Guidelines for the Protection of Fish and Fish Habitat at Small Hydro Developments in British Columbia

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Preface

This guideline is specifically designed and written for hydroelectric facilities with a design generation capacity less than 50 MW. There has been considerable interest in hydroelectric projects of this size because of BC Hydro's initiative to augment power production through their Independent Power Producers (IPP) program. BC Hydro and other utilities have invited independent developers to submit proposals to develop power generating facilities that can tie into the existing power grid or service small, remote communities or industries. Currently approximately 1,400 MW of electricity are produced from over 600 small hydro sites in British Columbia. More than 350 undeveloped sites are estimated to have the potential to produce an additional 1,300 MW.

This document was developed by for use by small hydro developers, and provincial and federal fisheries agencies in order to provide uniform and comprehensive guidelines. The guidelines provide advice for the construction and operation of small hydro facilities in order to minimize impacts on the fisheries resource.

This report also provides a basic overview of the various components of small hydro facilities, the potential impacts associated with facility development and operation, and some details of design and operational considerations that can be used to mitigate impacts of small hydro facilities. Impacts of small hydro on fish and habitat are similar to those associated with large installations: smaller in magnitude but similar in scale relative to the resources affected. These guidelines will assist the proponent in obtaining permits and approvals that pertain to the fisheries concerns associated with small hydro projects. Developers will be expected to mitigate fisheries impacts under the DFO *no net loss* policy for fish habitat.

The guidelines are intended to be kept as current as possible. In order that the input necessary for periodic updating is obtained, users of the documents are requested to provide comments to Fisheries and Oceans Canada through:

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1.0 Introduction

1.1 Background

The number of small hydro developments in British Columbia is expected to grow significantly over the next several years. "Small hydro" installations are defined as those producing less than 20 Megawatts (MW) of power, although most installations in British Columbia produce less than 100 kilowatts (KW). These facilities represent potential sources of disruption to fish and fish habitat. Fish and fish habitat are protected in Canada by the federal *Fisheries Act* (R.S.C., 1985, c. F-14 as amended by Statutes of Canada 1991 c.1), which is administered by the Department of Fisheries and Oceans (DFO). The federal *Fisheries Act* provides the power to:

- protect fish and fish habitat from the discharge of deleterious substances
- prohibit the destruction of fish
- prohibit any work which is likely to cause harmful alteration of fish habitat
- require installation of fish screens to prevent fish entrapment
- require construction, operation, and maintenance of fish passage facilities at obstructions
- require the maintenance of stream flows required for fish
- require financial support for construction and operation of hatcheries or other compensation required to maintain runs of migratory fish.

In response to the anticipated increase in the development of small hydro installations in BC, DFO and MELP have prepared these guidelines for the protection of fish and fish habitat at small hydro developments. DFO's current fish habitat management philosophy is detailed in a 1986 Ministerial statement entitled *Policy for the Management of Fish Habitat* (Department of Fisheries and Oceans, 1986). The guiding principle of this policy is to require developers to achieve *no net loss* of fish habitat productive capacity, with DFO's long-term objective to achieve an overall net gain in the productive capacity of fish habitat. DFO's focus when evaluating small hydro proposals is on protection and conservation of the fisheries resource, in order to achieve the no net loss objective.

It is the responsibility of the proponent to determine the nature and extent of the fisheries resource that will be impacted by the proposed development. The general approach is to identify fish species and habitats (using existing and, if necessary, new information), and to predict the impact of the project on the resource. The information required to provide an adequate assessment includes a site description, an assessment of the hydrology and water quality of the stream, an analysis of existing water use on the stream, and an inventory of fish populations, habitat, and instream flow needs.

To facilitate achievement of the no net loss objective, DFO has developed a hierarchical list of preferences:

1. Maintain without disruption the natural productive capacity of the habitat, by avoiding loss or harmful alteration.
2. If it is impossible or impractical to maintain the productive capacity of the existing habitat, consideration is given to the development of compensatory habitat. This compensatory habitat is considered as follows:

a. Creation of similar habitat onsite.
b. Creation of similar habitat offsite supporting the same fish stocks.
c. Increasing the productivity of existing habitat onsite.
d. Increasing the productivity of existing habitat offsite supporting the same fish stocks.

3. As a last resort, if damage cannot be avoided, and the habitat cannot be compensated for, then proposals may be considered for artificial production.

Under the fish habitat protection provisions of the *Fisheries Act*, the costs for providing facilities, undertaking mitigation and compensation strategies, and monitoring are the responsibility of the proponent.

1.2 Scope and Objectives of the Guidelines

The explicit focus of these guidelines is the protection of salmonid populations and their habitat. Salmonids include both Pacific salmon populations (managed by DFO), and also steelhead, trout, char and other freshwater populations (managed by the provincial Ministry of Environment, Lands and Parks, MELP). Equally important to the protection of these primary populations is the protection of the aquatic ecosystem upon which populations of other fish species and organisms depend. If used throughout the life of a small hydroelectric development project, these guidelines will minimize the impacts on the fishery resource, and assist a developer in achieving regulatory approval without costly delays. The guidelines present measures which can be incorporated into every phase of a project, from the conceptual design stage through to construction, operation and maintenance, and into the particular design of each of the physical components of a small hydro facility, in order to minimize the potential for damage to fish and fish habitat. The responsibility for providing acceptable mitigation and compensation measures is the proponent's; use of the guidelines will assist the proponent in meeting that responsibility. The following is a summary of the information requirements for works or undertakings that have the potential to impact fish and/or fish habitat:

1. **Fisheries Resource Values** - a description of the existing fisheries resource values of the area that could be effected by the proposed works, including hydrologic features, water quality, species of fish that frequent the waterbody, fish habitat present (e.g. spawning, rearing, over-wintering, or migration) and riparian vegetation;

2. **Description of Proposed Activities** - a detailed description of the proposed works and site plan that indicate how the works are to be carried out, including all machinery and materials to be used. A time schedule of activities and applicable instream work windows that may apply must be provided;

3. **Impacts to the Fisheries Resources** - anticipated impacts to fisheries values should be discussed including the identification of the nature, magnitude and location of potential impacts, and effects on fish and fish habitat in downstream areas. All anticipated changes to fish habitat as a result of construction and installation should be stated. Justification for any changes in the natural stream boundary, such as diversion or placement of fill or riprap, should be provided as well as any predicted changes to downstream flows, bars, and stream banks;

4. **Mitigation and Compensation Proposed** - a description of all actions and contingencies that will be taken to avoid, reduce or eliminate the impacts outlined in Point 3. If required, it should include a discussion of any proposed habitat compensation works which may be legally required in a *Fisheries Act* authorization in order to achieve "No Net Loss" of fish habitat as required; and

5. **Environmental Monitoring** - actions to be taken to ensure all of the proposed activities as outlined are completed to the satisfaction of environmental agencies granting approval for the works. This commonly involves an environmental monitor who reports directly to the regulatory agency and who acts at "arms-length" from the proponent and proponent's contractors.

DFO has a legal obligation to protect fish and fish habitat under the *Fisheries Act* for any project that could cause a harmful alteration, disruption or destruction of fish habitat by chemical, physical or biological means. DFO preferentially requires the loss of productive fish habitat be completely avoided during all phases of a project. If impacts cannot be avoided, then impacts to the fisheries resource are to be minimized and residual impacts offset.

If review of a proposal determines that there is the potential for harmful alteration, disruption or destruction (HADD) of fish habitat an authorization under subsection 35(2) of the *Fisheries Act* will be required. This requirement also triggers review of the proposal under the *Canadian Environmental Assessment Act (CEAA)*. It is hoped that project design and mitigation measures will make such an authorization unnecessary.

1.3 Regulatory Procedure for Approval of Small Hydro Developments

1.3.1 Provincial Review Process

The application process for provincial approval to build and operate a small hydro facility has been under review for some time. This process has recently been completed, and is described in the booklet entitled *Guide to the Small Power Project Review Process in British Columbia*, published jointly in 1992 by the Ministry of Environment, Lands and Parks (MELP), and the Ministry of Energy, Mines and Petroleum Resources (MEMPR).

Several permits, licenses, and approvals are required, from several agencies of the provincial government, and from DFO to develop a small hydro facility. The approval process for all proposals is coordinated by the provincial government. Although DFO and MELP work closely together, dialogue should be initiated with both agencies early

in the approval process, to ensure that all potential agency concerns are considered in the project design phase. Any inquiries regarding the small power project review process should be directed to either of the following:

Environmental Assessment Branch
Ministry of Environment, Lands and Parks
5th Floor, 1312 Blanshard St.
Victoria, British Columbia
V8V 1X5

Energy Project Analysis Branch
Ministry of Energy, Mines and Petroleum Resources
Room 433, 617 Government St.
Victoria, British Columbia
V8V 1X4

1.3.2 Federal Review Process

Under the *Canadian Environmental Assessment Act* (CEAA) has been passed by Parliament and is awaiting proclamation. DFO is such a scheduled agency with regard to section 22 (Release of Water for Fish), section 32 (Destruction of Fish), section 35(2) (HADD) and section 37(2) (Minister may order modifications) of the ***Fisheries Act***. There is provision for a public hearing process if the potential impacts of a project are significant. In such a case the hearing would be combined with any hearing under the British Columbia Utilities Commission (BCUC) in a joint federal/provincial process.

2.0 Small Hydro Planning and Siting Guidelines

2.1 Project Planning

From the conceptual design stage through to construction, operation, and maintenance activities, measures can be incorporated into the development of small hydro facilities which will minimize the current and future impacts of the project on fish and fish habitat. Proper planning to minimize impacts involves choosing an appropriate development site and locations for facilities, selecting the appropriate equipment, designing project facilities to minimize their potential impacts, and timing, scheduling and conducting construction, operation, and maintenance activities. The following general objectives are to be addressed in the project planning phase:

- Maintenance of fish passage in watercourses so that it is not restricted by either inadequate or excessive water volumes or velocities.
- Development of the facility in a manner that will maintain the productive capacity of fish habitat of all affected streams at the same levels as existed prior to development.
- Development and operation of the facility in a manner that will not create negative impacts on the hydrology or geomorphology of the stream. This will ensure the long term stability and diversity of fish habitat.
- Operation of the facility in such a way as to minimize direct and indirect damage to fish, fish populations, and fish habitat.
- Prevention of the discharge of sediment and other deleterious substances during project development, operation, and maintenance.

2.2 Project Siting

The initial identification of a suitable site or sites for small hydro development is based on the availability of sufficient head and stream flow to power the plant. The following siting guidelines provide criteria to minimize the fisheries impacts at an initial planning level.

- Select a small hydro development site in a section of river with no or extremely low fish production and fish habitat values. Sites located above the upstream limits of fish migration and presence are preferred (e.g., naturally impassable falls, gradients greater than 25%).
- Select a site where the diversion of water from one watershed to another is not required
- Locate the diversion to minimize the extent of flooding of riverine habitat.
- If a dam is required that blocks the upstream migration of fish, select a site that minimizes the height of the diversion structure in order to allow construction of an effective fishway.
- Select a point of diversion that will minimize the disruption to streamside vegetation.
- Site the development and all facilities in an area of stable terrain and soils to minimize potential increases in sediment loading to the stream during construction.
- Locate the diversion and powerhouse to minimize the length of river channel between the diversion and the tailrace.
- Locate the tailrace to minimize erosion of the main channel by discharge water.

- Locate the diversion to minimize the disruption of the natural TGP (total gas pressure) regime in the stream. For example, locating diversion works upstream of a natural waterfall is preferable to constructing a high head drop structure, which would increase TGP levels.

3.0 Mitigation of Small Hydro Development Impacts

If the siting or location of a small hydroelectric facility will impacting fish habitat or fish-bearing waters, the particular designs adopted for the physical components can have a significant bearing on the ultimate impacts of the project. The appropriate design options to minimize fisheries impacts can be identified and the best opportunities for mitigation can be integrated into the detailed design of the facility.

3.1 Dams and Reservoirs

Dams and reservoirs provide water storage for hydroelectric facilities. Dam design considerations can mitigate potential impacts of the dam and the reservoir. Specific guidelines are:

- Use collapsible or removable dam structures that allow unobstructed water flows, sediment transport and fish passage when not in use.
- Design earthfill dams to prevent entrainment of fish into the upstream dam face. Possible techniques include use of fine-textured fill material or installation of an impermeable cap on the upstream face.
- Design dam height on rivers to minimize flooding of riverine habitat.
- Provide effective upstream and downstream fish passage (See sections 3.9.1 and 3.9.2) if the dam can not be located above fish-bearing waters.
- Estimate reservoir sedimentation rates and subsequent storage, removal or flushing requirements and consequences.
- Vegetate and stabilize the drawdown zone as required to buffer reservoir fluctuations.

3.2 Spillways

Spillways are structures that provide the ability to spill water over the top and down the outer face of the dam without damaging the dam structure, often during peak flood or freshet flows. Spillways can be designed to minimize both direct and indirect impacts on fish. Direct effects include injury or death resulting from abrasion on the spillway face, from passage through areas of extreme turbulence and velocity shear, and from impact. Indirect effects include gas supersaturation and habitat disruption or loss in and around the plunge pool. Guidelines are:

- Design the spillway to reduce gas supersaturation in the plunge pool to limit TGP values below 76 mm Hg (atmospheres) or 103% saturation levels in surface waters. Use techniques which promote horizontal rather than vertical entry of water into the plunge pool.
- Design the spillway to prevent scouring of the plunge pool and areas immediately downstream.
- The spillway heights should be minimized. Properly designed, low height spillways can provide safe downstream passage with minimal injuries and mortalities.
- Minimize the roughness of the spillway face to reduce abrasion-type injuries and scale loss, and air entrainment which increases the potential for gas supersaturation.
- Use effective physical fish barriers and diversion channels above the spillway if fish injuries and losses are expected.

3.3 Intakes, Control and Diversion Structures

Intakes and diversion structures usually provide water to the penstocks which lead to the turbines that generate power at a hydroelectric facility. Additional control structures may be incorporated to discharge water through or below the dam or diversion structures to provide flows downstream of the facility, or for other operational requirements. The type, number and locations of the intake, control and diversion structures can also be designed to provide additional operational flexibility in terms of the quantity and quality of water discharged downstream of the facility. The *Fisheries Act* gives DFO the authority to require the installation and maintenance of fish screens at water intakes and diversions. Screening prevents the entry of fish into the facility and subsequent destruction by passing through the turbine. Where the entrainment and destruction of fish is unavoidable, DFO can authorize the destruction of fish pursuant to section 32 of the *Fisheries Act* with requirements to compensate for the loss of fish. Design guidelines are as follows:

- Provide an effective fish screen or barrier at the intake or diversion structure leading to the penstock and turbines.
- Design the intake or diversion structure to keep approach velocities low, minimizing the danger of fish entrainment in a fast-moving approach current, and provide a higher sweeping or transverse velocity along the screen face.
- Provide a fish bypass near the intake to allow downstream migrating fish to pass the dam without passing through the penstocks and turbines.
- Design the number and the locations of intakes to minimize the alteration of downstream flow, temperature, and water quality regimes.
- Design the diversion structure or intake to provide reservoir drainage and natural sediment transport for maintenance.
- Provide effective upstream and downstream fish passage (See sections 3.9.1 and 3.9.2).

3.4 Canals, Pipelines and Penstocks

Canals, pipelines and penstocks usually transport the water from the diversion or intake to the turbine units. Specific guidelines are as follows:

In the case of pipelines, an emergency shutoff device should be provided at the intake for emergencies such as rupture of the pipe.

- Select alignments which will minimize potential for damage to fish and fish habitat through erosion and sedimentation during clearing, construction, and operation.
- Avoid the use of long intake canals to penstocks that can attract and possibly trap fish.
- Line canals with concrete or other impermeable, non-erodible materials.
- Select appropriate pipeline and penstock materials to minimize potential for leakage or rupture.
- Design appropriate support to prevent structural failure and rupture of pipelines or penstocks.

3.5 Turbines

Turbines are devices that convert the forces of the flowing water into mechanical energy. This mechanical energy is then converted into electrical energy by the generator, which is usually attached to the turbine unit. Without screening, fish will pass through the turbines and suffer injury or mortality. The damage to the fish is caused by mechanical damage (impact of the turbine blades or impeller), extreme changes in pressure, turbulence and shear forces, and cavitation. Two general guidelines for turbine design are:

- Select a turbine that minimizes potential for fish damage. Reaction-type turbines (Francis and Kaplan) are have lower associated fish mortalities than impulse-type turbines (Pelton, turgo and cross-flow).
- Use the most efficient turbine for the required production rate, and operate at maximum efficiency. If necessary, use multiple units to achieve optimal efficiency over the range of expected flow conditions.

3.6 Tailrace

The tailrace is where the water is discharged after passing through the turbines. The tailrace structure and channel usually discharge back into the waterbody from which the water was diverted. Guidelines for tailrace design are as follows:

- Prevent fish from entering the tailrace and draft tube. A bar rack or screen, or drop structure should be placed at the entrance to the tailrace.
- Ensure upstream migrant fish are directed towards a fish bypass or ladder to keep them away from the tailrace area.
- Design the tailrace to prevent erosion of the channel itself, and of the downstream channel where the tailrace discharges.

3.7 Roads and Transmission Lines

Roads are required as part of the construction, operation and maintenance of a hydroelectric facility. Transmission lines are required to carry the electrical power produced at the facility to the power grid or load. Road design guidelines are as follows:

- Locate roads away from streams, canyons, wetlands, and unstable slopes. Provide adequate leave strips next to aquatic habitat.
- Specify a road design best suited to prevailing slopes, soil conditions, and topography to minimize the potential for slope erosion. Locate roads on terraced surfaces, ridge tops, or gently sloping hillsides.
- Stabilize and revegetate all disturbed slopes immediately following construction.
- Ensure that a road drainage network is designed and installed, and that drainage structures are adequately-sized and protected from erosion.
- Minimize the number of stream crossings.
- Design all necessary stream crossings to ensure migratory passage by all fish species.

Refer to DFO/MELP *Land Development Guidelines for the Protection of Aquatic Habitat* (1992) and the *British Columbia Forest Practices Act* related regulations and guidebooks. Transmission line alignment can influence the long-term impacts of a transmission line on fish and fish habitat. Guidelines for transmission lines are as follows:

- Route the transmission lines across the valley axis or along the ridges, rather than along the valley bottom or in the active floodplain.
- If towers must be placed in the active floodplain, design appropriate scour and erosion protection.
- Provide required leave strips in riparian areas and floodplains for right-of-ways and access roads.

3.8 Other Facilities

Other facilities include operator accommodation, tool and fuel storage huts, parking lots, maintenance yards, and office areas. Guidelines are as follows:

- Surround storage facilities for fuel and other deleterious substances by a structure designed to fully contain any spilled materials.
- Ensure all sewage from any buildings or portable facilities is properly contained and disposed according to provincial Ministry of Health (MOH) or MELP regulations.
- Ensure adequate supplies of the proper clean-up material are available in the event of spills of deleterious substances.

3.9 Fish Passage Facilities

The *Fisheries Act* gives DFO the authority to require the construction, maintenance, and operation of fish passage facilities. The objective in designing fish passage facilities is to enable the safe upstream and downstream passage of fish around an obstruction.

3.9.1 Upstream Passage

Upstream passage facilities will be required at hydroelectric facilities that block access to upstream spawning and rearing areas used by resident and anadromous fish. General design guidelines are as follows:

- Select a fishway design that has proven to be appropriate for the species and site conditions.
- Ensure flow velocities are high enough to motivate passage for the species using the fishway, but not so high that passage is prevented. Critical velocities must be kept well within the *burst swimming speeds* of the fish using the fishway.
- Provide sufficient resting areas for the species using the fishway. These velocities should be less than the *sustained swimming speed* of the fish using the fishway
- Locate the fish entrance and exit in a location that minimizes predation.
- Locate the fishway entrance and/or attraction water outlet to ensure that fish can find the entrance without experiencing significant delay.

3.9.2 Downstream Passage

Fish migrating downstream, whether adult or juveniles, must be able to pass through or around the hydroelectric facility. Fish either pass over the spillway, through the control structures or are bypassed around via a fish screening structure. If it is not possible to design and operate a spillway to provide fish with safe and timely downstream passage, fish screens or barriers should be designed to direct fish into a bypass structure that will allow fish safe passage around the facility.

3.10 Downstream Flow Requirements

The *Fisheries Act* gives DFO the authority to require the maintenance of a sufficient flow of water below an obstruction for the preservation of fish and fish habitat. Negative impacts may be reduced during the project design stage by careful consideration of the following upstream and downstream effects:

- Ensure the design of the dam and control works, and reservoir storage and operation will allow adequate flow storage and release capability to maintain instream flow requirements for fish and fish habitat downstream of the facility.
- Ensure that the water released meets both water quality and temperature requirements for fish and fish habitat downstream of the facility.
- Ensure that the controlled flow regime is adequate to maintain the downstream geomorphology and fish habitat diversity.
- Flow ramping rates should not lead to stranding of fish (decreasing flows), or flushing of fish downstream (increasing flows).

4.0 Compensation for Small Hydro Development Impacts

Compensatory habitat must be designed and constructed to offset any residual loss of fish habitat and productive capacity. Compensation strategies must follow the priority set out in DFO's *no net loss* policy:

1. Maintain without disruption the natural productive capacity of the habitat, by avoiding loss or harmful alteration. (Section 3.0 - Mitigation of Small Hydro Development Impacts)
2. If it is impossible or impractical to maintain the productive capacity of the existing habitat, consideration will be given to the development of habitat compensation. Compensatory habitat is considered in the following order of preference:
    a. Creation of similar habitat onsite.
    b. Creation of similar habitat offsite supporting the same fish stocks.
    c. Increasing the productivity of existing habitat onsite.
    d. Increasing the productivity of existing habitat offsite supporting the same fish stocks.
3. As a last resort, if damage cannot be avoided, and the habitat cannot be compensated for, then proposals may be considered for artificial production.

The development of hydroelectric facilities and associated actions may require the construction of compensatory habitat as a result of:

- flooding due to dams and diversion structures
- physical infilling for construction of structures
- reduction of stream flow or changes in stream hydrology
- stream morphological changes
- diversion and relocation of streams and rivers

The advice of both federal and provincial fisheries agencies should be sought by the proponent early in the planning process so that appropriate compensation techniques and technologies are used for the fish species and habitat types affected. Where fish habitat destruction or harmful alteration is deemed to be unavoidable by DFO, a authorization under section 35(2) of the ***Fisheries Act*** will be required. This authorization will set out the specifications and responsibilities to construct, maintain and monitor the required compensatory fish habitat. The compensatory fish habitat will possibly require physical and biological assessment and monitoring by the proponent to attest to its productive capacity. This monitoring work may be required over a span of several years, in order to assess both short-term and long-term success.

5.0 Small Hydro Construction Guidelines

The objective of the guidelines presented in this section is the minimization and mitigation of the short-term impacts of project construction and maintenance. During construction of a small hydro project, the potential for impacts on fish and fish habitat can be significant. There are four primary sources of impacts on fish and fish habitat:

- loss of riparian vegetation
- soil erosion and release of sediment associated with construction activities
- uncontrolled instream work including construction activities and stream/river diversions
- release of deleterious substances into fish-bearing water bodies.

The *Fisheries Act* gives DFO the authority to modify, restrict, or prohibit any work or undertaking which is likely to result in the harmful alteration, disruption, or destruction of fish habitat. The following section contains information specific to the construction of small hydro facilities. Further information and specific site requirements should be determined from the *Land Development Guidelines for the Protection of Aquatic Habitat* (1992), *Establishing Fisheries Management and Reserve Zones in Settlement Areas of Coastal British Columbia* (1997), *British Columbia Forest Practices Act*, guidebooks and regulations (2000), and in consultation with DFO and MELP.

5.1 Leave Strips

The primary objective of leave strips is to ensure the long-term integrity the riparian zone, which is critical to the maintenance of a healthy aquatic environment. Riparian zones, located next to streams, rivers, lakes and wetlands, have direct influence on aquatic habitat values. They can broadly be described as the area of the stream bank, including side channels and associated banks, and upland areas not normally inundated during high water conditions. Riparian zones and the instream aquatic habitat are both part of the *Fisheries Sensitive Zone* (FSZ). Leave strips should be provided on all watercourses that flow into or contain fish or fish habitat. This may include swampy areas, wetlands, small streams and side channels or intermittently wetted areas. The leave strip also helps to protect property from flooding and potential loss of land due to stream erosion and instability.

- Provide a **minimum 30 meter wide leave strip**, on both banks, for riparian zone protection should be provided from the natural boundary, usually the annual high water mark. Leave strips are measured perpendicular to and away from the stream bank, for the distance specified, on both sides of the stream.
- The 30 meter width may be altered by field staff to suite onsite conditions. In many cases, the leave strip may have to be widened to protect critical fish habitat within the FSZ. Field staff should be contacted if there is any difficulty in determining the existing high water mark or required leave strip width for a certain watercourse.

5.2 Erosion and Sediment Control

Clearing, excavating, tunneling, and grading activities are required for construction of most facilities at a small hydro facility (e.g., access roads, dam and intake structures, transmission lines, penstock, powerhouse, and office, storage, and parking areas). These activities disturb the natural vegetative cover and reduce the stability of soils and slopes, resulting in increased potential for mass wasting (e.g., slides and slumps) and soil erosion and sediment transport to

nearby watercourses. Sediment control plans should constitute an integral component of a small hydro construction plan. Further information on erosion and sediment control practices can be found in the *Land Development Guidelines for the Protection of Aquatic Habitat (1992)* and related references.

5.3 Instream Work

Some instream work will be required during construction of a small hydro development. Prior to commencement of instream work, proponents are required to forward plans and proposals to DFO to ensure impacts are fully mitigated or an authorization under section 35(2) is prepared. **Any instream work is also governed by approvals issued pursuant to the provincial *Water Act*, and approval from MELP Fisheries and Water Management staff is required before conducting instream work**. The objective of the instream work guidelines is to promote careful planning and construction practices to limit the potential for impacts on the aquatic environment. Instream work is defined as any work performed below the high water mark, either within or above the wetted perimeter, of any feature within the FSZ. Because instream work has the potential to be extremely destructive to fish habitat, methods and procedures to minimize instream activities should be considered during the planning and design stages of a project. General guidelines are as follows:

- Carefully plan the scope and timing of the work to avoid sensitive periods of the year, and avoid affecting existing habitat. FSZ operating windows are specific to species and region. Contact area DFO staff to determine safe FSZ operating windows.
- Consult with area DFO staff regarding presence, distribution and timing of migrations of fish species in the stream or watercourse, and FSZ window prior to work.
- Plan instream work and minimize the duration of the instream activities for periods within the confirmed FSZ window that will minimize disturbance and impact on fish and fish habitat.
- All material placed within the wetted perimeter must be non-erodible and non-toxic to fish. Do not remove gravels, rock or debris from any stream without approval.
- Minimize disturbance to stream banks where equipment enters and leaves the watercourse. Reconstruct and revegetate stream banks to their original condition as soon as activity has finished.
- Use the proper equipment for the proposed construction activity. Avoid damage caused by stuck equipment or delays because of insufficient capacity for proposed work.
- Ensure that all construction equipment is mechanically sound to avoid leaks of oil, gasoline, hydraulic fluids and grease. Steam clean and inspect construction equipment prior to instream use. Specify biodegradable hydraulic fluids in machinery used for instream work.

Note: It must always be assumed that fish are present in a watercourse since the utilization and residency times for different species vary widely in accordance with their spawning and rearing cycle requirements. The windows of allowable times when instream work can be tolerated are often based on the reduced sensitivity of the fish to disturbances rather than the absence of fish during these times. Timing windows of allowable

instream work should always be confirmed with field staff responsible for the area in which the proposed development is located.

5.4 Deleterious Substances

Common deleterious substances: sediments, raw and uncured concrete, mortar, glues, paints, lubricants, organic and inorganic contaminants, fuels and oils, can have detrimental or toxic effects on the aquatic environment and fish life. In most instances, the control of these substances can be dealt with through an awareness of their detrimental effects, the practice of good housekeeping (i.e., daily site clean-ups, use of disposal bins, etc.) on the project site, and the proper use, storage and disposal of such substances and their containers. The following guidelines should be used ensure no deleterious substances are released into fish habitat.

- Wood preservatives containing chemicals such as creosote, chlorophenols and zinc or copper napthanate solutions are extremely toxic to aquatic organisms. However, based on information on mobility, persistence, and aquatic toxicity, it is suggested that CCA (chromated copper arsenate) treatment should be used in freshwater and marine environments. With CCA treatments, the treated dry wood should be rinsed after application and drying, with wash waters contained or recycled, and weathered or seasoned for a minimum of 45 days before it is used in or near any water body. Pressure treated lumber containing CCA should be allowed to fully react and weathered for a minimum of 45 days. Application of treatment solutions to installed materials on or over water is not acceptable under any circumstances.
- Concrete, which contains lime in the cement, can kill fish by substantially raising the pH in stream water. All cast-in-place concrete should be totally isolated from flowing water for a minimum 48 hour period to allow the pH in water surrounding the concrete to reach background levels before continuing instream work. Pre-cast concrete should be used whenever applicable for the construction required.
- Dispose of raw or uncured waste concrete and grouts by removal or by burial on the site in a location, and in a manner that will not impact on a watercourse.
- Handle and transport fuels, lubricants and hydraulic fluids to avoid spillage, properly secure against unauthorized access or vandalism, and provide with spill containment according to codes of practice.
- Fuel and lubricate equipment only after it has been moved to a constructed service pad with a separate drainage collection system.
- Collect waste oils and hydraulic fluids in leak-proof containers and remove from the site for proper disposal or recycling.
- Trap and settle deleterious substances in runoff water. Floatable petroleum contaminants can be skimmed from the surface of a settling basin.
- Any spillage of fuels, lubricants or hydraulic oils should be immediately contained and the contaminated soil removed from the site and properly disposed of in accordance with the federal Environment Canada and the provincial MELP requirements. Spills should be reported immediately to both agencies for their counsel on appropriate clean up procedures.

5.5 Explosives and Blasting

The use of explosives in or near fish habitat must be approved by DFO. Each application will be considered individually on the site specific conditions and circumstances. Explosives may only be used when less detrimental methods are not feasible. General guidelines are:

- Schedule blasting for periods when fish are not present in the blast influence area.
- Physically remove or salvage fish from the blast zone prior to blasting.
- No blasting should take place near known spawning areas when eggs or alevins are still in the gravels.
- Minimize blast energy by using low velocity charges, multiple charges and special detonation techniques.
- Minimize damage to surroundings by the use of blasting mats and blast deflectors.

In some situations, it will be necessary to physically remove juvenile salmonids from, and block their re-entry back into, the blast zone. The underwater blast zone generally encompasses the area within a 400 meter radius of the detonation site depending on blast energy, rock type and explosive used. The proponent or developer must conduct such removal activities only under the direction and with the assistance of a qualified professional biologist. Information on explosives use can be found in *Munday et al*. (1986). Additional precautions must be taken when blasting rock to prevent degradation of fish habitat. These include:

- Leachate from waste rock produced in tunneling operations can be toxic to fish. This waste must be kept out of stream channels, and disposed of such that any leachate does not enter the stream directly, via infiltration or seepage.
- Prevent fragmented angular blast rock from entering the stream or river, infilling rearing areas or degrading spawning habitat.

6.0 Small Hydro Operating Guidelines

This section presents guidelines for minimizing the ongoing and long-term impacts of the operation of the facility in generating electricity. The main source of impacts caused by plant operation is the change in the natural hydrological regime of the stream, related morphological and water quality impacts, and impacts due to ongoing maintenance activities. Guidelines for water use are:

- Develop an operating rule curve and order system to accommodate fisheries requirements.
- Maintain downstream flows appropriate for the instream flow requirements of the aquatic ecosystem.
- Avoid rapid fluctuations in water release from the reservoir (i.e., avoid high ramping rates, rapid flow changes, surges, etc.). A turbine bypass or spillway should be utilized to avoid high ramping rates during shutdown.
- Minimize the impacts of flooding of habitat and destabilization of side slopes during initial filling of the reservoir by conducting a staged filling with monitoring.
- Minimize disruptions to the lacustrine habitat of the reservoir, and the stability of the shoreline and lower slopes, by controlling the frequency and extent of fluctuations in reservoir level.
- Ensure sufficient flow for correct operation of upstream and downstream fish passage facilities.
- Ensure fish screens are operating correctly and trash racks are regularly cleaned.
- Ensure fish bypass features function effectively.
- Operate intakes to minimize the downstream disruption of natural flow and temperature regimes.
- Operate turbines at maximum efficiency to minimize fish injuries and losses.
- Ensure that fish do not enter tailrace.
- Construct, maintain and monitor habitat compensation features to meet required DFO habitat compensation agreements.

The ongoing maintenance of small hydro developments has the potential to affect fish and fish habitat. However, if adequate advance planning is done, and precautions are taken during maintenance activity, the potential impacts can be minimized. Maintenance activities that can potentially impact fish and fish habitat are:

- Instream maintenance behind diversion structures and in or near tailrace channels.
- Maintenance of bank protection works or instream structures.
- Select equipment which will minimize the mobilization and downstream flushing of fine sediment (e.g., dry excavation or use of suction dredge with disposal to land).
- Design and construct a discharge structure that will allow for the natural transport of accumulated sediments during high flow conditions when the streams natural sediment transport capacities are high.
- Provide desilting or sediment exclusion devices on the water intake to allow for run-of-the-river operation during high flow/sediment transport periods to avoid the use of impoundments and dams.
- Design and construct instream structures for minimum instream maintenance.
- Allow for frequent inspections, particularly during high runoff periods.

- Check for improper functioning of a structure during or after a major storm event which may indicate the need for repairs or modifications.
- Perform repairs immediately in order to prevent the need for extensive repairs later, and to ensure safety and minimize environmental impacts.
- General maintenance should be carried out according to agreed schedule of works and agency contact procedure.
- If emergency measures are required, only justifiable essential preventative actions should be taken to protect life and property. If time allows, contact the fisheries agencies before carrying out emergency repairs.

7.0 Assessment and Monitoring for Small Hydro Developments

Fisheries agencies may require a proponent to monitor mitigation and compensation measures on a continuing basis. The timing of the start-up of such a monitoring program, the frequency of measurements, and the details of reporting mechanisms would be determined on a case-by-case basis. These decisions would require an understanding of appropriate time scales for evaluation of project-related changes to the natural environment, and of the mitigation and compensation strategies employed. Monitoring is defined as the continuous or periodic collection of data used to evaluate environmental change. Monitoring is an important component of project construction and operation that is specifically used to:

- evaluate the effectiveness of mitigation strategies
- ensure construction activities are confined to designated areas specified in the approved design
- ensure construction and operation practices comply with regulatory requirements
- evaluate unforeseen environmental changes resulting from project-induced activities and create an historical record
- identify the need for additional mitigative or compensatory actions for dealing with unforeseen impacts or to improve the effectiveness of existing strategies
- demonstrate compliance with conditions of approval.

Effective monitoring requires accurate baseline information on environmental components such as water quality, flow records, and fisheries inventory. Therefore, monitoring essentially begins with the initial environmental assessment and continues with the construction and operation phases to evaluate ecological change. Monitoring during construction and operation of a project should provide quantitative, objective information needed to support project management actions, decisions and recommendations.

7.1 Pre-Development Fish Habitat Assessment

Pre-development baseline data is required in order to effectively assess mitigation and compensation work. This data should be obtained through a monitoring program designed to include the following:

- Status of and proposed changes in fish habitat in streams affected.
- Status of and proposed changes in fish populations of streams affected.
- Status of and proposed changes in water quality in streams affected (e.g., dissolved oxygen, water temperature, gas saturation levels and other water chemistry parameters).
- Status of and proposed changes in suspended and bed load sediment regimes of the streams affected.
- Status of and proposed changes in the stream bed material composition of streams affected.
- Proposed mitigation structures or procedures (e.g., fish screens, fish bypasses, fishways, sediment and flow/temperature/water quality control works).
- Proposed fish habitat compensation based on productive capacity of fish habitat destroyed or damaged.

7.2 Construction Monitoring and Inspection

Where considered appropriate by government agencies, the proponent will be required to employ environmental inspectors to ensure a high standard of environmental protection during construction. Construction can be either continuously monitored or periodically inspected, depending on site sensitivity and the nature of construction. The Inspector provides the following services:

- acts as an intermediary between the proponent and regulatory bodies
- briefs the contractor on site-specific environmental requirements
- provides basic environmental education and construction guidelines to all field personnel
- closely supervises construction activity to ensure compliance with construction guidelines
- defines environmental standards for construction
- flags sensitive areas in advance of actual construction
- reports to the proponent and the regulatory agencies on the environmental performance of the contractor
- immediately stops construction practices which are harming the environment.

The benefit of environmental monitoring during construction is the early identification and solution of potential problems, which might otherwise result in construction delays and costly penalties for environmental violations. Regulatory agencies should ensure that environmental inspectors are given the authority to shut down construction operations in the case of non-compliance with approval conditions. However, the legislative authority vested in the government agencies is not passed on to environmental monitors. Therefore, regulatory agencies retain the right to overrule environmental inspectors, and have final authority in determining whether or not construction standards are being met by the contractor.

7.3 Post-Development Assessment and Monitoring

Post-development monitoring will include a report on the activities and impacts incurred during construction, habitat mitigation and compensation construction and initiation of long-term monitoring. Long-term monitoring is the only means by which the effectiveness of the constructed mitigation and compensation measures can be determined. A monitoring program will examine both physical and biological variables identified in the pre-construction assessment, during construction and as part of the long-term monitoring program including:

- effectiveness of construction site rehabilitation
- impacts of operation of the project
- success of existing mitigation and compensation measures
- need for additional mitigation and compensation measures.
- design, implementation and monitoring modifications to, or new, mitigation and compensation measures.
- documentation of monitoring efforts and results with production of an regular (annual) report forwarded to DFO.

The monitoring program will be designed in consultation with DFO and MELP. The duration and scope of the program at a particular site will depend on the characteristics of the hydro facility, on the mitigation and

compensation measures in place, and on the sensitivity of the fisheries resource. To ensure that habitat compensation measures are maintained and function as designed, the section 35(2) authorization will include details of the proponents responsibilities. The agreement will clearly define the required monitoring, maintenance, physical and biological assessment, timetables for reporting and criteria. This will be part of the proponent's continuing operational costs for any approved project.

7.4 Operational Monitoring

Once a small hydro facility has been commissioned, there will still exist a need for compliance monitoring to ensure the conditions of various approvals are met. The *Fisheries Act* provides DFO with the authority to request an operator to provide samples or analyses that indicate the effect of the operation on fish and fish habitat. Such requirements may involve the monitoring of water flow, dissolved oxygen levels, and water temperature in the tailrace. This information would be used to determine the effectiveness of prescribed downstream water releases for maintaining fish populations and habitat. Monitoring data would also be used to "fine tune" plant operations to minimize impacts on downstream fish populations during critical life stages such as migration or egg incubation.

7.5 Water Quality Monitoring Parameters

Generally the monitoring of a small hydro project may be required by various government agencies through either specific legislation, regulation, or conditions incorporated into licenses, approvals, or permits. The water quality parameters monitored usually include dissolved oxygen, suspended solids, pH, nitrites, nitrates, biological oxygen demand and general water chemistry. The need for monitoring and selection of appropriate parameters and frequency should be evaluated on a site specific basis.

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