Selecting a Crossing Method

The flow chart in ***Figure 1.2*** outlines the general sequence in selecting a crossing method.

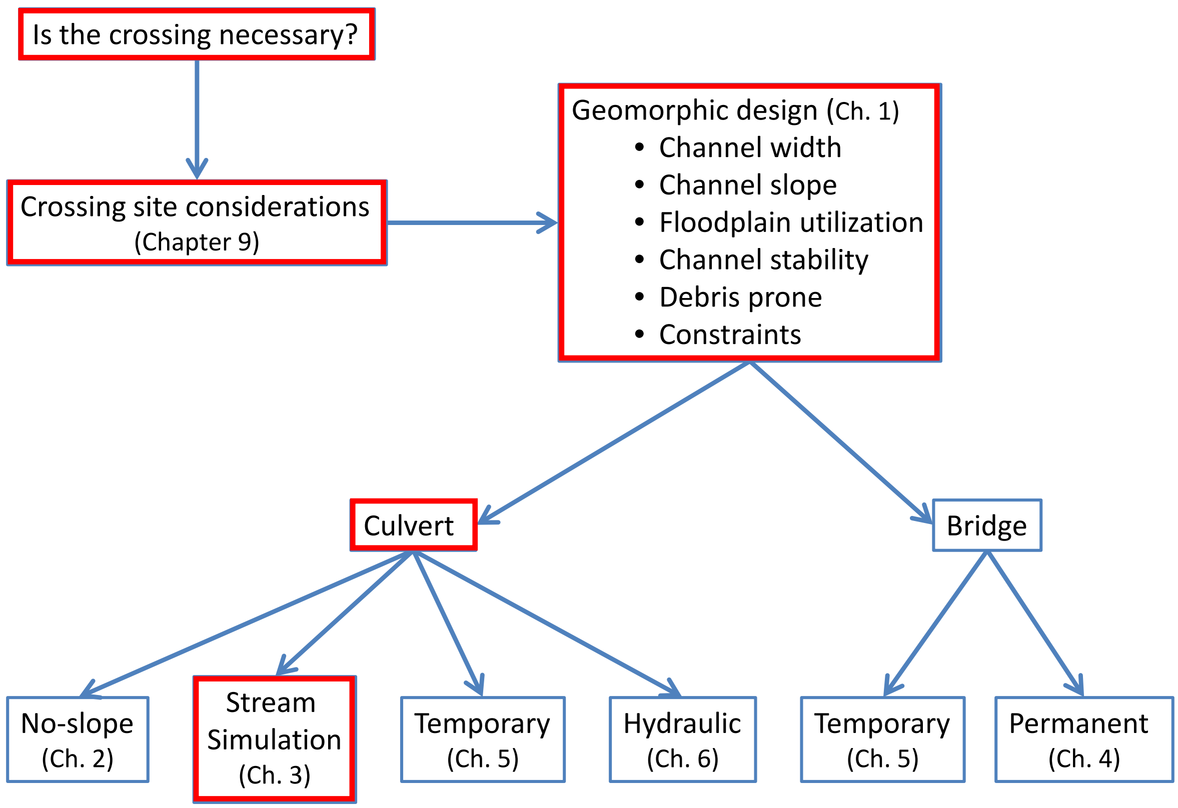


Figure 1.2: Flow chart for selecting a crossing method.

The crossing design methods at the bottom of Figure 1.2 are:

No-slope Culvert, ***Chapter 2.*** Small culverts laid on a flat grade used for small, simple installations on low gradient streams.

Stream Simulation Culvert, ***Chapter 3.*** Culverts placed at the same grade as the stream and appropriate for larger, more complex projects on low gradient streams and most projects on high gradient streams.

Bridge, *Chapter 4.* Bridges are designed to accommodate natural channel processes and provide better in-stream habitat and ecological connectivity than culverts for all streams.

Temporary Culverts or bridges, ***Chapter 5.*** Crossings in place for a short period of time, such as one time resource extraction or construction access.

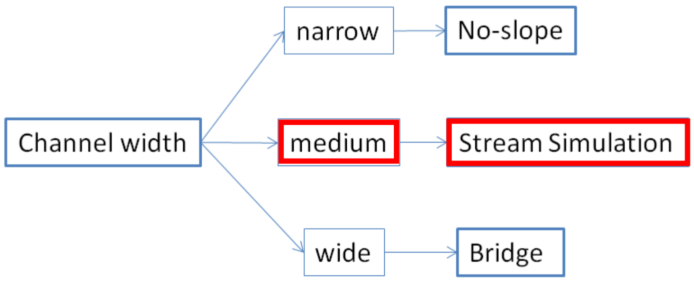
Hydraulic Design Fishways, ***Chapter 6.*** Mostly culvert retrofits, baffle design for exceptionally long culverts or retrofits, and roughened channels for culverts that exceed the maximum stream simulation slope ratio

The steps ***in Figure 1.2*** are discussed here in detail.

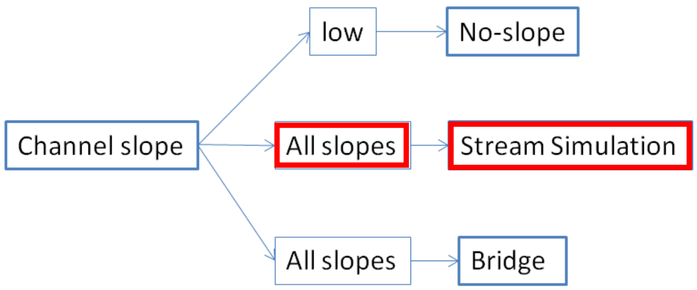
- In cases where the owner has the ability to manage the road system, abandoning and constructing roads to optimize use, cost, and impacts, they can decide whether a crossing is necessary.
- Site considerations are discussed in ***Chapter 9***. This is the point where the designer considers cumulative impacts caused by the crossing and the ways that proper planning can avoid or minimize them. Important issues are singled out here:
    - Use interdisciplinary teams to evaluate and plan crossing replacement projects
    - Cross streams by the most direct route where the stream is straight and uniform and at right angles to the natural flow of the stream
    - Avoid critical areas such as wetlands and spawning habitat
    - Avoid reaches showing signs of channel instability
    - Avoid areas that require constraining, re-aligning, or altering the natural channel
    - Design crossings to allow for natural stream processes
- The core of the selection method is based on the topics discussed in the preceding sections of this chapter. Below are criteria to assist the designer with selecting a method.
    - **Bankfull width**
        - Smalls streams, less than 10 feet[1] or so, are suitable for no-slope culverts
        - Streams between 10 and 15 feet are often crossed with stream simulation culverts.
        - Large streams over 15[2] feet usually require a bridge.
        - The width categories shown here are given as general guidelines. Site specific characteristics have a strong influence on crossing design so that a stream simulation culvert would work perfectly well on a 17 ft BFW stream. Likewise, there may be good reason not to use a no-slope culvert on a 5 ft stream.

[1] There are no unique characteristics of channels less than 10 feet which distinguish them from larger streams. This is simply a rule of thumb for a "small stream" to be used as a guide. Keep in mind that as stream width increases, often the proportion of overbank flow also increases and the size of no-slope culverts is based on the bankfull channel.

[2] Fifteen feet is used here because stream simulation culverts based on this width are 20 feet, often considered to be a "bridge."



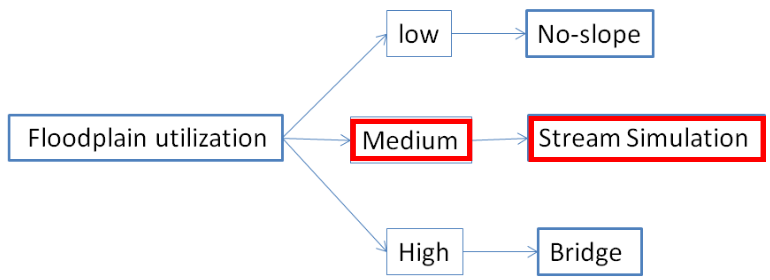
- **Slope**
  - Low slope channels < 3%; generally any crossing method can be used on these channels and other considerations, such as bankfull width, usually govern the decision.
  - Higher slope channels >3% lead away from no-slope and push the designer toward stream simulation or a bridge. The no-slope design option is recommended for channel slopes generally <3%[3] although there are situations where no-slope culverts may be acceptable for higher gradient channels.



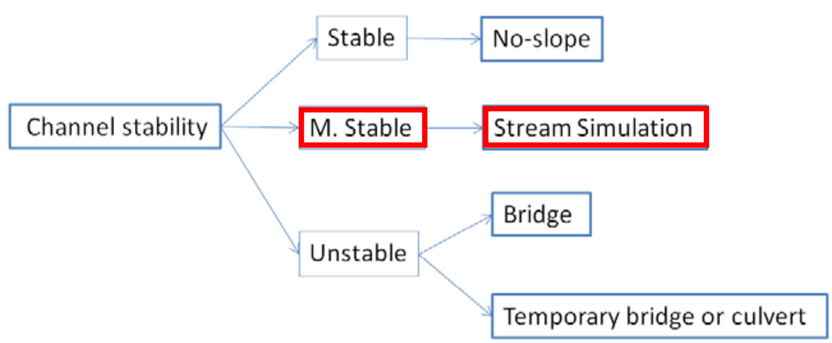
- **Floodplain utilization**
  - Floodplain utilization ratios (FUR) less than 3[4] indicate a confined channel where a culvert is better suited
  - FUR greater than 3 is an unconfined channel better suited for a bridge crossing.

[3] The "generally < 3%" recommendation gives the designer plenty of room to adapt the no-slope method to a variety of rise and length combinations. Steeper slope channels generally warrant a deeper fill and a sloped culvert (stream simulation) although low energy, stable streams that are over 3% may be appropriate for no-slope culverts.

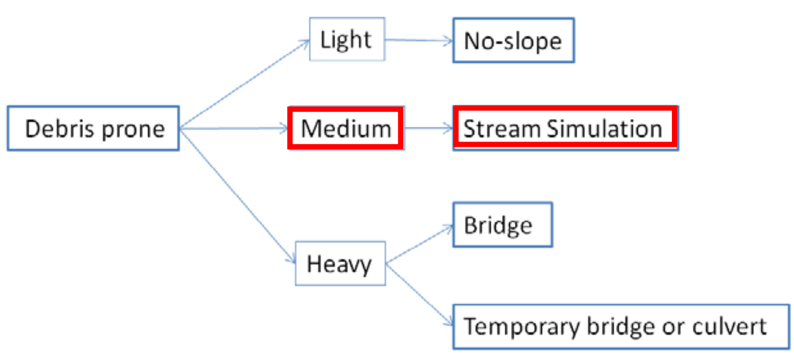
[4] FUR is on a continuum of steadily increasing floodplain width. Rosgen considered it a "well-developed floodplain" when this ratio exceeded 2.2 (Rosgen, D. L., 1994)..



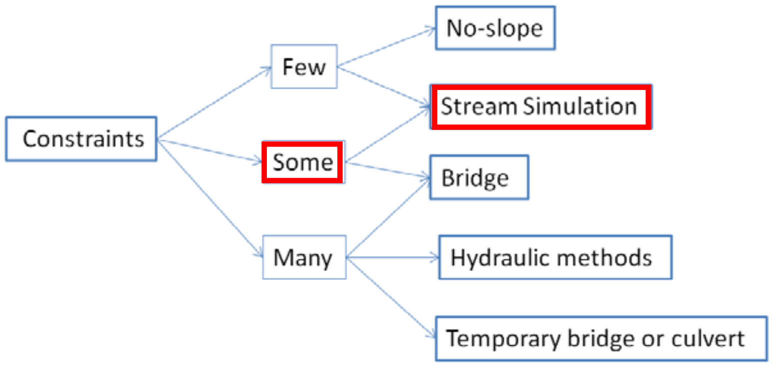
- **Unstable channel** is a channel that tends to rapidly or chronically change elevation or lateral location
  - Vertically unstable channels need a crossing design that can accommodate that change without compromising the structure, like exposing the culvert bottom or undermining a footing. In severe cases a bridge is best.
  - Horizontally unstable channels, channels that are meandering or prone to avulsion, usually require a bridge or temporary crossing.
  - The owner may want to consider moving the crossing to a new location if possible. See ***Chapter 9***.



- **Debris prone** channels commonly transport large wood and/or abundant sediment.
  - Channels that are debris prone are best crossed with a stream simulation culvert (medium amount of debris) or a bridge with high clearance between the bottom cord and the predicted flood surface.



- **Constraints** are infrastructure or land ownership issues that prevent the use of natural processes in crossing design.



There are a number of difficult sites that come up frequently. For channels with no discernable bankfull width, see ***Appendix C*** for methods to deal with this. For tidal sites, see ***Appendix D***. For roads that cross deltas or depositional areas, there are several alternatives:

- Move crossing upstream of depositional area
- Oversize the crossing to accommodate sediment deposition
- Raise crossing to allow for deposition
- Construct in-stream sediment trap

Roads that cross wetlands don't easily fit into the two culvert design methods described here for more confined channels, no-slope and stream simulation. Wetlands have unconfined channels where FUR (see page 36) is often much greater than 3. Nevertheless, culverts can sometimes serve effectively in these locations if designed appropriately. First, check to see if the wetland is artificially impounded by the road embankment, described in ***Appendix F.*** This appendix also explains an assessment process and alternatives for various conditions. If the road is built over a natural wetland, then the road crossing should provide both fish passage and ecological continuity, minimizing impacts to the channel and adjacent wetlands. A first step is to estimate channel width based on confined conditions (***Appendix C*** regression **Equation C.1**). By comparing this estimate with the measured bankfull width in the wetland, one can approximate the relative role of the floodplain wetland in the down-valley movement of flood water. If the measured width is similar to the estimated, then one would expect that the wetland is flooded but does not play significant part in the movement of water downstream. On the other hand, if the wetland channel is much smaller than the estimated bankfull width, then the wetland floodplain is part of the downstream flow and we should not use the wetland channel width for crossing size calculations. One possible solution to this problem is to use the bridge span method associated with unconfined channels (***Chapter 4***, **Floodplain and Overbank Areas**). An example using this strategy follows.

The wetland channel shown in Figure C.7 in ***Appendix C*** is 8 ft wide. The FUR is 11.9 but the wetland is heavily vegetated with saw grass. The watershed area is 0.34 square miles and the average annual rainfall is 118 inches per year. From **Equation C.1** the expected confined channel width would be from 8 to 13 feet. The range includes a 16% standard error. The measured channel width is within the range for a confined channel implying that the channel conveys the majority of the water, not the floodplain (which one would guess based on the dense vegetation). The culvert that crosses this stream was recently replaced with a deeply countersunk 9 ft culvert based on the no-slope method. This culvert is well-suited to the situation and maintains a fine gravel bed. Had the measured channel width been much less than the predicted confined width, then the culvert width would have to be increased relative to the measured channel width to accommodate the overbank flow.