BC Ministry of Forests

Bridge Hydrologic Design Standards

November 18, 2022

1.0 General

Forest Service Road (FSR) bridges shall be designed, with consideration of climate change, to accommodate the design flood, including any floating debris or ice where applicable, without resulting in damage to the structure, approaches, abutments, downstream resources or environmental values.

This document provides a detailed discussion of ministry requirements for hydrologic design of FSR bridges.

2.0 Peak Flow Return Periods

The *Forest Planning and Practices Regulation* (FPPR) specifies details (excerpt provided below) regarding peak flow return periods that bridges and culverts are required to be designed for.

Peak flow

74 *(1) A person who builds a bridge across a stream or installs a culvert in a stream for the purpose of constructing or maintaining a road shall ensure that the bridge or culvert is designed to pass the highest peak flow of the stream that can reasonably be expected within the return periods specified below for the length of time it is anticipated the bridge or culvert will remain on the site:*

Anticipated period the bridge or culvert will remain on the site	***Peak flow return period***
For a bridge or culvert that will remain on site for up to 3 years	*10 years*
For a bridge that will remain on site from 3 to 15 years	*50 years*
For a bridge that will remain on site for over 15 years	*100 years*
For a culvert that will remain on site for over 3 years	*100 years*
For a bridge or culvert within a community watershed that will remain on site for over 3 years	*100 years*

(2) A person may build a bridge that will not conform to the requirements of subsection (1) if

(a) the bridge will pass the flow that will occur during the period the bridge remains on the site,

(b) the construction of the bridge occurs during a period of low flow, and

(c) the bridge, or a component of the bridge that is vulnerable to damage by high flow, is removed before any period of high flow begins.

(3) A person may install a culvert that will not conform to the requirements of subsection (1) if

(a) the installation is temporary and the person does not expect to subsequently install a replacement culvert at that location,

(b) the stream in which the culvert is being installed is not a fish stream,

(c) the culvert will pass the flow that will occur during the period the culvert remains on the site,

(d) the installation of the culvert occurs during a period of low flow, and

(e) the culvert is removed before any period of high flow begins.

3.0 Factors Affecting Runoff

The runoff effect of a stream depends on many factors, most of which are not readily available or easy to calculate, such as:

- Rainfall (e.g., occurrence of cloudbursts; hourly and daily maxima);
- Snowpack depth and distribution, and snow melt;
- Contributory watershed area, shape, and slope;
- Topography and aspect;
- Forest and ground cover;
- Soil and subsoil composition;
- Weather conditions;
- Harvesting and road or other upslope development or disturbance;
- Drainage pattern (stream order, branches; lakes and swamps); and
- Stream channel shape, length, cross-section, slope, and "roughness."

Because topography, soil, and climate combine in infinite variety, design the drainage for specific sites individually from available data for each site. In addition, consult those who have long experience in maintaining drainage structures in the area, as well as observing evidence of local activity/events.

4.0 Flood Discharge Design Methods

There are too many analytical and empirical methods for estimating stream discharge to be discussed at any length in this document. Professional engineers, in the course of carrying out their function as designer of a bridge or a major culvert, are ultimately responsible for establishing the design discharge for a structure.

Methodologies for determining design flood discharge include:

• Working from available evidence of flood flows of the stream in question;
• Gathering evidence of flood flows in other streams, relating these to their drainage basin characteristics, and then, by comparison to the characteristics of the basin under consideration, estimating a flood flow; and
• Relating meteorological data to stream basin characteristics and estimating flood flow through empirical methods.

Obtain the necessary data for these methodologies from various sources, such as the following four possibilities:

a) Site Information
Use site-specific data at, and adjacent to, the proposed crossing to estimate the maximum flow. Records of culverts and bridges within the vicinity that have withstood known flood events can provide useful information in the estimation of flood flows.

b) Stream Basin Characteristics
Use stream basin characteristics such as length, slope, order, roughness, vegetative characteristics, and elevation band, combined with meteorological data, in empirical approaches to determine design flood flows.

c) Data on Other Streams
Use studies done on other streams in the vicinity, with similar characteristics, to provide information on relationships and comparative values.

d) Hydrometric Records
The Water Survey of Canada publishes Surface Water Data (annual reports of readings on hydrometric stations throughout the province), as well as Historical Stream Flow Summaries in which mean values and annual peaks are tabulated. Use these stream flow records to project design flood flows from theoretical analysis.

Determining design flood discharge usually involves applying several different methods and then using judgement to select an appropriate design value. In all stream flood discharge determinations, compare the proposed opening size with historically problem-free existing stream crossings serving similar drainages in the same area.

Compare the flood discharge estimates derived from the site information with other data and theoretical derivations. Base the final selection of design discharge and resulting bridge opening or major culvert size, taking into account these comparisons together with consideration of debris potential, ice jams, and any other local factors that might influence the structure opening.

One reference that has been used in BC for design discharge determination recommends use of Table C-1. This table should be considered by professionals responsible for determining design flows for a specific site, however other methods should also be considered as appropriate, and as described in this appendix.

Table C-1 Guidelines for Selection of Methods for Estimating Design Peak Flows

(Source: *Manual of Operational Hydrology in British Columbia*, B.C. Ministry of Environment, 1988)

Drainage area (km^2)	**Availability of hydrometric data**				
		Less than 5 years		**More than 5 years**	
	None	**On site**	**Nearby watershed**	**On site**	**Nearby watershed**
<10	rational formula	unit hydrograph or model	unit hydrograph transfer or model	frequency analysis	frequency analysis
10 - 100	Regional	unit hydrograph or regional	regional	frequency analysis	frequency analysis and regional
>100	Regional	regional	regional	frequency analysis and regional	frequency analysis and regional

5.0 Determination of Bridge Soffit Elevation

For bridges not subjected to debris flows, the bridge soffit elevation should be the higher of:

- The water level corresponding to the design flood discharge under ice-free conditions, plus an allowance (typically 1.5 m unless otherwise justified) for floating debris; or
- The water/ice level caused by ice jams having a return period comparable to that of the design flood (where applicable).

6.0 Debris Flows and Ice Loading

See the Bridge Standards Manual Section 3: Loads for details.