

Guidelines for Applying to Alter a Body of Water

**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
St. John's, NL, Canada
A1B 4J6**

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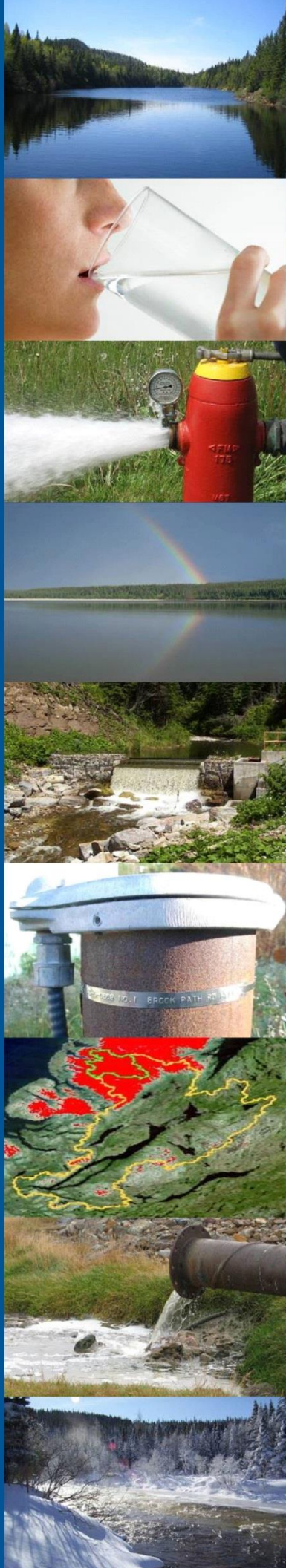
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Chapter 1: Introduction

**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
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Chapter 1

INTRODUCTION

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

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1.1 The Need and Purpose of Guidelines

The following document is a compilation of standalone guideline documents. The purpose of the guidelines is to aid in the process of applying for a permit to make alterations in and around water resources by providing guidance for the design and construction of these alterations. These permits exist to protect Newfoundland and Labrador's water resources by preventing any work or alteration that would have a negative or disruptive effect on a body of water.

As per Section 48 of the Water Resources Act, "A person may apply to the minister for a permit to carry out an undertaking that under this Act or the regulations requires a permit and the minister may issue that permit in accordance with this Act." Applications must be made using the required forms and must be accompanied by the required fee, and work shall not begin until the permit has been issued.

A permit may be issued under the consideration of the information included in the application, as well as the following:

- potential adverse effects of the proposed undertaking on the environmental, surface water, and groundwater conditions in the area,
- the effectiveness, purposes, and benefits of the proposed undertaking,
- if the proposed undertaking contravenes government policy, and,
- whether or not the location of the proposed undertaking is acceptable.

These guidelines are not a set of legal requirements, and should not be considered as such. They exist only to aid applicants in their understanding and completion of the forms required to apply for a permit. Even if the guidelines are followed, it is possible an application may not be approved.

1.2 Organization and Use of the Guidelines

The guidelines are organized into chapters based on the type of alteration that is being applied for. Each chapter is also broken up into sections based on different key aspects of the specific type of alteration.

The guidelines are meant to be used as a set of best-practices to consider when planning and designing an alteration to a water body before submitting an application. They can be used for clarification if concerns or questions arise during the preparation of applications.



Chapter 2: Legislative Requirement and Approval

**Water Resources Management Division
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November 29, 2018**



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Chapter 2

LEGISLATIVE REQUIREMENT AND APPROVAL

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

2.0 LEGISLATIVE REQUIREMENT AND APPROVAL

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2.0 LEGISLATIVE REQUIREMENT AND APPROVAL

2.1 General

Any work that involves alteration of a body of water or work taking place near a body of water is subject to provincial legislation, and must be approved by the Department before work can begin. The approval process requires anyone looking to undertake such work to submit a completed application form, including all relevant documents.

2.2 Water Resources Act

Section 48 of the [*Water Resources Act*](#) covers the permitting process. A summary of what it covers follows:

Any work altering a body of water requires a permit to be issued by the Department, and that no work may begin until the permit is issued. All permit applications must be made using the proper forms and must be accompanied by the required fees. The decision on whether or not to approve a permit is based on:

- The information submitted in the application,
- Potential adverse effects of the work on present and future water and water use,
- The purpose, benefits, and effectiveness of the work,
- The location of the work, and
- Whether the work violates any government policies.

The Department will issue a notification in writing if a permit application is declined. Any work that is done without a permit may be subject to an investigation by the Department. The Department may deem it necessary that such unauthorized work be altered, removed, or added to, at the owner's expense.

Section 49 of the *Water Resources Act* covers amendment and transfer of permits. A summary of what it covers follows:

A permit holder may apply for an amendment to their permit in order to add, remove, or alter a term or condition of the permit. The terms and conditions of a permit may be amended if:

- An adverse effect has occurred or may occur that was not reasonably foreseeable at the time the permit was issued,
- A term relates to reporting or monitoring requirements, or
- The alteration is related to the temporary suspension of the work.

A permit may be cancelled or suspended if:

- There has been a breach or default of the permit,
- New or corrected information on potential adverse effects has been made available, or

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- Failure to pay a penalty related to the work under the permit.

The holder of the permit will be notified in writing of any alteration, cancellation, or suspension of their permit. A permit may not be transferred, sold, leased, or assigned by the permit holder without approval from the Department.

2.3 Policy for Infilling Bodies of Water

It is common for landowners to apply to begin infilling a body of water on or adjacent to their property in order to increase the useable land area, creating more space to build on and develop. Such infilling can have a significant impact on the body of water and as such the work must be assessed and accounted for before being undertaken.

Infilling a body of water for additional land space also creates the risk of the infilled land being eroded away or flooded by the water that has been obstructed by the infilling.

The Department's policy is that any infilling occurring within 15m measured horizontally from a body's high water mark will be subject to Section 48 of the *Water Resources Act*, with the high water mark defined as the 100 year return period water depth. Infilling within 15m of a body of water is only permitted in exceptional circumstances, when the proponent of the work can show that no reasonable alternative exists.

Situations when infilling within 15m of a body of water may be permitted include:

- Infilling related to marine facilities such as wharves, fishplants, and boathouses,
- Infilling related to public or municipal projects such as roads, bridges, and water and sewer facilities,
- Infilling of very small bodies of water that do not appear on the 1:50,000 scale topographic map of Newfoundland and Labrador, and
- Infilling related to environmental improvements such as playgrounds, public beaches, and nature areas.

Infilling related to industrial uses such as mining and power development may also be permitted, but only the project has been cleared of all other requirements under the *Environmental Assessment Act*, and only if its registration, Environmental Preview Reports, and Impact Statement all clearly discuss the infilling requirements.

It is required that any land created by infilling must not be vulnerable to flooding or any flooding related effects such as erosion. Land created by infilling must also not increase the risk of flooding or alter the drainage in any adjacent land areas.

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2.4 Policy for Development in Wetlands

Wetland is a term that covers areas where the water table is near ground level, creating large, shallow bodies of water such as marshes, swamps, and bogs. These bodies of water serve many important purposes, and as such must be carefully protected. Wetlands reduce erosion and flooding downstream, clean water that passes through them, provide habitat for plants and animals, and allow for water to seep underground and recharge groundwater supplies. These benefits can be lost if the land is developed.

It is the Department's policy that any alteration to a wetland area that could cause increased flooding or have unmitigated adverse effects on water quality, quantity, or other hydrological impacts, will not be permitted. Development of wetlands that are within the recharge zone of a groundwater well will also not be permitted. Any material that has the potential to impair water quality in a wetland will not be permitted to be placed in a wetland, such as:

- Raw sewage,
- Municipal waste,
- Industrial waste,
- Fuel or fuel containers, and
- Herbicides and pesticides.

Some wetland developments, such as those for purposes of peat extraction, agriculture, or forestry, may be undertaken only with written permission from the Department. Development of wetlands for the building of residential, recreational, commercial, or industrial structures and facilities also require written permission, as well as flow control structures meant to alter water level fluctuations to enhance wildlife habitat. Any wetland development that has the potential to adversely affect water quality will require mitigative measures to be implemented to reduce any potential impacts, and effort must be made to restore the wetland to as close to its original state as possible after work is completed.

2.5 Policy for Use of Creosote Treated Wood In and Near Fresh Water

Creosote is a substance made using coal tar that has been traditionally used to treat wood in order to make it more durable. Creosote treating protects wood from rotting and pests such as animals and insects that would eat or otherwise damage the wood. These properties have made creosote treated wood a popular choice in the past for marine structures that were built to last a long time, since it kept the wood from rotting when submerged for long periods of time and prevented marine life like mollusks and crustaceans from damaging the wood.

Creosote treated wood poses a threat to water bodies because the creosote can bleed out of the wood and contaminate the surrounding water. This contamination is a serious issue

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because of creosote's carcinogenic and toxic properties. Creosote bleeding may worsen in hot weather and can be identified by an oily film forming on the water or by its odour.

Due to the risk it poses to public health, it is Department policy that creosote treated wood is not to be used in any project taking place in or around fresh water. Any application made for a permit under Section 48 of the *Water Resources Act* that involves the use of creosote treated wood in or near a body for fresh water will not be approved. This includes wetlands and bogs, ditches leading to bodies of water and any land within 15m of the high water mark, with the high water mark defined as the 100 year return period water depth. Creosote treated wood is not permitted to be used for any reason anywhere within a protected water supply area, or anywhere upstream of a source of drinking water or swimming area.

For projects in and around saltwater, the use of creosote treated wood may be permitted, but only if the proponent of the work is able to justify its use for the particular project, and designs using alternative materials must be considered.

2.6 Policy for Flood Plain Management

Any development in an area designated as a flood plain, flood risk area, or climate change flood zone must have prior written approval by the Department. A flood plain is the area around a body of water that water levels will rise above in the case of a 100 year flood event. Development of land in a flood plain is generally discouraged as it both exposes the development to the danger of flooding, and exposes the water body to potential contamination from the development. The reasons for restricting development in flood plains include:

- Preventing loss of life, injury, and other personal hardship,
- Minimizing damage to property, infrastructure, and environment,
- Preventing the degradation of water resources,
- Maintaining a waterway's flow capacity,
- Minimizing the disruption of day-to-day activity, and
- Minimizing cost to taxpayers.

Any Crown land within a flood plain will not be transferred to any private developer or municipality. Other undeveloped land in a flood plain will be discouraged by zoning regulations, planning around such areas in early stages, and by removing subsidies and other economic incentives or public funding from such areas. Where development in a flood plain has already occurred or is unavoidable, flood proofing measures will be taken to reduce potential damages, and it will be made sure that development does not impede the flow of water. Any renovation or alteration of an existing development in a flood plain that involves increasing the floor area will be considered in the same way as a new development. It is also Department policy to account for a predicted increase in flow due to climate change when considering in these situations.

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The Department's overall role in flood plain management includes but is not limited to:

- Evaluating applications to develop in flood plains made under Section 48 of the *Water Resources Act*.
- Carrying out hydrotechnical studies, flood risk analyses, and flood risk mapping, to the extent possible with the limited funds and resources available.
- Monitoring areas known to be at high risk of flooding in order to provide flood warning and flood status reports.
- Providing the public with material to help reduce flood damage such as flood data, flood risk maps, and guidelines for flood proofing.
- Providing technical expertise and assisting Fire and Emergency Services in the event of a flood emergency.
- Flood forecasting using computer models and real time data.

2.6.1 Categories of Flood Plain Development

Although the Department's policy is to preserve the natural state of flood plains, there are some projects that have benefits that outweigh the risk of developing in flood plains and other flood risk zones. Such projects are considered as one of nine categories that are ranked in order of preference to the Department, where higher ranked categories are more likely to be considered acceptable than low ranked categories. The ranked categories, from highest to lowest, are as follows:

- 1 Temporary alterations in or near a flood plain, or in the water body itself.
- 2 Non-structural uses such as parks, pastures, or wildlife habitat enhancement.
- 3 Structures related to use of water resources such as wharves, boathouses, or stormwater discharges.
- 4 Minor structural projects that only involve soil disturbance such as trails, transmission lines, and roads, given that the grade of the land is unaffected.
- 5 Other structures where there will be a change in the grade of the land, but no building will be constructed.
- 6 Industrial uses related to marine shipping or fishing.
- 7 Other industrial and commercial developments.
- 8 Institutional developments such as hospitals, senior's homes, and schools.
- 9 Residential and other institutional development.

Hydraulic structures are a separate category of development that exists outside the preference ranking. They include structures that are meant to interact with the flow of water such as dams, bridges, dykes, and canals. These structures are still subject to Section 48 of the *Water Resources Act* and must be approved by the Department. Hydraulic structures must be designed so that they do not adversely affect a body of water's ability to convey flow, as a reduction of flow capacity can increase flood risk in the surrounding area. Dams impact flow in a body for water by nature, so new areas of flooding and their impacts must be fully assessed by the proponent.

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2.6.2 Types of Flood Plains

Flood plains may be designated as different types such as floodways, floodway fringes, and climate change flood zones. Floodways are areas that will flood under a 20 year return period flood event, floodway fringes are areas that will flood under a 100 year flood event, and climate change flood zones are areas that are predicted to be at risk of flooding when the effects of climate change are considered. The different categories of development may not be permitted or may only be permitted with special conditions depending on the type of flood plain they've been proposed for. The effects of the type of flood plain on the category of development can be seen in **Table 2.1**.

Table 2.1: Effects of Flood Plain Type on Development Categories				
Category	All Flood Plains	Where Flood Plains are Designated		
		Floodway	Floodway Fringe	Climate Change Flood Zone
1	Permitted	Permitted	Permitted	Permitted
2	Permitted	Permitted	Permitted	Permitted
3	Permitted	Permitted	Permitted	Permitted
4	Permitted	Permitted with conditions*	Permitted with conditions*	Permitted with conditions*
5	Permitted with conditions*	Permitted with conditions*	Permitted with conditions*	Permitted with conditions*
6	Permitted with conditions*	Permitted with conditions*	Permitted with conditions*	Permitted with conditions*
7	Not Permitted	Permitted with conditions**	Permitted with conditions*	Permitted with conditions*
8	Not Permitted	Not Permitted	Not Permitted	Not Permitted
9	Not Permitted	Not Permitted	Permitted with conditions*	Permitted with conditions*

* See Section 2.6.3 for special conditions

** See both Sections 2.6.3 and 2.6.4 for special conditions

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2.6.3 Special Conditions for Development

For entries in **Table 2.1** that are permitted only with special conditions, the following conditions apply on top of the usual conditions associated with development under the *Water Resources Act*:

- The ground floor elevation of the structure must be above the 100 year flood level, and above the climate change flood zone where designated.
- The structure must obstruct or displace any water in a way that worsens flooding for other properties.
- The structure and any associated utilities must be designed and constructed in accordance with the Department's flood proofing guidelines.
- Entrances and exits of the building must be safe to use without hindrance in the event of a flood.
- The facility and site must not be used to store any potential pollutants such as fuels, pesticides, or other chemicals.
- Other conditions which may be appropriate for specific projects that may be included in a permit issued under Section 48 of the *Water Resources Act*.

2.6.4 Special Conditions for Development in Coastal Areas

There are some cases in coastal areas where a floodway will be at risk of flooding mainly due to effects of the ocean such as extreme high tide and backwater effects, which lead to flood of low flow velocities. Due to the low flow velocities and the desirability of these areas for tourism related developments such as eateries, attractions, and information booths, such developments may be permitted under the following conditions:

- Only a tourism-related structure and its associated utilities are permitted. This does not include accommodations such as motels or hotels.
- The tourism-related structure and its associated utilities would not be eligible for flood disaster compensation.

2.6.5 Flood Risk Mapping and Disaster Compensation

Where flood risk mapping has been done for a community, the information from the mapping must be incorporated in the municipal plan for the community, if one exists. Zoning for the community must also be done such that different types of flood plains and flood risk zones are restricted to only having permitted types of development. Where flood risk mapping doesn't exist, communities are encouraged to complete a flood risk map of the area using the Department's standard methods. If flood risk mapping cannot be completed, communities should plan to have a minimum setback distance from bodies of water for any future developments to provide some measure of safety and recognize the potential for flooding.

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Any development made in a flood plain or flood risk zone that was done without approval or does not conform with Department policy will not be eligible for any flood disaster compensation available through the government. Exception will be provided where the development was lawfully established prior to the area being designated as a flood plain.

In the event that victims of a flood are provided compensation through the government, the Department will encourage victims to put the compensation towards relocating rather than rebuilding or repairing property damaged by the flood. If the Department approves of rebuilding or repairing damaged property in a flood risk zone, then the compensation must be put towards appropriate flood proofing measures before anything else.

Individuals living or operating businesses in a flood risk area may not have flood insurance available, or may find it prohibitively expensive. Therefore it is recommended by the Department that people in this position implement flood proofing measure and prepare an emergency plan.

When proposing flood control measures, the cost/benefit ratio is very important to consider. Dykes, river diversions, retaining walls, and dams are all possible options, so care must be taken to assess which option is the most effective for the situation at hand. Some alternatives to flood control measures include relocating people out of flood risk zones, and providing compensation to victims should a flood occur. These alternatives may prove more cost effective than implementing preventative measures. If flood control measures are implemented, then existing flood risk designations will remain in effect until the area is reassessed in accordance with Department standards.

2.7 Policy for Development in Shore Water Zones

A shore water zone is the area where an ocean or freshwater body meets land along its edge. A shore water zone includes the area between the low water mark and high water mark of a body of water. The high water mark is taken as the 100 year return period water level. For fresh water bodies, this includes the effects of runoff and ice. In marine situations, the high water level must include maximum waves, wind, storm surge, and mean sea levels under current global climate forecasts.

Developments made in shore water zones may have negative effects on the water body such as decreased water quality, decreased water quantity, and detrimental effects on the habitat of both terrestrial and aquatic life. Developments like sewage disposal and runoff from urban and industrial areas can have negative impacts on industries such as aquaculture and shellfish harvesting, as well as impacts on recreational opportunities and land values. Shore water zones are also susceptible to flooding, which should be considered when planning development. Department policy is to permit development of

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shore water zones such that potential economic losses and negative impacts on bodies of water and animal habitats in the area are minimized.

There are a number of developments which will not be permitted in shore water zones. Developments involving infilling, drainage, dredging, channelization, or removal of surface or underwater vegetation along a shore water zone are of particular concern. Any such development that aggravates flooding problems, has adverse effects on water quality that cannot be mitigated, has significant impacts on water circulation patterns, or has significant impacts on sediment deposition or removal rates will not be permitted. The depositing or discharging of any waste material that has the potential to harm the water quality of a shore water zone will also not be permitted. This includes raw sewage, municipal and industrial wastes, fuel or fuel containers, pesticides or herbicides, and other chemicals or chemical containers. Construction of any paved surface along a shore water zone that changes the natural character of the zone will also not be permitted.

There are some developments that may be permitted if they receive prior written approval from the Department. Limited removal of surface vegetation, minor disturbances to water circulation patterns, and limited impacts on sediment removal and deposition may be permitted if it is for the construction of marine structures such as marinas, boathouses, and wharves. Any extension or upgrading of buildings already existing within shore water zones may also be permitted with written permission, as well as development related to recreational facilities such as campgrounds.

Any development that has that potential to negatively impact water quality in a shore water zone requires the implementation of appropriate measures to mitigate the impact on water quality. The terms and conditions for approval of any development in shore water zones will also specify the restoration measures required after work has been completed for the project.

Chapter 3: Environmental Guidelines for Watercourse Crossings



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Water Rights, Investigations, and
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Chapter 3

Environmental Guidelines For

WATERCOURSE CROSSINGS

Water Resources Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

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3.0 WATERCOURSE CROSSINGS

3.1 General

This section consists of general information and preferred methods for planning and installing watercourse crossings. For the purpose of these guidelines watercourse crossings are placed in three categories:

- Bridges, Culverts and Fording

More specific technical information and recommended practices for installing these types of watercourse crossings are contained in:

Chapter 4 - Bridges

Chapter 5 - Culverts

Chapter 6 - Fording

Any watercourse crossing has the potential to alter the existing natural flow regime for the entire range of low to high flow conditions. The alteration of natural stream flow, if carried out improperly, can result in many types of serious problems. Improperly installed watercourse crossings can result in extensive loss and damage to public and private property, danger to human life, as well as damage to the environment in general through flooding, erosion, and washouts.

While installations such as culverts always alter natural flow it is preferred that watercourse crossings be appropriately designed to alter the natural flow regime as little as possible. The final decision as to permitting any stream alterations through the installation of a crossing rests with the Minister of the Department.

3.2 Selection of Route and Crossing Site

In planning linear facilities such as roads, pipelines, railways or transmission lines which require crossings of watercourses, consideration is required in the route selection and corridor location to mitigate the impact of the development on water resources.

Route selection should be made to:

- Minimize the number of watercourse crossings.
- Avoid wetlands or floodplain areas.
- Maintain substantial buffer strips on all bodies of water.

3.0 WATERCOURSE CROSSINGS

In selecting a site for a proposed major watercourse crossing, it is important to examine the physical characteristics of the watercourse and its drainage basin and to identify the site which will provide the best features and conditions for a crossing.

The site selected should enable construction of an economical and easily maintained crossing, be suitable for routing and approach requirements, consider the nature of the waterway and its environment, and minimize the use of such training works as may be necessary to deal with adverse natural features.

Where there is a choice between alternative crossing sites on a watercourse the crossing should be located:

- where the stream is straight, unobstructed and well defined;
- on an existing right-of-way if one exists;
- where stable geological and soil conditions are present;
- where a minimum of scour, deposition or displacement of sediments are expected to occur at or near a crossing;
- where possible effects on other existing bridges and hydraulic structures can be avoided;
- where it is possible to minimize the risk of damage from environmental hazards such as floods, landslides, or avalanches;
- where aesthetic conditions are favourable;
- away and preferably downstream from areas such as fish spawning sites or water use intakes.

3.3 Types of Crossings

3.3.1 Distinction Between Culverts & Bridges

For the most part, the term culvert has become synonymous with galvanized corrugated steel pipe products although concrete pipe culverts still find limited use mostly for smaller size drainage installations. Installations which maintain the original natural stream bed are not considered to be culverts in these guidelines. (See definitions in Appendix "culvert", "bridge"). Poured in place concrete structures which form two sides and a top over a watercourse but maintain a natural channel bed have been referred to elsewhere as "box culverts". The term is a misnomer as these structures more closely resemble bridges in their construction, installation procedures, and hydraulic effects on flow in the channel. Similarly, structural plate arches, although they utilize corrugated steel, are considered for the purpose of these guidelines to be classed as bridge installations as they require concrete foundations and allow a natural channel bed. For further information on concrete box structures or structural steel plate arch structures refer to *Chapter 4, "Bridges"*.

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3.3.2 Preference of Bridges over Culvert Crossings

Bridges and bridge-type structures are environmentally preferred to culverts as a means of stream crossing. The following reasons are cited:

- Culvert installations usually result in the loss of a section of natural stream bed, whereas bridges leave the channel bed relatively unaltered.
- Confining stream flow to culverts can result in an extensive alteration of the flow regime which can result in problems such as erosion, or scouring at outlet or deposition of material at the inlet of the installation.
- Bridges usually provide better capacity to accommodate high flows than would a culvert crossing. Inadequate capacity can result in serious problems such as washouts and flooding.
- Bridges provide better inlet and outlet conditions than culverts thereby allowing safer passage of debris without causing constrictions and blockages.
- Culverts often create total or partial barriers to fish migration which is rarely a problem in bridge installations.

3.3.3 Timber "Culverts"

The use of logs or timber to construct an enclosed structure under road fill also known as timber culverts, is not considered an acceptable method of stream crossing. Such structures do not provide long term service and their final demise usually results in the collapse of the road material into the stream with such problems as siltation and deposition downstream, washout of the road, or the blocking of the stream with associated flooding.

3.3.4 Choose a Type of Crossing Appropriate for the Site Conditions

Prior to the construction of watercourse crossings careful study and examination of the environmental implications of each proposed crossing should be undertaken.

The decision to install a bridge or culverts for a proposed crossing should be made only after examining the hydraulic implications of the proposed structure with respect to the hydrology, physical conditions and features of the proposed site. Generally these factors include but are not limited to:

- Quantity or volume of peak flows
- Depth of flow

3.0 WATERCOURSE CROSSINGS

- Flow velocity
- Low flow characteristics

This will provide an indication of the appropriateness and ability of the structure to perform satisfactorily under those particular conditions identified. These are the determining factors to be considered in deciding between a bridge or culvert installation and the decision should not be based primarily on economic considerations.

3.3.5 Temporary Crossings

These guidelines have not made a substantial distinction between permanent and temporary watercourse crossings as all installations are expected to provide satisfactory performance during the intended period of use. In this regard the design capacity of a crossing may vary from an installation which is to be used only for several weeks during low flow summer conditions and subsequently removed, to installations which must safely accommodate high spring runoff or provide many years of satisfactory service for a major highway.

Where watercourse crossings are installed to provide service for a period of less than one year and the installations are not required to pass peak spring runoff, the following guidelines should be followed:

- The installation should provide adequate capacity to safely accommodate design flows without causing erosion, flooding, or other environmental problems.
- The installation should be carried out with the least amount of disturbance to the channel bed, banks, and adjacent vegetation and property.
- Upon completion of its intended function, the crossing and all associated works and material should be removed from the vicinity of the channel.
- Site restoration involving revegetation and stabilization of all disturbed areas should be carried out to return the channel to its previous condition. Further details on this are contained in *Chapter 11, "Restoration and Stabilization"*.

3.3.6 Choosing Between a Fording, or a Structural Crossing

There are a number of environmental factors to consider in deciding whether to ford a watercourse or provide an installation such as a bridge or culvert.

3.0 WATERCOURSE CROSSINGS

If a location with stable channel bed and banks has been identified, the flow is not too deep, and very infrequent use is anticipated, fording may be an acceptable alternative to installing a bridge or culvert.

In some instances the installation of a bridge or culvert and its subsequent removal would result in greater channel disruption and more potential for environmental problems than the installation of a fording site.

One of the initial factors to consider is the frequency and period of use of the proposed crossing. In instances where the fording would only involve crossing a watercourse to gain access into an area and subsequent return from the area, (two fording operations per piece of equipment), the installation of bridges or culverts may not be warranted provided the fording would not create environmental problems or conflict with downstream water users.

Details regarding the installation of fording sites and guidelines for their use are contained in *Chapter 6, "Fording"*.

3.4 Design Flow and Water Level

To design and construct an adequate watercourse crossing and provide appropriate environmental mitigation, it is essential that the flow regime at the crossing location be determined. The important flow characteristics are the timing and magnitude of the annual peak and low flow period, the range of flows which may be encountered, and flow velocities. Also of concern in some regions are the dates of freeze-up and break-up and the potential for ice blockage of culverts.

3.4.1 Return Period

The streamflow characteristic of major importance is the peak or flood flow usually related to a certain probability of being equalled or exceeded in terms of a "return period". Determining a design peak flow with a certain return period allows one to assess the probability that a crossing structure could be damaged or destroyed within a selected time period. For example, a 50-year return period peak flow will be equalled or exceeded, on the average, once in a 50-year period. The probability or risk of a 50-year return period peak flow occurring in the 25-year "life" of a structure is about 40%; the probability of a 100-year return period event occurring is about 22%.

3.4.2 Design Data

The main source of data for the analyses used to estimate peak flow is the hydrometric station network operated by Water Survey of Canada under the cost shared Canada - Newfoundland Hydrometric Surveys Agreement. The peak flow magnitude can be estimated by regionalization methods, or empirical formulae which relate peak flow to precipitation input. The method

3.0 WATERCOURSE CROSSINGS

used will depend on the climate, watershed characteristics (especially drainage area) and the data available.

3.4.3 Site Inspection

Much information required for the design of a stream crossing can only be obtained from a site inspection. Physical measurements of the stream include width, depth and flow velocity. Such measurements must include up- and downstream sections and these must be compared in terms of elevation in order to determine the channel slope. In addition a field inspection should establish:

- type and grading of bed material,
- existence of shoals and their composition,
- the material forming the banks,
- vegetation on the banks,
- steepness of banks and evidence of bank erosion,
- debris marks on shrubs, trees or banks which may indicate the water level of recent floods,
- elevation of ice scars.

Much of this information is vital to confirm the appropriateness of the hydraulic as well as the structural design.

3.5 General Installation Procedures

Design and the actual installation of a watercourse crossing are separate components often handled by different persons or agencies (engineers/owners vs. contractors). Invariably, it is necessary to consider the installation methods in the design of the crossing, thus a team effort is needed to ensure that a project is carried out in an environmentally acceptable manner. A crossing design must be such that it can have a realistic chance of being installed with a minimum of environmental disruption.

The contractor usually has the sole responsibility for the day to day construction effort. In this regard it usually falls upon the contractor to ensure that pollution, siltation, drainage problems and general disturbance be minimized. Each crossing installation is unique and a well-planned installation procedure as well as rules, specifications and regulations governing the site work are essential. More details about construction practices are given in *Chapter 10, "General Construction Practices"*.

3.0 WATERCOURSE CROSSINGS

3.5.1 Low Flow Conditions

It is preferred that all watercourse crossings be installed during times of low flow conditions during the summer months. Where flows must be diverted or confined to allow work to proceed in a portion of the channel, high flow conditions can create problems of erosion and flooding. Watercourse crossings installed during the summer months also will allow adequate time for stabilization and revegetation of disturbed areas before higher flows of the fall months occur.

3.5.2 Reduce Time Spent With In-Stream Work

The installation of any watercourse crossing should be carried out as quickly as possible to prevent prolonged channel disruption or exposure of vulnerable areas to erosion. The extent of channel disruption and other environmental problems such as siltation often relates directly to the amount of time spent with instream works.

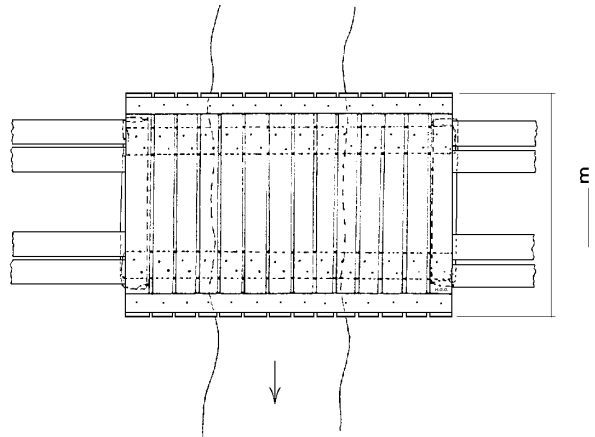
3.5.3 Watercourse Crossings and Fish Habitat

The installation of watercourse crossings has the potential to impede or block fish migration and destroy fish populations or fish habitat. In particular, culvert installations if improperly installed can create structural and flow velocity barriers to the passage of fish. The installation of bridges, culverts, and fording sites if improperly carried out can result in siltation and pollution which can kill fish or incubating eggs and ruin spawning locations.

The installation of watercourse crossings in areas of fish habitat should be scheduled to avoid instream work during periods of high environmental sensitivity such as fish migration, spawning, fish egg incubation and fry emergence. The installation should not impede fish migration or effect fish or incubating eggs.

The Federal Fisheries Act contains clauses which govern the alteration of fish habitat. Therefore, approval from Fisheries and Oceans, Canada, may be required in addition to approval from the Department.

Chapter 3A: Environmental Guidelines for Stream Crossing by All-Terrain Vehicles



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
St. John's, NL, Canada
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Chapter 3A

Environmental Guidelines For

STREAM CROSSING BY ALL-TERRAIN VEHICLES

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

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3A.1 Introduction

The purpose of these guidelines are to outline a simple yet consistent methodology for crossing small streams or any other body of water with all-terrain vehicles (ATVs) on licensed trails or any other "approved area" as defined in the *All-Terrain Vehicle Use Regulations, 1994*. Those regulations specify in Schedule B, Terms and Conditions of Licensed Trails, that all stream crossings must be authorized by a Certificate of Environmental Approval issued by the Minister prior to trail construction. These guidelines will assist any prospective license holder with making a proper application for the stream crossings that might be required for the licensed trail.

The main objective in requiring approval for stream crossings is to ensure that the least possible disturbance occurs when crossing streams. In fact, the best approach is to avoid crossing streams whenever possible by selecting routes that do not cross streams at all. Only when avoidance is not possible or practical, should we consider making a stream crossing. There are several alternatives such as fording or building bridges and these are discussed in the following pages. Generally for frequent crossing of the same watercourse, a bridge structure is recommended. These guidelines provide a design for a very simple wooden bridge that can be built with just a few logs, boards and nails. Nothing elaborate is required as long as the structure spans the stream and thereby avoids instream travel and prevents disturbance of the stream banks. These guidelines also discuss some good construction practices and restoration measures.

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3A.2 Selection of Route and Crossing Sites

In planning ATV trails careful consideration is required in selecting a route to mitigate the impact on all water resources.

Routes should be selected to:

- minimize the number of watercourse crossings,
- avoid steep slopes and other sensitive areas,
- avoid wetlands and floodplain areas,
- reduce travel and access through Protected Water Supply Areas, and
- maintain substantial buffer strips of 15 metres on all bodies of water.

Where there is a choice between alternative crossing sites on the same watercourse the crossing should be located:

- where the stream is straight, unobstructed, and well defined,
- on an existing right of way if one exists,
- where stable geological and soil conditions are present,
- where a minimum of scour, deposition, or displacement of sediments are expected to occur at or near a crossing,
- where possible effects on existing bridges and hydraulic structures can be avoided,
- where it is possible to minimize the risk of damage from environmental hazards such as floods, mudslides, or fires,
- where aesthetic conditions are favourable, and,
- away and preferably downstream from such areas as fish spawning sites or water intakes.

Much of the information required for selecting a site and for deciding the best method of crossing is obtained from a site inspection. Physical measurements of the stream should include its width at top and bottom, the depth of channel from top of embankment to bottom of stream as well as the depth of water and its flow velocity. Other necessary information includes:

- type and grading of bed material,
- existence of shoals and their composition,
- the type of material forming the stream banks,
- type and density of vegetation on the banks,
- steepness of banks and evidence of erosion,
- debris marks on shrubs, trees, or banks which may indicate the level of recent floods, and,
- elevation of ice scars which may indicate ice jam elevations

3A ATV STREAM CROSSINGS

3A.3 Fording

There are a number of environmental factors to consider in deciding whether to ford a watercourse or to provide a structure such as a bridge or culvert.

If a location with stable channel bed and banks has been identified, the flow is not too deep, and very infrequent use is anticipated, fording may be an acceptable alternative to the installation of a bridge or culvert. In some cases the installation of a bridge or culvert and its subsequent removal would result in greater channel disruption than preparing a fording site.

The fording site must be located at a shallow section of the channel where there are low approach grades, and where the channel consists of stable non-erodible rock or cobbles or better yet, exposed bedrock. Any areas with vegetated, silty, or sandy bottoms are not considered acceptable fording sites.

Timbers or rocks may be placed in the stream to facilitate crossing or to minimize damage to the channel section provided the stream is not unnecessarily constricted or backed up.

Stream banks at fording sites that contain loose or erodible material must be adequately stabilized before crossing to minimize any siltation of the stream. This can be done by placing brush mats, rocks or timbers on the stream bank. This material must be removed after use of the fording site is completed.

Fording may only be carried out during periods of low flow.

All vehicles and equipment must be clean and in good repair, free of mud and oil, or other harmful substances that could impair water quality.

3A.4 Bridges

Bridges are the preferred type of stream crossing because only bridges can avoid the alteration of flow regimes and protect the integrity of the stream channel. Bridges are recommended on all watercourses supporting fish because there is no need to disturb the streambed. Bridges must have sufficient flow capacity to ensure that flow velocities are kept slow enough or at their natural speed so that fish can swim upstream past the bridge. Culverts can be a fish barrier in this regard.

The proponent should avail himself of sufficient expertise to design and construct a crossing structure that will be sufficiently strong to safely carry a fully loaded ATV.

3A ATV STREAM CROSSINGS

Creosote treated wood must not be used within 15 metres of a body of fresh water. For this reason, bridges over fresh water should not use any lumber that originates from old or new railway ties, telephone poles or wharves that were built of creosote treated wood.

The completed bridge should safely accommodate reasonably predictable levels of water flow.

a. Bridge Location

The alignment of a bridge relative to a waterway should be at right angles. This will reduce the length of bridge required to cross.

Bridges should not be located near abrupt bends in the channel.

Bridges should be located at a narrow section of the watercourse but where stream banks are stable and are not likely to erode under the bridge supports.

b. Bridge Capacity

The bridge must provide adequate capacity to safely discharge flood flows without causing backwater effects upstream or increased flow velocity downstream. Also bridges that are too small for the amount of water flow anticipated will likely be washed away.

Where insufficient information is available to estimate the maximum discharge at the site over a design period of reasonable length, the physical characteristics of the site may be utilized to determine the peak flow. The maximum historical water level as observed or recorded at the site may be used and a bridge should be built higher than this level. For minor bridges, such as those for ATVs, if the bottom of the bridge span is at the elevation of the top of the stream embankment it may be inferred that the bridge has the same capacity as the existing channel.

Bridge abutments must be set back at least 0.5 metres from the normal edge of the watercourse to prevent constriction during high flow conditions.

c. Bridge Type

Once a suitable site for the bridge is selected and having established the height and width requirements, one must then choose a type of bridge. Bridges for all terrain vehicles will typically be of timber construction with width adequate for one ATV. An example of acceptable bridge design is shown in **Figure 1**.

3A ATV STREAM CROSSINGS

The basic design uses two or more sufficiently heavy logs laid on a flat rock or a log sill. Boards are nailed across the logs. A curb or toe-board should be provided to help guide the wheels and keep the ATV from running off the open edges. A solidly fastened handrail should also be added if the bridge is more than 1.12 metres (4 feet) high above the channel. If necessary, approach ramps can be made out of a few short boards or the gap can be filled with rocks. Pointed stakes should be driven into the ground to nail the bridge to in order to prevent the bridge from sliding off the sills and to prevent the bridge from washing away in the event of a flood.

3A ATV STREAM CROSSINGS

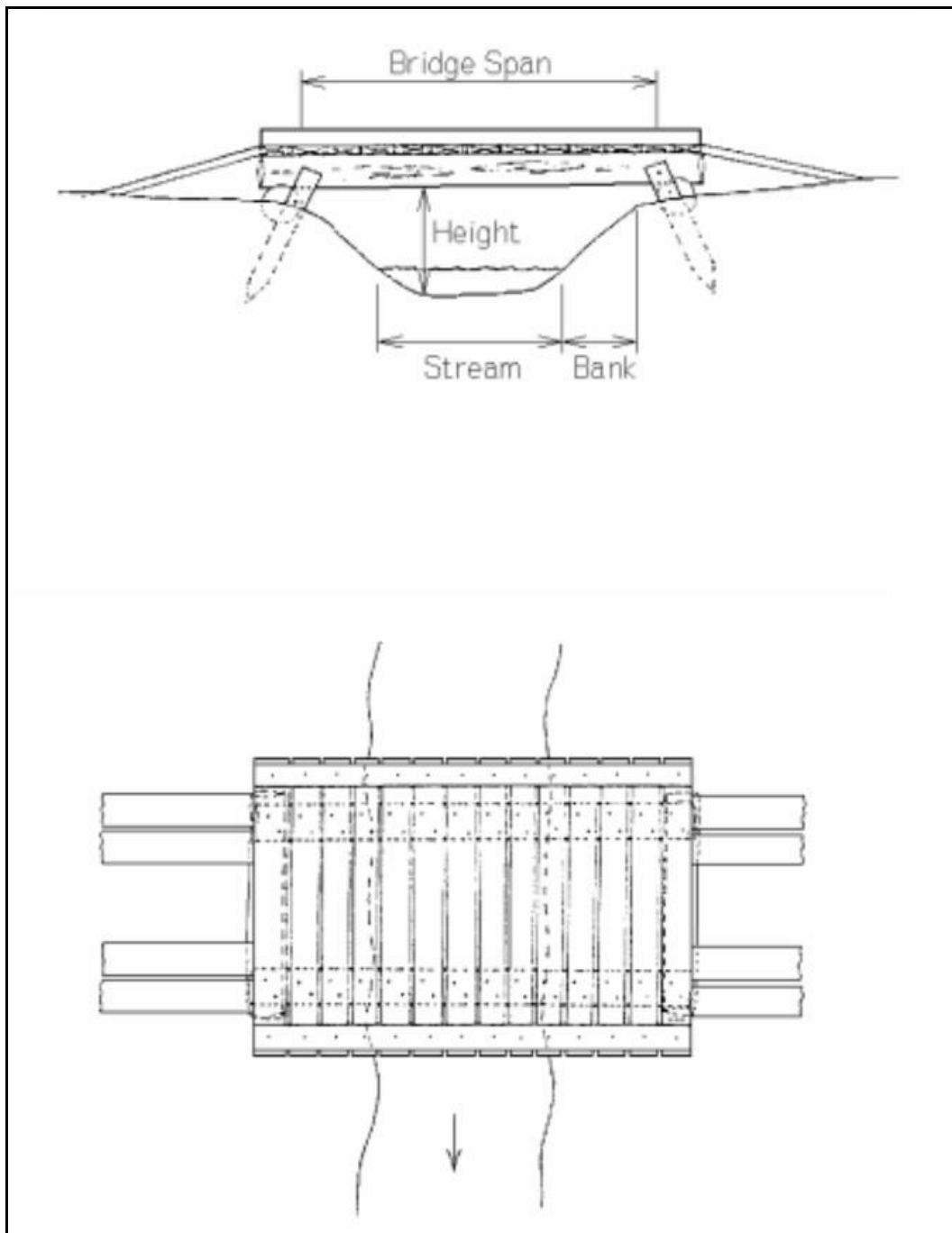


Figure 3A.1 Profile and Plan of a Simple ATV Bridge

3A.5 Construction Practices

At all times, every necessary precaution should be taken to prevent the disturbance of channel banks, bank vegetation, and land within the high water zone of the stream.

Any work that must be performed below the high water mark must be carried out during a period of low flow. It is not a good idea to do any work around a stream when the stream is in flood.

Winter is a good time for construction or at least for bringing materials to the site and for doing site preparation because one can work from an ice surface. No separate permits are required to cross ice covered bodies of water using an ATV or snowmobile.

All construction operations must be carried out in a manner that prevents damage to land, vegetation, and watercourses, and which prevents pollution of bodies of water.

The use of heavy equipment in streams or bodies of water is not permitted. The operation of heavy equipment must be confined to dry stable areas.

Wood preservatives such as penta, CCA or other such chemicals must not be applied to timber near a body of water. All treated wood or timber must be thoroughly dry before being brought to the site and installed. No treated wood shall be used on any portion of a trail that passes through a Protected Water Supply Area.

If the bridge is constructed using natural logs, then the bark should be removed from the logs. Peeled logs are better at resisting rot.

Abutments and piers must be constructed in the dry and during times of low flow.

The channel, including any land up to the high water mark, must be kept free of all excavated or unused construction materials at all times.

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. It is best however to make sure that the work is performed without disturbing vegetative ground cover and thereby avoid causing any silting to occur in the first place.

3A ATV STREAM CROSSINGS

3A.6 Inspection, Maintenance, and Other Concerns

Bridges require frequent inspection to determine if they are performing satisfactorily without causing any environmental disruption, and to identify any problems which may threaten the structural integrity of the bridge.

General maintenance work should be carried out as required from time to time. Periodic maintenance such as painting, resurfacing, clearing of debris, or minor repairs, must be carried out without causing any physical disruption of the watercourse. Care must be taken to prevent spillage of pollutants into the water.

3A.7 Site Restoration

All areas affected by a project must be restored to a state that resembles local natural conditions. Further remedial measures to mitigate environmental impacts on water resources can and will be specified, if necessary in the opinion of this Department.

When the fording site or a bridge is no longer required, the owner must dismantle and remove all constructed works and restore the site to its original condition. All material placed in the stream must be completely removed from the channel.

3A.8 Applying for Environmental Approval for Stream Crossings

All stream crossings must be approved in writing by the Minister before the crossing takes place or before beginning the construction of a bridge. Proponents should be aware that in addition to this requirement, other jurisdictions may require that the project be approved under their own legislation. A common example is the possible need to obtain a permit under The Fisheries Act if fish habitat is involved.

While these guidelines apply to any watercourse crossing no matter how small, written approval for each crossing need only be obtained for those stream crossings that appear on 1:50,000 scale topographic maps. An application form is attached in Appendix "A". One application must be completed for each type of stream crossing on each trail.

Applicants for licensed trails can apply for environmental approval for the necessary bridges either after the location of the trail is approved in principle by Crown Lands or at the same time. A recommendation that a trail will be eligible to be licensed must be made by Crown Lands before any certificate of approval is issued. Stream crossings on private land or any land that is not Crown Land must be approved but there is no need to have a license for that trail. In such cases, proof of title or land ownership will be required before any written approval is issued.

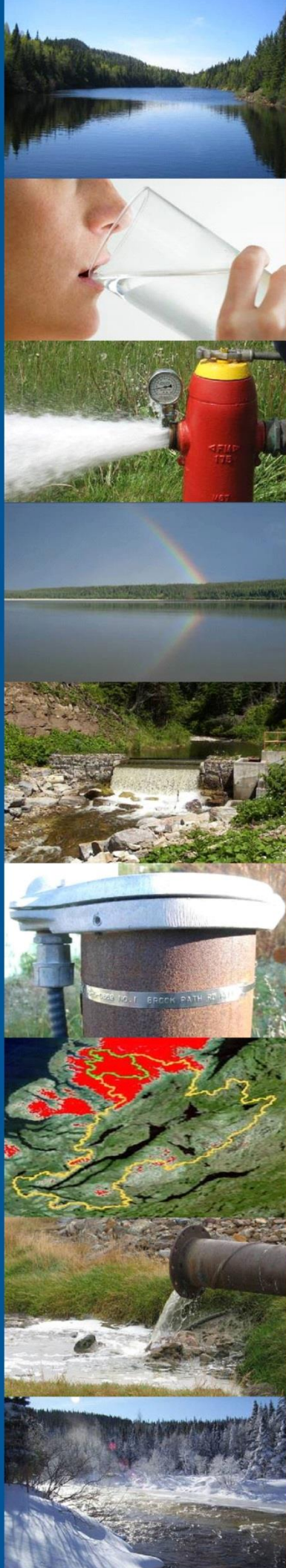
In actually filling out the application form, it is important that the details be provided accurately and completely. Incomplete applications cannot be properly evaluated and they will be returned. Obviously, this will cause delays in getting approvals issued. Where dimensions are asked for, these dimensions must be obtained by taking actual measurements at the site of the proposed stream crossing. The bridge design should be customized for each site. In designing the bridge one should follow the important principles of these guidelines but actual details will be based on the actual site conditions, availability of materials to use for construction, ability and skill of the proponent and the constructability. Some people like to build elaborate structures; others prefer to keep things simple. Regardless of what these details actually are, they should be described fully in the application.

Each application will be evaluated to determine if the crossing is likely to avoid causing any impact on water resources. Applicants should be aware that structures are not evaluated for personal safety requirements or structural strength in terms of load carrying capacity. This is the owner's sole responsibility. However, structures that appear likely to fail and can thereby cause obstruction of water flow or other environmental damage, can be refused environmental approval unless structural analysis is carried out.

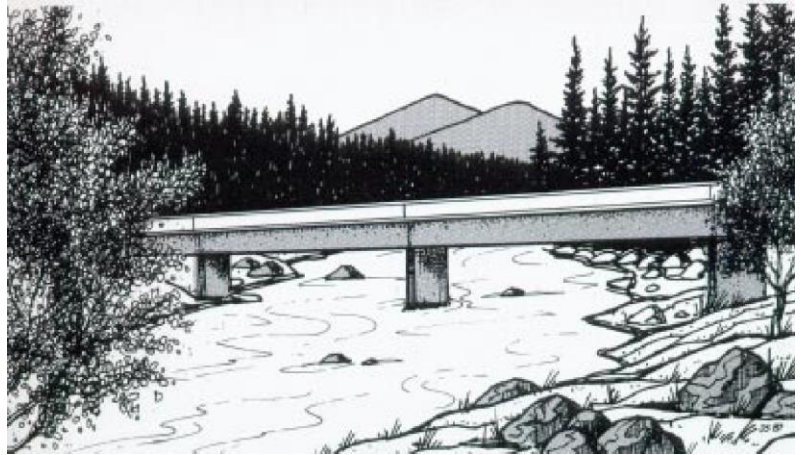
The certificate of environmental approval will be subject to terms and conditions specifying such details as the location, size, materials, methods of construction, site preparation and restoration, and methods to control silt. These terms and conditions must be adhered to strictly. When the crossing is completed a completion report which is a form attached to the certificate must be signed and returned promptly. A certificate of approval is generally valid for two years. This applies to the construction phase only. A bridge crossing can be used indefinitely as long as it is kept in good repair. A certificate of approval for fording will be valid only for the period specified in the certificate.

Applicants for approvals should note that it takes about 3 to 6 weeks to process an application for approval beginning from the time that it is received by the Water Resources Management Division. All applications are reviewed on a first come first serve basis. However, failure to provide complete information will result in delays since the proposal cannot be assessed properly and the approval may take considerably longer than 6 weeks.

An application form for ATV bridges is attached to these guidelines. Extra copies can be photocopied or additional forms can be obtained from the Department at the address shown on the title page. Regional offices should also have the application forms.



Chapter 4: Environmental Guidelines for Bridges



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
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Chapter 4

Environmental Guidelines For

BRIDGES

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

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4.1 General

Bridges are often required to provide access across large rivers, and streams, to cross wetland or flood plain areas, or to cross narrow lakes, ponds or ocean inlets. There is obviously a direct economic and social benefit for a bridge in that it shortens the time of travel between two points or it replaces an inconvenient mode of travel such as by ferry. Most bridges are constructed to carry traffic, however, bridges may also be constructed for railways, pedestrians, conveyors, pipes or other special uses. Not all bridges are new; sometimes there is a need to replace an old bridge or to improve a bridge to carry more traffic or heavier loads.

It is environmentally desirable, even on small streams, to construct bridges instead of other alternatives such as culverts because only bridges can avoid the alteration of flow regimes. (See **Figure 4.1**). Such problems as flooding, erosion, and siltation are avoided through the use of properly designed and constructed bridges. Bridges are recommended for all watercourses supporting anadromous fishes because there is no need to disturb the streambed and sufficient capacity will ensure that flow velocities are kept to a level where fish passage is maintained. Bridges are also recommended where the natural channel is too steep to accommodate maximum culvert slopes or where steep banks would necessitate a great deal of infilling if culverts were used.

Consideration of such factors as channel gradient, flow velocity, channel cross-section, channel roughness, discharge patterns, peak water levels, quantity of flow, ice formation, etc., are required for comprehensive hydraulic and hydrological design. Physical geographic and geotechnical considerations such as channel morphology, geological history, bed and boundary materials, sedimentation, and erosion are other points to be considered.

The completed bridge should safely accommodate reasonably predictable levels of flow and ice buildup as well as the forces of moving water and ice upon the structure without causing any adverse environmental impact at the crossing or in upstream or downstream areas. **Table 4.1** lists the major points for consideration of a proposed bridge design.

Improper or inadequate design and construction of bridges have caused problems of considerable magnitude. The erosive action of flowing water, high rates of discharge, and the movement of ice can be adversely affected by bridges and cause environmental damage, flooding, great expense in loss of property and even loss of human life. Usually the first thing to fail in a poor bridge design is the bridge itself. **Figure 4.2** shows bridge failures resulting from unanticipated bed scour.

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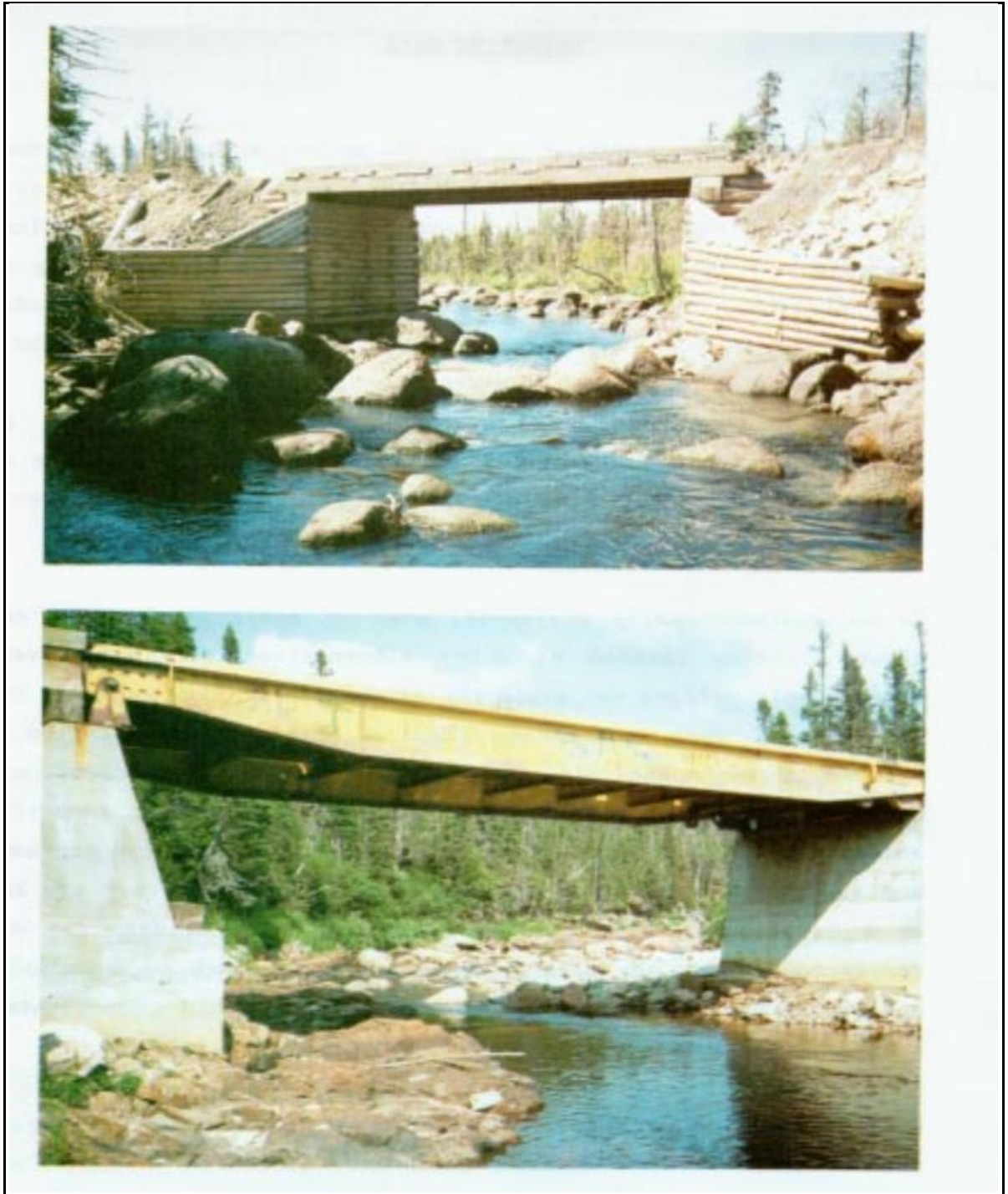


Figure 4.1 Bridges can avoid alterations to the flow regime

Table 4.1 Points for Review of Bridge Design Proposals

Bridge Location and Alignment	<ul style="list-style-type: none">- Is the need for a bridge in this area economical and fully justified?- Do plans show the relationship of the bridge to the river, floodplain, valley, etc.?- Does the location and alignment appear appropriate, having regard to the nature of the stream and to routing requirements?- Has attention been given to effects on adjacent works and property or effects of existing works on the proposed structure?
Bridge Height and Waterway Opening	<ul style="list-style-type: none">- How have design high-water level and discharge been determined?- Has adequate clearance been allotted in excess of the design high-water level?- How well would the bridge withstand a flood in excess of design flows?- What is the estimated velocity and scour through the waterway opening?- Is the bridge opening at least as large as the natural waterway?- Is blockage by ice or other debris possible?
Road Approaches	<ul style="list-style-type: none">- Are approach embankments, guide banks, or other training works secure against erosion or sliding failure following erosion at the toe?- If approach roads are liable to submergence in extreme floods, has adequate protection against washout been provided?- Have possible backwater effects of the project been estimated?- Has allowance been made for possible future shifting of the channel?- Are materials and workmanship for erosion protection adequately specified?
Pier and Abutment Details	<ul style="list-style-type: none">- Are foundations secured against general and local scour?- Are piers, abutments and foundations properly aligned with the principal direction of flow and are they adequately streamlined?- Do foundations require specification of backfill material, or scour protection aprons?

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Construction

- Will construction procedures cause partial blocking of the waterway and if so, what would be the consequences of high flows or ice runs during the construction period?
- Has provision been made for complete removal of temporary construction works such as cofferdams, sheet piling, berms, etc.?
- Has attention been given to scour around cofferdams?

Approvals and Standards

- Have all statutory requirements been met and approvals obtained from all authorities having jurisdiction?
- Does the project as a whole meet desirable standards for environmental preservation and have possible alternatives been sufficiently considered and evaluated?

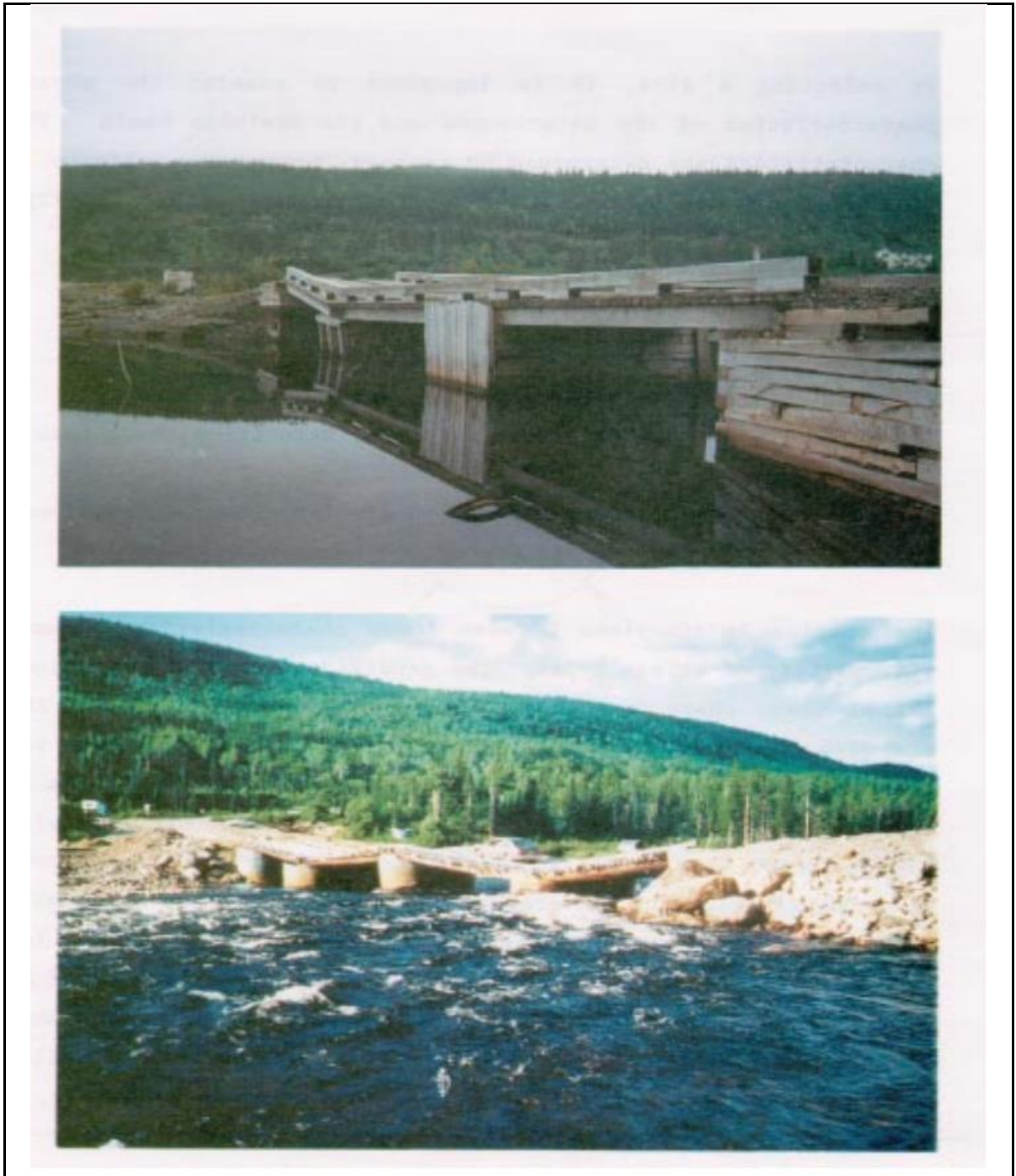


Figure 4.2 Bridge failure caused by scour around piers

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It is therefore imperative that all bridge installations be properly designed and constructed to perform safely and adequately under varying natural conditions. This always involves the use or application of proven methods of hydraulic and hydrological design.

4.2 Site Selection

The site selected should enable construction of a safe, economical, and easily maintained crossing, having regard to routing and approach requirements, to the nature of the waterway and its environment, and to minimize the use of such training works as may be necessary to deal with adverse natural channel features.

In selecting a site, it is important to examine the physical characteristics of the watercourse and its drainage basin. These characteristics are determined by geology, topography, climate, and land use, and may be divided into four groups. (Also see **Figure 4.3**).

- geographic: physiographic setting, geological history, channel pattern, etc.
- hydrologic: discharge patterns, water levels, ice etc.
- hydraulic: slopes, cross-sections, velocities, roughness, etc.
- geotechnical: boundary materials, erosion, scour and sedimentation, etc.

The complex interactions between these characteristics produce a wide variety of stream types. The general patterns of variation in all of these characteristics, and the relationships between them, are often referred to as the river's "regime", in the same sense that "climate" is used in considering meteorological variables. In regard to scour and erosion, behavior of a stream may fall within a wide range, from a very stable bedrock channel to a highly mobile alluvial river. Many rivers exhibit complex changes in behavior from point to point, because of the strong influence of local features associated with glaciation. Careful investigation of past behavior at a particular site is therefore important. The choice of site may greatly affect the difficulties and expense of building a crossing as well as its long term performance, stability, and amount of maintenance required. It is therefore necessary that field studies be conducted during route selection to choose the best location for the bridge installation.

4.2.1 General Route Selection

Bridges are a significant component of any new road especially in terrain where streams or flood plains are numerous. A new route should minimize the number and length of crossings required, thereby keeping environmental disruption as well as overall costs to a minimum.

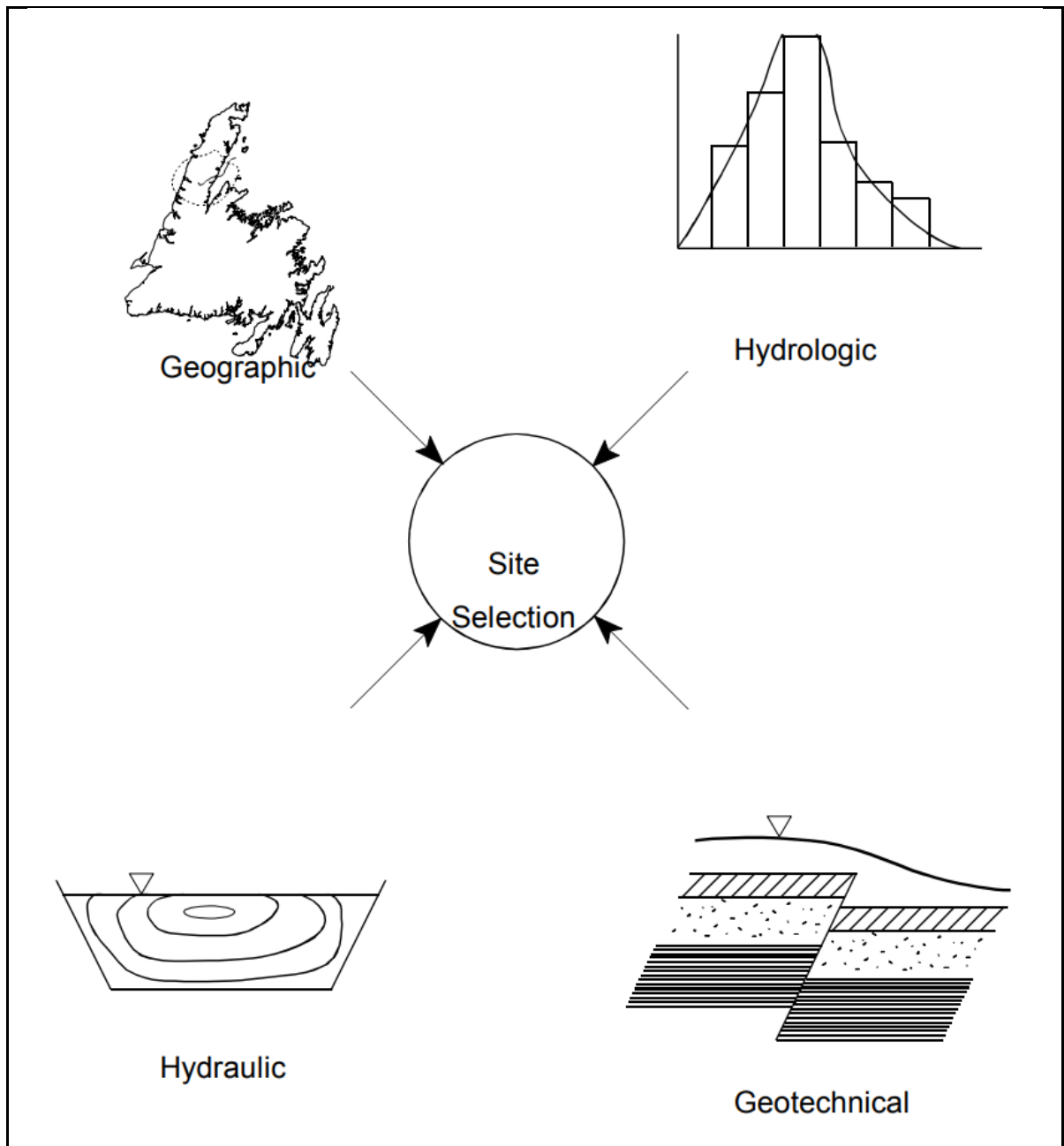


Figure 4.3 Bridge failure caused by scour around piers

4.0 BRIDGES

4.2.2 Suitable Site Characteristics

Stream characteristics and geology often vary significantly over short lengths of river. A suitable crossing site should be at a stable reach having good flow alignment. The liability of scour or bank erosion must be investigated and should be an important site selection criterion. When streams are braided, ie., split into two or more channels, a single channel location is preferred.

4.2.3 Bridge Alignment

The alignment of a bridge relative to the waterway should be at right angles. This will reduce the length of bridge required to cross. In meandering and shifting streams attention must be given to past trends to ensure that the stream at the selected location will not shift. In some instances it may be necessary to construct training works. Straight lengths of channel are preferred for the crossing. Crossings on abrupt bends should be avoided except when the stream is in erosion resistant materials.

4.2.4 Alluvial Fans

Crossings of alluvial fans should be avoided because of the aggradation of the channel. The preferred crossing location is near the apex or head of the fan.

4.2.5 Sites of Flooding

Bridges should not be located in areas which are known to flood periodically. The presence of a bridge often aggravates the problem. One should also be aware of typical ice jam locations and these should be avoided.

4.2.6 Location of Other Structures

There are so many possibilities here that possible precautions can only be discussed in general terms. The presence of other structures can have a significant bearing upon site selection. For instance other crossings may affect or be affected by the proposed bridge. Dams, both upstream and downstream obviously have considerable bearing. In some cases other structures are not even built but are proposed and may influence a bridge site.

4.2.7 Approaches

Approaches to the proposed bridge must meet requirements of grade and alignment for safety reasons.

4.3 Bridge Design

a) **Design Flood Frequency** - The hydrologic and hydraulic design of a bridge is essentially a two-step process. The first step is to estimate all of the forces or quantities which would impact on the installation for an appropriate return period. The second step is to design all the structural components to accommodate these forces or quantities with some margin of safety. While such factors as the weight of traffic, earthquakes, wind and other forces are of great importance, these guidelines are primarily concerned with the flow and quantity of water, hence the hydrologic and hydraulic design.

Obviously no structure is designed to last forever. Equally true however, is the fact that the more valuable or important the bridge is, the longer it should be expected to last. The longer a bridge is expected to last, the more likely it is that it will be subjected to an extreme event or flood. The term "return period" is used to indicate a probability that a flood of a certain magnitude will occur. For example a 100 year return period flood is a flood whose flow would be exceeded on average once every 100 years.

The selection of an appropriate return period as mentioned above depends on the value of the bridge. This includes the cost of repair or replacement if the actual flows exceed the design flow and cause damage to the structure. However the selected return period must also reflect the importance of the reliability of structure, possible secondary damages to other property and environmental consequences of bridge failure. An economic analysis or cost-benefit analysis should be considered in determining the most economical design of bridges.

4.3.1 Return Periods for Hydrologic Design

Return periods for bridges should be selected with reference to **Table 4.2**.

b) **Capacity** - The bridge opening is the product of the width and height plus the cross-sectional area of the stream as shown in **Figure 4.4**. The rate of flow that can pass through this opening without overtopping is referred to as the capacity. It must be noted however that width and height are independent of capacity requirements meaning that a bridge dimension may need to be larger than required by the design flow. For purposes of designing the bridge waterway opening and of calculating velocities, scour, and afflux, the design discharge arising from floods, tidal flows, or both in combination should be selected after due consideration of the following:

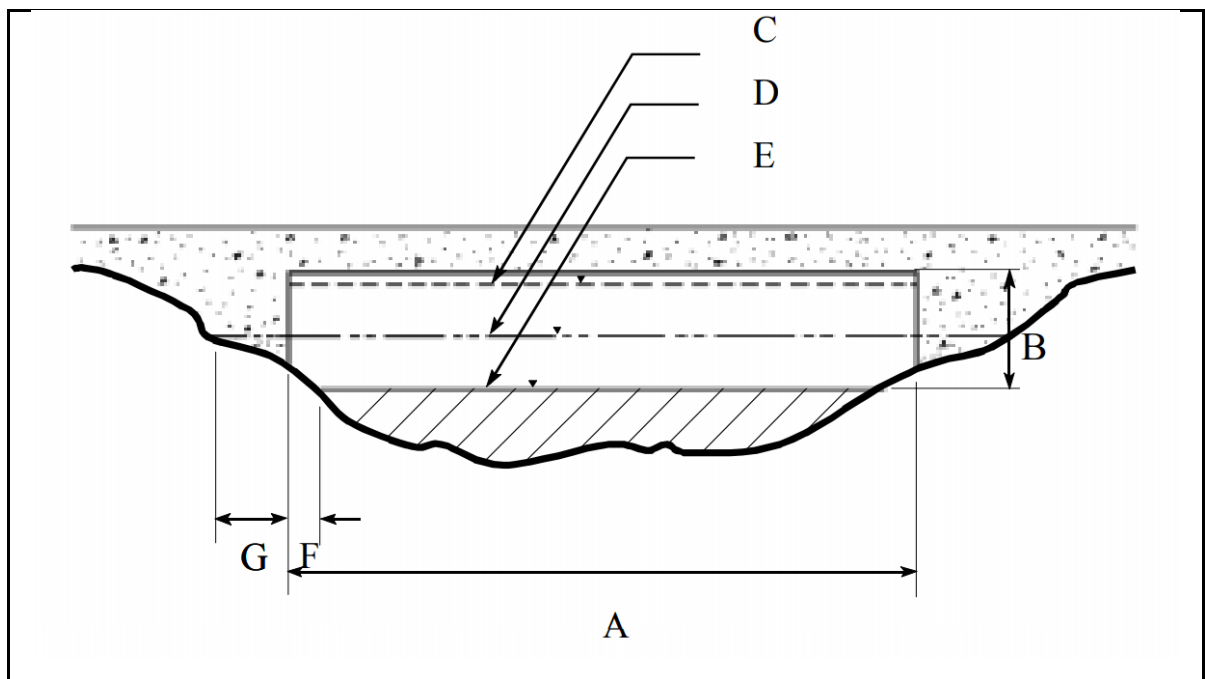
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Table 4.2 Recommended Design Return Periods For Bridges

Road Classification	Return Period in Years
Freeways, (Trans-Canada Highway)	100
Urban Arterials	100
Rural Arterials	50
Collector Roads	50
Urban Local	50
Rural Local	25
Forest Access Roads	20
Any Bridge Exceeding 6.0 m Span	20

Modification of these recommended return periods should be considered in the following cases:

- If flood hazards in the area are known to be unusually severe.
- If the road is the only route to a community or essential services such as a hospital.
- If the road classification is likely to be upgraded.
- If there is property or facilities which apart from the bridge itself, could be damaged in the event of flooding, scour or other damage related to the bridge failure.
- If the bridge is located in a 1 in 100 year flood zone as designated under the Canada Newfoundland Flood Damage Reduction Agreement.



- A - Length = normal stream width + (2 x 0.5 m), or,
1:10 year stream width - 10%
- B - Height = sufficient to pass design flow along with waves, ice, and debris,
without contacting the bridge
- C - Maximum Design Flow
- D - 1:10 year high water level
- E - Normal water level
- F - Abutment Placement = set back 0.5 m from normal water's edge
- G - Permissible Flow Constriction = total flow constrictions of no more than 10% of
the 1:10 year flow width

Note: Capacity of Bridge = (Length x Height) + (Shaded Area in Figure)

Figure 4.4 Typical bridge dimensions to be determined in bridge flow capacity design.

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4.3.2 Historical Flows

The maximum historical flows as recorded at the site, or as calculated on the basis of recorded water levels, or as calculated on the basis of measured discharges at other points on the river from which corresponding site discharges can reasonably be inferred, may be used.

4.3.3 Flood Frequency Analysis

The discharge derived from a frequency analysis and corresponding to flood and/or tidal conditions of a frequency appropriate to the importance and value of the structure. Results of Regional Flood Frequency Analysis (RFFA) are available from this department.

4.3.4 Other Discharge Estimates

Where insufficient information is available to yield an estimate of the actual maximum discharge at the site over a historical period of reasonable length, or to provide an adequate frequency analysis, the design discharge may be estimated by any other reasonable method such as regional flood frequency, unit hydrograph, maximum probable storm, rational method, etc. Estimates may be made of maximum flow rates based on the area of the drainage basin, rainfall intensity-duration, and other appropriate data, which would indicate the flows that could be anticipated.

4.3.5 Anticipated Land Use Changes

The marginal cost of increasing a proposed design parameter may be small enough to warrant over sizing in order to be assured of good future performance. This is especially true if land use changes are likely to occur in the drainage basin upstream of the bridge.

4.3.6 Design Discharge Verification

When the design discharge is based on historical maxima, frequency analysis, or other empirical methods, it is advisable to check whether the historical record reflects trends or discontinuities in the flow regime resulting from land use changes, engineering works, or other causes; and to consider whether such changes are likely to occur in the foreseeable future.

4.3.7 Discharges Controlled by Reservoir Releases

Before counting on significant reductions in natural flood peaks because of storage reservoirs or other upstream works, the probable operating and routing procedures should be investigated. Where possible, a written statement should be obtained from the competent authorities.

4.3.8 Flow Duration

The probable duration as well as the magnitude of large flows may be significant, especially with reference to scour.

c) Bridge Height - The height of the deck should be such that the superstructure is not endangered by the action of flowing water, ice, floating debris, or waves, and the roadway is not rendered impassable except under clearly understood and permitted conditions. The selection of design values and safety margins for high water level and discharge raises difficult questions. The approach recommended here is to adopt design values which set limits of serviceability for the structure, and then ensure that under design conditions the margins of safety against structural failure are sufficient. This margin should be set by the engineer in each case, having regard to the reliability of the data on which the design values are based, to the probability of occurrence of greater values, to the consequences of failure, to the type of structure chosen, and to economic factors.

For the purpose of selecting a minimum height for the bridge superstructure, the design high-water level should normally be selected after due consideration of the following:

4.3.9 Maximum Historical Water Level

The maximum historical water level as observed or recorded at the site, or as inferred from observed or recorded levels at another point on the river or waterway from which levels can reasonably be transferred to the site in question may be used.

4.3.10 Frequency Analysis

The water level derived from frequency analysis and corresponding to flood, tidal, or ice conditions of a frequency appropriate to the importance and value of the structure may be used for design parameters. The peak stage of flood flows may also be estimated using methods indicated in part (b) above.

4.3.11 Clearances

Additional height should be included if there is a history of ice accumulation, or if floating debris poses a potential problem. On navigable water courses sufficient clearance for vessels must be provided.

d) Bridge Length - The length of bridge works should be such that the opening is able to pass the maximum flows that may be expected without endangering the bridge or appurtenances by scour, without creating major maintenance problems, without causing unacceptable backwater effects upstream, and without causing currents, waves, or turbulence unacceptable to navigation or other legitimate interests. It should be possible to pass expected quantities of ice, logs, and other

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debris without endangering the structure or adjacent property as a result of jams and accumulations.

4.3.12 Width on Regular Channels

Where a stream has a single, well defined channel of fairly regular width, and flood flows are more or less confined to the channel, the bridge should clear the entire channel with abutments set back 0.5 m from the normal high water edge. Also, in no case should the bridge reduce the channel width by more than 10% of the 1:10 year flood flow width.

4.3.13 Width on Flood Plains

In situations with low flood plains, where a substantial portion of the design discharge normally flows across the overbank areas, the question arises of whether to divert all the overflow through a single waterway opening in the main channel, or to provide relief spans on the flood plain. The former solution is usually more economical, but if the road crosses the valley at an angle, relief spans or culverts may be necessary to prevent excessive backwater effects.

4.3.14 Width on Irregular Streams

In the type of stream where the channel width varies greatly from point to point, the narrower sections may normally be used as a guide to determine a suitable bridge length, provided overbank flow is taken into consideration.

4.3.15 Overtopping

In flat, low-lying terrain subject to widespread flooding it may be acceptable to allow overtopping of roadways in extreme floods, thereby reducing the discharge to be passed through the bridge waterway opening. In such design, provision must be made to prevent any road washout by having a designated overflow section which is suitably protected against erosion.

4.3.16 Existing Bridges

The hydraulic performance and capacity of existing bridge waterway openings should give valuable guidance on the required length of a new bridge at another site on the same stream. In some cases experience may indicate that an existing bridge has been too short, allowing approach washouts, overtopping of the approach roadways, or unacceptably deep scour to occur. The weight to be given to such evidence depends of course on how long the existing bridge has stood, to what extent it has endured severe floods and ice conditions, and to what extent stream bed

conditions at the new site conform to those at the existing site. A new or replacement bridge will generally be larger than an existing bridge.

e) Bridge Type - Having selected a site for the bridge and having established height and width requirements of the superstructure, the designer must then choose a type of bridge. This choice depends on the functional requirements of the bridge in regard to the hydrologic and hydraulic regime, the economics of construction, live-load requirements, foundation conditions, environmental constraints, maintenance considerations, policies of the owner, availability of materials, and preference of the project designer.

Some variables in bridge design include:

- the geometry and length of the approaches,
- the type and location of the abutments,
- the number and location of piers.

Commonly used bridges consist of fairly simple timber, steel or concrete spans, such as those seen in **Figure 4.5**. Certain applications may call for arch, truss or suspension design.

4.3.17 Environmental Impact of Bridge Type

The arrangement and details of piers, abutments, approaches, training works, and temporary construction facilities, so far as it is compatible with requirements of structural adequacy, safety, economy, and aesthetics, should be designed to minimize local scour, obstruction of flow, and inconvenience to legitimate interests.

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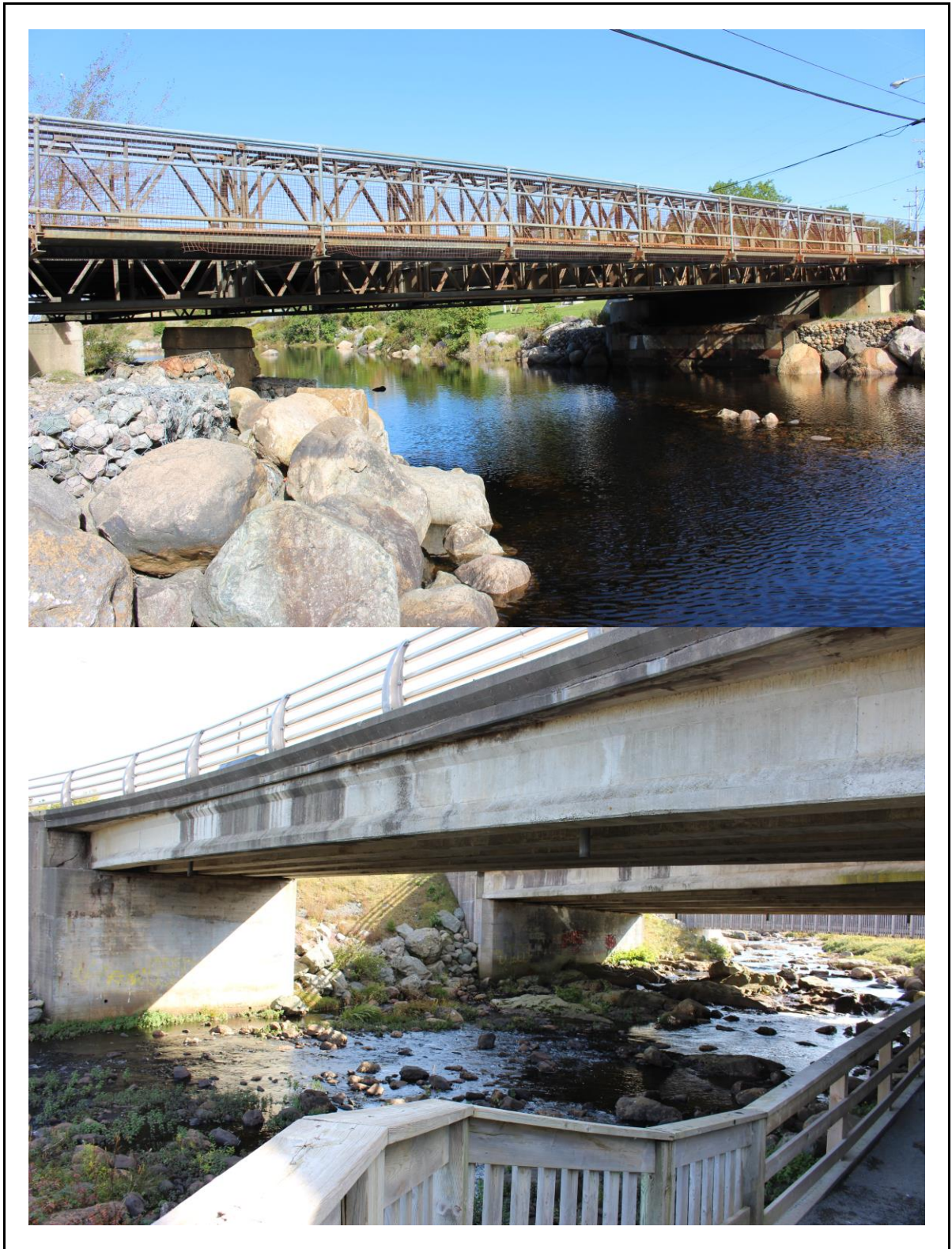


Figure 4.5 A steel span bridge (top) and a concrete span bridge (bottom)

4.4 Abutments and Piers

The erosive action of running water in streams resulting in the carrying away of material from around bridge piers and abutments has long plagued persons responsible for bridge design, construction and maintenance. Bridge embankments projecting into wide flood plains may cause concern because they can produce scour problems in two ways; first, by concentrating the flow at the upstream corners of the embankments, and second, by constricting the flow with a resulting increase in water levels. (See **Figure 4.6**).

4.4.1 Abutment Location

Abutments should be set back from the normal wetted perimeter of the watercourse to avoid constriction of the channel and reduction of the flow area. For the same reason, the bridge design should use as few in-stream piers as possible and the width of the piers, perpendicular to the direction of flow, should not be in excess of what is necessary for safe and adequate structural support.

4.4.2 Foundation Depth

All foundations for abutments and piers should be set well into the substratum to provide a solid base for the structures. The foundations should also extend below the estimated lowest scour levels.

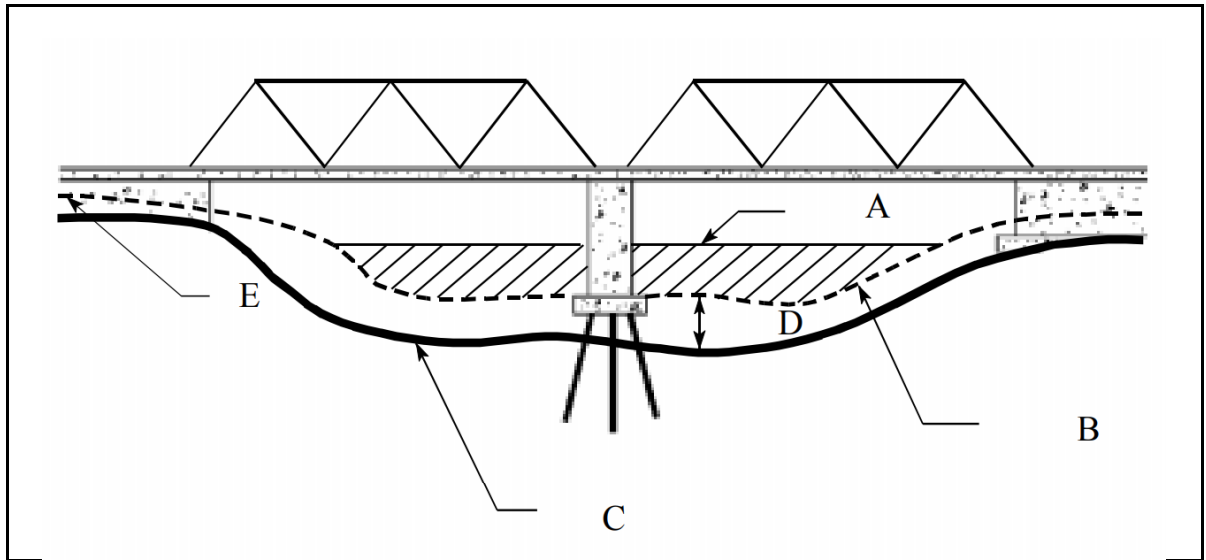
4.4.3 Hydraulic Design

Abutments and piers should be designed and constructed to provide the least amount of hydraulic resistance. Abutments should be constructed with tapered wing-walls upstream and downstream of the bridge and preferably be inclined into the embankment at a 1/16 angle to the vertical axis for increased structural stability. Piers should be constructed with ends which are tapered upstream and downstream in the direction of the main flow.

4.4.4 Erosion Protection

Where scouring around abutments or piers may occur, erosion protection should be provided. For this purpose a protective apron of rip-rap or other suitable material may be installed, preferably at a depth below the expected general scour level. Simply heaping stones around abutments is often unsatisfactory because this type of protection tends to require continual replacement.

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- A - Normal Water Level
- B - Original Stream Bed
- C - Scoured Bed at Flood Risk
- D - Depth of Scour
- E - Flood Plain

Figure 4.6 Bed load movement at times of high flow and general scour require careful consideration to prevent abutment or pier failure

4.4.5 Concrete Components Vs. Wood Components

Where a solid rock foundation is available, concrete structures are strongest, most erosion resistant, and provide a longer term of service. Concrete abutments and piers are therefore preferred from an environmental standpoint to wooden structures.

4.4.6 Wooden Abutments and Piers

If wooden abutments and piers are to be used, squared timber is preferred to round logs. Squared timber can provide relatively tight, uniform surfaces which provide less hydraulic resistance. Filler timbers should be used between the corner-lapped crib timbers to close all openings in the abutments or piers. The timber cribs should be filled with gravel and small rock and consolidated. Protection from ice damage should be provided where timber cribs are exposed to moving river ice, by surfacing vulnerable portions of the structure with steel plating.

4.4.7 Log Cribs

Log crib abutments and piers should only be used for temporary bridges and should be completely removed at project abandonment. Where possible, avoid the use of log cribs. Where log crib abutments and piers are used, such as on forest access roads, the following guidelines should be taken into account to mitigate environmental impact:

- Avoid constricting the watercourse between abutments or with large instream piers.
- Minimize crib pier width and ensure that the pier design prevents the accumulation of debris on the pier.
- Place the lower crib logs deep enough below the streambed to prevent undermining by scour.
- Backfill the lower section of the crib with clean, broken rock.
- Provide well graded rip-rap or armour rock around the structure for protection from scouring or erosion.
- Use "filler" logs between the timber crib logs to completely enclose the sides of the structure.
- All logs should be peeled.

4.5 Recommended Construction Practices

It is during the actual construction of a bridge that there is the greatest danger of causing environmental disruption. Common problems can be categorized as pollution, siltation or disruption of environmentally sensitive areas. Poor bridge construction practices having no regard for these potential problems are liable to cause destruction of habitat for fish, wildlife and vegetation as well as

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degradation of water supplies used for human consumption. These problems may be temporary or long term, or may not become evident until later. For instance, the loss of natural stream bank stability may cause erosion which in turn may create long term problems of channel instability.

The following guidelines cover the most typical areas of bridge construction where the engineer, contractors and site personnel must be made aware of good construction techniques and precautions. However, because of the similarity of all construction near water, the reader is directed to more detailed discussion of the various topics in the appropriate chapters.

4.5.1 Work in the Dry

Operation of heavy equipment should be confined to dry stable areas in order to reduce the amount of mud and heavily silted water at the construction site which could enter the watercourse.

4.5.2 Fording

The operation of heavy equipment in a watercourse or fording of watercourses with heavy equipment should be avoided wherever possible as this can contribute to destabilization of the channel bed and banks resulting in erosion and downstream deposition, and can also cause serious downstream siltation and water quality problems. If fording of the watercourse with heavy equipment is required this should be carried out according to the guidelines of *Chapter 6, "Fording"*.

4.5.3 Use of Cofferdams During Channel Excavation

When excavation is required within the channel, as in the placement of footings for abutments or piers, measures should be taken to separate the excavation area from the flow by cofferdams. *Chapter 10, "General Construction Practices"*, contains information on the construction and use of cofferdams.

4.5.4 Prefabricated Structures

Bridges do not have to be completely constructed on site. Prefabricated structures that can be transported to the site are preferred as they minimize the work adjacent to the watercourse. Precast or prefabricated superstructures also avoid extensive use of fresh concrete on site which can cause serious water quality problems and pollution.

4.5.5 Concrete Work

When fresh concrete is to be used in components of a bridge structure, all necessary precautions should be taken to prevent the fresh concrete from coming in contact with the watercourse and should be carried out

according to the guidelines of *Chapter 10, "General Construction Practices"*.

4.5.6 Use of Wood Preservatives

If creosoted or preservative treated wood is used in the bridge components, every precaution should be taken to prevent such toxic substances from entering a body of water. Any such substance should be applied to the wood at a site which is not environmentally sensitive and away from any water bodies. The treated material should be brought to the site and installed only after proper curing and drying has been achieved. Creosoted wood must not be used in bridges crossing over fresh water.

4.5.7 On-Site Use of Petroleum Products or Hazardous Substances

Where fuels such as gasoline, diesel fuel, kerosene or any other petroleum distillates or other substances which could cause pollution are being handled, stored or applied, containers containing in excess of 20 litres should be kept a minimum of 100 metres from any surface body of water. The storage and handling of gasoline and any petroleum derivative must be carried out according to *The Storage and Handling of Gasoline and Associated Products Regulations, 1982*.

4.5.8 Avoid Bank Disturbance

At all times, every necessary precaution should be taken to prevent the disturbance of channel banks, bank vegetation, and land within the high water zone, flood zone, or recommended buffer strip of any body of water outside of the land designated for construction of the roadway and bridge abutments. Further information is contained in *Chapter 10 "General Construction Practices"*.

4.5.9 Containment And Treatment of Silted Water

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. Effluent discharged into receiving waters must comply with environmental regulations. Further information on reducing the amount of silted water generated by construction operations and methods for treatment are contained in *Chapter 10 "General Construction Practices"*.

4.0 BRIDGES

4.6 Site Rehabilitation and Stabilization

4.6.1 The Necessity of Site Rehabilitation

Toward the completion of the bridge installation, site rehabilitation should be carried out to stabilize slopes, disturbed areas and other areas vulnerable to erosion, to provide revegetation, and to ensure the site is left in a condition which is environmentally acceptable. *Chapter 10, "General Construction Practices"*, contains detailed information on site rehabilitation.

4.6.2 Protect Bridge Abutments

Bridge abutments should be protected from erosion or scouring by the careful placement of armour stone or rip-rap at vulnerable areas upstream and downstream of the abutment wing walls.

4.6.3 Stabilize Road Embankments and Ditches

The roadside embankments and roadside ditches near the watercourse should be stabilized by providing low side slopes and low grade and by providing rip-rap.

4.6.4 Protect Vulnerable Areas

Where river banks or other vulnerable areas have been disturbed, rehabilitation should be carried out to reinstate these areas and ensure adequate erosion protection. Protective rock or vegetative covering should be provided, as appropriate.

4.7 Inspection, Maintenance and Other Concerns

4.7.1 Frequent Inspection Needed

Bridges require frequent inspection to determine if they are performing satisfactorily without causing any environmental problem and to identify any problems which may threaten the bridge structurally.

4.7.2 Comprehensive Annual Inspection

A full inspection should be carried out annually after peak flow as well as periodic spot checks during times of high flow conditions. The annual inspection should involve examining the stream channel above and below the bridge to determine if any significant changes in the channel are evident. Sounding around piers and abutments to assess scour and deposition should be carried out.

4.7.3 Periodic Spot Inspections

Periodic spot checks during peak flow should identify:

- The adequacy of the bridge's capacity to safely pass peak flows with sufficient freeboard to the bridge deck,
- The extent of backwater effects or flow constriction,
- Flow velocity,
- The high water mark,
- Locations where the hydraulic characteristics of the peak flow may induce scour or erosion,
- Locations where debris has caught on piers or abutments,
- If roadside and bridge deck drainage are working correctly and,
- Any apparent problem which may require further investigation or remedial measures.

4.7.4 General Maintenance

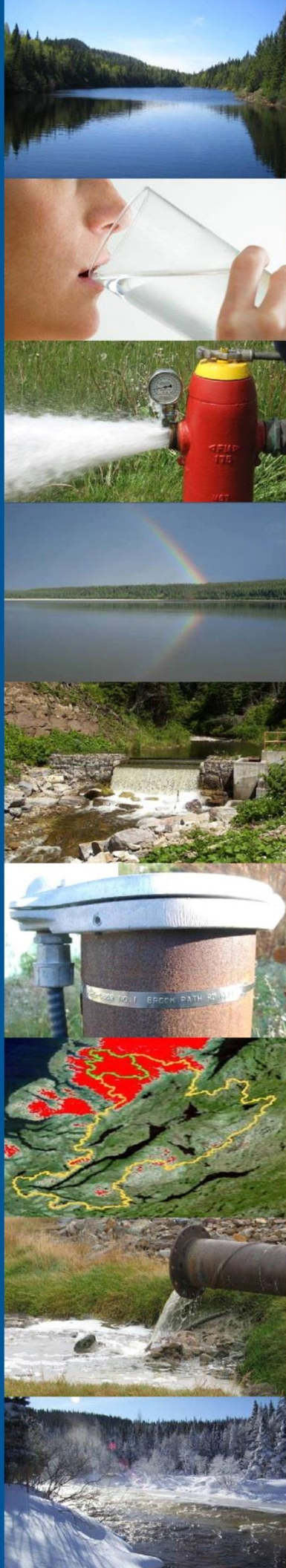
General maintenance work should be carried out as required from time to time. Grouting or resurfacing of structural components as well as the removal of debris which may become caught at piers, abutments, or locations upstream of the bridge will extend the useful life of the bridge and minimize the risk of failure.

4.7.5 Remedial Works

Where serious problems are evident such as extensive bed degradation, pier scour, bank erosion or considerable flow constriction, remedial measures may be required. Such problems are often the result of inadequate capacity or lack of erosion protection and preferably should have been addressed in the design stage. If, however, erosion control or river training works are to be carried out subsequent to the development of such problems, a comprehensive investigation or evaluation of the problem should be conducted. Prior to the installation of such works the effectiveness and the implications of the hydraulic changes must be determined. The use of scaled hydraulic models may be appropriate. Usually, a new environmental approval will be required because the work may be carried out by different contractors and because of the stream flow alterations involved.

4.7.6 Recreational Use

Some bridges are located at a junction of a major watercourse and a major transportation route. These sites may attract people who wish to gain access to the watercourse for fishing, boating, or other recreational activity. It is therefore desirable to provide off-road parking at a safe location near the bridge along with a foot path to provide ease of access and reduce the slumping of roadside embankments by foot traffic.



Chapter 5: Environmental Guidelines for Culverts



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
St. John's, NL, Canada
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Chapter 5

Environmental Guidelines For

CULVERTS

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

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5.1 General

Culverts are often used to provide access across drainage ditches, intermittent streams and small watercourses. Culverts can provide an efficient and inexpensive means of crossing provided they are properly designed and properly installed at suitable locations. Often culverts are also necessary to provide drainage where roads or other structures would interfere with the otherwise normal flow of surface runoff. Temporary or permanent culvert stream crossings are preferred to fording of small watercourses where extensive fording may give rise to channel destabilization.

On some streams it is environmentally desirable to construct bridges instead of culvert crossings because bridge installations can avoid extensive alteration of the flow regime which is inherent with most culvert installations. Bridges are also preferred to culverts in crossing all streams which support fish populations. Culvert installations usually result in more substantial alteration or loss of sections of the natural channel bed and can cause a partial or total barrier to fish migration. Installation of culverts in major watercourses and rivers, instead of bridges, is not considered a good environmental practice.

Many types of culverts are available from suppliers, the most popular being corrugated steel pipe. Reinforced concrete culverts, and plastic pipe culverts, are usually available in round sections only. Examples of corrugated steel and plastic culverts can be seen in **Figure 5.1**. Corrugated steel culverts are available in a large variety of cross sectional shapes and sizes to suit varying stream conditions or requirements, the most popular shape being round or arched.

All culvert installations of significant size, including multiple or gang culvert installation, should undergo thorough hydraulic and hydrologic analysis. Factors such as channel gradient, flow velocity, channel cross section, channel roughness, discharge patterns, peak water levels, quantity of flow, and ice formation must be considered.

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Figure 5.1 A Corrugated Steel Culvert Mitred to the Face of a Wall (Top), and a Small Plastic Culvert with a Masonry Headwall (Bottom)

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The completed culvert installation should safely accommodate reasonably predictable levels of flow and adequately resist the erosive action of moving water without creating any adverse environmental impact at the crossing or in upstream or downstream areas. Flow quantity may be predicted through a variety of methods including the rational method, unit hydrograph, SCS Method, or Regional Flood Frequency Analysis. In addition to utilizing any of these methods a relevant amount of data must be collected on the stream and its watershed such as:

- historical streamflows
- velocity distribution in stream
- high water marks
- ice shove marks
- precipitation data
- potential river scour data
- ice formation and ice jamming areas
- rating of erosion hazard
- surface drainage patterns
- floodplains
- surface area of rivers, lakes, bays, wetlands

While it is not always necessary or possible to determine all of the source data listed above it is generally advisable to have sufficient data to check expected flood flow by at least two independent methods.

The following sections of this chapter provide helpful information for culvert design and installation to ensure that the width and depth of flow expected in the stream under natural conditions is not significantly altered by the installation of culverts. Construction procedures should follow these guidelines with the primary objective being to prevent environmental damage such as pollution and siltation. These guidelines are intended to provide explanatory information and guiding principles but do not provide a complete code for design because certain design criteria such as load bearing capacity should be derived from appropriate texts. Engineering advice should be sought by lay people who wish to purchase and install their own culverts.

5.2 Culvert Location and Shape

The location of culverts is perhaps the most important consideration in installing an environmentally satisfactory culvert crossing. While the location of the road will probably be the primary consideration, it is important to realize that minor changes in road alignment may be necessary to avoid problem areas as far as culvert installations are concerned.

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5.2.1 Select a Stable Location

Avoid locations where there are abrupt or short radius bends in the stream channel and areas where erosion, undercutting, or fine soils are evident. These areas are often subject to greater erosive force which could create problems for a culvert installation.

Heavy erosive action can lead to undercutting of the culvert and structural damage. In addition, these areas are often unstable and the channel may be shifting. If the stream bed is mobile it may eventually bypass the culvert, rendering the installation useless. Culvert crossings should be located on straight, stable channel segments with no evidence of heavy erosive action.

5.2.2 Select a Site With Uniform Channel Gradient

Select a culvert site where the channel gradient is uniform for a distance upstream and downstream in the channel. This will avoid areas where there may be sudden increases in water velocity immediately upstream or downstream of the installation. The gradient must be constant at the crossing itself. Culverts should never be installed with bends in them.

Steeper channel gradients result in higher flow velocity. This could mean that the installation would be subject to greater risk of erosion and washout caused by the momentum of water striking the culvert inlet area. Areas of low gradient should therefore be given preference.

5.2.3 Location With Regard to Ice

A culvert should not be located where large quantities of solid sheet ice are formed upstream. During spring runoff such ice may break loose and block the culvert. Outlet areas of small pools or ponds should therefore not be culverted.

5.2.4 Culvert Shape

The shape of a culvert should conform to the site conditions and to the flow regime at that location. While round culverts are the most popular, a variety of shapes are available (see **Figure 5.2**). Design options are limited by flow characteristics and highway alignment. Where elevation is restricted the designer may select a shape which is horizontally elongated to produce the same cross sectional area with less height.

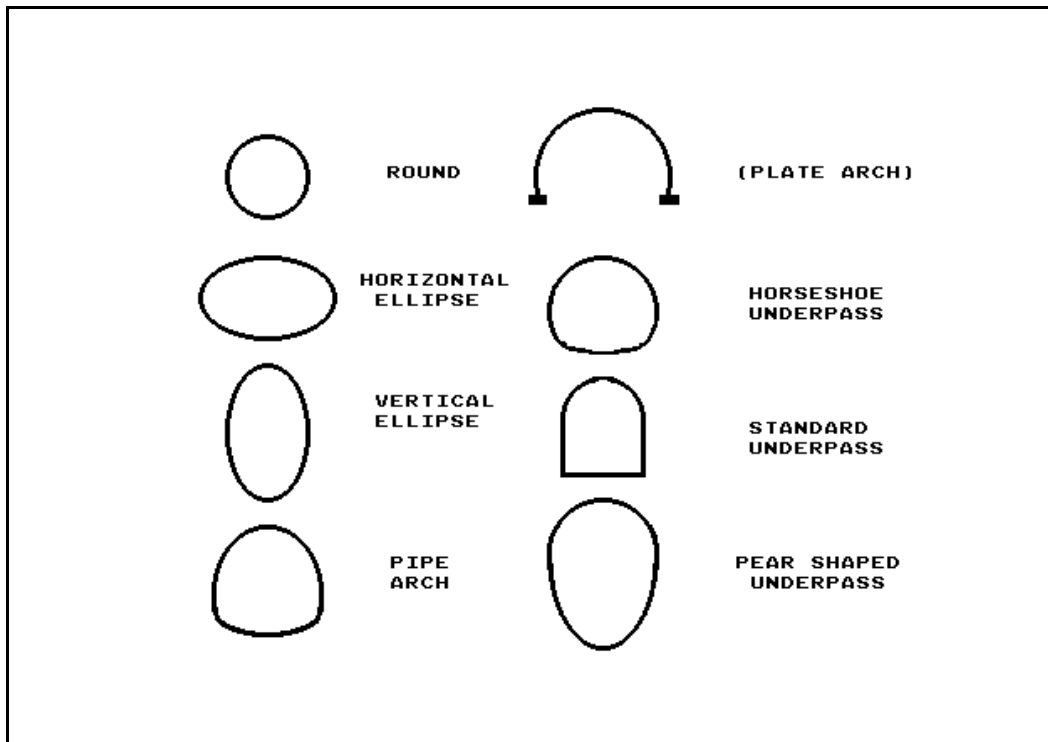


Figure 5.2 Common Shapes for Corrugated Steel Culverts

Although an open bottom arch is shown in **Figure 5.2**, arch "culverts" can be treated as bridges and are discussed in *Chapter 4, "Bridges"*. A photo of an arch culvert can be seen in **Figure 5.3**.



Figure 5.3 Corrugated Steel Arch Culvert

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Wider culverts result in lower flow velocity. At low flows wider culverts may have insufficient water depth to allow fish passage.

Generally, arch shapes are useful to reduce the elevation of fill, but they are more difficult to install. Elliptical shapes provide better low flow characteristics. Multiple barrels of the same size or different sizes may be easier to install and conform to the stream shape, but these installations are generally less efficient hydraulically when compared to larger single size pipes.

5.3 Culvert Capacity

All culvert installations should be designed to safely accommodate peak flow volumes estimated for that section of channel during the expected life of the culvert. This means that the size or capacity of a culvert should be commensurate with its expected serviceability. For instance a culvert installed under an infrequently used forest access road would not be expected to give the same degree of performance as a culvert installed under a major highway. Nevertheless all culverts must be installed in a manner which is acceptable from an environmental standpoint. When culvert capacity is exceeded by a very large volume of flow or the capacity is reduced by blockage, there is a danger of:

- overtopping, damage to the roadway and traffic interruption
- consequential threats to human safety
- damage to adjacent property or the environment
- unsafe outlet velocities
- injurious deposition of bed load

Excessive headwater depth can contribute to a "piping effect" through the backfill material surrounding culverts. This can undermine culverts and result in a major washout.

Surcharge conditions can cause flooding upstream of the culvert and/or scour and erosion at the culvert inlet.

5.3.1 Provide Adequate Capacity to Prevent Surcharge

Culverts should be designed with adequate capacity to carry maximum design flows without creating surcharge or backwater conditions. In this regard culverts should be designed to carry the design flow with a headwater depth not greater than the vertical dimension of the pipe. Large culverts (over 2.0 m) should have a freeboard.

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Small culverts under 2.0 m can use the California Balanced Design Method (see **Figure 5.4**), which specifies (1) a 10 year return flood can be carried without static head at the inlet, and (2) a 100 year return flood will be carried utilizing the full head available at the inlet.

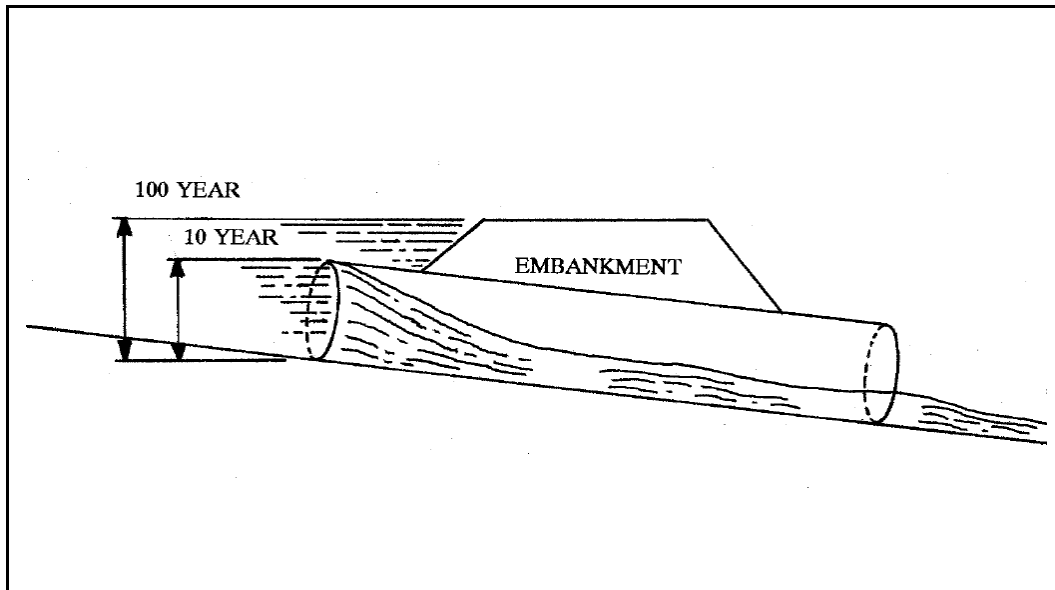


Figure 5.4 California Balanced Design Method

Where overtopping can be tolerated (ie. if none of the previously mentioned consequences of inadequate capacity apply except overtopping itself), the 100 year return period can be reduced to:

Freeways	50 year
Arterials	50
Urban local and collector streets	25
Rural and forest areas	20
Driveways and farm lanes	10

Typically, in Newfoundland, stream widths are greater than the culvert opening. The flow may become constricted, causing critical conditions at the inlet, a case called inlet control. The discharge of the culvert is controlled by the entrance conditions, which are:

- headwater depth
- cross sectional area
- type of inlet edge

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The roughness, length, and outlet conditions of the culvert do not influence culvert performance. The entrance of the pipe acts as an orifice and is governed by the equation:

$$Q = C_d * A_o * (2gh)^{0.5}$$

where

Q = flow

C_d= experimental coefficient

A_o= area of orifice

h = height from centre of orifice to headwater surface

g = gravity constant (9.81 m/s²)

C_d has a wide range and is primarily an indicator of the roughness of the opening. The influence of the edge roughness of the culvert decreases as the culvert diameter increases.

It is important to remember that under inlet control, the slope of the culvert does not affect the flow capacity. However, at high slopes the flow velocity in the pipe will be increased and may result in undermining at the outlet, downstream bed scour and damage to control structures.

5.3.2 Allowance for Limited Gravel Deposition

Culvert capacity should be designed to include provision for limited gravel deposition within the culvert if required for fish habitat reasons. (See **Figure 5.5**). This gravel should be sufficient to mimic a natural type of stream bed within the culvert, if the stream is a natural habitat for fish. Typically, the depth of allowable gravel deposition is 1/3 of the diameter for culverts under 0.75 m diameter, and 0.3 m for culverts over 0.75 m diameter. Because the gravel deposition reduces the cross sectional area of the pipe, the diameter of the culvert must be selected to produce sufficient flow capacity even with gravel deposition.

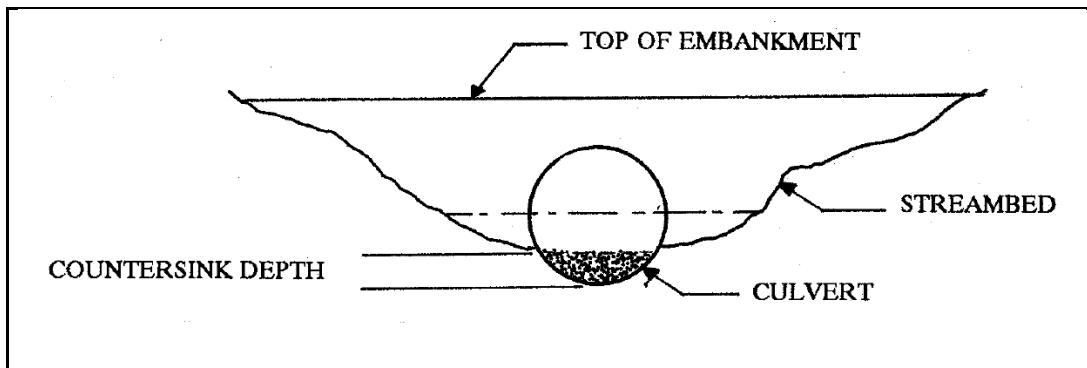


Figure 5.5 Countersunk Culvert

Size selection is further complicated because the flow actually has three distinct hydraulic stages:

- | | | |
|----|---------------------------|------------------|
| 1. | Weir or open channel flow | $H = 0$ to $D/2$ |
| 2. | Flow known experimentally | $H = D/2$ to D |
| 3. | Orifice flow | $H > D$ |

where

H = depth of water at inlet

D = diameter of culvert

Gravel deposition affects channel roughness, orifice roughness, and opening size. Consequently, in sizing a culvert allowance must be made for the reduced capacity resulting from this installation feature. Having used normal culvert design methods to estimate the appropriate size of culvert, **Figure 5.6** may be used to select the proper larger sized culvert to provide for countersunk installation.

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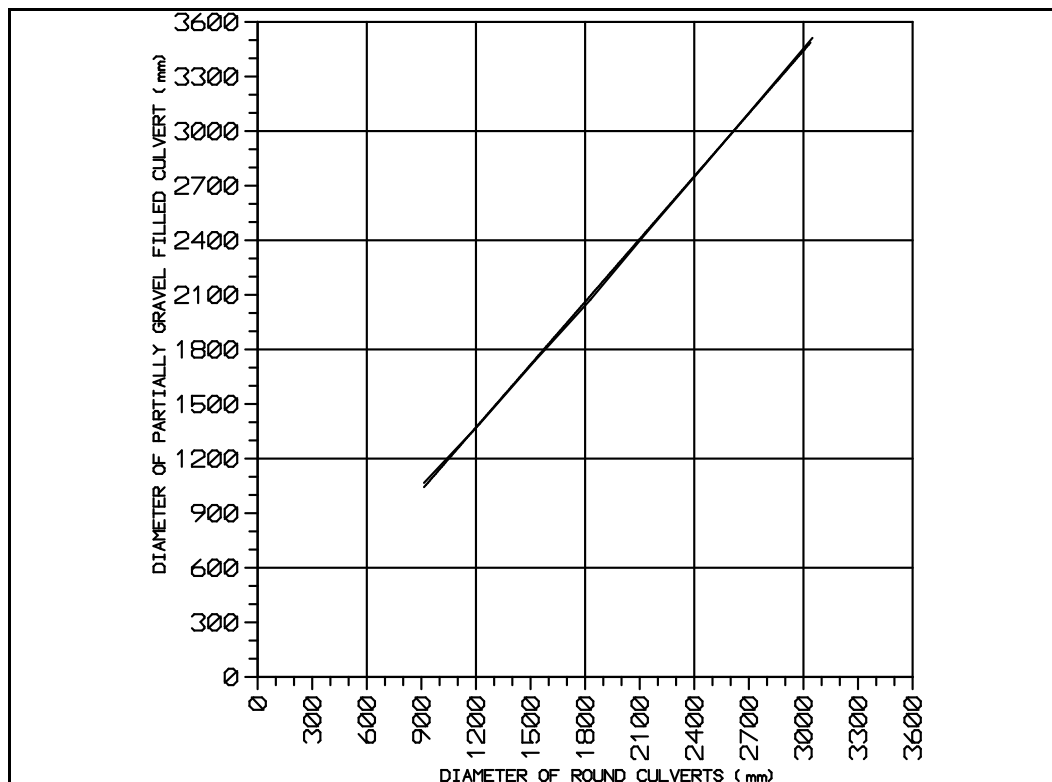


Figure 5.6 Conversion of Normal Round Culvert to Countersunk

5.3.3 Maintain Natural Stream Channel Capacity

Culvert installations should provide capacity equivalent to that of the existing natural channel. In this regard infilling of the channel or reduction of the natural cross sectional area of the channel due to the culvert placement and backfilling should be avoided. Pipe arches are a preferred shape over circular pipe in wide and flat bottomed streams.

5.3.4 Debris Control Structures and Culvert Capacity Should Address Maintenance Requirements

Many debris barriers or trash racks require cleaning after every storm. The expected frequency of debris removal should be considered in selecting the debris control structure. If a low standard of maintenance is anticipated, the designer should choose to pass the debris through the structure by ensuring adequate capacity.

5.3.5 Anticipate Reduced Capacity

Whereas the design capacity for a culvert installation may indicate an adequate installation purely from a hydrologic point of view, the possibility of reduced capacity must be anticipated. This is particularly important where

there is ice, debris from logging or other forestry operations or debris from vandalism and littering. A culvert may require dramatic over sizing to allow passage of debris.

5.4 Flow Velocities in Culverts

5.4.1 Choose Design Velocities to Suit Existing Flow Conditions

The design flow velocity in culverts should be chosen to conform with existing natural upstream and downstream flow velocities. All factors which determine flow velocity through a culvert should be examined. These include:

- The slope of the culvert (grade on which it is placed),
- the roughness of the inside of the culvert,
- the design of the culvert inlet and outlet,
- the flow volume,
- the level or head of water at the inlet,
- backwater effects from downstream controls, and,
- the culvert type or more specifically the cross sectional shape which determines the perimeter in contact with the flowing water.

Low inlet and outlet flow velocities are preferred for all culvert installations. High velocity flow can result in undermining, erosion, and washouts of culverts and can also create an impasse to migrating fish. The flow velocity at times of normal flow conditions should not exceed 0.9 m/s except in instances where very steep natural channel grade and high velocity flow in the channel dictate a high flow velocity through the culvert.

5.4.2 Results of High Velocities

The downstream results of higher velocities may involve:

- bed scour
- bank erosion
- structural damage or overtopping of control structures
- undercutting of culvert.

If the velocity is dissipated quickly by the stream the main problems will be bed scour and undercutting in the immediate vicinity of the culvert. The flow velocity causes sufficient shear force to overcome the gravitational and frictional forces holding bed material in place. Transport velocities for streambed materials are given in **Table 5.1**.

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Table 5.1: Transport velocity for various sizes of streambed materials		
MATERIAL	PARTICLE SIZE mm	VELOCITY m/s
silt	0.005 - 0.05	0.15 - 0.30
sand	0.25 - 2.5	0.30 - 0.65
gravel	5.0 - 15	0.80 - 1.20
pebble	25 - 75	1.40 - 2.40
cobble	100 - 200	2.70 - 3.90

5.4.3 Choose Correct Gradient

In most cases, culverts should be installed such that the gradeline coincides with the average streambed gradeline. Attempts to control flow velocity by changing the grade will have the following consequences:

- a) Culvert grade greater than stream; inlet will be elevated causing upstream ponding or outlet will be submerged and the barrel will act as a silt and gravel trap, eventually becoming blocked.
- b) Culvert grade less than stream; inlet will have a drop or outlet will be hanging.

Both cases will act as an obstruction for fish passage.

While some deviation from the stream grade may serve to decrease flow velocity in a culvert, calculations justifying this deviation must be performed. If the desired flow velocity cannot be achieved this way, then it is obvious that a bridge, rather than a culvert, is required.

5.5 Culvert Installation and Construction Practices

Improperly installed culverts are a waste of the owner's money, a threat to aquatic life, and may be a threat to the users of any structure built over or adjacent to them. A photograph of a poor culvert installation is shown in **Figure 5.7**.



Figure 5.7 Poorly Installed Culverts

Figure 5.7 illustrates several obvious problems encountered with culvert installation. The pieces of corrugated metal lying in the water indicate that sections of culvert have failed under load and collapsed onto the stream bed. The culverts are projecting from the fill. There is no end protection to resist erosive action. It appears that the culverts have been placed haphazardly with very little concern for hydraulics, aesthetics, fish passage, or embankment protection. The embankment is poorly constructed and unstable.

Hopefully these guidelines will help installers avoid situations like the one pictured above.

5.5.1 Installation to Manufacturer's Specifications

The installation of all culverts should comply with the specifications prescribed by the manufacturer of that product, particularly in regard to pipe zone bedding material quality, degree of compaction, and minimum or maximum pipe cover for design loadings.

5.5.2 Operation of Heavy Equipment

The use of heavy equipment in waterbodies should be avoided. The operation of heavy equipment should be confined to dry stable areas.

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5.5.3 Work During Times of Low Flow

All work involving minor alterations to the stream channel to permit culvert placement should be carried out at a time of low flow conditions. It is prudent however to be prepared for increased flows by scheduling work according to the weather forecast and to have a contingency plan for unexpectedly large runoff from a sudden storm.

5.5.4 Avoid In-Stream Excavation, Work in the Dry

In-stream excavation can cause considerable siltation and pollution of watercourses. If excavation of bed material or other extensive in-stream work is necessary, to make a level bed for the culvert for example, all flow should be diverted or confined to a section to allow the work to be carried out in the dry.

5.5.5 Control of Stream Flow for Culvert Placement

Streamflow may be controlled in any of a number of ways in order to provide a dry working area. Four methods which may be used include the following:

1. A temporary diversion channel. (See *Chapter 7, "Diversions, New Channels, Major Alterations"*).
2. A temporary culvert(s).
3. Pumping. (See *Chapter 10, "General Construction Practices"*).
4. Confining flow to a channel section by use of cofferdams. (See *Chapter 10, "General Construction Practices"*).

5.5.6 Culvert Gradient to Follow Stream Gradient

The gradient of all culverts as far as possible should follow the stream channel gradient and should be placed in line with the direction of the main flow.

5.5.7 Multiple Culvert Installations

In multiple (gang) culvert installations, one culvert should be set at an elevation lower than the others to provide adequate flow depth and velocity for fish passage during low flow conditions. **Figure 5.8** shows an example of culverts from two separate crossings having outlets at the same point. The elevation is not as much of a factor here since it is not a true gang culvert.



Figure 5.8 Two Culverts with a Shared Outlet Location

5.5.8 Place Culvert at Correct Elevation

Culverts should be placed at such an elevation that there is no ponding of water at the upstream inlet of the culvert and there is drop or hydraulic jump created at the outlet of the culvert. Similarly, outlets should not be submerged.

Large culverts may be countersunk into the channel bed. This also permits some gravel deposition in the culvert which creates a natural type of bed within the culvert.

5.5.9 Quality of Bedding and Backfill Material for Culverts

Suitable material of good quality should be used in backfilling culverts to ensure a good culvert installation. A compactable granular material "Granular Class B" quality or better is suitable for most installations. Cohesive soils or material containing large amounts of sand, fine silt or clay should not be used, because erosion of the material may result. Well graded granular material also provides better load carrying capability than poorly graded material or cohesive soils. Small culverts may be backfilled with the same material used to construct the road, provided that the material meets road construction standards. Larger culverts should be backfilled more carefully, using select material if necessary.

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5.5.10 Procedure for Backfilling Culverts

Backfill material placed under the haunches of the pipe should be in intimate contact with the entire bottom surface of the structure. Pre-shaping the bedding material to match the culvert curvature may assist in this regard. Backfill material should be placed in layers not exceeding 300 mm in thickness and compacted with suitable hand operated compacting equipment. Backfilling should be done in a manner that will prevent any deformation or displacement of the culvert. Proper compaction is necessary to provide adequate load bearing capacity above the culvert, and is necessary to reduce the voids which can cause "piping effect". The soil compaction around the culvert should achieve 90% standard Proctor density or better. The major factors which influence soil compaction and which should be taken into consideration include the following:

- moisture content of the soil,
- nature of the soil, its gradation and physical properties,
- type and amount of compaction effort required.

Granular soil types are best compacted by applying a continuous vibratory action.

5.5.11 Removal of Shipping Supports

Large diameter culverts are often shipped with bracing to prevent deformation of the culvert during transport and installation. These braces should be removed upon completion of the work as they may contribute to blockages by debris or ice.

5.6 Culvert Inlet and Outlet Structures

Culvert end structures, pre-built or constructed in place are attached to the ends of culverts to reduce erosion, retain the fill, inhibit seepage, improve the aesthetics and hydraulic characteristics and make the ends structurally stable.

Headwalls may be made of concrete, lumber, steel sheet piling or rock either grouted or cemented or simply left plain. Headwalls are sometimes skewed relative to the culvert to fit the angle of crossing. Wingwalls may be used to aid in funnelling the approaching flow of water directly into the inlet and to prevent erosion on the stream banks adjacent to the culvert. **Figure 5.9** shows a masonry headwall and wingwalls.

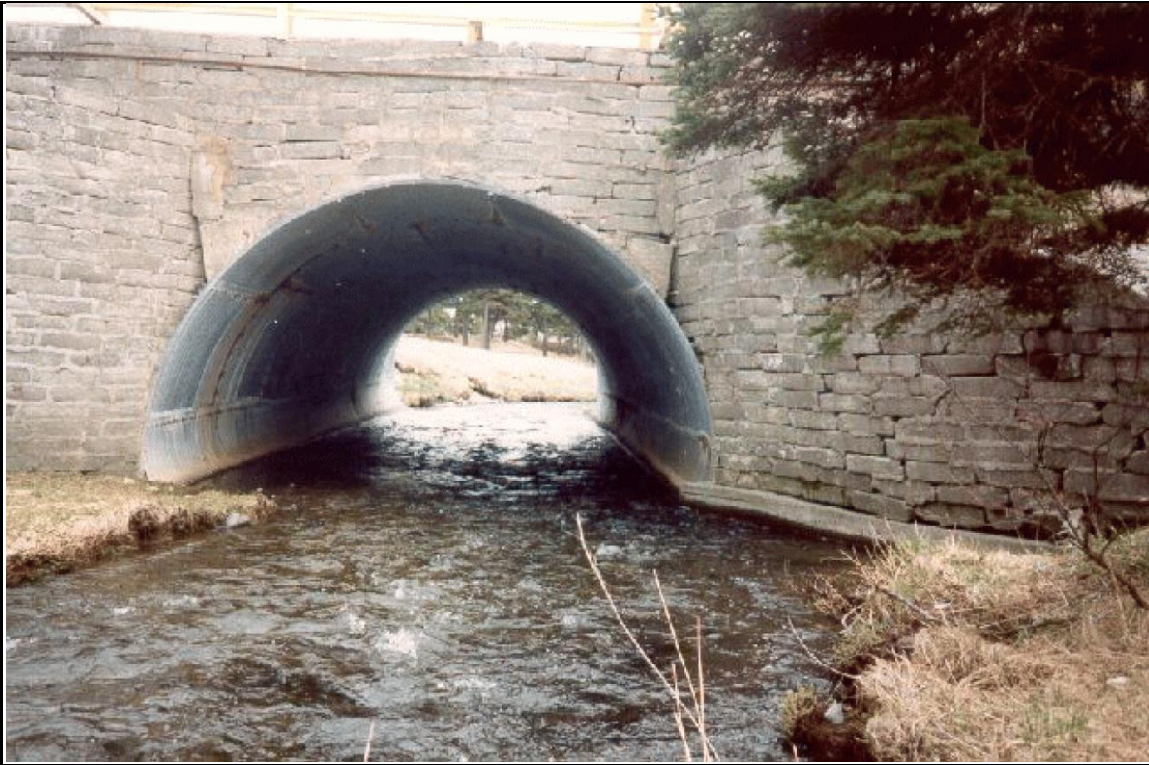


Figure 5.9 Pipe Arch Culvert with Masonry Headwall and Wingwalls

Larger culverts may be provided with specially shaped inlets. These inlets provide a smooth transition from a wide channel to a slightly narrower culvert barrel with the result that entrance losses are reduced and the culvert will effectively be able to carry a larger quantity of flow.

Special outlets or spill aprons are used to prevent erosion where high velocity flow re-enters the channel downstream. Trash Racks are optional end structures which serve to remove debris and also prevent unauthorized access.

5.6.1 Headwalls Required

Small sized culvert installations such as drainage culverts do not always require headwalls provided the fill is stable and is placed at a very mild slope. The necessity of providing headwalls generally increases with the culvert size.

5.6.2 Use of Armour Rock

Attractive, long term, economical and efficient protection of culvert inlet and outlet areas can be provided with rock when properly installed. Rock of sufficient size to form a permanent stable structure should be used. The foundation rocks should be set below the bed of the watercourse to prevent

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undermining. Wingwalls and headwalls of fitted rock should be leaned into the embankment at an inclination of at least 1/6 from the vertical axis to ensure stability. Joints can be pointed with concrete or mortar to provide a more uniform or water tight surface but the structure should not be dependent on the jointing material for structural stability. Where irregular or rubble rock is used to protect inlet and outlet areas, the rock should form a slope no steeper than one horizontal to one vertical and it should be well consolidated.

5.6.3 Use of Slope-Tapered Inlets

A tapered inlet slope provides less inlet head loss and thus can provide greater capacity and efficiency for culverts installations. Projecting culvert ends can be cut with a tapered slope to conform to the finished embankment slope and provides a neater and more aesthetically pleasing installation. Slope tapered inlets also provide less likelihood of serious blockage of the inlet by debris. However, special measures must be employed to prevent uplift of the projecting lip.

5.6.4 Use of Steel End Sections

A variety of steel end sections which are shop fabricated for assembly in the field, are available for attachment to corrugated steel pipe. These can provide better hydraulic inlet and outlet conditions and protection from erosion or scour of the road embankment and bed material, and can provide protection to the culvert ends as well.

5.6.5 Use of Concrete

Headwalls, wingwalls, spill aprons or other end structures constructed of cast in place concrete should be installed in accordance with the guidelines on use of concrete in *Chapter 10, "General Construction Practices"*.

5.6.6 Trash Racks Should be Sloped

Where a trash rack is used to catch debris and prevent it from entering a culvert, the rack should be installed with a low incline to prevent floating debris from being held against the rack by the flow (as with vertical trash racks) as this can cause serious flow constriction flooding, or washouts. An inclined rack allows debris to be pushed up to the top of the inlet structure where it will not seriously constrict flow and where it can be easily removed.

5.6.7 Use of Spill Aprons for Scour Protection

An apron of fitted rock or rip-rap can be installed at the outlet of a culvert to provide protection to the stream bed and prevent scour or undermining. Such a structure can also provide a sufficient roughness factor to reduce the velocity at the outlet thus providing further protection from erosion or scour. This is preferred to concrete or steel aprons which do not significantly reduce outlet velocities and which often cause scour of the bed material at the apron lip.

5.7 Inspection and Maintenance

5.7.1 Inspect Culverts Regularly

Culvert installations should be inspected regularly so that immediate action can be taken to clear blockages caused by ice or debris and to identify any apparent problems, such as erosion, which may require remedial action.

5.7.2 Inspect Culverts During and After Major Floods

An inspection of culverts should be made during and after major floods to observe the culvert operation and record high water marks. Conditions which require corrective maintenance should be noted including debris accumulations, silting, erosion, piping, scour, and structural damage. Performance information that reflects a need for design or construction changes due to unexpected large flood peaks should be submitted to the regulatory authority or owner for further action.

5.7.3 Establish a Culvert Maintenance Program

Culvert failures can be both disastrous and expensive. A comprehensive program for maintaining culverts in good repair and operating condition will reduce the probability of failures and prove to be cost effective. The program should include periodic inspections with supplemental inspections following flood events.

5.7.4 Mark Culvert Inlets and Outlets for Identification

All culvert inlets and outlets should be clearly marked so as to be identified during snow clearing and road grading operations.

5.7.5 Protect Inlets and Outlets

Inlet and outlet areas of culvert installations must be adequately protected by placing rip-rap, or fitted stone, or concrete headwalls to prevent bank and channel erosion.

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5.7.6 Replace Damaged Culverts

Culverts which have been damaged by ice or debris, by improper installation or construction procedures, or are in a condition which could impair their proper functioning should be replaced immediately to prevent overtopping, erosion, or flooding.

5.7.7 Maintenance Access

Provisions for maintenance access are necessary especially where debris control structures are installed. A parking area for equipment such as a crane may be necessary in order to remove debris without disrupting traffic. Also such access should not disrupt the site rehabilitation efforts.



Chapter 6: Environmental Guidelines for Fording



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



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Chapter 6

Environmental Guidelines For

FORDING

Water Resources Division
Water Rights, Investigations, and Modelling Section

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6.1 General

Under certain circumstances, properly designed and constructed fords may be used as watercourse crossings. *Chapter 3, "Watercourse Crossings"* provides information on choosing between a fording installation and other methods of watercourse crossing. The use of a fording site is usually limited to periods when low flow conditions prevail. The appropriateness of fording may depend upon the type of vehicle using the site. While vehicles with low pressure tires may ford a stream with little disruption, tracked machinery may cause severe environmental damage and as such may not be generally suited for fording watercourses.

Installation of a fording site should entail minimal disturbance to the stream channel and surrounding vegetation. Concerns normally associated with culverts or bridges, such as size of waterway opening, provisions for debris passage and the need for channel or embankment rip-rap are largely avoided. In addition, the degree of maintenance required is normally less than for other types of crossings. In hilly or mountainous terrain, fords are particularly useful for crossing streams subject to dramatic increases in water level or flash floods, where installation of a rarely used bridge or culvert would be very expensive.

There are, however, several disadvantages of fording a stream. Crossing on an unstable stream bed or unstable approaches will cause direct disturbance of the stream. Mud holes can form on the approaches and subsequent rains combined with traffic travel will discharge sediment into the stream. In addition, the washing of pollutants from equipment travelling through streams can cause water quality degradation. Very frequent use can result in channel destabilization and problems of bank or bed erosion and siltation of the watercourse.

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6.2 Selection of Fording Sites

Fording sites chosen for crossings should be least vulnerable to disruption of land, vegetation, and physical features of the channel.

6.2.1 Choose a Location with Stable Bed Material

A channel bed consisting of bed rock is preferred but a stable channel bed consisting of cobbles or coarse gravel may be satisfactory. Areas containing sandy or silty deposits are not considered satisfactory locations for fording.

6.2.2 Choose a Location with Low Graded Banks

Choose a location where existing approach grades and bank slopes are low, to permit movement of equipment into and out of the channel without extensive excavation or alteration of the channel banks and riparian land.

6.2.3 Confine Fording to Specific Locations

All fording should be confined to specific locations which have been identified as appropriate sites and have been approved. The fording sites should be made clearly visible to equipment operators by markings and the equipment should be confined to within those narrow corridors which have been identified.

6.3 Enhancing a Fording Site

A certain amount of work may be required to prepare a fording site. Such work is intended to make the crossing easier, to protect the stream from disturbance and to simplify restoration measures that may be required.

6.3.1 Preparing Access to The Watercourse

Access to the fording site should be approached at right angles to the stream. Any clearing of vegetation should be restricted to a width of not more than 3m within 15m of the stream bank. All slash must be removed from the area and under no circumstances should it be disposed of near the watercourse. It is important to try to maintain as much vegetative ground cover on the approach area as possible.

6.3.2 Approach Roads

Should grading of the approach be required, a back-blading technique should be used but only to the extent absolutely necessary. The approach road, especially if it is on a steep incline to the watercourse, should be cross ditched to prevent surface runoff along the travelling surface which could cause severe erosion and sedimentation problems.

6.3.3 Stabilize and Protect Vulnerable Areas

Where areas such as bank sections or approach roads contain loose material that could be subject to erosion, adequate stabilization and erosion protection should be carried out. Brush mats, log ramps or placement of rock may be appropriate depending on the circumstances and the type of material readily available.

6.3.4 Use of In-Stream Rock

If in-stream rock placement is required for fording sites, the crossing should not constrict flow in the river to cause flooding conditions upstream. The material used should be clean blasted rock free of fines. Under no circumstances may such rock be excavated from the stream. Furthermore all material placed in the stream must be completely removed from the channel when the fording site is no longer required.

6.3.5 Avoid Infilling of Channel

Avoid pushing bank sections into the channel or any infilling of the channel which could constrict flow or contribute to flooding, erosion, or siltation.

6.4 Proper Use of Fording Sites

6.4.1 Condition of Vehicles Using Fording Sites

All vehicles using fording sites must be kept reasonably clean and free of mud to prevent siltation or water quality deterioration. The vehicles should also be maintained in good repair, free of oil, gasoline, hydraulic fluids or other deleterious substances which could impair water quality. It may be necessary to have vehicles steam cleaned prior to fording.

6.4.2 Avoid Channel Disturbance and Downstream Siltation

Fording must be carried out in such a manner as to cause the least amount of disturbance of channel bed and bank material which could cause erosion, siltation and pollution of downstream areas. The channel should be approached and forded by vehicles moving slowly in low gear.

6.4.3 Limit Use of Fording Sites

Fording sites should be used as infrequently as possible. If frequent use is required, a bridge or culvert installation may be necessary.

6.4.4 Fording During Low Flow Conditions

Fording should be carried out only during low flow conditions to avoid unnecessary disturbance of the channel or siltation. It may be necessary to undertake an assessment of the flow conditions for a stream to ensure that the water depth and the flow velocity will be such that the stream can be safely

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forded without having the vehicles stall due to flooding of the engine or even having the vehicle overturned by the current.

6.5 Removal of Fording Works

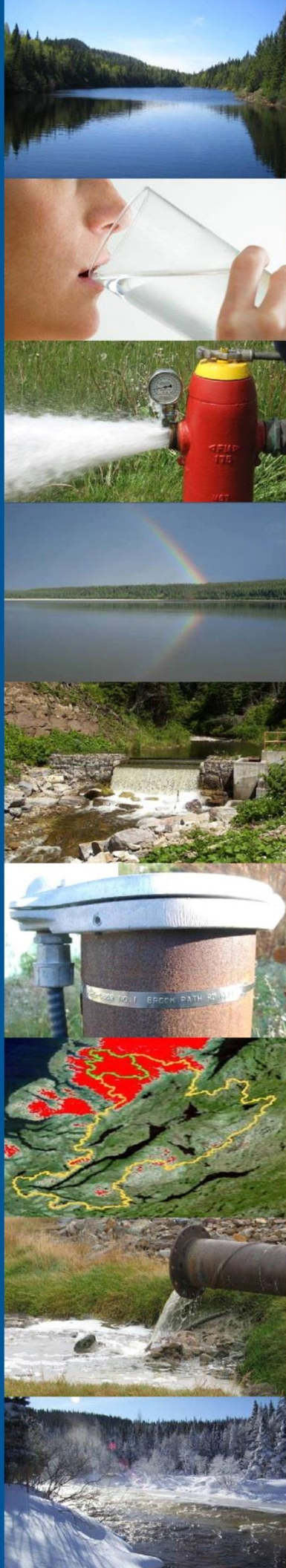
When fording sites are no longer required all constructed works such as in stream structures, rock fill, approach ramps, corduroys, etc. should be dismantled and removed from the site.

6.5.1 Site Restoration

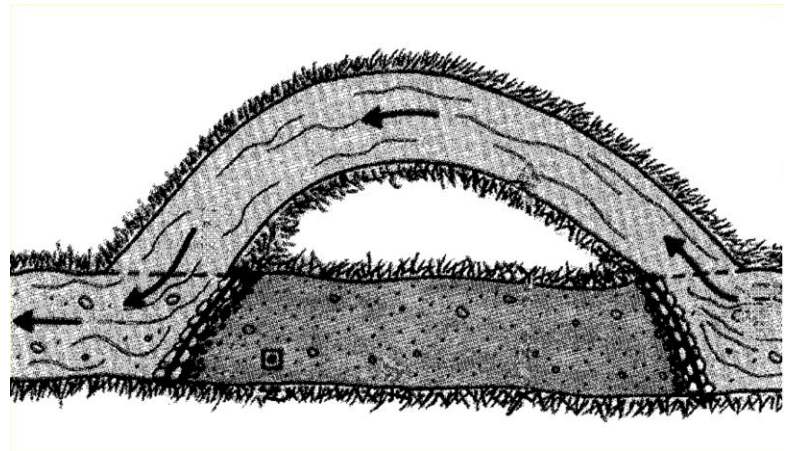
In far as possible fording sites should be returned to their previous condition. Low bank sections should be reconstructed and stabilized through placement of rip-rap and revegetation. See *Chapter 11, "Restoration and Stabilization"*.

6.5.2 Ensure Fording Site is Left Inaccessible

Further to the removal of fording works, measures should be taken to ensure the site is not left readily accessible to illegal fording. Such measures should include cross ditching the access road and placement of large boulders across the road.



Chapter 7: Environmental Guidelines for Diversions, New Channels, Major Alterations



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
St. John's, NL, Canada
A1B 4J6**

Chapter 7

Environmental Guidelines For

DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

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7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

7.1 General

The need for new channels, diversions, and major watercourse alterations often arises from land development such as urban, residential, industrial and commercial land use. In areas where such developments are proposed, new channels may be required to accommodate increased volumes of flow from developed areas, to lower the water table, to accommodate drainage and storm water systems, and to maximize land use. In many instances the restoration of existing watercourses can accommodate the needs of storm water management in developing areas.

Many other needs arise where major watercourse alterations are required. Watercourse diversions or new channels are sometimes required to temporarily reroute flow so that work in the original channel may be carried out in the dry. New channels may be constructed adjacent to existing watercourses to act as overflow channels to safely contain high flows and help prevent erosion or overtopping in the original channel. New channels are sometimes constructed to provide controlled conditions for agriculture and fish enhancement strategies. Hydroelectric projects often require diversions and new channels.

Extensive manipulation of natural watercourses can cause very serious and costly problems due to unforeseen circumstances even if carried out properly. In many instances alternatives to diversions can accomplish the same objective, avoiding major disruption of natural channels. The provision of undeveloped buffer strips on watercourses, overflow channels, and storm water detention facilities, can provide beneficial, convenient, low cost and environmentally satisfactory results, especially in urban areas. For these reasons proposed alterations to watercourses should be properly justified.

It has been demonstrated in the past that inappropriate and shortsighted planning often results in improper and sometimes unnecessary alterations to natural watercourses. This has been displayed most noticeably in areas where extensive "channelization" has resulted in the total removal of the stream side vegetation and natural channel bed and bank material. Serious long term problems in bank and bed erosion, downstream deposition and costly maintenance are but a few of the problems associated with such work. Such watercourses are virtually lost as a natural resource and are unsightly. When properly protected and maintained watercourses in both rural and urban settings are a valuable resource and an amenity in providing storm water control, and attractive and useful space for leisure or recreational activity

7.1.1 Regulations and Regulatory Bodies

Diversions and major watercourse alterations are regulated under provincial legislation. Federal and municipal statutes and regulations also apply in most situations.

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The Province has the mandate to protect all water resources from potential impact such as pollution, changes to domestic, municipal or industrial water supplies, flooding, aesthetic damages, changes in the flow regime, impact to wildlife, or any other alteration. Prior written approval must be obtained from the Department for diversions and watercourse alterations because of the potential to adversely affect water resources or the environment in general. In addition to this, the Department of Fisheries and Oceans retains direct management of fisheries and, accordingly, their regulations apply, but only if fish habitat is affected; and the Canadian Coast Guard requires approval of all construction in navigable waters under the *Navigable Waters Protection Act*.

A certificate of environmental approval for watercourse alterations includes terms and conditions which are binding on the proponent and any persons working for the proponent. An application for approval must be completed by the proponent or the proponent's agent or consultant and submitted to the Department.

7.2 Planning

7.2.1 Alternatives to Watercourse Alterations

Before a decision is made by a proponent to seek approval for any alteration of a watercourse, other possible alternatives should be examined which would mitigate environmental impact and maintain the features of the natural watercourse. Existing bodies of water within a proposed development area should be included in the overall development concept and adequate protection provided.

Flood protection may be provided on watercourses without substantially altering existing channels. The preferred approach is the construction of elevated banks or levees set well back from the existing channel which would provide an outer channel or flood plain to safely hold and convey flood water during times of very high flow conditions.

7.2.2 Ensure proper Channels are Provided for All Flow

A watercourse should not be diverted into an undefined channel. The flow must be diverted into a properly designed and constructed channel which has been adequately stabilized. Diverted streams not confined within a proper channel can cause serious erosion and siltation downstream.

7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

7.2.3 Maintain Watercourse Through Existing Property

The relocation of watercourses outside existing property boundaries to provide more easily developed land, accommodate development of property, or other such purposes, is not considered a proper environmental approach. Watercourses passing through a property must be maintained through that property and not rerouted so as to cause any adverse effects on adjacent properties.

7.3 Design of New Channels

7.3.1 General

It is important that new channels be properly designed according to established engineering principles. The hydrologic and hydraulic design parameters must be based on the physical geographic features of that particular drainage basin. The climatic conditions, geology and drainage basin features will determine such factors as quantity of flow, peak water levels, discharge patterns, ice formation, etc. These factors will then determine what specific channel dimensions and features will be required to provide a stable channel which can safely accommodate predicted flow conditions from that drainage area. The completed channel must also adequately address aesthetic and ecological concerns in reinstating fish habitat, vegetation, and features which blend attractively with the surroundings.

Where a simple diversion is proposed which involves the rerouting of a section of a watercourse, extensive hydrologic design may not be necessary. In such cases, the hydraulic design must at least ensure that capacity equivalent to or greater than the capacity of the original channel is provided.

Tributaries that feed into the original channel must be made to tie into the new channel. The same design and construction procedures used for the diversion must also be used for altering these tributaries.

7.3.2 Capacity of New Channels (Hydrologic Design Criteria)

The term "return period" is used to indicate the probability that a flood of a certain magnitude will occur. For example a 100 year return period flood is a flood whose flow would be exceeded on average once in 100 years. The return period for a diversion is often determined in conjunction with other related works that are being undertaken. A diversion as part of a dam construction, for instance, must be designed to the same return period as the dam to be able to handle the design outflow from the dam. If there are no significant works associated with the diversion, the designer should use his discretion in determining the appropriate return period. A 100 year return

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period should be used as the hydrologic design criteria of a diversion unless there is a valid reason for using a lesser return period.

In general, this hydrologic design criteria means that the channel must be able to safely convey the flood flow without overtopping. The selected return period must take into account possible damages to adjacent properties and environmental consequences of overtopping of the channel. An economic analysis or cost-benefit analysis should be considered in determining the most economical design of diversions.

New channels should provide adequate capacity to safely discharge the design flow. In determining the channel capacity the drainage basin should be examined in regard to land use zoning and plans for future development of land within the basin. Adequate capacity should be provided to safely accommodate future flow conditions, as land development often results in increased volumes of storm water and higher stage of flow within natural or existing channels.

7.3.3 Specified Channel Dimensions

New channels should be designed and built to predetermined dimensions which specify the following:

- Bottom width
- Depth of channel
- Bank slope
- Flow area
- Bed slope
- Freeboard

A new channel need not be uniform throughout its length. In fact it is desirable to recreate natural channel variabilities, if possible. The performance of a channel can be determined using Manning's Equation if the channel is uniform. Channels with variable dimensions should be modelled using an appropriate computer model such as HEC-2 or HEC-RAS.

7.3.4 Specified Channel Features

New channels should be designed and constructed with specific features that address hydraulic, aesthetic considerations, and where applicable, fish habitat requirements. These may include but are not limited to the following:

- channel banks and bed with a compacted substratum
- lower channel banks stabilized with protective rock

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- upper banks stabilized and revegetated with topsoil, seeding or sodding and shrubs or trees
- channel bottom of clean coarse gravel
- in-stream rock placement
- pools, falls or riffles, meanders, etc.

7.3.5 Flow Velocity in New Channels

New channels should provide flow velocities which are similar to those that occurred in the original channel. High flow velocity contributes to sediment transport and erosion. If the new channel reduces the velocity, sedimentation will occur and eventually the new channel may become blocked. Alternatively, where low velocities occur in the natural channel, the new channel may be designed to provide higher velocities to reduce the probability of flooding.

7.3.6 Freeboard Required

An adequate freeboard must be provided between the design high water level and the top of the embankments to prevent overtopping. The amount of freeboard to be provided is developed with consideration of the design flow volume, return period, future flow conditions in the channel, and the potential impact of an overtopping on surrounding properties and lands.

7.3.7 Channel Embankment Slope

To ensure adequate stability and prevent slumping of bank materials, the channel embankments should be no steeper than two horizontal to one vertical. Where fine grained or erodible soils are present, bank slopes should not exceed three horizontal to one vertical.

7.3.8 Emulate Existing Flow and Channel Conditions

Major channel alterations may disrupt the natural system regime. The effect of these changes may vary from negligible to significant. The time/effect relationship depends on the magnitude, duration and frequency of floods, stream morphology, and the nature or extent of the alteration. When dealing with channel modifications, the preferred procedure is:

- establish the nature of the present regime (slope, section, meander pattern, stage-discharge relationship)
- determine thresholds for changes in the various regime parameters
- duplicate the existing regime, where possible, or keep within the established tolerances for change, where duplication is not practical or possible.

In short, the discharge and velocity at either end of the diversion should be the same as that of the old channel at the same locations.

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7.3.9 Channel Length and Storage Capacity

Channel realignment or diversion should result in no net loss of channel storage capacity or channel length. The new alignment or new channel should provide equivalent or greater storage capacity and channel length, as existed in the original channel. "Cut off" channels or straight line diversions have a shorter length than the original channel resulting in loss of storage capacity and increased flow velocities as well as larger volumes of flow in downstream areas. This can result in destabilization of banks or overtopping and flooding in downstream areas (See **Figure 7.1**).

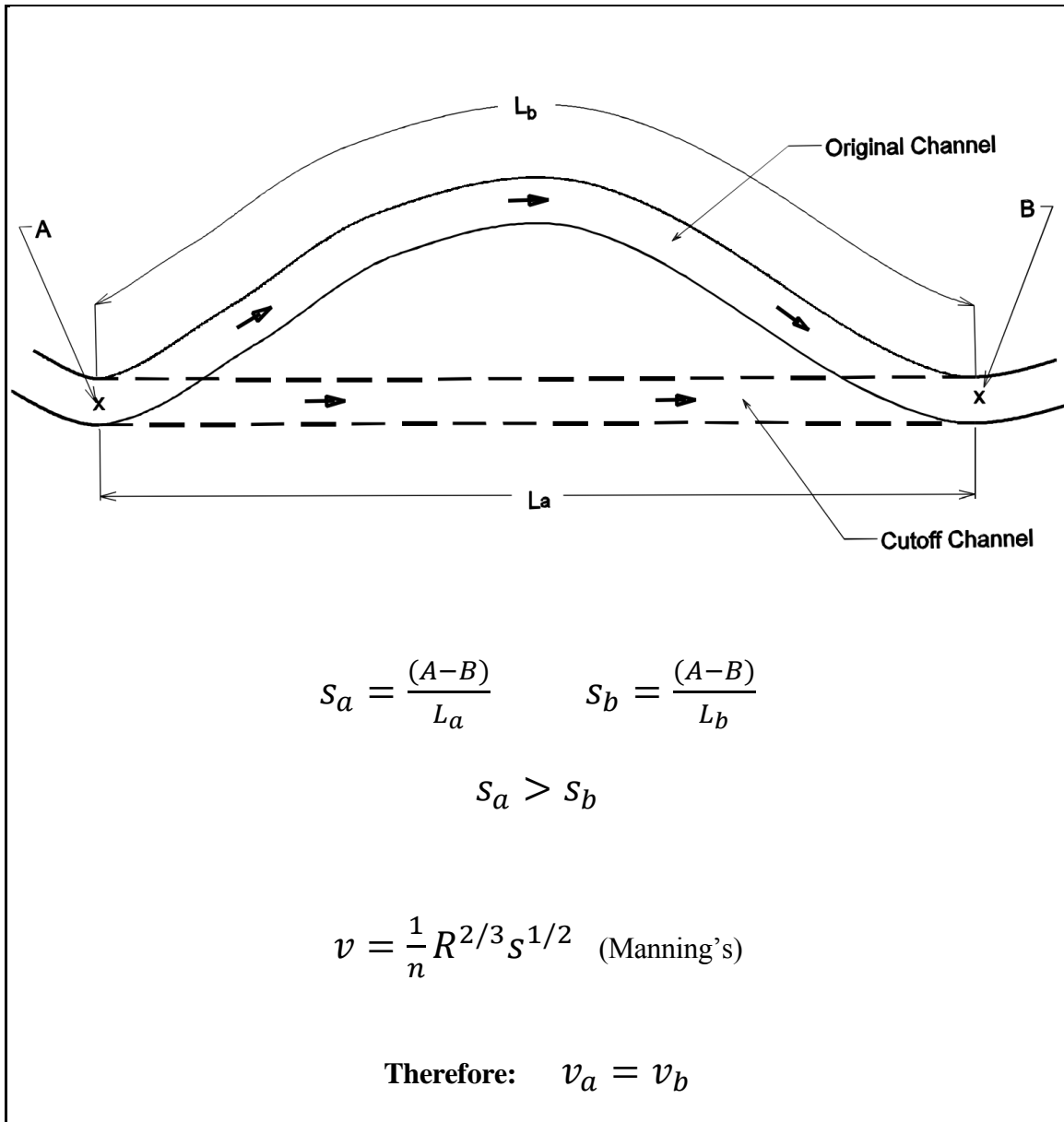


Figure 7.1 Cutoff channels cause increase in velocity and downstream problems.

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7.3.10 Channel Gradient

Stream realignment or diversions, and especially cut off channels always increase the channel gradient. This may induce channel responses which can create problems upstream and downstream of the project. A cut off channel usually results in abrupt changes in the channel slope which can cause erosion and degradation of the upstream channel section and aggradation downstream. This increase in gradient will also tend to increase the flow velocity, further contributing to the problems of degradation and aggradation.

7.3.11 Meandering Channel

New channels should be designed with a meandering pattern which would simulate or reinstate the original channel as opposed to a straight channel. This provides a more beneficial flow regime of convergence and divergence which more closely emulates natural watercourses, facilitates the development of pools and riffles and increases aesthetic quality.

7.4 Erosion Control, Stabilization, and Protective Works

New or altered channels usually require appropriate erosion control works to ensure that adequate stability of the channel is maintained.

Channels can be affected by erosion in a number of ways which can cause serious and costly damage to property. Channel bed erosion or "degradation", the undercutting of the toe of channel embankments, or the erosion of the upper portion of channel embankments are common forms of erosion in watercourses. The erosive process, once started, will progress rapidly.

Properly designed and constructed channels which are engineered to resist erosion are necessary, coupled with frequent inspection for early identification of potential problems so that appropriate remedial measures can be taken. The causative factors of an erosive process are usually complex and require detailed examination for effective solutions. "Quick and easy" solutions to such problems are often ineffective or of short duration.

A number of design features and stabilization or erosion control structures are used to ensure channel stability. Stabilization and erosion control in channels should be examined and addressed on a site specific basis.

7.4.1 Low, Non-Erosive Flow Velocities

An important factor to consider in planning a new channel in regard to concern over erosion is providing a low flow velocity which is not capable

7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

of eroding the channel bed and bank material. Coarse gravel and cobbles can withstand moderate velocities but exposed fine or light materials require lower velocities to ensure stability.

7.4.2 Channel Linings

New or man-made channels should be designed and constructed with appropriate non-erosive material. In most cases the use of a coarse gravel over a well compacted substratum will provide an adequate channel bed. For steeper channel grades coarser rock may be used which will resist erosion and provide greater channel roughness to reduce flow velocity. The use of concrete, asphalt, gabions, or similar materials for lining channels is not preferred. Such materials usually provide a flow regime inconsistent with that of the natural channel, result in maintenance problems and loss of the ecological amenity of flora and fauna, and are aesthetically inferior.

7.4.3 Channel Banks at Drainage Ditches

Where drainage ditches or streams enter a channel, adequate erosion protection is required. Low approach grades in the ditches or streams are preferred. In-stream rock placement or protective rock may be required to prevent erosion of bank areas where steeper approach grades are present.

7.4.4 Surface Runoff From Adjacent Areas

Where extensive surface runoff is likely to enter the channel, the runoff should be confined and allowed to enter the channel through properly protected drainage ditches. Other means such as rip rapped bank sections or half-culvert sections can be used to prevent erosion or slumping of the channel embankment.

7.4.5 Protective Rock at Toe of Channel Embankments

Protective rock should be installed at the toe of channel embankments to prevent undercutting of the embankments and erosion due to rapid or high flows. The size of rock used will be dependent upon the velocity and direction of flow in relation to the bank, the flow stage, and volumes of flow anticipated in the watercourse. The size of rock used will vary from "one-man-stones" to armour stone.

7.4.6 Armour Stone

Where the potential exists for bank erosion, particularly where flow is directed toward an embankment, velocity and stage are high, and erodible bank material is present, large rocks should be installed which will safely resist erosion. These rocks should be set into the bed and bank material so as to resist undermining. The rocks should also be leaned into the bank at an inclination of at least 1/6 from the vertical axis to ensure stability.

7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

7.4.7 Gabions

Where gabions are used for stabilization of channel embankments the structures should be installed according to the manufacturer's specifications. The structures should be set on a solid foundation, adequately anchored and leaned into the embankment at an inclination of at least one horizontal to six vertical, to ensure stability. The structures should be surfaced with soil and revegetated.

7.4.8 Deep-Rooted Plants

Deep-rooted type plants such as trees and shrubs should be planted along channel embankments to provide stability for the channel, shade for water temperature control, ecological value, and aesthetic value in creating an attractive watercourse. Willow and alder are fast growing plants, which develop substantial root systems, helping to prevent slumping of embankments. Alder is also a nitrogen fixing plant which makes it a good starter shrub for other plant succession. See *Chapter 11, "Restoration and Stabilization"*.

7.4.9 Seeding, Hydro-Seeding and Sodding

The upper section of channel embankments should be stabilized with fine rooted plants such as grasses and clovers to bind the topsoil and prevent surface rutting and deposition in the watercourse. Details on the application and use of seeding, hydro-seeding, and sodding are provided in *Chapter 11, "Restoration and Stabilization"*.

7.4.10 Rock Filled Timber Cribs

The use of rock-filled timber cribs or timber retaining walls for channel bank stabilization is not recommended as these structures contribute to watercourse siltation and deposition, and do not provide long term stability.

7.5 Construction Procedures

The construction of new channels, diversions and major alterations to bodies of water has the potential to cause environmental damage and create serious problems in siltation, pollution, erosion and deposition. Many of these problems occur during the construction phase of the work and are often the result of inappropriate construction procedures. These problems can be mitigated or prevented by following preferred construction procedures and techniques. Further detailed information on construction practices is presented in *Chapter 10, "General Construction Practices"*.

7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

7.5.1 Heavy Equipment

The use of heavy equipment in streams or bodies of water is generally not permitted. The operation of heavy equipment should be confined to dry, stable areas.

7.5.2 Excavate in the Dry from the Downstream End

New channels should be excavated in the dry, beginning at the downstream end and working in the upstream direction to the point of diversion.

7.5.3 Maintain Upstream and Downstream Cofferdams

Upstream and downstream cofferdams should be maintained during construction to prevent flow from entering the new channel under construction and to prevent silted water from entering the watercourse downstream.

7.5.4 Prevent Water from Entering the Channel Under Construction

Small drainage courses and surface runoff should be intercepted and diverted around the construction area by such means as pumping or temporary culverting, to allow construction to take place in the dry.

7.5.5 Control of Stream Flow for Culvert Placement

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. Effluent discharged into receiving waters must comply with environmental regulations. Further information on reducing the amount of silted water generated by construction operations and methods for treatment are contained in *Chapter 10, "General Construction Practices"*.

7.5.6 Divert Flow After All Work is Complete

Flow should be diverted into the new channel only after all excavation, lining, and bank stabilization work has been completed. Flow should be introduced into the new channel gradually and the channel should be monitored visually for any indications of failure, excessive siltation or other problems.

Care should be taken when diverting flow from the old channel that any fish that are stranded be relocated to the new channel.

7.5.7 Closure of Old Channel

Where flow is completely and permanently diverted from an old channel to a new channel, the old channel should be completely closed to all flow of water. The fill material or structure diverting flows into the new channel should be adequately constructed and protected to prevent erosion or

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washout and an adequate freeboard be provided to prevent overtopping of the structure.

The old channel should be backfilled with good quality fill, compacted and provided with a vegetative cover to prevent erosion.

7.6 Inspection and Maintenance

7.6.1 Frequent Inspections

Diversions, new channels and reconstructed channels require frequent inspection to ensure they are performing satisfactorily. Subsequent to visual monitoring of the initial introduction of flow into the channel, frequent spot checks should be carried out to ensure that the stability of the channel bed and bank is such that erosion is prevented.

7.6.2 Annual Inspections

Annual inspections should be carried out after the spring runoff or after the major peak flow in the channel during that year, to determine:

- if the channel is functioning properly;
- if erosion is being adequately prevented in all areas; and
- where maintenance may be required.

7.6.3 Comprehensive Inspections to Verify Design Parameters

A comprehensive inspection should be carried out during the first major high flow event to determine if flow characteristics are according to design, with particular regard to flow velocity, stage, flow direction, etc.

7.6.4 Regular Maintenance

Regular maintenance such as removal of debris in the channel should be carried out to ensure there is no flow blockage or constriction which could cause erosion or washout. Debris removal should be carried out by hand to prevent destabilization of the channel.

7.6.5 Area Vulnerable to Erosion

Any bank sections which have become exposed and appear vulnerable to erosion should be immediately protected in an appropriate manner so as to prevent or arrest the erosive process before further damage to the channel can occur.

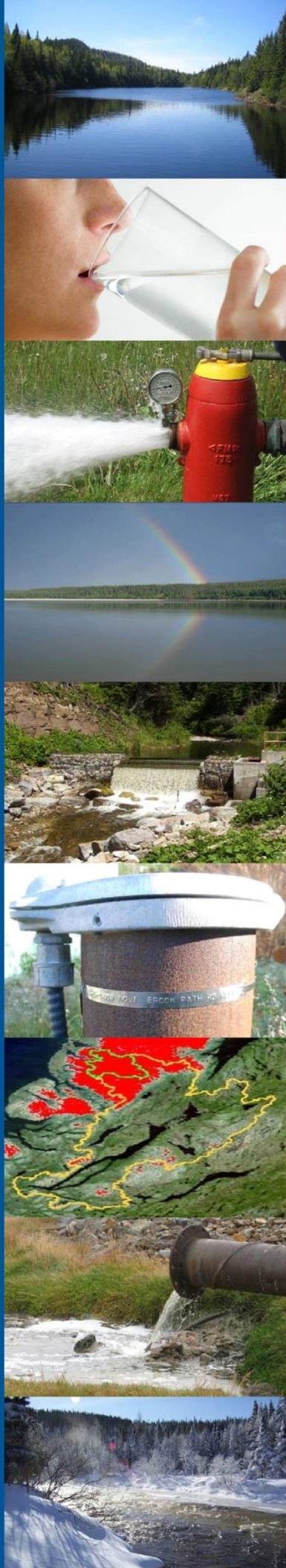
Chapter 8: Environmental Guidelines for Construction and Maintenance of Wharves, Breakwaters, Slipways, and Boathouses



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
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Chapter 8

Environmental Guidelines For

**CONSTRUCTION AND MAINTENANCE OF WHARVES, BREAKWATERS,
SLIPWAYS, AND BOATHOUSES**

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

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8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

8.1 General

Wharves, breakwaters, slipways and boathouses are all marine structures used for various recreational and commercial purposes. Wharves (docks and piers) are structures located on the shore and can be used for swimming, fishing or for securing boats; breakwaters protect the shore line from wave action and coastal erosion; slipways are ramps that aid in moving boats in and out of the water; and boathouses are built along the shoreline to store boats or other related items.

When it comes to these structures, the main environmental consideration in their construction and design is that they do not affect the water quality; cause loss to fish or other wildlife habitat; adversely affect the environment or impede the passage of fish and ice; movement of water and waves; or cause erosion and sedimentation of shorelines or banks.

These guidelines offer the reader an understanding of important environmental and construction considerations when undertaking the altering of a body of water with a structure such as a wharf/dock, breakwater, slipway or boathouse.

8.1.1 Regulations and Regulatory Bodies

Permits are required for any works in or adjacent to a body of water. As of January 1, 2011, a permit is no longer required under the Act for the construction and maintenance of wharves, breakwaters, slipways and boathouses as long as the work is completed in accordance with these guidelines and the work is outside of a Protected Water Supply Area (PWSA). A permit will be required for any dredging work and infilling of a body of water associated with the construction or installation of these structures.

The proponent may require approvals from other agencies prior to constructing a wharf, breakwater, slipway or boathouse. Approvals may be required from the following:

- The Municipality
 - For projects within municipal boundaries
- Department of Environment and Conservation
 - Crown Lands Administration Division - Lands Act
 - Water Resources Management Division - for work in Protected Water Supply Areas
 - Environmental Assessment Division - Environmental Protection Act

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

- Department of Fisheries & Oceans, Habitat Management Division
 - Fish Habitat (Fisheries Act)
 - Species at Risk Act
- Canadian Coast Guard
 - Construction in Navigable Waters (wharves, dredging etc.)

8.2 Guidelines

8.2.1 Wharf/Dock

There are various types of wharf or dock structures, such as:

- Floating
- Pipe/Pile
- Cribbed
- Concrete Piers; and,
- Cantilever or suspension

Of these structures, cantilevered docks, docks supported on posts, pipes or piles, and floating docks such as seen in **Figure 8.1** are least likely to have an adverse environmental effect. The pushing or placement of materials into the water and placement of decking on top is not considered a wharf. Material used for ballast should be cribbed and armor stone placed around cribbing, where required to prevent erosion.



Figure 8.1 A wooden floating dock in a small harbour

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

8.2.2 Breakwater

Breakwaters are structures composed of various rock or concrete material placed in the water to protect coastal erosion. They can be of various shapes and sizes but should be professionally engineered for maximum efficiency, longevity and environmental consideration. The most common are rubble mound breakwaters. **Figure 8.2** shows a breakwater constructed from wood in order to prevent coastal erosion as well as protect boats docked in a harbor from large waves.



Figure 8.2 A wooden breakwater protects boats docked in a harbour

8.2.3 Slipway/Boat Launch

Construction of a boat launch ramp / slipway should be done in a manner that minimizes the amount of excavation required hence reducing the risk of sediment entering the watercourse. A boat launch or slipway may be constructed with untreated wood, clean gravel/stone or concrete and should be stabilized. All material used should be clean, good quality material, free of metals, organics or other chemicals that may be harmful to receiving waters.

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

8.3 Maintenance and Removal

8.3.1 General Maintenance

General maintenance work should be carried out as required from time to time. Grouting or resurfacing of structural components as well as the removal of debris which may become caught at piers or locations upstream of marine structure will extend its useful life and minimize the risk of structural failure.

Periodic maintenance such as painting, resurfacing, clearing of debris, or minor repairs, must be carried out without causing any physical disruption of any watercourse. Care must be taken to prevent spillage of pollutants into the water.

The owners of structures are responsible for any environmental damage resulting from dislodgement caused by the wind, wave, ice action, or structural failure.

8.3.2 Removal

These guidelines should be followed during the removal of these structures. As with their construction and installation, care should be taken to prevent any adverse environmental effects on the surrounding water body.

8.3.3 Site Restoration

Any areas adversely affected by this project must be restored to a state that resembles local natural conditions. Further remedial measures to mitigate environmental impacts on water resources can and will be specified, if considered necessary in the opinion of the Department.

The bed, banks and floodplains of watercourses, or other vulnerable areas affected by this project, must be adequately protected from erosion by seeding, sodding or placing of rip-rap.

All waste materials resulting from this project must be disposed of at a site approved by the regional Government Service Center of the Department of Government Services. The Department of Government Services may require samples to be submitted for testing and analysis.

8.4 Preconstruction Preparation

All work must take place within the proponent's legal boundaries or with the approval of the land owner. The constructed work must comply with all other terms and conditions provided in the Crown Lands grant, lease or license for occupancy.

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

Suitable booms must be deployed around construction sites to contain any floating debris that might otherwise be carried away. All booms must be properly maintained and remain in place until all work is completed.

Sediment and erosion control measures must be installed before starting work. All control measures must be inspected regularly and any necessary repairs made if damage is discovered.

8.4.1 Scheduling

Proper scheduling of work is an important consideration in the implementation stage of an undertaking and is important from the standpoint of fish habitat protection and the environment. It can also be economically advantageous as well.

The Department recommends that construction near a body of water take place:

- During low flow (easier to restore bank vegetation and sediments will carry slower and settle out quicker); and
- At periods of low rainfall (reduces the chance of erosion and overland runoff).

These conditions generally would occur between June 1st and October 30th. The Department of Fisheries and Oceans (DFO) should be contacted to determine any restrictions to the construction season with regards to protection of fish and fish habitat.

8.5 Construction Practices/Procedures

All operations must be carried out in a manner that prevents damage to land, vegetation, and prevents the pollution of bodies of water. The construction of marine structures has the potential to cause environmental damage and create problems with respect to siltation, pollution, erosion and deposition. Many of these problems occur during the construction phase of work and are often the result of poorly executed construction procedures. These problems can be mitigated or prevented by following preferred construction procedures and techniques. Detailed information on construction practices can be found in *Chapter 10, "General Construction Practices"* (Located on the Department's website).

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

8.5.1 Equipment Operation

All vehicles and equipment working near a body of water must be clean and in good repair, free of mud and oil or other harmful substances that could impair water quality.

The use of heavy equipment in streams or bodies of water is not permitted. Heavy equipment must be kept outside the high-water mark of all drainage courses and bodies of water. The operation of all heavy equipment must be confined to dry, stable areas to reduce production of mud and silt laden water.

Suitable measures must be taken to prevent or reduce the generation of silted or muddied water from the operation of heavy equipment. High traffic areas must be kept well drained to prevent the formation of mud puddles which can contribute to siltation.

Water pumped from excavations for work areas, or any runoff or effluent directed out of work sites, must have silt and turbidity removed by settling ponds, filtration, or other suitable treatment before discharging to a body of water. Effluent discharged into receiving waters must comply with the environmental regulations.

8.5.2 Use of Concrete near a Body of Water

Where cast-in-place concrete is required, all fresh concrete must be kept from coming in contact with the watercourse until adequate curing is achieved. The formwork must be constructed with tight joints to prevent leakage and all necessary precautions taken to prevent spillage of concrete in or near a body of water. Dumping of concrete or washing of tools and equipment in any body of water is prohibited.

8.5.3 Use of Wood Preservatives

The use of creosote treated wood is strictly prohibited within 15 meters of all bodies of fresh water in the province and strongly discourage in other water bodies. Before using any creosote treated wood, the proponent should contact the Department's Water Resources Management Division.

Wood preservatives such as penta, CCA (chromated copper arsenate) or other such chemicals must not be applied to timber near a body of water. All treated wood or timber must be thoroughly dry before being brought to any work site and installed. Untreated wood is ideal from a water quality perspective and, if submerged completely underwater, will last indefinitely. Some wood, such as cedar, contain natural preservatives and is an excellent material for building wharves or piers.

8.0 WHARVES, BREAKWATERS, SLIPWAYS, AND BOATHOUSES

Please note, there are additional restrictions on use of treated wood in Protected Water Supply Areas and a permit is required for all work activities in these areas.

8.5.4 On-Site Use of Petroleum Products or Hazardous Substances

The proposed use of any facility and site must not involve any storage of pollutants such as chemicals, pesticides etc. The storage and handling of gasoline and any petroleum derivative must be carried out according to *The Storage and Handling of Gasoline and Associated Products Regulations*, 1982.

8.5.5 Other Materials

Recycled materials such as old metal, plastic drums or tires are not encouraged to be used as construction materials. They may contain substances which can affect water quality and be harmful to aquatic life.

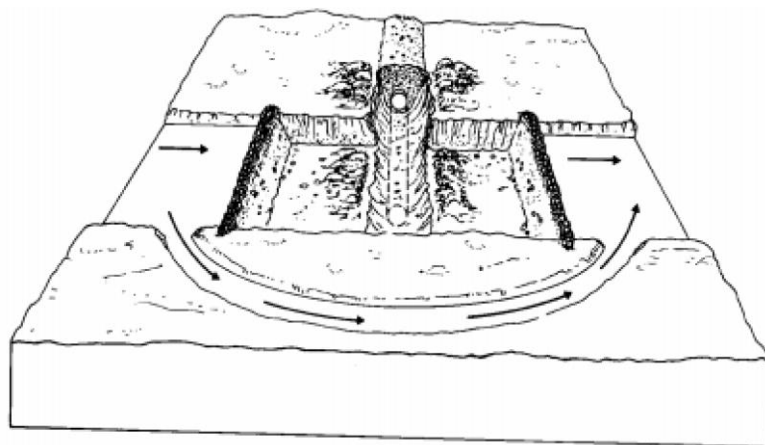
For floating docks, wharves or piers, non-recycled plastics provide excellent flotation, are inert and are durable in the water. Styrofoam also provides excellent flotation, is relatively stable in the water but may break apart. If it is used, it must be enclosed; it is a potential hazard to fish if mistaken for food.

Any fill or ballast material must be of good quality, free of fines or other substances including metals, organics or chemicals that may be harmful to the receiving waters.

8.5.6 Bank Disturbance

At all times, every necessary precaution should be taken to prevent the disturbance of channel banks, bank vegetation and land within the high water mark, flood zone or 15m environmental buffer of any body of water. A minimum 15 meter wide vegetated buffer zone must be maintained along the edge of the water body in order to provide bank stability and maintain local aesthetics.

Chapter 9: Environmental Guidelines for Pipe Crossings



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
St. John's, NL, Canada
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Chapter 9

Environmental Guidelines For

PIPE CROSSINGS

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

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9.1 General

Almost always, as land is developed for residential, commercial and industrial purposes, the need arises to provide water and sewer services across a watercourse or a body of water. Water and sewer services are, of necessity, buried and therefore, they must normally cross under the body of water. Where grades permit a choice, buried crossings are preferred over aerial crossings (i.e. via bridges) because they are subjected to less exposure, accidental damage or vandalism. Pipe crossings can include water pipe crossings, sanitary sewers, gas pipelines or other pipes but these guidelines are equally applicable to any conduit crossing under a watercourse (ie. electrical or communications cables).

Consideration of factors, such as the hydraulic and hydrologic characteristics of the stream, substrate material and stream bank characteristics, are important in the selection of a suitable site for pipeline crossings. The number of pipeline crossings, if given a choice, should be kept to a minimum during construction in order to reduce the risk of causing any adverse impacts. The potential for streambed scouring and bank erosion must be determined in order to provide the necessary depth and length of burial required to prevent exposure. Pipeline exposure, as well as subsequent scour downstream, could create an obstruction to the upstream movement of fish. In order to provide adequate channel stability, it is necessary to account for channel migration, high velocity flows during peak runoff, ice jamming and scour, and any future stream alterations which may be anticipated during the design stages of a pipeline crossing.

This chapter is intended to provide helpful information for the installation of pipe crossings to ensure that streambed stability is maintained under natural conditions and that construction does not cause unnecessary environmental damage.

9.1.1 Regulations and Regulatory Bodies

Watercourse crossings are regulated under provincial legislation. Federal and municipal statutes and regulations also apply in most situations.

The Province has the mandate to protect all water resources from potential impact such as pollution, changes to domestic, municipal or industrial water supplies, flooding, aesthetic damages, changes in the flow regime, impact to wildlife, or any other alteration. Prior written approval must be obtained from the Department for watercourse crossings because of the potential to adversely affect water resources or the environment in general. In addition to this, the Department of Fisheries and Oceans retains direct management of fisheries and, accordingly, their regulations apply to watercourse crossings, but only if fish habitat is affected; and the Canadian Coast Guard requires approval of all construction in navigable waters under the *Navigable Waters Protection Act*.

9.0 PIPE CROSSINGS

A certificate of environmental approval for a pipe crossing includes terms and conditions which are binding on the proponent and any persons working for the proponent. An application for approval must be completed by the proponent or the proponent's agent or consultant and submitted to the Department.

9.1.2 Other Applications of the Guidelines

Within these guidelines, the term pipe or pipeline can be substituted to accommodate any type of crossing under a body of water. Most commonly these include ductile iron, PVC and HDPE pipes which are used in water systems, storm and sanitary sewers and drainage applications. In addition, the guidelines also apply to gas and slurry pipelines, electrical conduits, fibre optic cables as well as other communication lines which must be buried under ground and subsequently under streams. Although each product may have a different set of manufacturer's specifications for installation, they all present similar potential for environmental damage to water resources.

The term "watercourse" is used in relation to stream alterations throughout this chapter but these guidelines may also pertain to any body of water in Newfoundland (beaches, marshes and bogs, rivers, lakes, etc.). Therefore, the following guidelines should be taken into consideration wherever an undertaking involves the placing of a pipeline or similar apparatus beneath the substrate of a waterbody.

9.2 Design Considerations

When installing a pipe crossing under a watercourse, the general contractor is responsible for the quality of work done at the site, but the contractor's work is subject to the design constraints of the system to be installed. The designer must ensure that safeguards can be implemented to provide protection of the body of water. The designer must also make the design as efficient and cost-effective as possible while adhering to environmental guidelines and habitat preservation procedures

9.2.1 Potential Low Scour Point

When designing a pipe crossing, one must consider the potential low scour point which is caused by shifting currents. It is generally necessary to maintain a level trench or specified grade for the full length of the crossing in unconsolidated substrates to prevent a pipe from being exposed due to lateral shifts in the low scour point (See **Figure 9.1**). If this is not compensated for in the design, the pipe may become exposed which will

greatly increase the risk of pipe failure and alteration of the natural substrate of the watercourse.



Figure 9.1 Pipeline crossing a stream with an active substrate

9.2.2 Ditch Plugs

During the excavation stage, a ditch plug should be left in place on both sides of the stream until the pipe is ready for installation. It is important to leave plugs in place until the last possible moment to ensure that little or no flow from the ditch can enter the stream and that no stream flow can enter the ditch (See **Figure 9.2**). All work should be carried out in the dry as much as possible to reduce pumping and minimize the need to treat water for removal of silt.

9.2.3 Buoyancy Control

If buoyancy control at a stream crossing proves to be inadequate, then the pipe will tend to float and have to be repaired. Buoyancy control weights are required at river crossings. Where pipe exposure is inevitable under design flow conditions, these weights must be adequately secured to prevent them from slipping off the pipe. Once the pipe has been backfilled, the soil will have a sufficient internal resistance to prevent movement of the weights.

9.0 PIPE CROSSINGS



Figure 9.2 Leaving a plug to isolate the trench from the main channel during excavation

9.2.4 Scheduling

The scheduling of work that deals with stream alterations is an important consideration in the implementation stage of an undertaking. Proper scheduling is important from the standpoint of environmental and fish habitat protection, and can be economically advantageous as well.

From the standpoint of the Department, the ideal time of year to construct a pipe crossing is when:

- the lowest possible flow rate occurs. This makes it easier to restore the streambank and there is less sediment generated; and when
- the seasonal rainfall period is at its driest because this reduces the chance of flash flooding.

These guidelines mean in practice that the best time to install pipe crossings is during the season lasting from June 1st to October 30th.

Although the Department of Fisheries and Oceans scheduling guidelines are governed by a different set of circumstances, their ideal construction season closely corresponds to that of the Department. The Department of Fisheries and Oceans generally states that the June 1st to September 30th construction season would not severely affect the spawning, incubation and hatching of fish in inland waters. (Note: This is a general guideline. These

9.0 PIPE CROSSINGS

times may vary from river to river and specific scheduling of work should be discussed with a Department of Fisheries and Oceans Regional Habitat Coordinator.)

The amount of time spent constructing a crossing can have an increasingly adverse effect on water quality. The longer the stream bed is disturbed and left exposed, the larger the amount of sediment that will be introduced into the watercourse and the further the sediment will be able to travel within the watercourse.

9.2.5 Site Location

With a given undertaking, there may be some flexibility regarding choice of a route. Every water crossing represents increased costs for construction, maintenance and environmental protection requirements. Therefore, whenever possible, one should minimize the number of water crossings and avoid sensitive wetland areas or routes immediately adjacent to watercourses.

When designing a tentative route that includes a pipe crossing, the final location should be:

- downstream from areas such as fish spawning sites or water use intakes
- upstream of natural fish barriers such as waterfalls
- where the stream is straight, unobstructed and well defined
- on an existing right-of-way, if one exists
- where stable geological and soil conditions are present
- where a minimum of scour, deposition or displacement of sediments are expected to occur at or near a crossing
- where it is possible to minimize the risk of damage from environmental hazards such as floods, landslides, etc.

It is highly unlikely that any one stream crossing will meet all of these criteria. The more criteria that can be met, the more efficient the installation will be and the less chance that problems will arise in the future.

9.0 PIPE CROSSINGS

9.3 Pipe Crossing Installation Practices

Pipe crossings can vary in size from a major trunk sewer with a diameter greater than one metre to an 18 millimetre diameter domestic water pipe. Regardless of size, there are a number of general procedures to follow which can limit the potential of causing sedimentation as a result of in-stream or near-stream activities. These vary depending on specific site conditions.

9.3.1 Site Preparation

Clearing and grubbing removes trees and shrubs from the banks of the stream to provide a right-of-way for the pipe crossing. It is important to maintain a minimum 15 metre undisturbed buffer along the approach on both sides of the stream until the pipe installation across the stream is ready to begin. Once the protective covering has been removed, the potential for sedimentation increases. The area to be cleared and grubbed must follow the proposed route of the pipe and the width of the disturbed area should be kept to a minimum.

Wherever possible, the site should be accessed from either side of the stream to reduce the need to have equipment to ford the stream.

9.3.2 Trench Excavation

Once clearing and grubbing has been completed, selective removal and stockpiling of topsoil from the buffer zone is required. All stockpiled material must be located further than 15 metres from the high water mark. The stockpiled topsoil must be reapplied to promote revegetation once the pipe crossing has been completed.

Occasionally, blasting is required in order to excavate the trench to the desired elevation and size. The section of the stream channel where blasting is to be carried out should be isolated by diverting or pumping flows around it. If poorly executed, blasting can be detrimental to fish by destroying their swim bladders.

The excavated trench must be carefully graded in order to evenly support the pipe along its entire length. In some cases, it may be necessary to over excavate the trench and backfill it with a granular material to achieve a proper bedding.

During trenching operations, it is important for the contractor to be extremely careful to prevent sedimentation by strictly adhering to the terms and conditions of the environmental approval.

9.3.3 Isolation of Work Area

The method used to cross a stream with a pipeline depends on size of the stream, channel hydraulics, cost effectiveness and timing of the project. It is important that the installation be carried out as quickly and efficiently as possible in order to minimize any disturbance to the streamflow, water quality and aquatic environment. A pipeline crossing may involve a diversion of flow around the trench by using pumps and/or cofferdams, fluming small streams over the trench by using culverts and, in some instances, it may be economically feasible to install the pipe by drilled or slip boring procedures. *Chapter 10, "General Construction Practices"*, contains additional information on procedures used to isolate a work area.

9.3.4 Pipe Installation Procedures

From a nearby stockpile, the quantity of pipe required to complete the pipe crossing is hauled in and placed in an end-to-end fashion adjacent to the trench. The sections of pipe are then joined by mechanical joints (ductile, iron, PVC, HDPE) or thermal fusing (HDPE only). Either of these types of construction will ensure that the crossing is both flexible and water tight. When it is necessary to provide a sag in the pipe, it should be located outside the limits of any possible channel meander.

Valves should be located at both ends of the water crossing so the section can be isolated for testing or repairs and to prevent them from flooding. The valve closest to the supply source should be in a manhole. Permanent taps should be made on each side of the valve to allow insertion of a small meter for testing to determine leakage and for sampling purposes.

9.3.5 Backfilling

During the backfilling operation, the stockpiled material is selectively placed in the trench. This prevents material capable of damaging the pipe from being placed against it. If the excavated material contains boulders, frozen soil, organic material or other materials which do not meet the required specifications, it may be necessary to replace it with granular material. The material must be able to withstand erosion and scouring and must not extend above the original grade of the channel.

To prevent possible damage or failure to a pipe crossing, resulting in severe pollution, it is required that a minimum cover of 0.6 metres of stable compact soil be provided. Where the pipe crossing is located in bedrock, a minimum cover of 0.3 metres is acceptable.

In areas where high groundwater occurs, pipe zone cutoff walls, or other means, are required to prevent drawdown of the water table due to groundwater flow through the porous pipe zone material.

9.0 PIPE CROSSINGS

9.3.6 Pressure Testing

As a final step to ensuring a water tight pipeline, pressure testing is done. The pipeline is pressurized (by pumping water into it) to a test pressure of 1.25 times the working pressure. The line is then left for at least two hours. If a leak is encountered through a loss of pressure, it is located and repaired and the line is retested.

9.4 Site Rehabilitation and Restoration

As with any stream alteration, it is necessary to carry out site rehabilitation in order to stabilize slopes, disturbed areas and other areas vulnerable to erosion, to provide revegetation and to ensure the site is left in a condition which is environmentally acceptable. *Chapter 10, "General Construction Practices"*, contains detailed information on site rehabilitation.

9.4.1 Erosion Control

Once the backfilling has been completed, some form of erosion control must be implemented. If not, the banks of the stream will quickly erode especially when there are higher flows later. This will introduce sediment into the watercourse and could ultimately alter the substrate of the watercourse.

One of the most effective methods of erosion control is to return the disturbed right-of-way to as close to its original condition as possible and then to seed or sod the affected area. Replacement of vegetation will only work however, if the vegetation can get proper root before higher flows occur. Other things that can be done to prevent erosion are rip-rapping the bank to one metre above the high water mark, installing diversion ditches, etc. (See **Figure 9.3**).

9.4.2 Fish Habitat Preservation

The installation of a pipe under a watercourse has the potential to impede or block fish migration and destroy fish population or fish habitat. These installations, if carried out improperly, can result in siltation and pollution which can kill fish or incubating eggs and ruin spawning locations.

The Fisheries Act contains sections which govern the alteration of fish habitat. Therefore, approval from Fisheries and Oceans Canada may be required in addition to approval from the provincial Department.



Figure 9.3 Erosion control on sloped approached to streams

9.5 Inspection and Maintenance

Once the initial construction and clean-up of a pipeline crossing is completed, the potential for environmental damage is not eliminated. Through incorrect construction procedures or inefficient design, unforeseen factors could cause damage to the pipe system or the crossing site itself. However, the effect of these problems can be minimized by simple periodic inspections, routine general maintenance and some remedial work, if necessary.

9.5.1 Periodic Inspection

Pipeline crossings require periodic inspections in order to determine:

- The effectiveness of the erosion control measures used to stabilize the streambed and stream banks
- Evidence of scouring around pipeline structure
- Evidence of lateral migration of the channel
- Signs of pipe movement caused by buoyancy or frost heave
- Signs of leakage in the pipe
- Changes in water quality
- Signs of channel constriction.

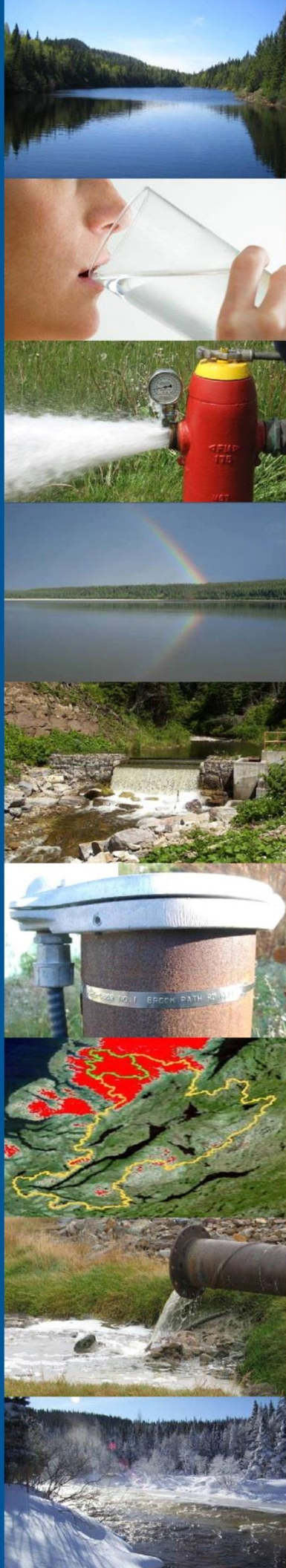
9.5.2 General Maintenance

General and minor maintenance work should be carried out from time to time. Minor flaws in a pipeline could be temporarily repaired during sensitive periods using a low impact procedure with more permanent repairs to be made during non-sensitive periods.

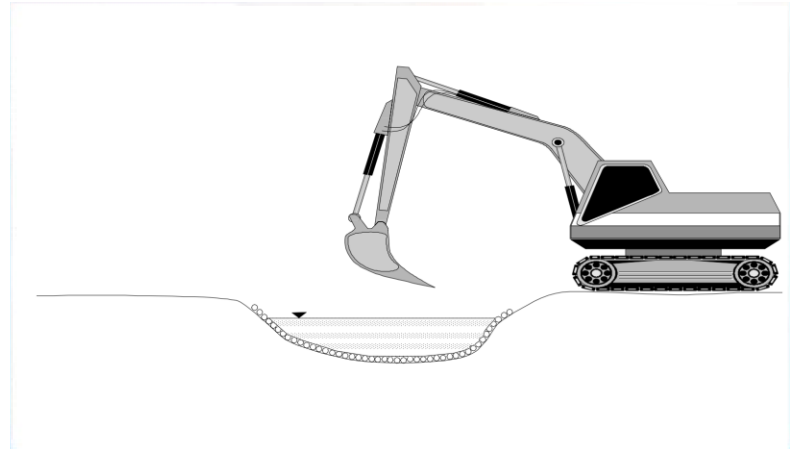
9.0 PIPE CROSSINGS

9.5.3 Remedial Work

Where serious problems are evident, such as streambed instability, pipe failure or systems malfunction, remedial measures may be required. Such problems are often the result of inadequate installation procedures or lack of erosion protection which should have been addressed in the design stage. If, however, erosion control or river training works are to be carried out subsequent to the development of such problems, a comprehensive investigation or evaluation of the problem should be conducted. A new environmental approval will be required to carry out remedial work to a pipeline.



Chapter 10: Environmental Guidelines for General Construction Practices



**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
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Chapter 10

Environmental Guidelines For

GENERAL CONSTRUCTION PRACTICES

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

10.0 GENERAL CONSTRUCTION PRACTICES

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10.0 GENERAL CONSTRUCTION PRACTICES

10.1 General

All too often construction sites are a significant source of pollution to natural waterways. Soil erosion from the site can result in stream degradation and turbidity miles downstream. Stream channels may become unstable because of higher rates of runoff from surrounding land stripped of vegetation. Toxic wastes from construction materials and equipment can impair water quality and thereby interfere with downstream uses. For these reasons, properly planned and implemented controls are essential during the construction period, if detrimental changes to the surrounding water bodies are to be minimized. Proper site preparation procedures are required to minimize sedimentation and eliminate the need for costly remedial actions.

Many serious construction problems arise because important drainage and water-related factors were overlooked or neglected in the location and planning phases of the project. Adequate soils, geologic and hydraulic studies will provide much guidance in solving erosion, drainage and landslide problems as well as being helpful in minimizing or avoiding these problems during construction. Risk of damage by siltation of ponds and reservoirs during construction often can be reduced by studying flood and precipitation records and proper scheduling of work.

Time of construction is important. A structure or embankment is usually most vulnerable to damage from heavy rain or floods when partially complete. The onset of winter or spring break-up may pose unique difficulties, thus the timing of proposed construction requires due consideration.

10.1.1 Regulations and Regulatory Bodies

Alterations to bodies of water and construction adjacent to bodies of water are regulated under provincial legislation. Federal and municipal statutes and regulations also apply in most situations.

The Province has the mandate to protect all water resources from potential impact such as pollution, changes to domestic, municipal or industrial water supplies, flooding, aesthetic damages, changes in the flow regime, impact to wildlife or any other alteration. Prior written approval must be obtained from the Department for alterations because of the potential to adversely affect water resources or the environment in general. In addition to this, the Department of Fisheries and Oceans retains direct management of fisheries and, accordingly, their regulations apply, but only if fish habitat is affected; and the Canadian Coast Guard requires approval of all construction in navigable waters under the *Navigable Waters Protection Act*.

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A certificate of environmental approval for alterations and construction adjacent to bodies of water includes terms and conditions which are binding on the proponent and any persons working for the proponent. An application for approval must be completed by the proponent or the proponent's agent or consultant and submitted to the Department.

10.2 Culvert Location and Shape

10.2.1 Environmental Reconnaissance of Site

Early in the planning stages, a joint engineering and environmental reconnaissance of the site should be conducted to locate and identify all bodies of water which may require special attention during construction. All small feeder streams or intermittent watercourses must also be included in the assessment.

Specific mitigative and protective measures to be taken at particular locations should be identified. Naturally, the specific measures to be taken depend on the activity and their potential impacts. An example of a well laid out construction site can be seen in **Figure 10.1**.

10.2.2 Scheduling

The scheduling of work that deals with stream alterations is an important consideration in the implementation stage of an undertaking. Proper scheduling is important from the standpoint of environmental and fish habitat protection, and can be economically advantageous as well.

From the standpoint of the Department, the ideal time of year for construction near a body of water would be during:

- low flow (makes it easier to restore stream bank and the sediment will carry slower and settle out quicker)
- the low rain fall period (reduces the chance of flash flooding).

These guidelines roughly translate to a season lasting from June 1st to October 30th.

The amount of time spent on construction can have an increasingly adverse effect on water quality. The longer the stream bed is disturbed and left exposed, the larger the amount of sediment that will be introduced into the watercourse and the further the sediment will be able to travel within the watercourse.

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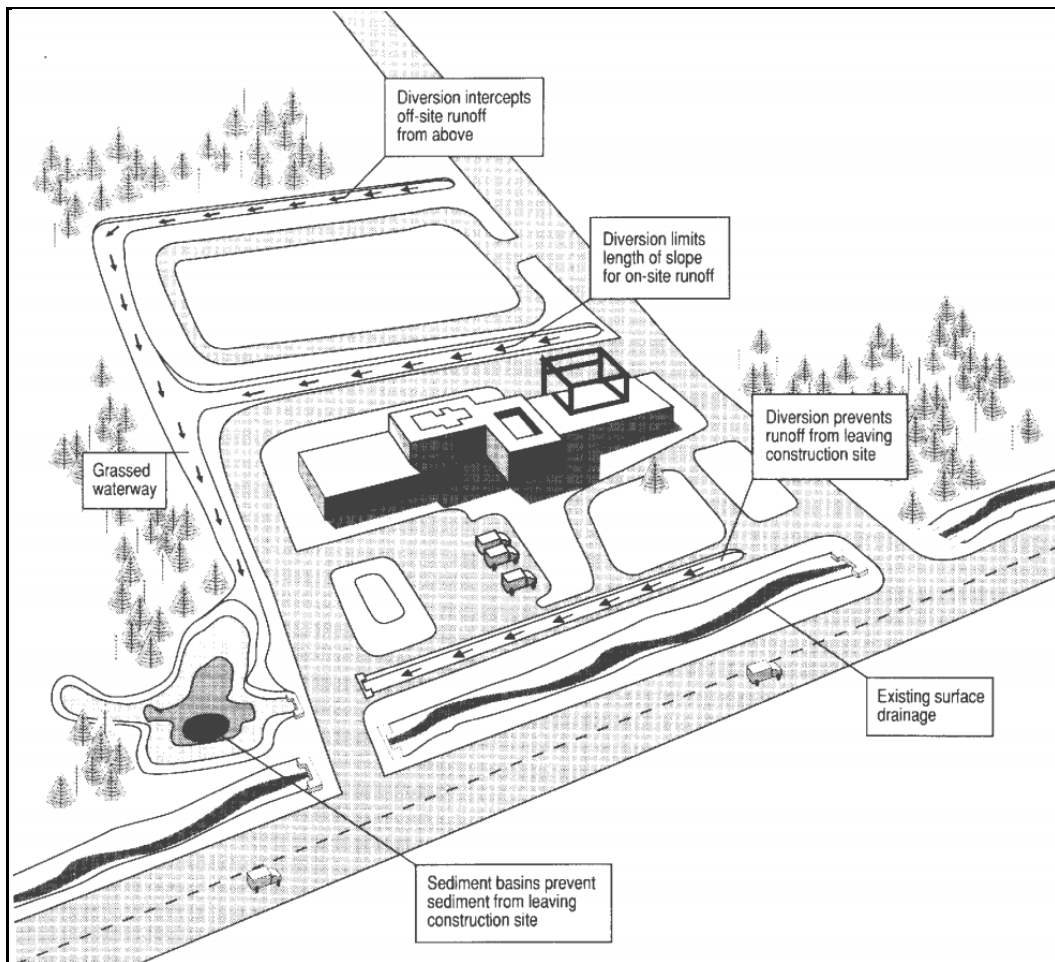


Figure 10.1 A Well Laid Out Construction Site

10.2.3 Construction Methodology

Prior to the operation of heavy equipment or deployment of labour forces at or near a body of water, the construction methodology and procedures to be used should be planned so as to minimize any impact of the project on the body of water and adjacent lands. This would include the preparation of clear instructions for the use of contractors and their equipment operators.

10.2.4 Conveyance of Regulatory Requirements

All important details or procedures which would be necessary to mitigate environmental impact or which are required by a municipal, provincial, or federal regulatory authorities must be clearly conveyed to site personnel and those actually carrying out the work.

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10.2.5 Site Access

Wherever possible, the site should be accessed via existing roads. Where no roads exist, fording of streams by vehicles other than one man ATV's should be limited to one trip in / one trip out. For further details on fording, refer to *Chapter 6, "Fording"*.

10.2.6 Site Layout

The construction site should be planned and "laid out" with prominent markers to clearly indicate designated areas such as:

- The outer boundary or limit of the project site or area to be cleared, stripped, grubbed or excavated.
- Spoil areas or areas where topsoil and other material may be stored for later use.
- Protected or no entry areas such as areas outside the designated site, buffer strips on bodies of water or on site features such as drainage ditches, culverts, settling basins, etc. which require protection.

10.3 Clearing and Grubbing

Before starting to clear and grub in preparation for construction, all environmental protection measures must be in place. To reduce the exposure of erodible soils, appropriate scheduling should be arranged so that grubbing, stripping and excavation will be quickly followed with the remainder of required construction work. All infilling, compaction, grading and surfacing must then be completed as soon as possible to stabilize and protect exposed soils

10.3.1 Salvage Useable Materials

Where extensive removal of tree cover is required, salvage of useful wood such as saw logs, pulp wood, and firewood should be carried out. Under no circumstances should wood or slash be dumped into or near a body of water.

All topsoil and/or organically rich soils which are stripped or removed, must be stored at or near the construction site and protected from erosion so that the material may be subsequently used to help revegetate disturbed areas.

If armour stone or rip-rap is required as part of the project, suitable rock which could be used for this purpose should be set aside for subsequent use.

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10.3.2 Equipment Operation

All vehicles and equipment working near a body of water must be clean and in good repair, free of mud and oil or other harmful substances.

Suitable measures must be taken to prevent or reduce the generation of silted or muddied water in the operation of heavy equipment. Heavily travelled areas must be kept well drained to prevent the formation of mud puddles which can contribute to siltation. Generous use of gravel or installation of roadside drainage culverts may be required.

Heavy equipment such as bulldozers, front end loaders, backhoes and cranes must be kept outside the high-water mark of all drainage courses and bodies of water. The operation of all heavy equipment must be confined to dry, stable areas to reduce the production of mud and silted water.

Fuels, chemicals or deleterious materials must not be stored near a body of water. No vehicles or equipment shall be serviced near a body of water.

10.3.3 Temporary Culverts or Bridges

Small streams or drainage courses which must be crossed frequently by heavy equipment should be provided with a temporary culvert or bridge at the proposed crossing location. *Chapter 3, "Watercourse Crossings", Chapter 4, "Bridges", Chapter 5, "Culverts", and Chapter 6, "Fording",* provide detailed information on stream crossings and the use of bridges and culverts.

10.3.4 Surface Water Diversion

Peripheral ditching should be provided to intercept surface water where such water would enter the site and then divert it around the area of construction. Keeping such water clean reduces the amount of silted water which will require treatment.

Separate peripheral ditching or a low basin should be provided along the lower boundary of the construction site to intercept and contain silted or muddied surface water from the site. Silt fences and/or straw or rock check dams (See **Figure 10.2**) must be used to slow the flow of water in the ditches, allowing the sediment to settle.

10.3.5 Dust Control

Measures must be taken to control dust that may impair the quality of an adjacent body of water. Water and wood chips are safe methods of controlling dust. Calcium chloride and oil based suppressants must not be used near a body of water.

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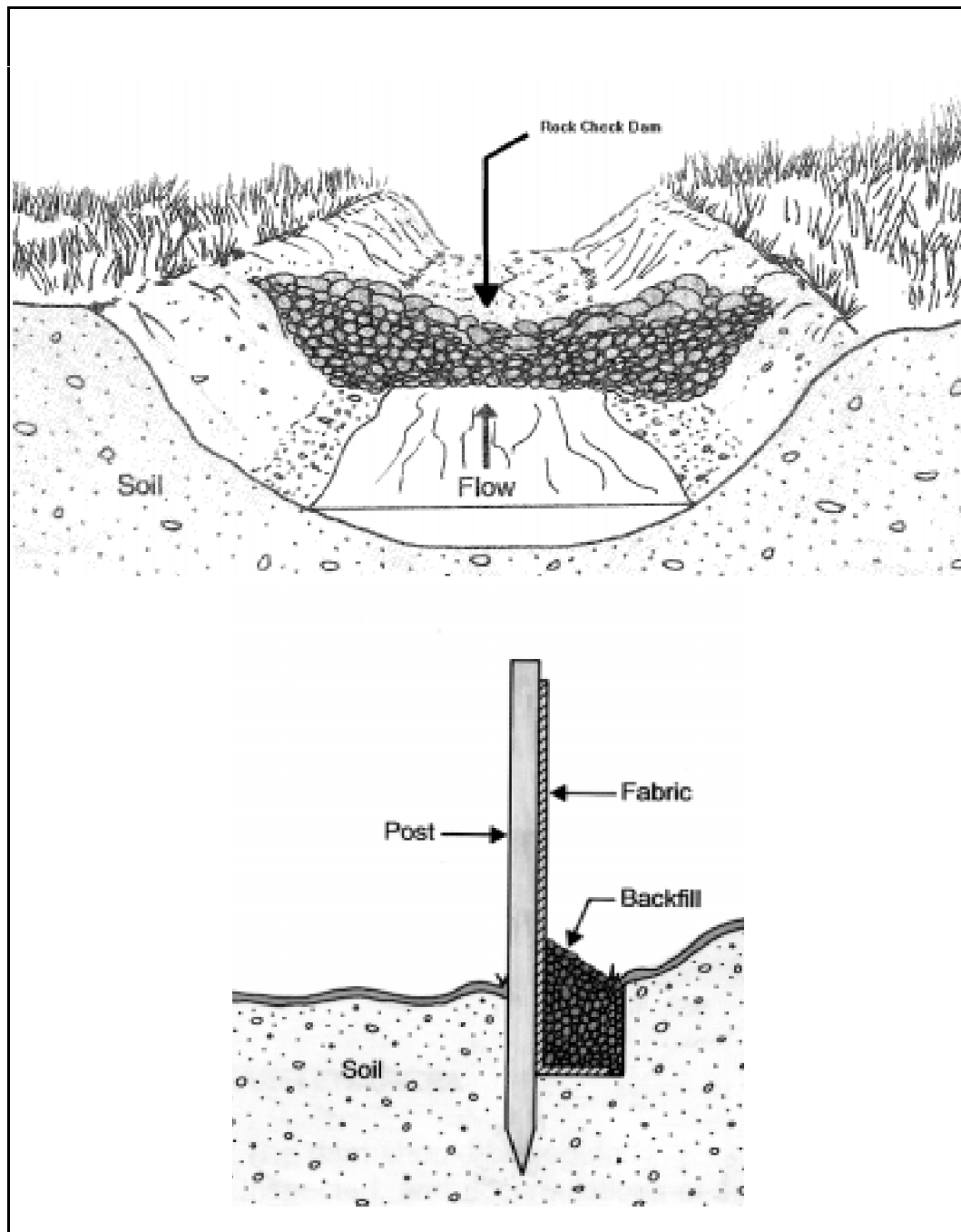


Figure 10.2 Rock Check Dam and Silt Fence Installations Reduce Flow Velocity Reducing Erosion and Allowing Silt to Settle

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10.3.6 Waste Material Disposal

All waste materials must be disposed of at a site approved by the Department.

Where slash and debris are burned, the location must be a sufficient distance from any body of water to prevent pollution by cinders or ash.

10.4 Working in the Dry

10.4.1 Use of Cofferdams

Where excavation or other extensive in-stream work is to be carried out, properly designed and constructed cofferdams must be used to separate the work area from the water so that work can take place in the dry, minimizing the generation of silt.

Cofferdams may be used to completely cut off flow through a section of a small stream or drainage course in order to isolate the construction area while the flow is diverted around the site by temporary culverting or pumping.

When a watercourse is too large to divert by pumping or temporarily culverting, part of the width of the stream may be blocked off to allow work to take place in the dry. Not more than one third of the width of a watercourse should be blocked at any time in order to ensure efficient remaining capacity in the channel to safely accommodate flow without causing excessive high velocity, erosion or overtopping of banks.

Cofferdams should be constructed of non-erodible material to prevent washout of the structure which may result in downstream deposition and siltation. Cofferdams must be constructed tightly to prevent or reduce the amount of seepage into the work area. This also reduces the amount of silted water and mud which would have to be pumped from the work area and be treated prior to release into bodies of water.

Sheet metal or wood panel cofferdams are preferred to cofferdam constructed of till or pit run material as they can provide a tighter structure and do not create problems of siltation and erosion. Sandbags are also a preferred method as they can be removed easily.

Upon completion of the instream work, the cofferdam structure must be removed from the channel carefully and completely, to prevent disturbance of the channel and downstream areas.

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10.4.2 Use of Pumps

Pumps may be used to divert very small streams or drainage courses around an area of construction to prevent the water from becoming silted by contacting disturbed areas and to maintain the site in a dry condition. Where pumps are used to divert flow, cofferdams must be maintained above and below the area of construction. The upper cofferdam should prevent any water from entering the construction area and should provide a sump area from which the water may be pumped. The lower cofferdam should prevent any silted water or mud in the construction area from draining directly into the watercourse as well as prevent clean water from entering the work area.

Pumps of adequate capacity must be maintained at all times, to safely accommodate the volumes of flow occurring in the stream. In the event of pump breakdown, back-up pumps must be immediately available or an alternate method to accommodate the flow around the construction area must be provided without causing siltation in downstream areas.

Pump intakes should be set just below the surface of the water in the sump area to avoid sucking up bottom sediments. This will prevent or reduce silt being transported to downstream areas. The discharge point should be located in an area of vegetation or an area with rock where the flow can be returned to the natural channel without causing erosion or picking up further sediment.

Silted water which is pumped to receiving waters must comply with environmental regulations, with particular regard to suspended solids. All necessary measures such as settling and/or filtering must be carried out to remove suspended solids from heavily silted water prior to release into receiving waters.

10.4.3 Temporary Diversion of Channels

Another means of isolating the work area is to construct a temporary diversion channel. The channel should be large enough to handle the predicted flows and should be lined with plastic sheeting or another suitable material which will prevent erosion of the channel.

Upon completion of the instream work, flow should be reinstated to the original channel and the diversion should be backfilled. For further details on diversions, refer to *Chapter 7, "Diversions, New Channels, Major Alterations"*.

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10.5 Treatment of Silted Water

10.5.1 Water Quality Requirement

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. Effluent discharged into receiving waters must comply with environmental regulations.

10.5.2 Settling Basins

A properly designed and constructed settling basin is preferred to other methods of silt removal because it provides more effective hydraulic parameters for the separation of heavier particles from the water.

Settling basins must be properly designed taking into consideration such factors as the loading of suspended solids in the water, the particle size gradation, the volume of water to be treated, the rate of inflow and outflow from the settling and the surface area available.

Settling basins should be located in low lying areas where they will not contribute to high ground water conditions and where the water may be either returned safely to the body of water or recharged to the water table. For treating heavily silted water or where large amounts of residual silt are anticipated, an area should be set aside which is accessible by heavy equipment for removal and disposal of the silt. The area may subsequently be upgraded and landscaped.

10.5.3 Use of Other Low Lying Areas or Wetland

For treating lightly silted water or smaller quantities of water, natural low lying areas with some minor modifications can be utilized. Very light organic materials and very fine sediments are more effectively settled in areas where there is active vegetation such as marsh land where biological processes provide natural separation. Such areas can often be utilized effectively with only minor modifications required and can be easily restored without significant detrimental impact on the natural flora and fauna of the marsh or lowland.

Pumping smaller quantities of water into such an area and allowing it to percolate into the ground or gradually make its way back to the body of water is a low cost method of filtering suspended solids.

10.5.4 Other Methods for Removal of Suspended Solids

In some circumstances chemical or mechanical processes may be used to separate suspended solids. The addition of alum (aluminum-potassium sulphate), or similar flocculating agent helps precipitate very fine or

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colloidal particles. Hydro-dynamic separators or similar mechanical processes can provide a fast method for separating heavy particles. Filtration may be used when the quality of water involved is small and adequate provision is made for periodically cleaning the filters.

10.6 Use of Concrete Near a Body of Water

Where cast-in-place concrete is required, all fresh concrete must be kept from coming in contact with the watercourse until adequate curing is achieved. The formwork must be constructed with tight joints to prevent leakage and all necessary precautions taken to prevent spillage of concrete in or near a body of water.

Tools and equipment which have been used for working fresh concrete must not be washed in any body of water or stream.

10.7 Control of Slumping and Erosion

10.7.1 Inspections

Inspections of the construction site and surrounding areas must be carried out periodically and after heavy rains to identify any areas subject to erosion.

10.7.2 Remedial Measures

Where erosion or slumping has already become evident, immediate and appropriate remedial measures are necessary to stabilize the area. Such action can often prevent more serious and extensive erosion problems before the erosive process becomes well established.

10.7.3 Embankment Grading

Final embankments, including roadside and stream embankments, must have finished grades no steeper than two horizontal to one vertical. More gradual slopes will be required where the type of material is extremely fine and subject to washout. Long slopes should be provided with intermittent benching to interrupt the flow of water and prevent cuts and surface erosion.

10.7.4 Protection Of Fill During Construction

Fill material should be placed in layers not exceeding 400 mm and each layer adequately compacted or consolidated to resist slumping or erosion. Exposed embankments or any unstable material which is vulnerable to soil erosion should be protected, as appropriate, by any of the various methods of temporary surfacing including but not limited to:

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- plastic sheets
- economical anti-erosion mats
- mulches (such as wood chips).

10.7.5 Site Restoration and Stabilization

Site restoration and stabilization must be carried out in accordance with the guidelines provided in *Chapter 11, "Restoration and Stabilization"*.

10.8 Energy Attenuation for Erosion Control on Water Courses

Streams which have a small channel capacity with steep banks, will have high flow velocities during storm runoff and are very susceptible to erosion. Streams which flow through areas of very erodible soil (common in low lying areas adjacent to watercourses) and streams having sharp meanders or bends are also prone to erosion. In general, whenever exposed erodible soil along a stream bank is found, especially in conjunction with a restricted channel, or sharp turns, corrective measures must be taken if the resulting construction will itself result in an increased peak flow.

Any mechanical technique that will slow the water velocity is an energy attenuation device. Common examples are the use of rip-rap in steep ditches and grass linings in ditches with a lower gradient. The rocks or the blades of grass serve to slow the velocity of water and prevent the transfer of energy to soil particles.

Where long, steep gradients are involved, energy attenuations are commonly constructed by imbedding bricks, concrete blocks or rocks into the natural stream bed or into concrete or asphalt ditch linings so that the force of water will be retarded and its energy attenuated. The use of check dams, weirs and drop spillways made of a variety of materials, both temporary and permanent, will reduce channel grade and dissipate the energy of flowing water.

10.8.1 Design of Energy Attenuation Structure

Special care has to be taken that the energy attenuation device will adequately dissipate the energy of the water so as not to damage banks or the toe of the structure. Energy attenuation devices frequently result in a concentration of the volume of the water flow with a consequent increase in water velocity at the structure, therefore, banks around grade control structures often require additional stabilization measures.

10.8.2 Reduce Slopes

In those circumstances where steep slopes will result in an unacceptable level of erosion, the flattening of those slopes should be considered as an erosion control practice. The use of retaining walls incorporated into a slope

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will allow the flattening of slopes above and below the structure within the same horizontal cross section. The use of a grade control structure in a stream not only provides energy attenuation but reduces stream gradient upstream and downstream of the structure. A major disadvantage of energy attenuating structures used to reduce channel grade is that they can obstruct the passage of fish. The Area Habitat Coordinator at the Department of Fisheries and Oceans should be contacted before a decision is made on the use of these devices.

10.8.3 Protection of Adjacent Properties

The protection of adjacent properties from accelerated erosion and sedimentation is an important concern. A developer has a legal, as well as a moral responsibility to ensure that his work is of sufficient high quality so as to not create erosion or sedimentation problems on adjacent properties.



Chapter 11: Environmental Guidelines for Restoration and Stabilization

**Water Resources Management Division
Water Rights, Investigations, and
Modelling Section
November 29, 2018**



**Government of Newfoundland and Labrador
Department of Municipal Affairs and Environment
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Chapter 11

Environmental Guidelines For

RESTORATION AND STABILIZATION

Water Resources Management Division
Water Rights, Investigations, and Modelling Section

November 29, 2018

11.0 RESTORATION AND STABILIZATION

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11.0 RESTORATION AND STABILIZATION

11.1 General

Restoration and stabilization involves:

- The removal of all temporary construction facilities and structures.
- The removal and proper disposal of all excess and waste construction material and debris.
- Final reshaping, grading and stabilization of subsurface soils.
- The placement, grading and stabilization of topsoils.
- Revegetation through seeding, sodding, and planting of shrubs and trees.
- The placement of permanent erosion control structures including riprap and armour rock.

Restoration and Stabilization is required in order to:

- Stabilize slopes from eroding or slumping which can cause environmental damage.
- Stabilize drainage ditches, streams, river banks or other disturbed areas vulnerable to erosion by concentrated flows, which can cause serious washouts or erosion resulting in loss of property and environmental damage.
- Ensure aesthetically acceptable surroundings by removing and disposing of all grubbed material, excess and waste construction material and debris.
- Provide aesthetically acceptable and stable conditions through the placement of topsoil along with revegetation which beautifies the surroundings and prevents surface erosion or slumping.

11.1.1 Removal of Temporary Structures and Facilities

Structures and facilities which do not form part of the completed project including temporary service buildings, construction equipment and machines, as well as works for watercourse crossings including temporary culverts or bridges must be carefully removed from the area.

11.1.2 Restoration of Temporary Watercourse Crossing Sites

When temporary works for fording, culverts, or bridges have been removed, the sites should be restored as far as possible to their previous condition and adequately stabilized to prevent erosion.

11.1.3 Disposal of Grubbed Material and Excess Fill Material

Materials grubbed or stripped from the site which are not required for subsequent use, should be disposed of at locations designated by the regulatory authority (s). Grubbed materials including stumps, slash etc. may be buried or burned at designated locations.