FISH HABITAT PROTECTION GUIDELINES

Road Construction and Stream Crossings

Fisheries and Oceans | Pêches et Océans

Saskatchewan Environment and Resource Management

Canada

Saskatchewan

Fish Habitat Protection Guidelines - Road Construction and Stream Crossings

These guidelines were prepared by SENTAR Consultants Ltd. for the federal Department of Fisheries and Oceans, Fisheries and Habitat Management, Central and Arctic Region, and Saskatchewan Environment and Resource Management, Fisheries Branch.

SENTAR would like to thank all who contributed to the Guidelines and to acknowledge that relevant information from other Canadian guidelines (cited in Section 8) has been used in the development of the Saskatchewan Guidelines. This was done to promote a more unified approach to Canadian fish habitat protection while still meeting the habitat requirements and construction practices found in Saskatchewan.

For copies of this report, contact one of the Saskatchewan Environment and Resource Management District Offices listed in Appendix B. These Guidelines will be reviewed and updated periodically to account for changes in technology, standards or requirements relating to the impacts of road construction and stream crossings on the aquatic environment in Saskatchewan. Comments and suggestions are welcome and should be forwarded to:

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1.0 OBJECTIVES

Fish are an important subsistence, commercial and recreational resource in Saskatchewan. Although most Canadians want to protect the environment, many do not realize that their activities are affecting fish, especially when streams are small or impacts seem to be minor. Poorly designed and constructed roads and stream crossings can result in the loss of fish and aquatic life by, for example, restricting fish movement, destroying spawning habitat and contaminating water due to spills or soil erosion. The following guidelines are intended to eliminate or minimize the impact of stream crossings and road construction on adjacent lakes and streams in Saskatchewan.

These *Fish Habitat Protection Guidelines* are to be followed when planning, designing, constructing, maintaining, upgrading and decommissioning stream crossings and roads adjacent to water bodies. They provide practical advice, including mitigation techniques, to ensure minimum disturbance to the aquatic environment. They also provide guidance on government regulations and project review processes that apply to fish habitat protection.

The *Fish Habitat Protection Guidelines* are intended to:

- conserve fish habitat including spawning ,rearing, nursery, food supply and migration components,
- allow for free movement for fish,
- increase awareness of the potential adverse effects to fish of stream crossings and roads adjacent to lakes and steams,
- provide advice on protective measures that can be incorporated at every phase of the development,
- provide guidance to departmental staff, and
- help proponents understand and enter the regulatory process that provides habitat protection.

These guidelines are not regulations. There may be situations where they are not applicable, or other guidelines or regulations take precedence. The Regional Fisheries Biologist (Appendix A) will be able to advise proponents whether these guidelines are applicable to their proposed development activities.

2.0 LEGISLATIVE AUTHORITY AND POLICY

2.1 Legislation

The *Fisheries Act* regulates the environmental impacts of projects and activities which may affect fish and fish habitat. The habitat provisions of the *Fisheries Act*[1], principally section 35, prohibit any harmful alteration, disruption or destruction of fish habitat unless authorized by the Minister of Fisheries and Oceans or authorized under regulations. *The Environmental Management and Protection Act*, a provincial act, requires that a permit be obtained before any work is carried out in or near water.

The habitat provisions of the *Fisheries Act* and *The Environmental Management and Protection Act* are enforced in Saskatchewan by Saskatchewan Environment and Resource Management.

Proponents planning to conduct work in or near water must ensure that they meet the requirements of other federal, provincial and municipal legislation. Table 2.1 provides a partial list of agencies and legislation which regulate various activities in or near water.

2.2 Policy for the Management of Fish Habitat

These guidelines are based on the Department of Fisheries and Oceans' *Policy for the Management of Fish Habitat* (DFO 1986). The Policy is designed to achieve a net gain of productive capacity of habitats for Canada's fisheries resources. The Policy has three goals; habitat

1 Habitat provisions of the *Fisheries Act* are summarized inthe publication entitled *Canada's Fish Habitat Law* (DFO 1991).

TABLE 2.1 Partial List of Legislation Potentially Affecting Development Activity In or Near Water

AGENCY	LEGISLATION	DESCRIPTION
FEDERAL:		
Fisheries and Oceans	Fisheries Act	Regulates activities that impact fish and fish habitat in Canada
Transport Canada: Canadian Coast Guard	Navigable Waters Protection Act	Regulates activities in and around navigable waters for commerce, transportation and recreation in Canada
Environment Canada	International River Improvement Act	Regulates activities affecting water quality and environment of rivers flowing outside of Canada
PROVINCIAL:		
Environment and Resource Management:		
- Environmental Assessment Branch	The Environmental Assessment Act	Regulates developments which have significant impact on the environment
- Fisheries Branch	The Environmental Management and Protection Act	Regulates aquatic habitat alteration in Saskatchewan
- Forestry Branch	The Forest Act	Regulates management, conservation and utilization of Crown timber and forest lands
- Municipal Branch	The Environmental Management and Protection Act	Regulates waterworks, water pollution control, and disposal of hazardous substances, sewage and effluent in Saskatchewan
- Parks and Protected Areas Branch	The Parks Act	Regulates management, maintenance and development of provincial park lands in Saskatchewan
- Sustainable Land Management Branch	The Provincial Lands Act	Regulates sale, lease and license of occupation, rights-of-way, special use permits, easement, map reserves and permission to construct on Crown lands
- Wildlife Branch	The Critical Wildlife Habitat Protection Act	Regulates management, protection, disposition and alteration of Crown lands critical for wildlife in Saskatchewan
Health	The Public Health Act	Regulates potable water supplies, sewage disposal, sanitation and food supply operations in Saskatchewan
Municipal Government	The Planning and Development Act	Limits the use and development of shoreland in municipal, public and environmental reserves and authorizes municipalities to control the use of land
Saskatchewan Water Corporation	The Water Corporation Act	Regulates water use in Saskatchewan
MUNICIPAL:		
Local Municipal Councils	Municipal By-laws	Permits construction, clearing and burning; approves zoning or re-zoning; regulates local land use and building codes; owns and controls shoreland in municipal (public) reserves

conservation, restoration and development. The **No Net Loss** principle applies to the conservation goal and calls for the preservation of the productive capacity of existing fish habitats by avoiding loss or harmful alteration of habitats resulting from development activities. Using this principle, Saskatchewan Environment and Resource Management, Fisheries Branch and the Department of Fisheries and Oceans will strive to prevent habitat loss and to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions of fisheries resources due to habitat loss or damage may be prevented.

3.0 APPLICATION AND REVIEW PROCESS

Proponents planning to work in or near water should submit an application to the district Conservation Officer of Saskatchewan Environment and Resource Management (Appendix B). Information provided should include:

- a description of the proposed works with sufficient detail to enable fisheries staff to determine whether impacts on fish and fish habitat are likely to occur;
- a map indicating the location of the proposed project;
- a construction schedule, including dates for start-up and completion of works in or near water; and
- a description of the mitigation measures, including erosion and sediment control plans, which will be implemented to eliminate or minimize potential impacts on fish and fish habitat, during construction, operation and decommissioning of the proposed works.

If potential impacts on fish and fish habitat can be prevented through re-design, re-location or the use of mitigation measures, the project will be approved. If impacts still exist after exploring all feasible alternatives for re-design, relocation and mitigation, compensation for lost or damaged fish habitat may be considered. Compensation is not an option for replacement of critical habitats or as a means of dealing with chemical pollution or contamination problems. When compensation is being considered, an agreement must be worked out to the satisfaction of Saskatchewan Environment and Resource Management, Fisheries Branch and the Department of Fisheries and Oceans.

For small projects, involving physical activities (e.g. stream crossings) which may disrupt fish habitat, fisheries staff will assist proponents to the extent feasible in identifying the potential biological impacts of the project and the adequacy of proposed mitigation measures. For larger projects, the proponent is responsible for obtaining and presenting all relevant information on the fish habitat which is likely to be affected, the potential impacts and the proposed mitigation and compensation measures.

All project proponents are responsible for the costs associated with installing and maintaining mitigation (and compensation) measures. Proponents may also be required to conduct follow-up monitoring programs to determine the effectiveness of the mitigation or compensation measures. For larger projects, a financial guarantee may be required.

4.0 IMPACTS ON FISH AND FISH HABITAT

In general, the construction of crossings without any disturbance to the stream and its banks is neither economical nor practical. Impacts on the stream and stream banks cannot be avoided when approach roads, culverts and bridges are installed, but these impacts can be minimized during every phase of the construction of the crossing.

4.1 Change in Flow

Fish complete a cycle of upstream and downstream movements which may extend more than 100 kilometres for some species. Upstream migrations by adult fish are well known, but early life stages must be able to migrate downstream and, occasionally upstream as well. Fish migrate to reach spawning grounds, to find food, to escape predators, and to avoid low water levels, especially during freeze-up. Fish must be able to migrate through all crossing structures on their route. One poorly designed or installed culvert can affect the fish stocks of an entire drainage basin.

Stream crossings that restrict the width of the channel increase the velocity of water flowing through the culvert or bridge. High velocity acts as a barrier to fish swimming upstream to spawn. The spring spawning period from April to June often coincides with periods of peak flows. A delay of more than three days due to high velocity at a stream crossing may impair spawning success of spring spawners such as northern pike, arctic grayling, sauger, walleye and suckers. They may abandon their spawning run or spawn in a less suitable habitat.

Whitefish, cisco and brook trout which spawn in the fall, when flows are often low, may be restricted by improperly embedded culverts which do not have sufficient water depth. A continuous band of water of sufficient depth to submerge the largest fish passing through the structure should exist throughout the length of the culvert during periods of fish migration.

Bridges usually alter the natural streambed the least. Bridges and open-bottom culvert designs which retain natural morphological features such as stream width, slope and cross-sectional area are preferred for fish protection. However, culverts that are countersunk below the streambed can also simulate natural conditions if natural materials are secured in place to increase roughness, thereby reducing the velocity for low volume flows. A circular culvert tends to increase the velocity within the culvert and is the least desirable for fish passage. Velocities in unmodified circular culverts generally exceed the sustained swimming speeds of fish (Katopodis 1993).

Migrating fish must be able to pass through the culvert outlet, the culvert barrel and the culvert inlet without harmful delay. Water velocities and depths at each of these locations must be suitable for passage during both the highest and lowest stream flows expected during fish migration.

Factors that influence fish passage through culverts are the number and size of culverts, the gradient, the inlet and outlet conditions, and the length of the culverts (Fig. 4.1 and Fig. 4.2).

Fig. 4.1 Improperly installed Culverts Block Fish Passage on the Nemei River

Photo supplied by Saskatchewan Highways and transportation, Prince Albert

Fig. 4.2 New Three Metre culverts Restore Fish Passage on the Nemei River

Photo supplied by Saskatchewan Highways and transportation, Prince Albert

Fish need to swim continuously for the entire culvert length once they enter it, unless resting opportunities have been provided. Therefore, the combination of water velocities and culvert length must match the swimming ability of the fish entering the culvert.

Fish swimming performance has been classified into burst speed (highest speed attainable and maintained for less than 10 seconds), prolonged speed (a moderate speed that can be maintained for up to 30 minutes), and sustained speed (a speed that can be maintained indefinitely) (Katopodis 1993). Prolonged speeds are used for continuous passage through culverts when no resting is available. Fish cannot maintain burst speeds long enough to swim the entire length of most culverts. Thus, both the length of the culvert and the water velocity are important factors in designing culverts for fish passage.

Fish moving upstream will take advantage of resting spots or low velocity zones that generally occur in natural streams. In culverts, fish will also seek out low velocity zones that exist closest to the culvert barrel and in the vicinity of baffles or rocks within the culvert.

Not all fish have equal swimming ability. Generally, larger fish can handle higher velocities than smaller ones; however, small fish can sometimes take advantage of the lower velocity water behind rocks or near the edge of structures. Weak swimmers such as northern pike are stopped by velocities that are not a barrier to other species.

Road crossings attract beavers which add materials to the man-made structures in the channel. The activities of beavers result in plugged culverts which block fish passage and greatly alter the flow regime of a stream by replacing riffle areas with slow-flowing areas. Riffles are generally very productive, the habitat of many aquatic insects eaten by fish.

4.2 Erosion and Sedimentation

Removal of vegetation and topsoil in the vicinity of the watercourse, without proper erosion control measures, will result in sedimentation. Sites requiring extra precautions include those with fine-grained soils, steep slopes, high moisture levels and permafrost.

A culvert that is too small or is clogged with ice or debris can dramatically increase erosion and siltation if a washout occurs during peak flows. A culvert that does not fail, but increases velocity may cause scour of the streambed and erosion of the streambanks if the culvert outlet is inadequately protected. Sediment from these processes may be carried downstream and adversely affect fish spawning, egg incubation and food supply.

Poor construction practices such as excessive clearing to mineral soil, failing to stabilize cut stream banks, and allowing surface run-off from the road, or right-of-way, to flow into streams all increase the erosion of soils that are washed into the stream and deposited downstream.

Silt suspended in the water is abrasive to aquatic plants and the mucous coating of fish, irritates the respiratory systems of invertebrates and fish, reduces the vision of animals that feed by sight, and reduces the penetration of sunlight to plants on the stream bottom.

When suspended silt is deposited further downstream it may clog spawning beds by filling spaces within the gravel. Water flow through the gravel is reduced, causing oxygen concentrations in the gravel to fall below the concentrations needed by developing fish eggs.

Suspended solids deposited in an area of lower velocity may change the habitat to an unstable sand or silt which smothers small inhabitants and makes the area unsuitable for many aquatic insects and the attached algae which is their food source.

Some species of fish are less tolerant of increased sediments than others. Generally the effect of increased siltation on shallow clear streams with gravel or cobble bottoms is more severe than the same increase in a larger river with a sand bottom which has naturally high suspended solids during peak flow periods. Acceptable limits on the amount of sediment lost from the work site are dependent on the background level of sediment in the stream at the time of construction.

In general, the type of sediment, the timing and duration of its release, the fish species, their life stages, and the nature of their habitat (including water quality) will determine the extent and degree of the impact.

4.3 Deleterious Substances

If accidental spills of oily materials or toxic chemicals reach the water, or if water from the construction area drains into the stream, “fish kills” may occur as a result of the contamination. Increased mortality of sensitive early-life stages of fish, or of other aquatic organisms which form their diet, may have just as severe an effect on the fish population, but go unnoticed due to their small size.

5.0 GUIDELINES FOR THE PROTECTION OF FISH HABITAT

5.1 Scheduling

Scheduling is one of the most successful, and often least costly, means of protecting fish. In almost all cases, instream activities can be scheduled to avoid conflicts with fish migration, spawning and incubation periods. Completing the stream crossing as quickly as possible makes sense for both project management and habitat protection.

Construction of instream portions of stream crossings should not be undertaken at times when spawning runs of fish occur in the stream. Construction of approaches to the crossing may be carried out when spawning runs occur if proper erosion and siltation controls are in place. Critical dates are between April 15 and June 1 for spring spawning species, and between September 15 and November 1 for fall spawning species. These dates may vary according to the latitude. The eggs of fall spawners overwinter and remain at risk to construction impacts such as sedimentation until April 30. Therefore, there may be restrictions on construction activities through the winter at some locations. Exceptions can be made only with the approval of the Regional Fisheries Biologist.

Whenever possible, work in the river should be scheduled for the driest time of the year to minimize erosion if there is no conflict with fish migration.

To minimize erosion and sedimentation, every effort should be made to complete instream construction as quickly as possible once the work begins. Grading operations should be completed as soon as possible after the grubbing operation exposes the soils.

Reclamation should commence as soon as possible after construction so that erosion will not have a chance to start. Erosion-prone areas should have highest priority.

To prevent obstruction of a stream, temporary winter crossings constructed with metal or timber should be removed prior to spring break-up unless they are designed and constructed to withstand peak runoff; those constructed of ice and snow should be channelized prior to break-up.

5.2 Route Planning

Planning the route to avoid conflicts with fish passage and habitat is preferred over the later addition of mitigation techniques to reduce the conflict. By positioning the crossing according to the following guidelines, productive fish habitat can be preserved, sedimentation reduced and disruptions kept to a minimum.

Roads must be preplanned and marked before clearing.

Roads are not to be constructed within the reservation limits of streams and lakes (see Section 5.3) except at designated crossings. The reservations act as buffer zones.

A route that minimizes the number of streams to be crossed and crosses streams near their headwaters is preferred.

Existing crossings should be used where possible.

Crossings should be located upstream of natural barriers to fish passage (e.g. waterfalls).

The route should avoid stream crossings at environmentally sensitive areas such as known fish spawning beds and nursery areas.

Crossings should be located at least 500 metres upstream of spawning areas.

Crossings constructed at least 500 metres upstream of a river mouth or lake outlet are preferred because outlets are favoured fish habitats.

Locations where the river is braided or the banks are steep or actively slumping should be avoided, due to the potential for increased siltation.

Trails and roads should approach stream crossings as nearly perpendicular to the channel as possible in order to minimize bank disturbance and reduce the crossing length.

Locations where the channel is straight, unobstructed and well-defined are preferred so that the crossing structures can provide a direct entrance and exit for water flow.

Crossings that can conform closely to the natural topography of the site and avoid extensive cut or fill sections are preferred to reduce erosion.

Disruption of groundwater flow should be avoided. Road construction in some areas may disrupt subsurface movement of water, causing ponding of water on one side of the road and slowing discharge to the other side of the road. Flow regimes in adjacent streams can be severely disrupted.

Muskeg should only be crossed with winter roads and permanent construction should be avoided. Where muskeg cannot be avoided, roads crossing muskeg must preserve flow patterns within the area by having good and frequent cross drainage.

5.3 Reservation Limits

Reservations of undisturbed vegetation located along the edges of lakes and streams filter runoff before it reaches the stream. If forest canopy is present in the reservation, it will shade a stream, reducing mid-summer temperatures and adding organic matter to the aquatic food chain.

Reservations are to remain between the right-ofway and the normal high water mark of a stream or lake, except at designated crossings. The following reservation limits are recommended to protect fish habitat.

- Lakes or streams not capable of supporting fish and not connected to a recognizable stream system require no reservation.
- Small streams that are a part of a recognizable system (with a gross drainage area of less than 50 km^2), but do not support permanent or seasonal populations of fish require a reservation of 15 metres.
- Lakes and streams with seasonal populations of fish, other than those outlined in the following section, require a reservation of 30 metres.
- Lakes and streams possessing permanent fish populations, or capable of supporting a fish population introduced by stocking, require a reservation of 90 metres.

The Regional Fisheries Biologist may alter these reservations in special circumstances.

5.4 Construction within Reservations

Reservations are buffer zones. Some of the protection to the stream provided by the natural vegetation is unavoidably lost when road crossings are constructed. To maintain habitat quality, methods to minimize soil disturbance and reduce the transport of soil and debris to the stream should be incorporated into the design and construction of the crossing.

To reduce erosion, ground cover is to be maintained within the reservation. Other than within the actual road cross-sections, the right-of-way should not be bared to mineral soil within the reservation. If large vegetation must be removed to improve site lines and allow rapid drying of the road surface, it should be done with the least disturbance of ground cover.

In areas of fine-grained soils (clays, silts and fine sands) which are subject to erosion, retain natural vegetation in reservations as long as possible, to reduce the time that the soil is exposed.

In areas of fine-grained soils, grubbing should be avoided during wet weather to prevent unnecessary disturbance of the clay, silt or fine sand.

Bare slopes draining into streams, should be stabilized by riprapping, mulching, seeding, gravel paving and/or other erosion control structures as soon as possible after construction begins. All slopes should be checked one year after construction and further action taken if necessary.

Borrow material, other than in the road cross section, should not be taken from within the reservation. Borrow material must not be taken from the stream channel.

Where there is a steep slope leading to a water body, erosion control measures during road construction should start at the top of the slope.

Cut and fill slopes that are steeper than 2:1[2] will likely increase erosion while slopes flatter than 2:1 may increase the width of the slope unnecessarily. A slope of 2:1 is recommended unless other factors such as soil type necessitate a different slope.

Clearing of unstable or erodible banks should be done in a manner that will minimize soil disturbance. Appropriate methods, depending on the circumstances, may include hand clearing or the use of a feller buncher.

Debris from right-of-way clearing must not be left where there is a possibility that it can be transported into a lake or stream.

Piles of waste soil from channel realignment or bank cuts that may significantly increase sediment concentrations in streams should be removed from locations where there is a possibility that it can be transported into a lake or stream. Waste soil temporarily stored at such a location should be protected by a silt fence.

2 2:1 = 2 horizontal:l vertical

Collection ditches and frequent cross drainage may be required to maintain normal groundwater flow patterns if the road disrupts subsurface movement of water.

5.5 Design of Crossing Structures

Fish migrating to spawn, feed or meet other requirements provide challenges to the design and installation of stream crossings. In all cases, ensuring no net loss of fish habitat is of prime concern. New approaches to locating, designing and placing bridges and culverts have evolved to meet these challenges.

5.5.1 General

Fish passage must be accommodated through all culverts and bridges on fish-bearing streams, otherwise all the remaining upstream (or sometimes downstream) habitat is unavailable.

All permanent stream crossing structures should be either bridges or culverts. Bridges are the preferred crossing structure for streams possessing fish on a seasonal or permanent basis and for streams that are actively eroding their banks (Fig. 5.1).

Fig. 5.1 Bridge on the Clearwater River

Photo provided by Saskatchewan Environment and Resource Management, Fisheries Branch

Although requirements at specific locations vary, the following structures (Table 5.1) are listed in order of preference:

- bridge,
- open-bottom arch or box culvert,
- closed-bottom arch or box culvert,
- pipe arch culvert, and
- round culvert.

Passage of debris should be considered in the design of the stream crossing. Bridges and culverts should be sized to permit passage of anticipated flood volume, based on the design flood frequency (usually 1:25 years). Where only a limited amount of hydrological and biological information is available, a safety factor should be used in the design to reduce the risk of crossing washouts.

Permanent and temporary erosion and sedimentation control measures should be shown on construction drawings or included in the special provisions of the contract.

5.5.2 Bridges

To minimize potential adverse affects on fish habitat, foundation investigations such as excavating test pits or driving test piles should meet the following guidelines:

- keep the width of the access road to a minimum,
- avoid access to the stream at the outside of sharp bends,
- limit access to one location on each bank,
- temporary stream crossings should follow guidelines in Section 5.6,
- backfill test pits using the excavated material,
- fill all test holes using soils and/or logs,
- cut off all test piles at streambed level, and
- remove temporary facilities, equipment and waste construction materials after the site investigation.

Minimize the number of piers and footings in the stream.

Approaches to bridges must be stabilized. Approaches consisting of erodible material should be constructed with a minimum slope of 2:1 .

Where an erosion hazard exists, protect bridge abutments with granular or other non-erodible materials such as concrete, rock riprap and vegetative cover.

5.5.3 Culverts

5.5.3.1 Culvert Design

Spawning fish can only tolerate short delays in migration. The period during which the culvert is impassable to fish should not exceed three days with a one in ten year flood frequency if a stream contains fish seasonally or permanently. Three days is the maximum period for which fish may be delayed on their journey to the spawning grounds without causing serious disruption of the spawning cycle.

Fish species have been grouped (Katopodis 1993) into anguilliform (eel like form in which most or all of the body takes part in propulsion) swimmers (Fig. 5.2a) and subcarangiform (trout-like form in which most of the motion is in the posterior half or third of the body) swimmers (Fig. 5.2b). Most Saskatchewan fish species are subcarangiform, except burbot which are anguilliform. Although northern pike do not swim in the anguilliform mode, the few data points available are close to the anguilliform performance curves. The curves shown in Figure 5.2 represent the mean distance that a fish can swim at a given water velocity. The curves are based predominantly on an analysis of laboratory tests with fish under optimum water temperature conditions. Swimming capabilities in the field may vary, depending on the maturity and condition of the fish, the water temperature and the dissolved oxygen concentration.

TABLE 5.1 Fisheries and Design Considerations for Stream Crossing Structures (adapted from Chillibeck et al. 1992)

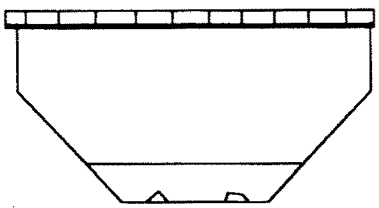
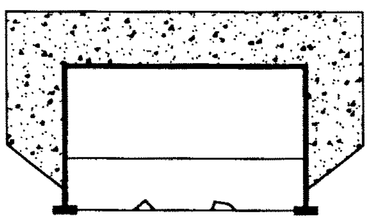
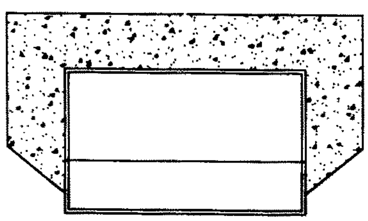
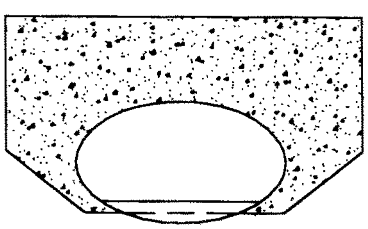
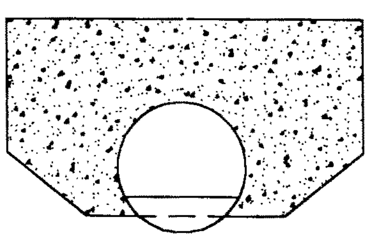
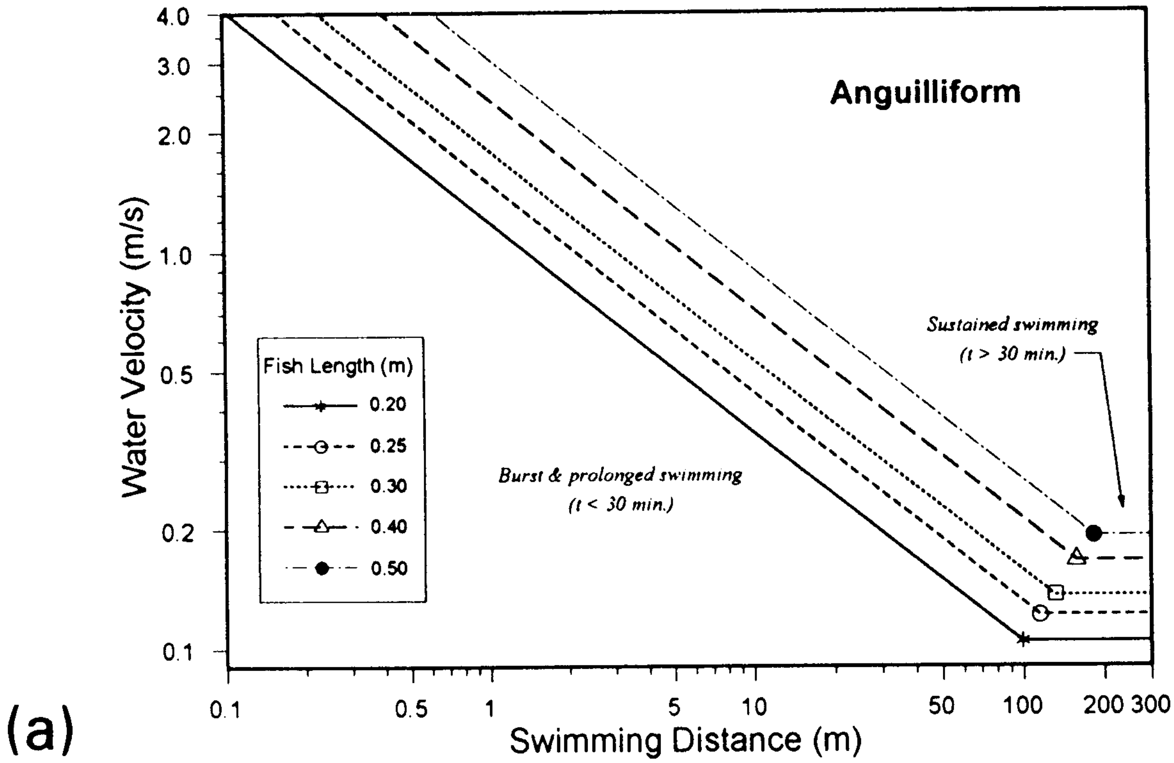
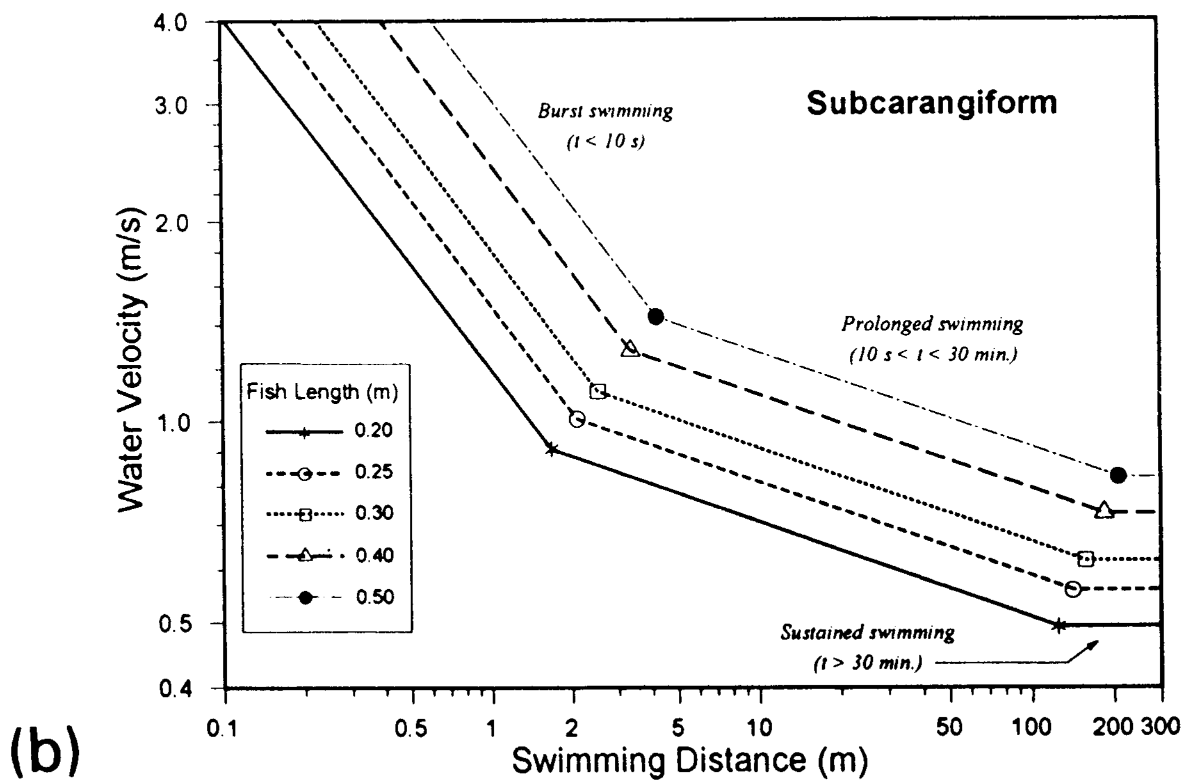
TYPE OF STRUCTURE	FISHERIES CONSIDERATIONS	DESIGN CONSIDERATIONS
BRIDGE 	Can retain existing bottom substrate, bank structure and riparian vegetation. Does not alter large organic debris or bed load transport capacity of stream reach. Can retain natural fish passage stream qualities.	No limit to stream hydraulic capacity if encroachment of piers or footings is limited. Ability to cross large streams and rivers. Structure can be designed with no instream work required.
OPEN BOTTOM CULVERT 	Does not limit fish passage if properly designed and constructed. Retains natural stream substrate. Water velocities are not significantly changed if as wide as the natural stream. Loss of riparian vegetation because of infilling around culvert.	Can be designed to provide good flow capacity. Can be placed in multiple units to provide wider section and larger end area. Provide suitable footing for wall section to prevent undermining by stream erosion.
BOX CULVERT 	Can limit fish passage at low flows by reduced water depth in culvert (with no baffles). Baffles can be easily installed to provide fish passage. Wide bottom area allows retention of bottom substrates.	Can be designed to provide good flow capacity. Can be placed in multiple units to provide wider section and larger end area. Precast units can be installed quickly limiting instream construction time.
PIPE ARCH CULVERT 	Can limit fish passage at low flows due to reduced water depth in culvert (with no baffles). Baffles can be installed to provide fish passage. Wide bottom area allows retention of bottom substrates.	Wide bottom area provides good flow capacity with limited depth increase. Good for low clearance installations. Multiple units can be installed to provide greater capacity. Reduced depths at low flows may require backwatering.
ROUND CULVERT 	Difficult to provide passage in small diameters. Concentrates flow and velocities. Generally poor for fish passage situations. Loss of habitat because of infilling around culvert as with all fill structures.	Concentrates flows and increases velocities and potential scour at high flows. Reduced depths at low flows may require backwatering. Can have poor bed load transport through culvert.

Fig. 5.2 Swimming Distance Curves for (a) Anquilliform and (b) Subcarangiform Fish (Katopodis 1993)





In regular culverts where there are no built-in resting places, fish must swim continuously from one end of the culvert to the other. This requires a continuous zone of water of sufficient depth and appropriate water velocity within the culvert. Figure 5.2 may be used to assist in designing culverts to provide appropriate water velocities for fish passage. For a given fish species, fish length and swimming distance, Figure 5.2 provides the water velocity against which the fish is capable of swimming.

In typical culverts, water velocities are highest at the water surface and lowest near the bottom and outside edges of the culvert. The mean cross-sectional velocity occurs between these two areas but detailed information on water velocity distribution within culverts is lacking. The only quantitative information that is readily available is the mean cross-sectional velocity.

The mean cross-sectional velocity in a culvert can exceed the water velocity values provided in Figure 5.2 but still allow fish passage since lower water velocities will occur near the bottom and outside edges of the culvert. Thus, Figure 5.2 can only be used as an aid in assessing culvert design as it does not relate those velocities required to allow fish passage to the mean cross-sectional velocity.

In the absence of detailed information on cross≠sectional water velocity distributions in culverts, general guidelines may be followed. For the larger adult subcarangiform swimmers, mean cross-sectional water velocities should not exceed 0.8 metres per second in culverts greater than 25 metres length or one metre per second in culverts less than 25 metres length. Lower mean cross-sectional velocities may be required for weaker swimmers such as northern pike.

If the velocity within a culvert is not acceptable, some modifications that may be tried to reduce the velocity include:

- change barrel roughness, slope or bed material to reduce velocity,
- install a larger size or different shape than required for hydraulic flow,
- increase the embedment depth,
- add baffles or large boulders to reduce the velocity, and
- construct a tail-water control structure.

Culverts with a diameter of 2000 millimetres or greater, or a maximum design discharge of six cubic metres per second or greater should be designed by a professional engineer using further technical guidance on fish passage available from Katopodis (1993) and other sources.

If passage cannot be assured by these methods, construction of an open arch culvert or a bridge should be considered.

If fish do not use a stream, hydraulic design of the crossing for fish passage is not necessary. Provisions to maintain the water quality must still be considered.

If it can be demonstrated that peak flows do not coincide with fish movement, the design may be adjusted to accommodate fish at the non-peak period. Several years of data and the approval of the Regional Fisheries Biologist will be required to define fish movement and flood peaks.

One large culvert is preferred over two or more small culverts which may be more susceptible to blockage by ice or debris.

5.5.3.2 Baffled Culverts

When desirable water velocities cannot be achieved in culverts, installation of a baffled culvert should be considered. These culverts incorporate metal, wooden or cement-filled baffles along the culvert bottom to slow the current and provide resting places for fish as they ascend the culvert. Rather than using prolonged swimming speeds as in ordinary culverts, fish use their burst speed capability to advance from baffle to baffle. Baffled culverts are, therefore, designed so that the outlet velocity and the jet velocity of the baffles do not exceed the burst speed of the fish. Figure 5.2 provides burst speed capabilities of fish for various distances.

For multiple culvert installations, only one culvert is normally fitted with baffles, provided it is located near the stream bank. On larger rivers, it may be desirable to install baffled culverts adjacent to both banks to ensure that they can be located by migrating fish.

5.5.3.3 Culvert Installation

Installation of multiple pipe culverts should be done carefully as there is a greater danger of washouts. Pipe culverts set one metre apart allow for good compaction between the pipes which is important in preventing washout (Brathwaite 1992).

The depth of flow in the culvert should not be less than 200 millimetres to allow the passage of adult fish during low flow periods (Fig. 5.3).

The installation of culverts should follow the existing gradient of the stream, as a general rule. However, a design process such as that described by Katopodis (1993) may lead to a superior crossing design with a different gradient.

Culverts should be embedded a minimum of 200 millimetres below the natural channel bed elevation to enable a substrate of natural materials to establish within them (Fig. 5.3).

A gradual transition is needed from the upstream channel to the culvert inlet and from the culvert outlet to the downstream channel to prevent drawdown (a rapid drop in water surface elevation) and high local velocities which may hinder or prevent the passage of fish.

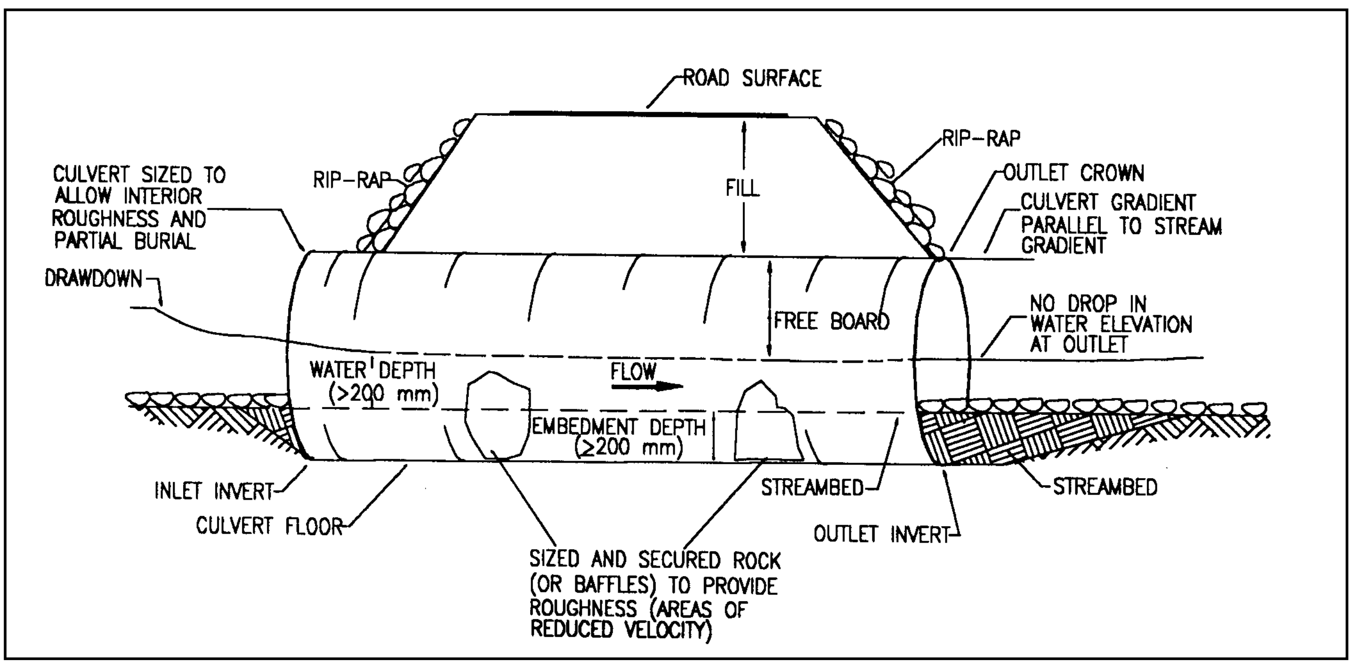
A stream crossing should provide a direct entrance and exit for water flow. The stream should not change course immediately before it enters a structure or immediately after it exits the structure. Culverts should be designed so that the discharge is not directed at a potentially unstable stream bank.

Culverts should be installed to prevent upstream ponding from occurring.

If necessary, soft unsuitable foundation material should be excavated below gradeline and carefully backfilled with suitable granular material.

Soil around a pipe culvert should be well graded, pit-run granular material and should be compacted around the pipe.

Fig. 5.3 Culvert Design



Adapted from Alberta Transportation and Utilities and Alberta Forestry, Lands and Wildlife, 1992

All pipe culverts should be cambered slightly Raising the pipe slightly in the middle will prevent a sag in the middle as the culvert settles.

The length of the culvert can be reduced if the ends are riprapped or if headwalls are used to protect the ends.

Where the potential for severe erosion and sedimentation exists, the following erosion protection should be constructed after culvert installation.

- The streambed should be armoured with riprap material heavy enough to withstand high velocities. The riprapping should be extended upstream from the structure, as necessary.
- Riprap should be placed from the bottom of the streambed up the sideslope above normal high water, or to the top of the existing bank whichever is less.
- Place an erosion-resistant riprap apron in the riverbed downstream of the pipe, where increased flow velocities could cause serious scour. It should be sloped toward the centre of the channel to allow fish migration at low water flows:
- Slopes above the riprap should be stabilized in a manner appropriate to the soils, vegetation, grade and ice content encountered.
- Side slope protection is required upstream and downstream of the culvert and should be tied into the armoured streambed blanket.

5.5.4 Low Level Crossings

Low level crossings (where the spring freshet is expected to overtop the road) are used for infrequently travelled roads in Saskatchewan. These crossings may block fish passage. The Regional Fisheries Biologist should be contacted if a low level crossing is being considered for a fish bearing stream.

Low level crossings should incorporate one or more culverts to ensure continuous year-round flow of water.

At low water levels, all water flow occurs through the culverts and water velocities in the culverts should be within the range of swimming capabilities of fish species expected to use the crossing.

At high water levels, water flow occurs through the culverts and over the road surface. Water velocities either in the culverts or over the road surface should accommodate fish passage.

The surface of the crossing should be constructed from erosion proof material, such as cement or rock cobble.

A rough surface is preferred to provide lower water velocities. Surface roughness can be increased by forming grooves in the surface, perpendicular to water flow. Further reductions in water velocity may be obtained by installing a series of wooden timbers (100 millimetres by 100 millimetres) perpendicular to flow.

Sideslopes of the crossing should not exceed a 3:1 slope.

5.6 Temporary Stream Crossings

Because summer crossings are often semi-permanent and winter crossings may cause ice jams, temporary crossings should abide b y the same general environmental constraints as permanent crossings to minimize interference with fish habitat and movement. Fords are natural, shallow water crossings. Because their construction and use directly affects the streambed, they should only be used for temporary low-frequency access during low flow conditions.

5.6.1 Summer Crossing Structures

When feasible, use temporary detour structures (culvert or bridge) at sites where sediment generated by fording a stream during construction is unacceptable.

Temporary stream crossings such as Bailey bridges and culverts should be designed and constructed according to the same criteria as permanent crossings.

When a gravel surface is required on top of the deck of a temporary bridge, geotextile fabric should first be placed on the decking and supported on the sides of the bridge to prevent gravel from entering the stream.

Serious consideration should be given to native timber bridges as a substitute for culverts on development roads.

Skid bridges constructed of metal or logs can be used as temporary summer crossings.

All temporary structures at water crossings should be removed and the area returned to as near original condition as possible upon completion of the work. If the terrain has been damaged, the area should be recontoured and vegetated.

5.6.2 Winter Crossing Structures

Ice bridges and snow fills constructed of ice, snow, and, if necessary, clean limbed logs (but not debris) can be used for winter crossings of ice-covered streams. Logs can only be used on the surface and only if they are cabled together so that they can be removed before thaw.

Where feasible, locate ice bridges to minimize the length of crossing and the amount of grading necessary for the approaches (Alberta 1992).

Winter crossings should avoid areas of fast water.

Culverts should be used with caution on winter roads due to difficulties with proper installation during winter and settling of the culverts during spring thaw.

Because ice bridges may cause ice jams and flooding, they should be removed before spring breakup. Approval may be given for partial removal. In these cases, a V-shaped notch in the middle of the stream will result in the removal of the structure by the spring freshet.

5.6.3 Fords

Fords should only be used in exceptional circumstances and used for only a very limited number of crossings. Environmental concerns can be reduced by the following measures:

- construct and use fords during the driest times of the year,
- avoid the construction and use of fords during critical spawning periods,
- minimize the amount of vegetation removed adjacent to the water crossing,
- if necessary, stabilize the approaches by using non-erodible material up the bank on both sides of the ford,
- select sites with firm streambed to minimize siltation from traffic,
- ensure that sites selected for fords are not spawning sites,
- use clean granular material for fill within the channel
- maintain a water depth of at least 200 millimetres, or the natural stream depth at the location, to accommodate fish passage,
- limit crossings to one general area,
- limit road width to that necessary for a single vehicle (it should be well marked to be visible to drivers),
- avoid access to fords on the outside of sharp bends unless the banks are stable,
- maintain vehicles and equipment in clean condition and in good repair to avoid leakage of petroleum products, and
- after construction of the permanent crossing structure, restore and stabilize the streambed and banks of the ford to prevent long-term erosion and subsequent siltation. Removal should be done during periods that are not critical for fish.

5.7 Stream Alteration

In larger streams, the satisfactory construction of a water crossing requires that flowing water be diverted away from work areas so that the structure can be constructed under dry conditions. Excavation for a bridge in the riverbed, or placement of a large culvert, should not be done in flowing water. Rather, the work area should be isolated by sheet piling or a stream diversion.

The challenge in a channel realignment or the installation of a water control structure is to meet the goal of no net loss of fish habitat by minimizing sedimentation, locating the realignment away from sensitive or productive habitat, and ensuring that fish can migrate through the altered area during critical periods.

5.7.1 Instream Structures

Instream work should be isolated from the stream by the use of sheet piling. The use of earthen coffer dams and berms should be avoided, where possible. Any berm placed in a stream should be protected with a granular facing or erosion control fabric.

If the work area has been isolated from the stream, at least one-third of the flowing channel that existed before construction should remain open during any instream work that may be scheduled during fish migration.

A culvert installation on small creeks may not have to be isolated from flowing water by a stream diversion or sheet piling. This decision would be based on the sensitivity of the downstream habitat, the size of the stream and the volume of flow.

Water from within the work area which contains excessive sediment should not be released directly into the stream but should be pumped to a settling pond. The Saskatchewan *Surface Water Quality Objectives* (SEPS 1988) recommend a maximum increase in suspended solids of 10 milligrams per litre over existing background if the background concentration of suspended solids is < 100 milligrams per litre, or a maximum increase of 10% over background, if the background concentrations are >100 milligrams per litre.

Berms should not be removed during critical periods for fish spawning and migration.

5.7.2 Channel Realignment

Avoid channel realignment in areas of sensitive fish habitat.

If feasible, excavate channel realignments under dry conditions with the inlet and outlet of the diversion closed.

Any dewatering flows should be directed to a settling pond to remove sediments.

Minimize siltation by opening the channel realignment at the downstream end first.

Protect unstable sharp bends in the channel realignment against erosion.

The gradient of permanent channel realignments should approximate those of the existing stream. The channel realignment should provide for fish passage at low flows.

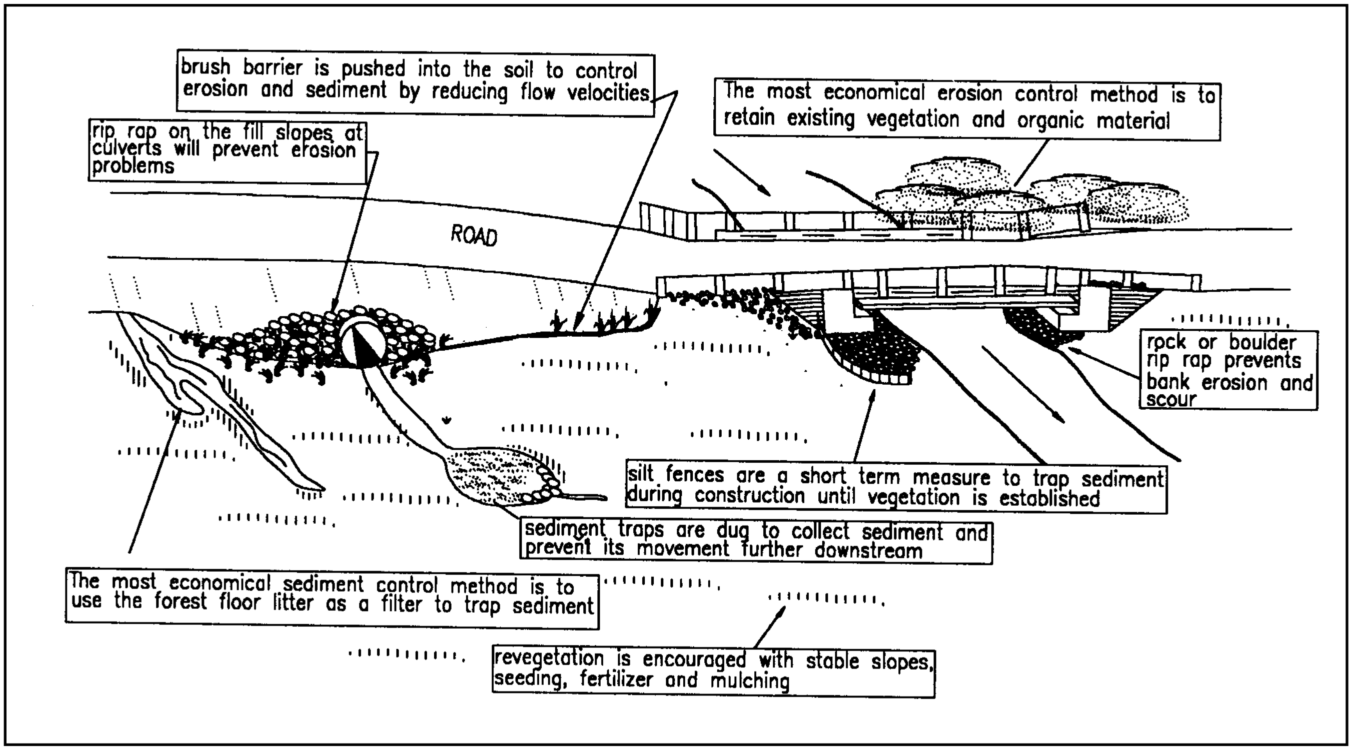
Temporary channel realignments that have been abandoned should be plugged or stabilized where there is potential for erosion. All bare areas on banks must be stabilized or revegetated.

5.8 Stream Crossing Approaches

The key factors in erosion and sediment control are to intercept and manage runoff, and to reduce the soil content of the runoff (Fig. 5.4). The water quality of the stream can be protected by a variety of erosion control measures recommended in the following guidelines. Revegetation is the permanent method of controlling erosion. Most other methods are intended to control erosion temporarily until vegetation is established.

The width of the right-of-way required for approach road construction at the crossing should be kept to a minimum, subject to safety, construction and maintenance constraints.

Fig. 5.4 Erosion Control Measures



Adapted from Ontario Ministry of Natural Rresources, 1988
Note: detailed descriptions of erosion control measures are provided in Section 6.

Clearing to mineral soil should not be done within the right-of-ways from the crest of the stream valley down to the stream.

General erosion control measures which may be used in addition to revegetation are listed below:

- construct berms at tops of cuts to redirect surface drainage,
- construct terraces, ï construct interceptor ditches or diversion ditches on cut slopes,
- excavate cuts, serrations or ditches perpendicular to the direction of flow (except in highly erodible soils),
- erect soil or stone dykes in ditches perpendicular to the direction of flow,
- erect straw or flax ditch blocks,
- scarify slopes to increase roughness,
- use erosion control measures such as riprap (rocks) or geotextiles (filter fabric),
- use silt fences on the lower perimeter of slopes,
- use silt fences around soil stockpiles,
- spread crushed rock, gravel or mats of non-erodible material (e.g. cellulose) on the surface. Steep slopes may require armouring of the surface with rigid structures, and
- use heavy equipment to compact brush into bare soil in the ditches.

Erosion control measures should be appropriate to the site. The preferred approach is revegetation. The following revegetation procedures are recommended:

- Where topsoil has been stockpiled, it should be spread over the area to be reclaimed prior to revegetation.

- If fall seeding is planned, it should be done early in order that ground cover can develop before winter.
- Plant species and varieties should be selected for their known ability to establish a self-sustaining, soil stabilizing cover under the climatic, topographic, road maintenance (e.g. salt application), and soil conditions at the site. Species native to the area are preferred.
- Special seeding techniques, such as hydroseeding, seed-impregnated jute, and sodding are recommended for slopes which may be subject to serious erosion.
- In erosion-prone areas, mulching or erosion control blankets are recommended.
- Roadside ditches should not discharge directly into waterways. Run-out ditches should divert flow into the bush so the water filters through natural vegetation before entering the waterway. Construction of diversion berms in the ditch-line may form part of the off-take ditch scheme.

To prevent build-up of excessive runoff and to prevent runoff that contains sediment from directly entering the stream, long roadside ditches on slopes over 3% may require check dams, intermediate cross culverts or run-out ditches, to reduce flow velocity and volume if erosion is a problem.

Cross drainage should be installed at points where natural drainage crosses the road and run-outs can be constructed to lead the runoff into non-erodible areas, siltation ponds or sediment traps.

Line unavoidably steep interceptor or conveyance ditches with filter fabric, rock or polyethylene lining to prevent channel erosion.

Interceptor ditches may be necessary to divert water away from steep cut or fill slopes.

To ensure that drainage ditches are not blocked, side roads should be located on high ground, or entrance culverts should be installed.

5.9 Control of Deleterious Substances

Construction materials (e.g. concrete, lime, paint or preservatives) and petroleum products may be toxic to fish. Special care is required in the use of some common, but highly toxic, construction materials in and around areas of instream work.

Whenever possible, untreated wood should be used for construction in water. Cedar contains natural preservatives that resist decay.

Wood preservatives containing chemicals such as creosote, chlorophenols and zinc or copper napthanate solutions are extremely toxic to aquatic organisms. Chromated copper arsenate (CCA) treatment is recommended as the preferred wood preservative treatment. CCA treated wood has a shorter life expectancy than creosote or pentachlorophenol treated wood. Where long life spans are required, such as for bridge pilings, creosote or pentachlorophenol treated wood may be considered for use. Steel pilings provide an acceptable, though more expensive, alternative.

All paints are toxic and should be prevented from entering water courses.

Uncured concrete can kill fish by substantially altering the pH in stream water. All cast-in-place concrete should be totally isolated from flowing water for a minimum 48 hour period to allow the pH to reach neutral levels before continuing instream work. Pre-cast concrete should be used whenever applicable for the construction required.

Debris or topsoil must not be pushed into a stream or onto the ice of a stream. Debris inadvertently added to the stream must be removed with the least possible disturbance, by hand if necessary.

Camps and fuel caches associated with construction should not be located in the reservation. For developments which depend on the use of lakes for access by aircraft and include trail or road construction only as an incidental activity, temporary camps and small fuel caches may be located within the reservation. In this case, the caches must be located above the normal high water mark of the lake or stream.

Significant spills of fuels, lubricating oils or other petroleum products (Appendix C) must be reported immediately to Saskatchewan Environment and Resource Management (24 hour phone number: 1-800-667-7525) as required by the Environmental Spill Control Regulations.

Avoid washing any type of equipment or machinery in streams or lakes or on sites where wash water may enter a stream or lake.

Temporary facilities, equipment and waste construction materials should be removed and the sites reclaimed after construction is complete.

5.10 Road Maintenance

The operations carried out for road maintenance can be divided into routine operations, such as grading, snowplowing and cleaning out blocked culverts and ditches, and non-routine maintenance, such as major repairs and restoration. The level of maintenance varies depending on the amount of use, but the usefulness of a road and the productivity of the streams it crosses depends on the maintenance of the drainage system and crossing structure.

Mechanical control of brush is preferred. Where herbicides are used, a minimum reservation of 25 metres for ground spraying and 50 metres for aerial spraying should be provided between areas where herbicides are applied and the edge of streams or lakes.[3] Vegetation near the water should be controlled by hand clearing.

To minimize ground cover loss near streams, materials for roadway repairs within a reservation must be imported. Materials must not be taken from stream beds.

Materials such as oil, asphalt and tar used in road repairs must not enter streams or lakes.

Windrows of loose surface materials such as gravel should be broken at frequent intervals near stream crossings to prevent runoff from the road surface from entering streams.

Culverts in fish-bearing waters must be inspected prior to freeze-up and during break-up for any blockage by ice or debris. It is particularly important to remove blockage before spring fish migration.

Where it has been determined that fish passage is impeded by high water velocities in existing round or pipe arch culverts, these culverts may be retrofitted with baffles (refer to Section 5.5.3.2 for more information).

If beavers are active in the area, culverts should be inspected regularly. Some of the methods used to prevent blockage by beavers will also prevent fish passage and should not be used on streams with spawning runs. If beaver activity becomes a problem, the district conservation officer should be contacted.

Sediment traps and check dams should receive regular maintenance as long as they are needed.

Cut and fill slopes of approaches should be inspected for erosion and unsuccessful revegetation. Remedial measures should be taken promptly.

5.11 Decommissioning

If a road is not maintained it should be abandoned according to the following guidelines. Erosion and decay processes can gradually lead to sediment problems in the area of the stream crossing.

All stream crossing installations should be removed when decommissioning a road. Culverts should be salvaged, the channel restored, and all unstable fill material removed from the channel.

Where erosion has occurred, slopes should be contoured to a stable angle; if very steep they should be mulched, fertilized and or seeded to enable natural vegetation to establish itself.

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3 Ground spraying within 25 metres and aerial spraying within 50 metres of streams or lakes requires a permit from the Municipal Branch of Saskatchewan Environment and Resource Management.

Vehicular access to abandoned crossings should be prevented.

6.0 EROSION AND SEDIMENT CONTROL[4]

6.1 Brush Barriers

Brush barriers (shown in Fig. 5.4) filter the water runoff by reducing flow velocity and trapping sediment in the branches and limbs of the brush pile. A conservative estimate of the sediment trapping efficiency of the windrows is 75% to 85%. The brush barriers also serve to protect the fill slopes from erosion. This sediment control technique utilizes natural materials, provides immediate protection, requires no additional disturbance width, and is inexpensive. It is aesthetically acceptable in remote areas, but less acceptable in more developed areas. The material used includes logs, brush and other slash debris.

The maximum slope length upstream of a barrier should be no more than 30 metres.

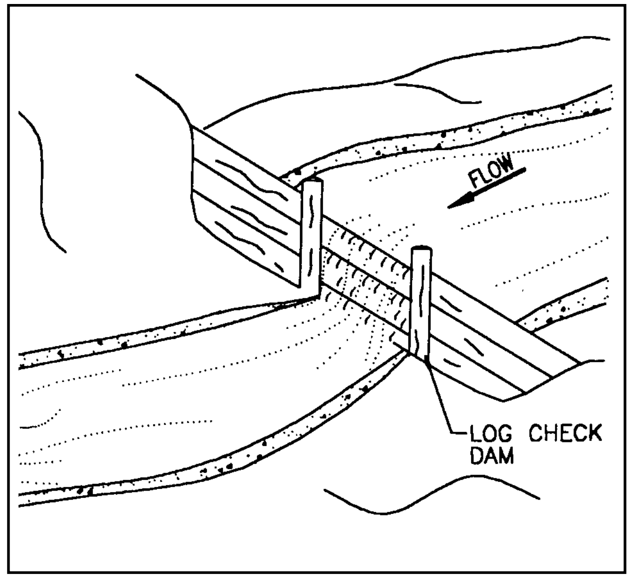
The large anchor log is placed in position at the toe of the fill, parallel to the direction of the road. It is anchored in position by placing it against stumps, rocks or trees. Stockpiled slash is then placed on the fill slope above the log. Slash debris consists of tops, limbs and brush not exceeding 150 millimetres in diameter and four metres in length. Stumps should not be included. The windrow is compacted by tamping the slash with the backhoe bucket. This produces a relatively dense windrow embedded in the fill surface. It is important that the slash be embedded to prevent flow under it.

6.2 Ditch Blocks

Ditch blocks (Fig. 6.1) are used to create a series of overflow weirs in ditches that reduce velocity, thus reducing erosion and trapping sediment. Runoff is stepped down in the sloping ditch at ditch block locations. They are constructed by placing selected material across the ditch channel perpendicular to the flow.

4 Summarized from Ontario Ministry of Natural Resources (1988) and Chillibeck et al. (1992).

Fig. 6.1 Log Ditch Blocks Used to Reduce Water Velocity in Ditches



Redrawn from Ontario Ministry of Natural Resources, 1988

They may be either temporary, until vegetation is established, or permanent. The drainage area of the ditch being protected should not exceed four hectares.

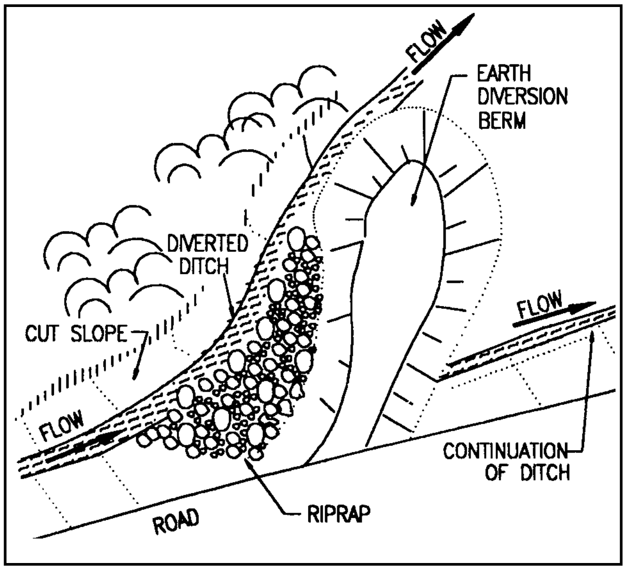
Frequent clean-out is needed for best performance. Unless properly designed and keyed at the side and bottom, erosion around the edges may occur. If the ditch block washes out, it may cause more sedimentation downstream than would have occurred if the ditch block had not been used. Ditch blocks are excellent erosion control devices, but they often fail because they are used improperly.

6.3 Forest Floor Filter

The forest floor, with its litter and vegetative material, provides a natural sediment filter at virtually any location on the downstream side of the road. Its use at water crossings prevents turbid runoff from flowing down the ditch and stream banks into the water directly. The drainage area upstream of the diversion berm should be less than two hectares.

This treatment may require construction of an earth diversion berm across the ditch line, and excavation of a channel to carry water to the edge of the right-of-way (Fig. 6.21. A diversion berm is different from a check dam because water is diverted out of the ditch and not allowed to flow over the berm. Berms should have a top width and height of at least 500 millimetres and sideslopes of 2:1 or flatter. Since the diversion berm will be redirecting flowing water, the upstream surface should be resistant to erosion from the expected flow velocities.

Fig. 6.2 Diversion Berms Used to Redirect Runoff to Forest Floor Filter



Redrawn from Ontario Ministry of Natural Resources, 1988

The length of forest floor required for effective filtering and sediment entrapment is generally recommended as 30 metres for slopes less than 15%, and up to 90 metres on steeper slopes.

6.4 Revegetation

Seeding speeds up revegetation by ensuring that sufficient seed is on the exposed soil at the end of construction. Quick revegetation will minimize erosion by providing suitable protection of mineral soil against erosion.

Revegetation normally consists of the application of grass and legume seeds, and fertilizer to provide nutrients for growth. Having a variety of species, rather than a single plant type, will increase the chances for success. Mulch will increase the odds of successful revegetation by holding the seeds in place until germination can occur. Mulches include straw, wood chips, matting and slash debris.

Fertilizer aids in the establishment of vegetation, particularly where organic soil has been removed in grubbing. The amount and type of fertilizer depends on local soil and water conditions.

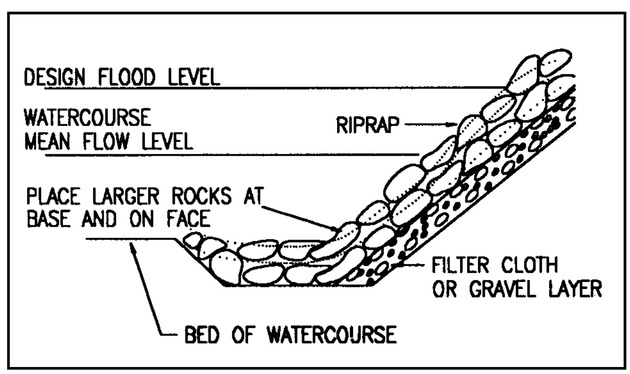
The seeds should be evenly distributed and in contact with the soil, covered with a shallow layer of soil. Low cost seeding of small areas, such as water crossings, can be done using hand broadcast seeders. Hydraulic seeding and mulching is efficient for larger areas. It is a one step process for spraying a slurry of seed, fertilizer, wood fibre mulch and water. The critical factor in hydroseeding is the ability of the fibre to adhere to the soil and hold the seed in place during rainfall and wind.

6.5 Riprap

Riprap may be used on any exposed mineral soil subjected to flowing water where the velocity of water flow, seriousness of erosion, steepness of slope, or material type, prevents satisfactory establishment of vegetative cover.

Riprap linings can be made to withstand most velocities if the proper size of rock is selected. The reduced flow velocity encourages water infiltration into the ground and vegetative growth between the riprap particles. The construction sequence would include surface grading, possible placement of filter layer (either geotextile, sand or gravel) and placement of the riprap layer (Fig. 6.3). Slopes should be shaped to a steepness no greater than 2:1.

Fig. 6.3 Riprap Used to Protect Erodible Surfaces



Redrawn from Canadian Association of Petroleum Producers, 1993

Filter layers are required if there will be groundwater emerging from the soil under the riprap layer.

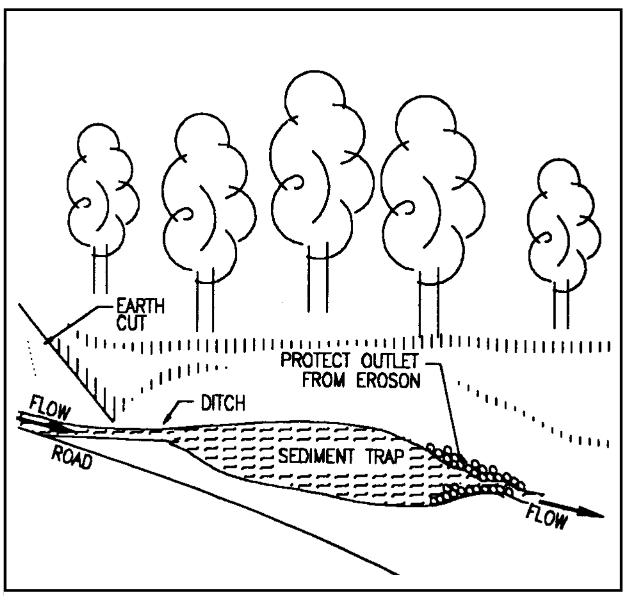
Blasted rock fragments make the most suitable riprap material because of their rough angular shape. Boulders from a borrow pit may be used, but they will tend to roll on each other and a flatter slope may be necessary. Rocks should be heavy enough to withstand expected water velocities.

The riprap material is placed by hand or by machine, usually a backhoe. It is levelled to a uniform layer thickness approximately one and a half times the median particle size. In a ditch bottom lining, the protection should extend up the sideslope and backslope above the expected high water level in flood.

6.6 Sediment Traps

Sediment traps (Fig. 6.4) are used downstream of erodible soil sites such as earth cuts, to keep sediment from flowing downstream and entering water courses. The traps reduce the flow velocity as water passes through the small pond. This allows larger suspended material, such as sand size particles, to settle out.

Fig. 6.4 Sediment Traps Used Downstream of Erodible Sites



Redrawn from Ontario Ministry of Nautral Resources, 1988

The trap should be located in natural low areas. They are effective for drainage areas less than two hectares.

The outlet end of the sediment trap should be adequately protected against erosion since it acts as an overflow weir.

Sediment traps do not eliminate all sediment and turbidity; they only remove large particle sizes. They become ineffective when filled with sediment. The trap is a temporary measure until erosion stops.

6.7 Silt Fences

Silt fences are intended for silt control during construction of the stream crossing. They are temporary devices and are not considered long term sedimentation control measures.

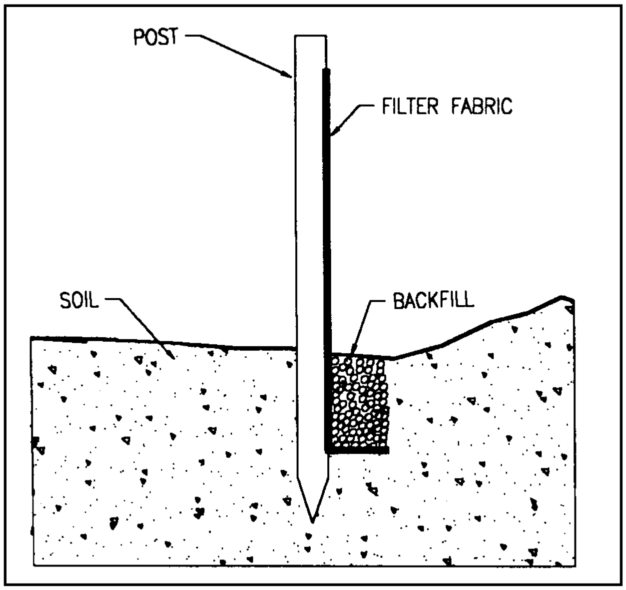
Silt fences and related structures effectively filter sediment out of sediment-laden runoff. The fine openings do not allow the passage of sediment coarser than about 0.02 millimetres. Silt fences trap the sediment close to the erosion source and prevent it from being suspended in runoff water; however silt or filter fences have a limited sediment retention capacity. They should be installed on the lower perimeter of slopes (lower 1 /3 to 1 /2 of site) and areas where the erodibility is high (shown in Fig. 5.4).

Filter fabric or geotextile may be a pervious sheet of woven polypropylene, nylon, polyester, or ethylene yarn, having the following specifications (Chilibeck et al. 1992):

- minimum filtering efficiency = 90%;
- minimum flow rate = 0.012 m^3/m^2/minute;
- minimum grab tensile strength = 700 Newtons; and
- minimum equivalent opening size = 0.15 mm (median 0.21 mm).

If standard strength filter fabric is used, it must be backed by a wire fence supported on posts not over two metres apart (Fig. 6.5). Extra strength filter fabric may be used without wire fence backing if posts are not over one metre apart. Fabric joints should be lapped at least 0.15 metres and stapled. The bottom edge should be anchored in a 0.3 metre depth trench, or some equivalent manner, to prevent flow under the fence.

Fig. 6.5 Silt Fence Installation



Redrawn from Department of Fisheries and Oceans, Newfoundland Region Fact Sheet No.6

6.8 Slope Modification

A cut or fill slope constructed too steeply will mean that the surface soil particles are inherently unstable and satisfactory revegetation would not be possible. Grade slopes, such as earth cuts and fills, should be 2:1 (two meters horizontal to one metre vertical) or flatter. Flattening a steep slope involves adding more fill, or taking out more cut material, than would otherwise be the case, to create a more stable angle. Since the type of soil affects the stability of the slope, the 2:1 slope is only a general guideline which may vary depending on factors such as soil type.

Once a stable angle is reached, there is little benefit in further flattening; this will just increase the area of soil exposed to erosion.

Changes in slope angles should be rounded in shape to reduce erosion potential and to blend with the natural landscape. Rounding is particularly important at the top of cut excavations.

Surface roughening, using special grading techniques, can reduce the amount of runoff travelling downslope, reduce flow velocity, increase infiltration, and intercept some of the sediment before it reaches the toe of the slope. Graded areas can be roughened in a variety of ways. One of the simplest is to drive a bulldozer or other tracked machine up and down the slope. This process, called track walking, leaves a pattern of tread imprints parallel to slope contours. The tread indentations are ideal for trapping seeds and encouraging plants to become established. The tracks also slow the velocity of runoff.

7.0 GLOSSARY OF TERMS

Baffles: an obstruction used for deflecting, checking or slowing fluid flow.

Bailey Bridge: a patented pre-fabricated type of bridge used since 1942 on low volume roads. A variety of bridge lengths and configurations can be assembled from standard components and the unit can be “launched” into position.

Berm: A low earth fill constructed in the path of flowing water to divert its direction, or constructed to act as a counter-weight beside the road fill to reduce the risk of foundation failure.

Cofferdam: a temporary enclosure built in a watercourse and pumped dry to permit work on bridge abutments or piers, thereby separating the work area from the water.

Design Flood Frequency: The return frequency (see ten-year flood definition) of a flood used to design a culvert or bridge.

Ditch Block: a low head dam structure constructed in a ditch in the path of flowing water to reduce erosion. Water flows over a check dam so it is provided with a spill-over section that is erosion-resistant.

Fish: “includes parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat, and juvenile stages of fish, shellfish, crustaceans and marine animals." (*Fisheries Act*, sec.2).

Fish-Bearing Stream: any stream, including an intermittent stream, that is used by migratory or resident fish at any time of the year, or has the potential for such use if stocked.

Fish Habitat: "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." (Section 34[1) of the *Fisheries Act*).

Geotextile: a recently-developed product used as a soil reinforcement agent and as a filter medium. It is made of natural or synthetic fibres manufactured in a woven or loose non-woven manner to form a blanket-like product. It is normally supplied in rolls that would cover four metres wide by 100 metres long.

Grubbing: the removal and disposal of stumps, logs and organic material overlying the mineral soil. Grubbing is done to expose the mineral soil.

Jet Velocity: Velocity of water passing between the baffles of a baffled culvert.

Lakes: a general term referring to all bodies of standing water without regard to size.

Mulching: The addition of material (usually organic) to disturbed land surfaces to curtail erosion or retain soil moisture.

Normal High Water Mark: The location on the stream bank which visibly marks the end of terrestrial vegetation and the beginning of effects due to high flows (e.g. scouring) or aquatic vegetation.

Proponent: a person, business, corporation or government body who proposes or desires to undertake a development.

Reservation: a strip of undisturbed vegetation along a stream or lake left to protect the water body from the effects of road construction on adjacent land. Reservation width is measured on each side of the stream from the top of the actual streambed bank, or on lakes from the lakeward edge of the terrestrial vegetation.

Right-of-Way: the cleared area along the road alignment which contains the roadbed, ditches, road slopes and backslopes.

Riprap: a layer of boulders or shot rock fragments placed over a soil to protect it from the erosive forces of flowing water.

Run-out (or off-take ditch): a ditch excavated to carry roadside drainage away from the roadway to a point downstream and off the right-of-way to which water will flow. In flat terrain, an off-take ditch may extend into the bush outside the right≠of-way.

Sediment Traps: temporary water retention ponds used to trap and retain sediments.

Stream: a general term referring to bodies of flowing water without regard to the volume of water transported, including intermittent and ephemeral streams.

Ten-year Flood: the maximum quantity of water flow per second expected at a particular water crossing with a 10% probability of occurring in any given year. Other return frequencies (e.g. 1:25) are defined in a similar manner.

8.0 REFERENCES

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APPENDIX A

SASKATCHEWAN REGIONAL FISHERIES BIOLOGISTS

Regional Fisheries Biologists may be contacted at the telephone and fax numbers listed below:

La Ronge
- Telephone 306-425-4576
- Fax 306-425-2580

Meadow Lake
- Telephone 306-236-7556
- Fax 306-236-7677

Melville
- Telephone 306-728-7491
- Fax 306-728-7447

Prince Albert
- Telephone 306-953-2875
- Fax 306-953-2502

Saskatoon
- Telephone 306-933-7943
- Fax 306-933-8442

Swift Current
- Telephone 306-778-8210
- Fax 306-778-8212

APPENDIX B

SASKATCHEWAN ENVIRONMENT AND RESOURCE MANAGEMENT DISTRICT OFFICES

Conservation Officers may be contacted at the telephone numbers listed below:

Assiniboia....................................306-642-7242
Battleford Prov. Park 306-386-2212
Beauval 306-288-2050
Big River 306-469-2520
Buffalo Narrows 306-235-4301
Buffalo Pound Prov. Park 306-694-3819
Candle Lake..................................306-929-4656
Carrot River 306-768-2741
Christopher Lake 306-982-2002
Creighton 306-688-8205
Cumberland House 306-888-2077
Cypress Hills Prov. Park 306-662-4411
Danielson Prov. Park 306-857-2155
Dore Lake 306-832-4503
Dorintosh 306-236-7680
Douglas Prov. Park 306-854-2177
Duck Mountan Prov. Park...............306-542-3482
Estevan 306-634-0765
Fort Qu'Appelle 306-332-3215
Glaslyn 306-342-2112
Green Lake 306-832-2044
Greenwater Lake Prov. Park 306-278-2972
Hudson Bay 306-865-2274
Humboldt 306-682-2664
Ile-a-la-Crosse 306-833-2500
Kindersley 306-463-5458
La Loch 306-822-2033
La Ronge 306-425-4234
Leader 306-628-3100
Lloydminster..................................306-825-6430
Loon Lake 306-837-2092
Lower Fishing Lakes 306-426-2622
Maple Creek..................................306-662-5434
Meadow Lake................................306-236-7557
Melfort 306-752-6214
Melville...306-728-7489
Mistatim 306-889-2161
Moose Jaw....................................306-694-3664
Moose Mountain Prov. Park 306-577-2131
Moosomin 306-435-4545
Nipawin 306-862-1790
North Battleford 306-446-7416
Pelican Narrows............................306-632-2101
Pelly...306-595-2135
Pierceland 306-839-2002
Pinehouse 306-884-2060
Preeceville 306-547-2936
Prince Albert..................................306-953-2322
Regina 306-787-2080
Rowan's Ravine Prov. Park 306-725-3013
Sandy Bay 306-754-2066
Sask Landing Prov. Park 306-375-5525
Saskatoon East 306-933-6240
Saskatoon West 306-933-6966
Shaunavon 306-297-5433
Smeaton..306-426-2611
Southend-Reindeer 306-758-2177
Spiritwood 306-883-2306
Stony Rapids 306-439-2062
Swift Current 306-778-8205
Uranium City 306-498-2134
Wadena 306-338-2452
Weyakwin......................................306-663-5620
Weyburn..306-848-2344
Wollaston Lake..............................306-633-2112
Yorkton...306-788-1463

APPENDIX C

EXCERPTS FROM THE ENVIRONMENTAL SPILL CONTROL REGULATIONS

A. Petroleum product spills to be reported under the Environmental Spill Control Regulations

Pollutant	Form, Character or Concentration	Spills to be Reported if Amounts Equal or Exceed		Time Period
		On-site (Litres)	Not On-site (Litres)	(Hours)
1. Gasoline	Liquid Liquid from above ground container Liquid from below ground container	200 500 any sub-surface loss	100	24 any period any period
2. Diesel Fuel	Liquid Liquid from above ground container Liquid from below ground container	200 500 any sub-surface loss	100	24 any period any period
3. Bunker Oils, Aviation Fuel, Jet Fuel, Kerosene, Stove Oil	Liquid Liquid from above ground container Liquid from below ground container	200 500 any sub-surface loss	100	24 any period any period
4. Lubricating Oils	Liquid	100	50	24 h
5. Asphalt	Liquid	500	100	24
6. Other Petroleum Products	Liquid	100	50	24

Notes:

1 . "On-site" means on and completely contained within the boundaries of property owner or occupied by the owner of a pollutant or the person having control of a pollutant.
2. Extracted from The Environmental Spill Control Regulations. Full reporting requirements are found only in the Regulations.