and banks of streams crossed, CZN has committed to using temporary spans, and snow and ice fills for all crossings. This has addressed some of DFO's concerns around maintaining the integrity of the bed and banks of streams. CZN has committed to protecting the bed and banks of streams crossed, either with ice or matting (Commitment table, May 8, 2011).

Outstanding concerns relate to mobilization of sediment and erosion at stream crossings, particularly stream crossings in vulnerable areas (e.g. permafrost), and runoff from the winter access road at freshet or during a large precipitation event. While commitments have been made by the proponent to provide a sediment and erosion control plan for the access road, DFO was hoping to receive a draft of that plan as part of this environmental assessment to give us more certainty that impacts to fish and fish habitat would be minimized. Use of best practices are identified by CZN (DAR p. 229, 307) to be employed in the construction of the winter access road; however the best practices are not identified either specifically or by referencing a guide or best management practices manual.

The proponent has committed to using DFO's Operational Statements for snow and ice fills, and clear span bridges. These Operational Statements are attached in Appendix I. Special note should be taken to the situations in which these apply, and what mitigation measures must be done to mitigate potential impacts to fish and fish habitat. In committing to following the Operational Statements, CZN is committing to implementing the mitigation measures included in these Statements.

Sediment and Erosion Control Monitoring

DFO does not consider CZN's preliminary monitoring comments for the winter road, provided in the main report to responses to IR round 2, are adequate for addressing potential stability or erosion problems. Currently over-flight inspections are proposed followed by secondary inspection in a helicopter if an issue is suspected. Readily transported materials, such as hand tools and silt fencing will be taken to stabilize areas that are eroding or producing sediment. DFO is of the opinion that

vulnerable locations should be identified during the planning and construction phases, and a plan to take immediate action be developed if inspections indicate that sediment and erosion are occurring.

Recommendation#3: DFO recommends that CZN follow DFO's Operational Statements for temporary crossings, which include span structures, ice bridges and snow fills. Special attention should be paid to when and where the Operational Statements are appropriate for use, and all mitigation measures contained therein should be incorporated into the construction and operation of the winter access road in order to avoid a HADD.

Recommendation#4: DFO recommends that CZN develop a comprehensive Sediment and Erosion control plan, to the satisfaction of DFO, prior to construction of the road. This plan should include annual inspections of the access road.

3.2 Water Withdrawal

3.2.1 Documents Reviewed

- DAR, March 2010:
  - Section 6.22, p.230
- IR Round 1 DFO_04
  - Appendix E "*Road Construction and Fish Habitat*"
- IR Round 2 DFO_2-4
  - Appendix B "*Preliminary Estimate of Water Consumption for the Construction & Maintenance of the Prairie Creek Mine Access Road*"
- CZN sent document to DFO on April 5th, 2011 – "*Prairie Creek Mine Access Road Recee March 29, 2011 – Water Sources*"

3.2.2 Proponent's Assessment and Conclusions

CZN will require water in order to construct the road beds and snow and ice fills at stream crossings. The road will be built seasonally and will require maintenance throughout the operational period. As part of the DAR, CZN did not provide any locations or predicted volumes of water needed for the construction and maintenance of the road. In CZN's initial response to DFO_04, one waterbody (Mosquito Lake) and several watercourses were identified as potential water sources for the construction and maintenance of the winter road and crossings. CZN, in Appendix E, also identified groundwater upwelling or groundwater fed systems as potential water sources, specifically from Sundog Creek and Polje Creek. CZN also committed to using "*DFO Protocol for Winter Water Withdrawal from Ice covered Waterbodies in the Northwest Territories"*.

During the Second Round of IRs (DFO_2-4), DFO requested again that CZN identify locations and volumes (per source) of water needed for the construction and maintenance of the road and crossings. CZN provided estimates of water usage (Appendix B in response to our Second Round of IRs), including the identification of 4 main water sources (Moquito Lake, Gap Lake, Liard River and mine site well).

3.2.3 DFO's Conclusions and Recommendations

DFO has outstanding concerns related to water withdrawals and cannot predict the potential impacts to fish and fish habitat without additional information from CZN on:

- Location of water withdrawals;
- bathymetry of any lakes that will be used as water sources;
- methodology for assessing the amount of water that can be withdrawn from watercourses to avoid impacts to overwintering fish, including eggs.

DFO has also advised CZN that our water withdrawal protocol only applies to lakes and that additional information is required for streams and rivers. CZN has committed to contacting DFO prior to removing water from any streams or rivers.

Recommendation#5 DFO recommends that CZN follow DFO's "Protocol for Winter Water Withdrawal from Ice-covered waterbodies in the NWT" as well as "DFO Freshwater Intake End-of-Pipe Fish Screen Guidelines"). Bathymetry on all lakes should be provided to DFO prior to the regulatory phase, as well as an indication of the effect of drawdown on the bathymetry resulting from winter water withdrawal.

Recommendation#6: DFO recommends that CZN identify any streams or rivers considered for water withdrawals and consult with DFO on information requirements, and the appropriateness of using streams and rivers, to ensure impacts to fish and fish habitat are avoided.

3.3 Aggregate Sources

3.3.1 Documents Reviewed

- DAR, March 2010:
  - Section 6.13, p. 200
- DAR Addendum, May 2010
- IR Round 1 DFO_02:
  - Appendix E "*Road Construction and Fish Habitat*"
- IR Round 2 DFO_2-2:
  - Appendix C

3.3.2 Proponent's Assessment and Conclusions

The DAR stated that aggregate materials will be required in order to build and maintain the mine site and access roads, but specific locations have not been provided. During the first round of IRs, DFO had asked for the exact locations of the proposed aggregate sources and to confirm that these sources would not be situated in or within the high water mark of river beds. The locations of potential aggregate sources for the construction of the road as well as transfer stations were provided in a map in Appendix C following the Second Round of IRs. This map indicated several locations of potential aggregate sources, including some that were within water courses.
During the October 6-8th, 2010 technical session, CZN committed to not using materials within the high water mark of streams as an aggregate source.

3.3.3 DFO's Conclusions and Recommendations

DFO appreciates CZN's commitment to not using materials within the high water mark of any streams as an aggregate source, however, it is still unclear what sources of materials will be used for the construction and maintenance of the road. In Appendix D of the CZN's written IR response submission, borrow sites were identified on a map (Figure II-4) including locations that were either within or near watercourses. As mentioned during the technical sessions, DFO also noted that some of the borrow sites identified on the map in Appendix D were located off the main road right of way and that additional spur roads and/or crossings may be required to access these materials. As stated in DFO_02 and the technical sessions, DFO would still require CZN to identify the locations of all aggregate sources in order to determine if additional access roads and/or crossings may be required.

Recommendation #7: DFO recommends that CZN ensure that aggregates will not be removed from within the high water mark of any streams or rivers, and to identify borrow site locations such that potential stream crossings to access them can be identified.

4.0 TECHNICAL COMMENTS – OTHER

4.1 AEMP/Monitoring

4.1.1 Documents Reviewed

- DAR, March 2010
- "Aquatic Effects Monitoring Final Plan", Pugsley/ Dubé Consulting Inc, June 2, 2010
- IR Round 1 DFO_10
- commitments table from technical sessions April 12, 2011 outlined 2007 AEMP guidelines

4.1.2 Proponent's Assessment and Conclusions

CZN proposed in their DAR (pg. 324) that an Aquatic Effects Monitoring Program (AEMP) would be developed through the EA process or in the permitting phase. In response to IRs, issued in July 2010, CZN indicated that the Environmental Effects Monitoring (EEM) program would be similar in design to the one conducted by INAC, the University of Saskatchewan and Parks Canada, and would include sampling periphyton, benthic invertebrates, sediments and perhaps Slimy Sculpin. The EEM would form part of the AEMP. The AEMP would include sampling for water quality. Both programs would be developed at the permitting phase (IR Round 1 Response, pg. 59).

In CZN's second round of IR responses, Appendix O, pg.7 it is indicated that the AEMP will follow guidance provided for EEM programs. Action triggers are identified on pg. 9 of Appendix O. Actions identified involve an increase in the frequency of monitoring, and depending on the trigger, an increase in the type of monitoring.

In the most recent commitments table, dated May 8, 2011, CZN will develop an AEMP, following the 2007 INAC publication *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories.*

4.1.3 DFO's Conclusions and Recommendations

An AEMP should provide measureable and defensible results and assess change occurring in Prairie Creek. In order to be effective, acceptable thresholds, triggers and actions need to be identified. A robust AEMP should be conducted within an adaptive management framework, so that appropriate actions can take place quickly and effectively. A multitrophic ecosystem approach should be used. The AEMP should be developed to the satisfaction of all interveners.

Recommendation#8: DFO recommends that CZN develop and implement an Aquatic Effects Monitoring Program (AEMP) to monitor and detect change in the Prairie Creek aquatic ecosystem. A multitrophic approach (such as the INAC's 2009 Aquatic Effects Monitoring Program Guidelines) should be used. The AEMP should be within an adaptive management framework, where thresholds, triggers and management actions are identified.

4.2 Closure and Reclamation

4.2.1 Documents Reviewed

- DAR, March 2010:
  - Section 10.2.3, p.306
  - Appendix 27 - *Prairie Creek Mine Draft Preliminary Closure and Reclamation Plan***"** CZN, February 2010
- IR Round 1 DFO_09

4.2.2 Proponent's Assessment and Conclusions

On page 306 of the DAR, CZN has stated that impacts to fish due to sedimentation at closure "should be minimal". CZN has indicated that the Funeral Creek road bed will be modified to promote stable, long-term runoff (DAR Appendix 27, section 3.9). In IR Round 1 Response, pg 58, CZN indicates that organic or coarse material will be placed next to the creek to prevent sediment entering the creek, until vegetation is established. Channels that develop over the re-contoured road will be armoured. It was further indicated that silt fencing may initially be used to prevent sedimentation of the creek. The road bed will be re-contoured to the natural slope, and culverts will be removed.

In response to the second round of IRs, CZN indicated that decommissioning of the Funeral Creek road is not part of the current EA, and is willing to discuss with DFO at a later date, how to address road closure.

4.2.3 DFO's Conclusions and Recommendations

CZN has indicated in several areas (DAR Appendix 27 and IR Response Round 1 to DFO_09) that sediment and erosion will be prevented by using silt fencing. CZN's monitoring, maintenance and Reporting program (Appendix 27, p.13) indicates that monitoring for erosion will occur monthly from March to November for the first three years. Monitoring and inspections will occur bi-monthly from May to September for the next five years. Monitoring will be reduced to once annually, in July, for the last five years of proposed monitoring. Silt fencing must be installed correctly and routinely be monitored to ensure it is effective. There may be other materials available to stabilize disturbed areas that will not require the same degree of continued maintenance and may provide for more stability.

Sediment and erosion will be a concern along the length of the winter access road while it is being reclaimed. CZN indicates that natural revegetation is planned for the road and the mine site. The mine site is anticipated to revegetate in 20-30 years. No timelines were given for the revegetation of the winter access road. To promote the stabilization of the road area and to reduce sedimentation to creeks, CZN may consider a more active approach to reclamation.

Recommendation #9: DFO recommends that CZN develop a comprehensive Closure and Reclamation Plan in consultation with, and to the satisfaction of all interveners.

5.0 SUMMARY OF RECOMMENDATIONS

Recommendation #1: Should the project proceed, DFO recommends that CZN provide a detailed fish habitat assessment and appropriate mitigation measures for the construction of the double-piped exfiltration trench to ensure adverse impacts to fish and fish habitat are avoided.

Recommendation #2: DFO recommends that fish passage be maintained at all times of the year and that specific parameters be monitored to ensure fish passage such as temperature, flow, and total suspended solids.

Recommendation#3: DFO recommends that CZN follow DFO's Operational Statements for temporary crossings, which include span structures, ice bridges and snow fills. Special attention should be paid to when and where the Operational Statements are appropriate for use, and all mitigation measures contained therein should be incorporated into the construction and operation of the winter access road in order to avoid a HADD.

Recommendation#4: DFO recommends that CZN develop a comprehensive Sediment and Erosion control plan, to the satisfaction of DFO, prior to construction of the road. This plan should include annual inspections of the access road.

Recommendation#5 DFO recommends that CZN follow DFO's "Protocol for Winter Water Withdrawal from Ice-covered waterbodies in the NWT" as well as "DFO Freshwater Intake End-of-Pipe Fish Screen Guidelines". Bathymetry on all lakes should be provided to DFO prior to the regulatory phase, as well as an indication of the effect of drawdown on the bathymetry resulting from winter water withdrawal.

Recommendation#6: DFO recommends that CZN identify any streams or rivers considered for water withdrawals and consult with DFO on information requirements, and the appropriateness of using streams and rivers, to ensure impacts to fish and fish habitat are avoided.

Recommendation #7: DFO recommends that CZN ensure that aggregates will not be removed from within the high water mark of any streams or rivers, and to identify borrow site locations such that potential stream crossings to access them can be identified.

Recommendation#8: DFO recommends that CZN develop and implement an Aquatic Effects Monitoring Program (AEMP) to monitor and detect change in the Prairie Creek aquatic ecosystem. A multitrophic approach (such as the INAC's 2009 Aquatic Effects Monitoring Program Guidelines) should be used. The AEMP should be within an adaptive management framework, where thresholds, triggers and management actions are identified.

Recommendation #9: DFO recommends that CZN develop a comprehensive Closure and Reclamation Plan in consultation with, and to the satisfaction of all interveners.

6.0 References

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Appendix I – Operational Statements
Appendix II – Water Withdrawal Protocol
Appendix III – DFO's Freshwater Intake End-of-Pipe Fish Screen Guidelines

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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http://www.dfo-mpo.gc.ca/oceans-habitat/habitat/modernizing-moderniser/epmp-pmpe/index_f.asp

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.

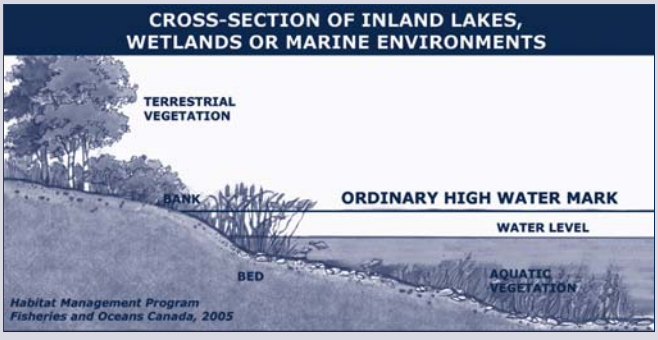
9. Stabilize any waste materials removed from the work site, above the HWM, to prevent them from entering any watercourse. This could include covering spoil piles with biodegradable mats or tarps or planting them with preferably native grass or shrubs.

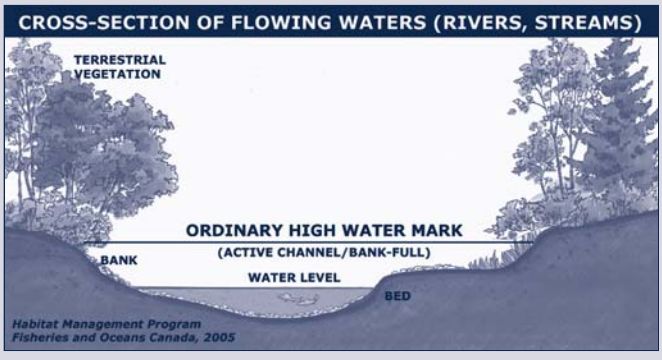
10. Vegetate any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses and cover such areas with mulch to prevent soil erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed 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.

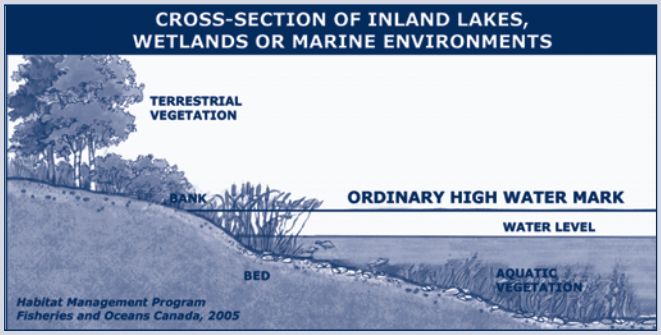
10. Stabilize any waste materials removed from the work site to prevent them from entering the watercourse. This could include covering spoil piles with biodegradable mats or tarps or planting them with preferably native grass or shrubs.

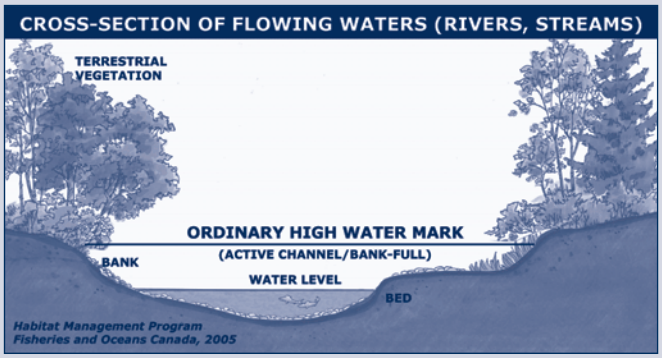
11. Vegetate any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses and cover such areas with mulch to prevent erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed areas 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:

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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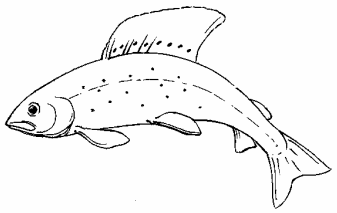


DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut

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:

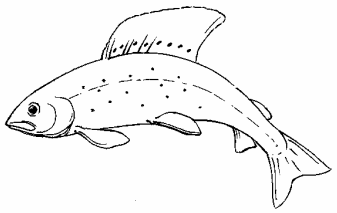
1. In one ice-covered season, total water withdrawal from a single waterbody is not to exceed 10% of the available water volume calculated using the appropriate maximum expected ice thickness provided in Table 1.
2. In cases where there are multiple users withdrawing water from a single waterbody, the 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.



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

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. For all waterbodies: 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. For waterbodies equal to or less than 1 km in length: 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. For lakes greater than 1 km in length: 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.

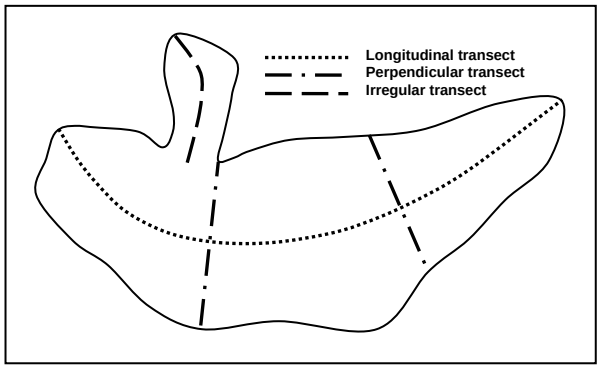
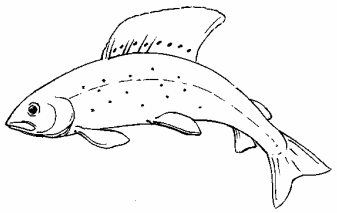


Figure 1. Minimum transect layout for a lake that is less than 1 km in length, with an irregularity.

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.



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

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

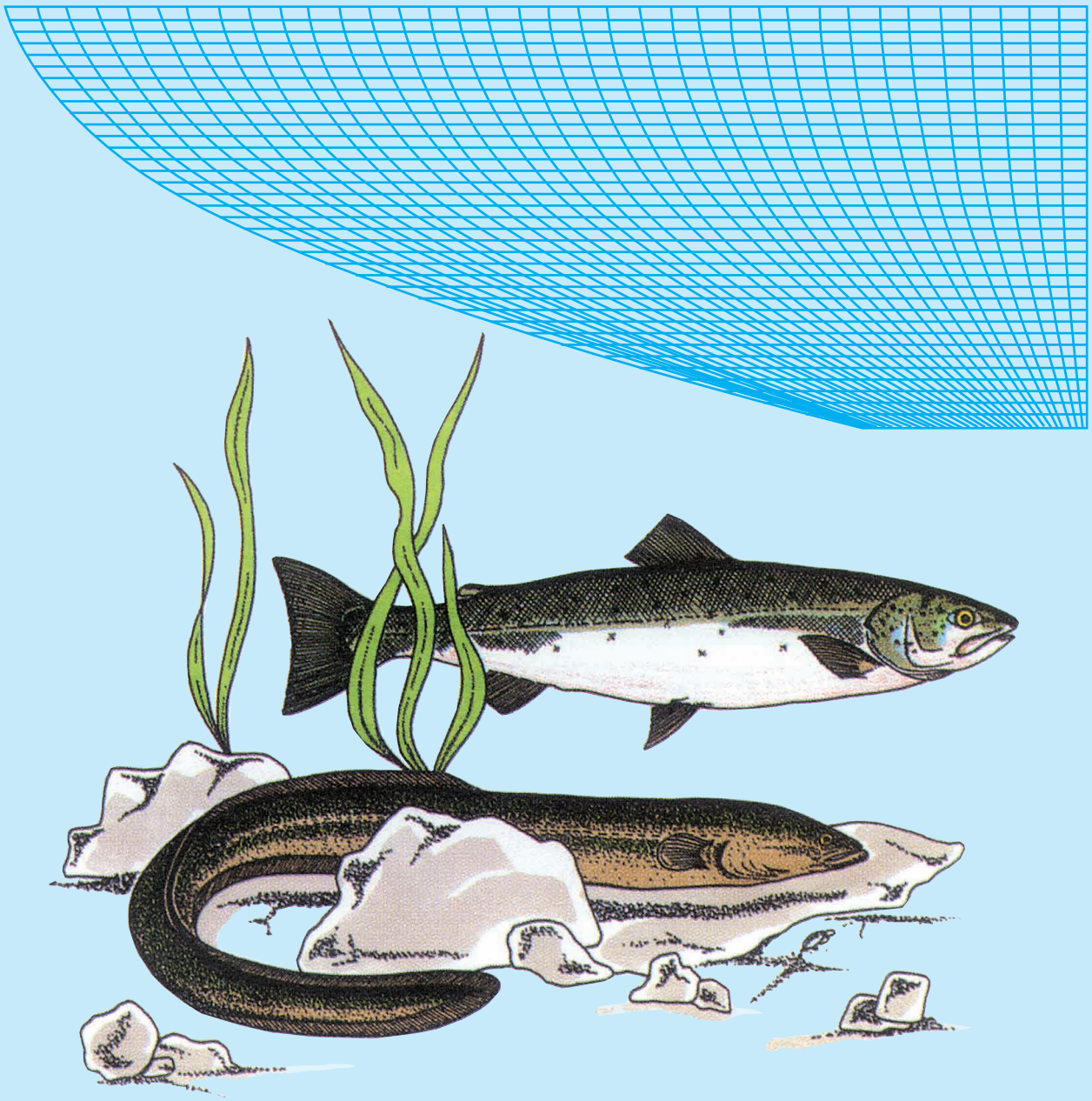
Many species of animals are highly sensitive to water fluctuations. In areas where beaver and muskrat may occur, the appropriate agencies or organizations should be consulted to determine if harmful effects will result from your activities, and whether these effects can be successfully mitigated through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

Department of Fisheries and Oceans

Freshwater Intake End-of-Pipe Fish Screen Guideline



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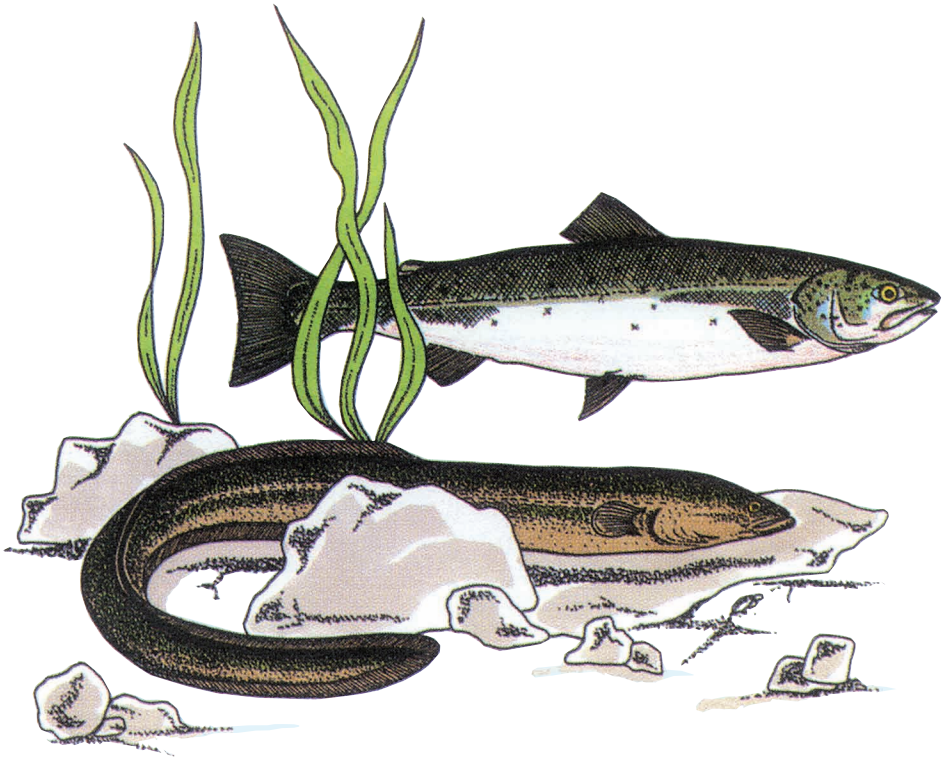
Freshwater Intake End-of-Pipe Fish Screen Guideline



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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 for 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 Sereens

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			Non-Metric Units		
Flow (L/s)	Subcarangiform (m^2)	Anguilliform (m^2)	Flow (US gpm)	Subcarangiform (ft^2)	Anguilliform (ft^2)
1	0.01	0.03	10	0.1	0.2
5	0.05	0.13	50	0.3	0.9
6	0.06	0.16	100	0.6	1.8
8	0.07	0.21	150	0.9	2.7
10	0.09	0.26	200	1.3	3.6
12	0.11	0.31	250	1.6	4.5
14	0.13	0.37	300	1.9	5.4
15	0.14	0.39	350	2.2	6.2
16	0.15	0.42	400	2.5	7.1
18	0.17	0.47	450	2.8	8.0
20	0.18	0.52	500	3.2	8.9
22	0.20	0.58	550	3.5	9.8
24	0.22	0.63	600	3.8	10.7
25	0.23	0.65	650	4.1	11.6
26	0.24	0.68	700	4.4	12.5
28	0.26	0.73	750	4.7	13.4
30	0.28	0.79	800	5.0	14.3
32	0.30	0.84	850	5.4	15.2
34	0.31	0.89	900	5.7	16.0
35	0.32	0.92	950	6.0	16.9
36	0.33	0.94	1000	6.3	17.8
38	0.35	0.99	1050	6.6	18.7
40	0.37	1.05	1100	6.9	19.6
45	0.42	1.18	1150	7.2	20.5
50	0.46	1.31	1200	7.6	21.4
55	0.51	1.44	1250	7.9	22.3
60	0.55	1.57	1300	8.2	23.2
65	0.60	1.70	1350	8.5	24.1
70	0.65	1.83	1400	8.8	25.0
75	0.69	1.96	1450	9.1	25.8
80	0.74	2.09	1500	9.4	26.7
85	0.78	2.23	1550	9.8	27.6
90	0.83	2.36	1600	10.1	28.5
95	0.88	2.49	1650	10.4	29.4
100	0.92	2.62	1700	10.7	30.3
110	1.02	2.88	1750	11.0	31.2
120	1.11	3.14	1800	11.3	32.1
125	1.16	3.30	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

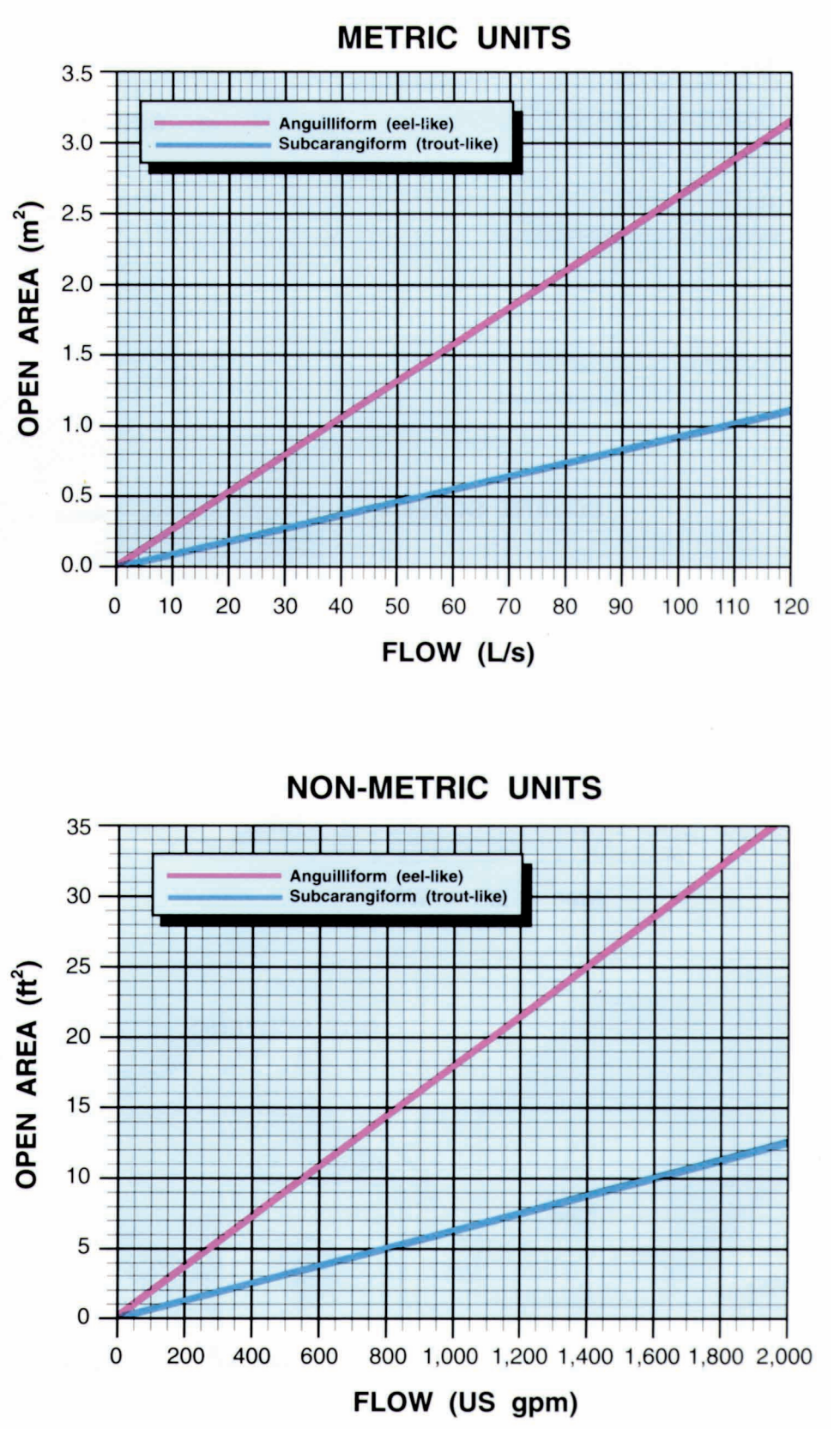


Figure 2
Common Screen Shapes and Area Formulae

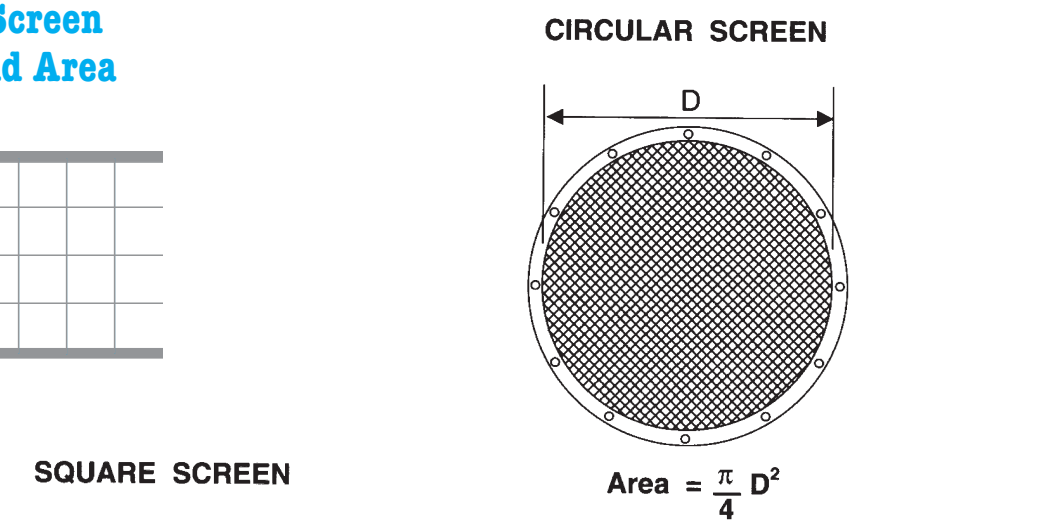
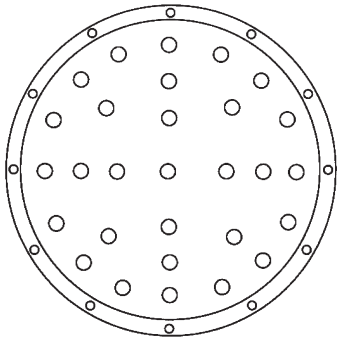
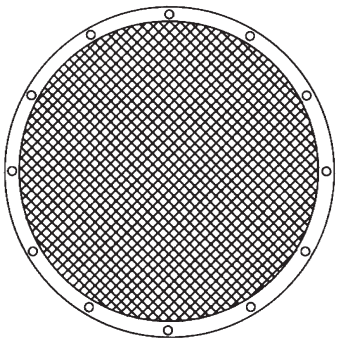


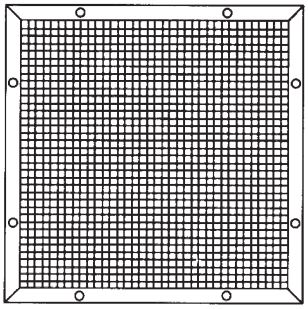
Figure 3
Typical Applications and Features of End-of-Pipe Screens



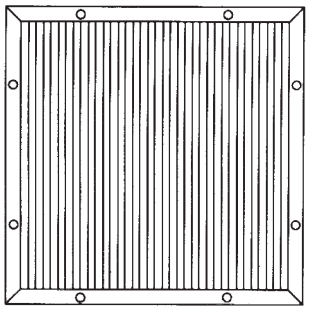
PERFORATED PLATE (PUNCHED)



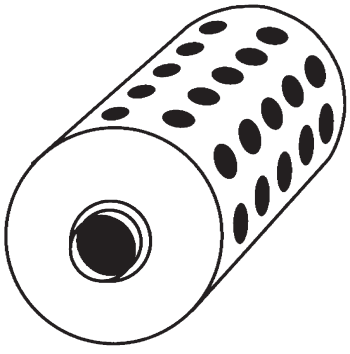
CIRCULAR MESH SCREEN



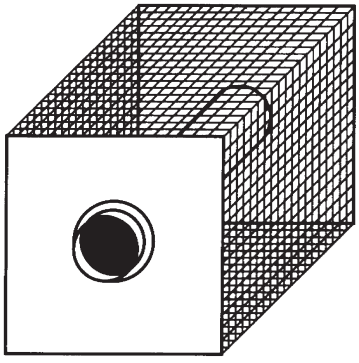
SQUARE MESH SCREEN



SQUARE WEDGE WIRE SCREEN

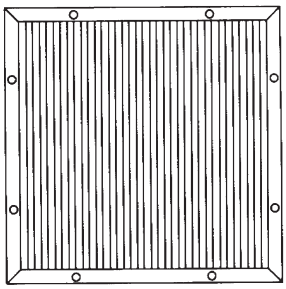


DRUM OR CYLINDER WITH PERFORATED PIPE

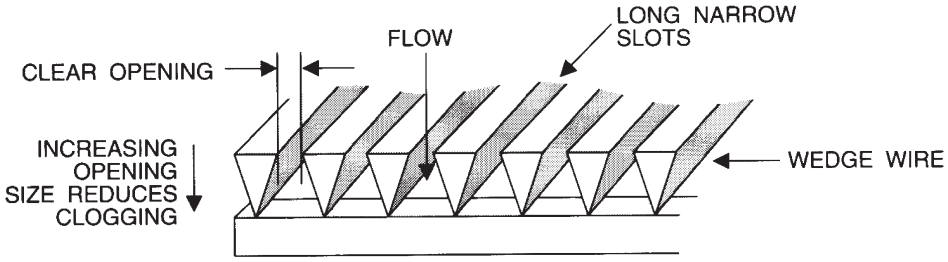


BOX-TYPE WITH MESH SCREEN

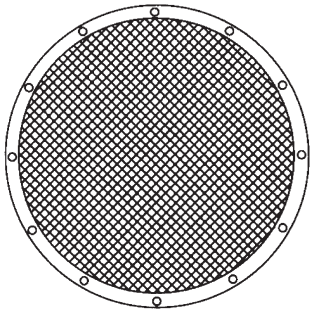
Figure 4
Examples of Typical Screen and Material Types



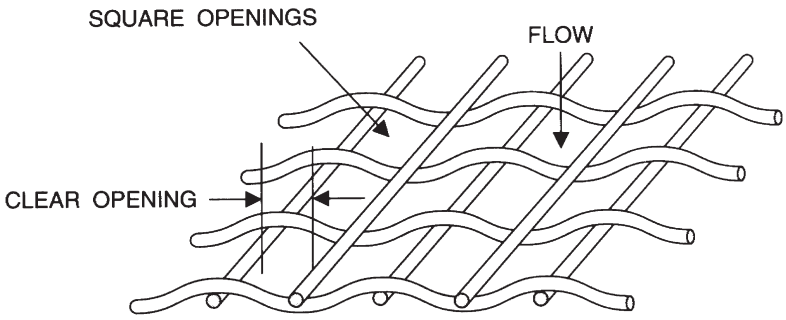
SQUARE WEDGE WIRE SCREEN



WEDGE WIRE PROFILE



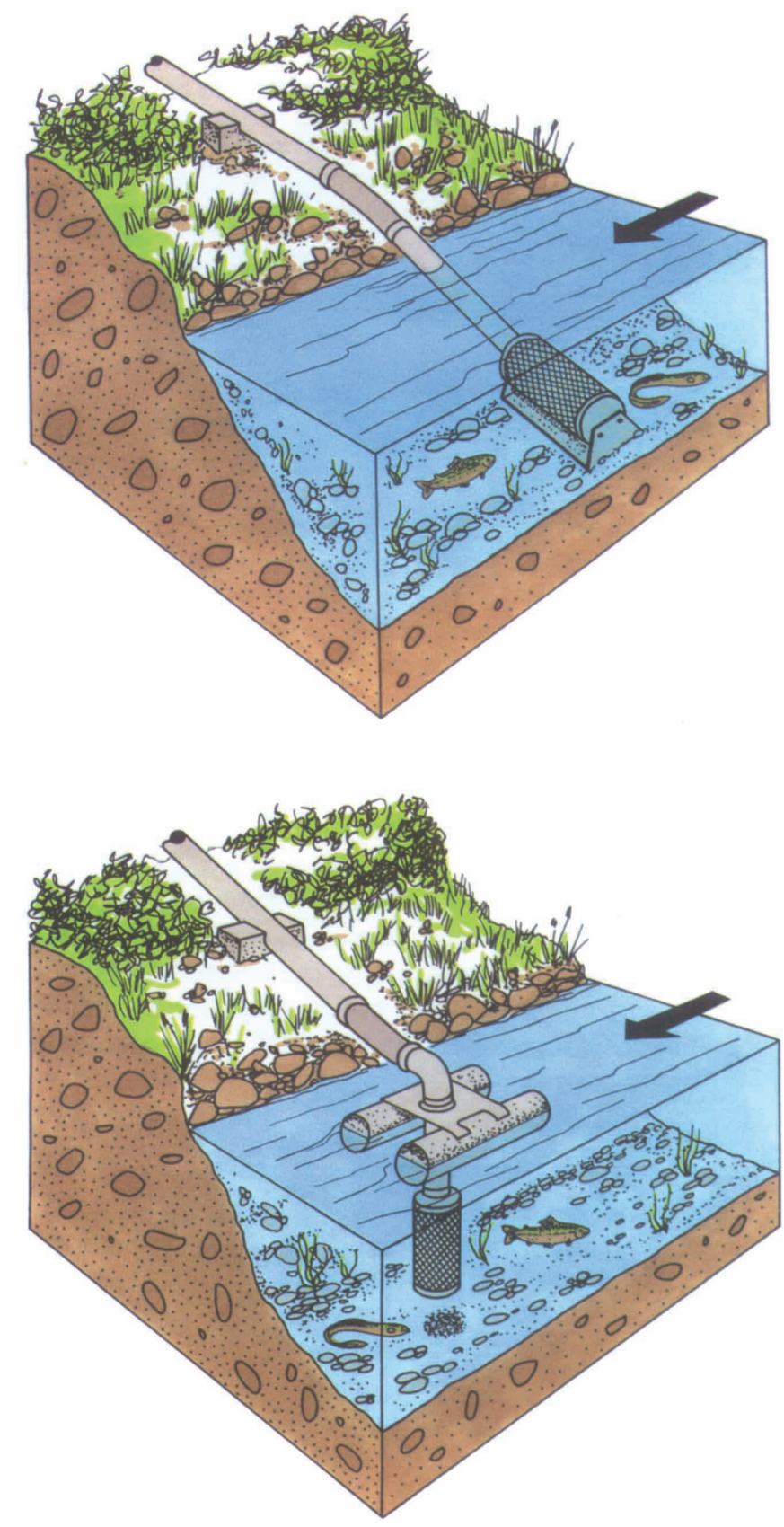
CIRCULAR MESH SCREEN

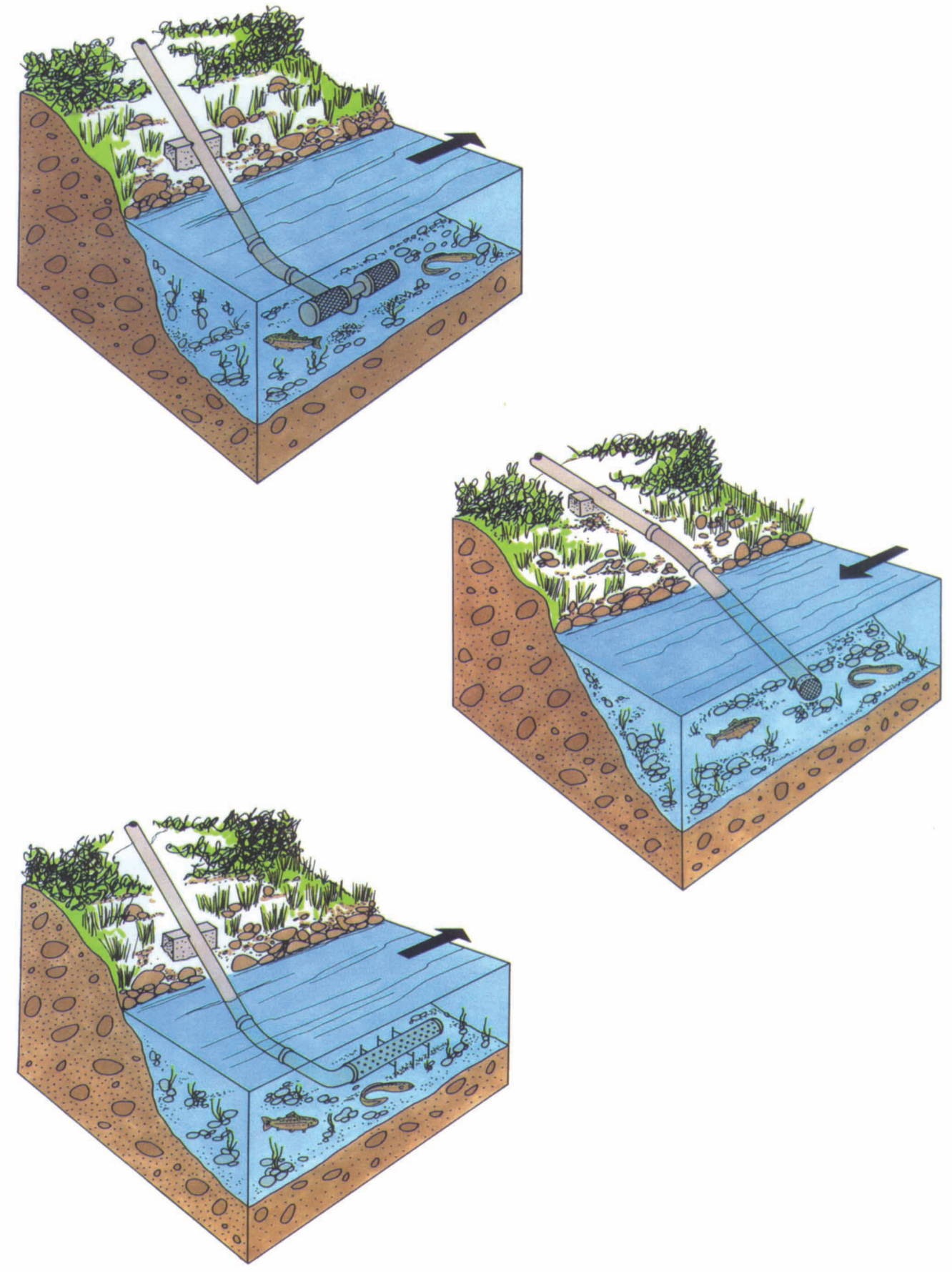


WOVEN WIRE MESH PROFILE

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.

References

Fish Screening Directive. 1990. Department of Fisheries and Oceans, Ottawa, Ontario,

Katopodis, C. 1990. *Advancing the art of engineering fishways for upstream migrants.* Proceedings of International Symposium on Fishways '90, Oct. 8-10, 1990, Gifu, Japan, p. 19-28.

Katopodis, C. 1992. *Fish screening guide for water intakes*. Working Document, Freshwater Institute, Winnipeg, Manitoba.

Katopodis, C, 1994. *Analysis of ichthyomechanical data for fish passage or exclusion system design*. Proc. International Fish Physiology Symposium, July 16-21, 1994, Vancouver, B.C. American Fisheries Society and Fish Physiology Association.

Katopodis, C. and R. Gervais, 1991. *Icthyomechanics*, Working Document, Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba.

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

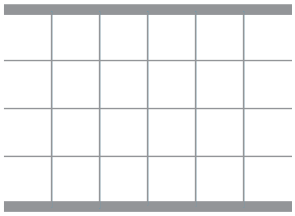
Other Information

- 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.

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

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.

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

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

$$= 3.111\ \text{m}^2$$

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:

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

$$3.111\ \text{m}^2 = (0.600\ \text{m})L$$

$$3.111\ \text{m}^2 = (1.885\ \text{m})L$$

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

$$L = 1.65\ \text{m}$$

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.