9.1 Introduction

9.1.1 Purpose of Chapter

The purpose of this chapter is to provide guidance in the hydraulic design of a stream crossing system through appropriate design practice and design criteria and technical aspects of hydraulic design. It also presents non-hydraulic factors that influence design including environmental concerns, emergency access, traffic service and consequence of catastrophic loss.

Proper hydraulic analysis and design is as vital as the structural design. Stream crossing systems should be designed for minimum cost subject to criteria, desired level of hydraulic performance, mitigation of impacts on stream environment and accomplishment of social, economic and environmental goals.

Bridges are defined as structures that transport traffic and/or pedestrians over waterways (streams, rivers, floodplains, etc.) or other obstructions. The bridge system includes the approach roadway and the bridge structure.

9.1.2 Structural Alternatives

A myriad of structure alternatives are available for use in a highway-stream crossing system when all of the possible combinations of bridge lengths, spans, pier types and orientation, geometries, parapet designs, and superstructure designs are considered. In addition, at many crossings, multiple bridges or a single bridge may be viable alternatives or large culverts may be used in lieu of one or more bridges.

The hydraulics of the highway-stream crossing system should be given considerable study in choosing the preferred design from the long list of available alternatives. **The selection should be based on a collective effort of bridge, soils and foundations, highway, and hydraulic engineers. This process is further outlined in Chapter 3, Design Development**.

9.1.3 Bridge or Culvert

Occasionally, the waterway opening(s) for a highway-stream crossing can be provided for by either culvert(s) or bridge(s). Estimates of costs and risks associated with each will indicate which structure alternative should be selected on the basis of economics. Other considerations which may influence structure-type selection are listed in Table 9-1 and discussed in subsequent sections and Chapter 8.

Table 9-1

BRIDGE OR CULVERT

Bridges	
Advantages	Disadvantages
Less susceptible to clogging with drift, ice and debris Waterway generally increases with rising water surface until water begins to submerge superstructure Flowline is flexible Minimal impact on aquatic environment and wetlands Widening does not usually affect hydraulic capacity	Require more structural maintenance than culverts Fill slopes susceptible to erosion and scour damage Piers and abutments must be designed not to fail due to scour Susceptible to ice and frost formation on deck Bridge railing and parapets hazardous as compared to recovery areas when it is possible to extend the culvert beyond the safe recovery area Deck drainage may require frequent maintenance cleanout Buoyant, drag and impact forces are hazards to bridges Susceptible to damage from stream meander migration
Culverts	
Advantages	Disadvantages
Provides an uninterrupted view of the road Roadside recovery area can be provided Grade raises and widening projects sometimes can be accommodated by extending culvert ends Require less structural maintenance than bridges Frost and ice usually do not form before other areas experience the same problems Capacity increases with stage Capacity can sometimes be increased by installing improved inlets Usually easier and quicker to build than bridges Scour is localized, more predictable and easier to control Can be used to arrest headcutting Storage can be utilized to reduce peak discharge	Silting in multiple barrel culverts may require periodic cleanout No increase in waterway as stage rises above soffit as the bottom is fixed May clog with drift, debris or ice Possible barrier to fish passage Susceptible to erosion of fill slopes and scour at outlets Susceptible to abrasion and corrosion damage Extension may reduce hydraulic capacity Inlets of flexible culverts susceptible to failure by buoyancy Rigid culverts susceptible to separation at joints Susceptible to failure by piping and/or infiltration