

CHAPTER 11.0 BRIDGES

11.1 Introduction

This chapter provides design criteria and procedures to be used for bridges within the County. Bridges provide passage above a surface water drainageway and are designed to minimize disturbance to flow.

11.2 Design Criteria and Considerations

Bridge design is dependent on several factors, including the roadway classification and the debris-potential of the stream. The design storm must pass underneath the low chord of the bridge with a minimum amount of freeboard to accommodate waves, debris, and ice. Most bridge construction results in some constriction of the stream channel, creating localized changes in flow, including the potential for backwater and increased velocity. Whether a stream is in a state of deposition or erosion influences the scour potential under the bridge. The design of any bridge is site specific, and the engineer is strongly encouraged to consult with the County early in the planning process.

These Standards do not provide guidance for structural design of bridges. For structural design, the engineer is directed to the American Association of the State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges*, the Colorado Department of Transportation (CDOT) *Bridge Design Manual*, *Larimer County Urban Area Street Standards* (LCUASS) and *Larimer County Rural Area Road Standards* (LCRARS).

11.2.1 Design Events

At a minimum, bridges shall be designed to convey the same minimum design event(s) required for culverts (Table 10-1), based on the road classification/description that the bridge is located on. However, different design events may be required under one or more of the following conditions:

1. Any bridge located in or crossing a FEMA floodplain shall be designed based on the 100-year design event. Bridges constructed in a regulatory floodway must demonstrate no rise in water surface elevation, or a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR).
2. Bridges constructed within a Drainage Area of Interest may be required to meet more stringent requirements than other areas in the County. The County's Bridges and Culverts guidance document provides additional information regarding regulations for construction of crossings in Larimer County Drainage Areas of Interest. This document may be accessed on the County's website, and all technical requirements shall be met as prescribed therein.
3. Any bridge located in an adopted storm drainage basin master plan shall be designed based on design events/discharges defined in the plan.

11.2.2 Freeboard

Any bridge that must be designed to fully pass (without overtopping) the 100-year design event shall also provide freeboard between the low chord of the bridge and the energy grade line (EGL) according to the following:

1. If the 100-year design flow is less than 1,000 cfs, the freeboard shall be at least 1 foot
2. If the 100-year design flow is equal to or greater than 1,000 cfs, the freeboard shall be at least 2 feet.

11.2.3 Debris Control (Post-Fire Areas)

The engineer should consider if a new bridge may be impacted by recent wildfires in the contributing area upstream and take appropriate actions as necessary. These areas will produce higher than usual runoff rates and may also be subject to debris flows that can damage bridges. The *Debris Control Structures: Evaluation and Countermeasures* publication from the Federal Highway Administration (FHWA, 2005) provides guidance for design of debris control structures.

11.3 Design Procedures

11.3.1 Hydraulic Analysis

Guidance for performing hydraulic analysis can be found in the *Culverts and Bridges* chapter of the MHFD Manual. Additional references for bridge hydraulics include:

- Federal Highway Administration, *Hydraulic Design of Safe Bridges*, Hydraulic Design Series No. 7 (HDS-7), 2012.
- Federal Highway Administration, *River Engineering for Highway Encroachments – Highways in the River Environment*, Hydraulic Design Series No. 6 (FHWA HDS-6), December 2001.
- American Association of State Highway and Transportation Officials (AASHTO), *Highway Drainage Guidelines*, 2007. Chapter 7: Hydraulic Analysis for the Location and Design of Bridges.
- Arizona Department of Water Resources. *Design Manual for Engineering Analysis of Fluvial Systems*. March 1985.

11.3.2 Scour Analysis

Scour analysis shall be performed for all bridges to demonstrate the integrity of the structure will withstand flows in excess of the design event. All scour analysis shall be performed without the presence of riprap. Table 11-1 provides guidance for design flood frequencies to be used in scour analysis.

The following publications should be consulted for additional guidance for evaluating bridge scour and implementing countermeasures:

- Federal Highway Administration, *Evaluating Scour at Bridges*, Hydraulic Engineering Circular No. 18 (HEC-18), Fifth Edition, 2012.
- Federal Highway Administration, *Stream Stability at Highway Structures*, Hydraulic Engineering Circular No. 20 (HEC-20), Fourth Edition, 2012.
- Federal Highway Administration, *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance*, Hydraulic Engineering Circular No. 23 (HEC-23), Third Edition, 2009. Volumes 1 and 2.
- Colorado Department of Transportation, *Drainage Design Manual: Chapter 10 Bridges*, 2019.

Table 11-1. Hydraulic Design, Scour Design, and Scour Design Check Flood Frequencies (modified from HEC-18)

Hydraulic Design Flood Frequency, Q_D	Scour Design Flood Frequency, Q_S	Scour Design Check Flood Frequency, Q_C
Q_{10}	Q_{25}	Q_{50}
Q_{25}	Q_{50}	Q_{100}
Q_{50}	Q_{100}	Q_{500}
Q_{100}	Q_{500}	Q_{500}

11.4 Submittal Requirements

Submittal documents will vary based on the method and design procedures used. All submittals must include at least the following items:

- Design discharge,
- Backwater calculations,
- Elevation of low chord of bridge,
- Freeboard,
- Hydraulic analysis,
- Scour analysis (include contraction scour and local scour of piers and abutments), and
- Printouts of inputs and outputs for all computer applications.

11.5 Permits

Bridge construction may require one or more permits from the County and other organizations. The applicant shall contact the County prior to providing any submittals to determine what permits will be required. Below is a list of some of the permits that may be required for bridges.

- Building Permit – Larimer County,
- Floodplain Development Permit – Larimer County,
- Right-of-Way Work Permit – Larimer County,
- Access Permit – Larimer County,
- Private Road Construction Permit – Larimer County,

- Development Construction Permit – Larimer County,
- Land Disturbance Permit – Larimer County,
- Water Quality Permits related to stormwater management and dewatering – Colorado Department of Public Health and Environment
- Section 404 Permit – Army Corps of Engineers

11.6 References

Colorado Department of Transportation (CDOT), *Drainage Design Manual*, 2019.

Federal Highway Administration, *Debris Control Structures: Evaluation and Countermeasures*, Hydraulic Engineering Circular No. 9, (HEC-9), October 2005.