Appendix E

Step by Step "Cookbook" for culverts placed flat and for embedded sunken culverts

Introduction

1. Based on monitoring and field visits the two most common solutions to provide fish passage at road crossings on Oregon forestlands at this time are placing the culvert flat or providing for natural streambed simulation by sinking and sometimes embedding a round or pipe-arch culvert. For this reason, this appendix was developed to give a step by step guide on how to use these two methods. For any forest operation a notification must be filed. If the road fill is over a fish bearing stream then a written plan must be submitted. In submitting the written plan, the Road /Stream Crossing Restoration Guide (6/8/99) must be used to develop the written plan. Before going to the added expense of doing a written plan and installing a more carefully designed crossing, check to make absolutely sure the stream is fish bearing.

Steps for the Culvert Placed Flat Option

1. Get required information about the stream at and near the location of the stream crossing

   (p. 34-37 Road/stream crossing guide). Of key interest for this design is if the stream is low gradient (less than 2.5%). Another consideration is that if the stream width at normal high water is greater than about 15 feet, a bridge may be a better option as culvert prices increase greatly as their sizes increase.

2. Design Assumptions:

   - Adequate valley fill material present to place culvert on and to countersink up to a foot or two.

   - Overall stream gradient is less than 2.5%. Placing a culvert flat for streams with slopes greater than this can be problematic and is outside the scope of the Road/Stream Crossing Restoration Guide.

3. If the gradient is low then size the culvert for the 50 year peak flow (page 54-64). Keep in mind that if you are in a wide flood plain (see page 62-63) then you can size the culvert for the 1-2 year peak flow and an overflow dip to carry the excess water. (OAR 629-625-320(3))

In sizing the culvert, the following steps must be done:

A. Determine the watershed size in square miles (p. 58)

B. Multiply the watershed size times the runoff factor from the runoff map (p. 56-57) to get the streamflow expected . Note a large scale version for the runoff map for western Oregon can be obtained from ODF state or local field offices.

C. If the culvert is to be placed flat via countersinking the inlet into the streambed then you must oversize to compensate for the degree of countersinking that will occur at the inlet (p. 60-61). You must also oversize to compensate for 8 inches of backwatering. For instance, if a culvert is 50 feet long and the stream is 2% gradient then you must counter sink one foot to place the culvert flat, plus there is the 8 inches that is needed for backwatering. This creates a loss of 12" + 8" = 20". If the culvert is a 60 inch round culvert this means that 33% of the diameter is lost to flow capacity (20"/ 60" ~ 30%) which corresponds to about a 30% loss in cross-sectional area. You must, by trial and error , check the culvert size on Table 6 (p. 57) in light of the cross-sectional area loss until you have a size equivalent to the diameter required to pass the 50 year flow. In determining the length of the culvert you can assume a side slope angle of 1.5 to one. Knowing the length is important as it helps determine the degree of countersinking which in turn is a factor in sizing.

D. This design requires a downstream weir. The weir can be made from wood or from boulders. A design diagram for boulder weirs and considerations for all weirs is given in the Road/Stream Crossing Restoration Guide (p. 51). The weir should back water up into the culvert eight inches. The top of the weir should be eight inches greater in elevation than the invert of the culvert. The total drop associated with a weir should be less than six inches for a log weir and less than one foot for a rock/boulder weir. A description of the weir(s) to be installed should be included in the written plan.

E. For installation, the culvert must be placed at or less than 0.5 %. Because of settling concerns we strongly recommend that the culvert be placed flat 0%. It is important to use a level or comparable device to insure that the bed that the culvert is placed on is indeed flat. The bed should also be stable and the under bed and haunches be compacted to prevent settling.

Steps for the Streambed Simulation using sinking and embedding option

1. Get required information about the stream at and near the location of the stream crossing (p. 34-37 Road/stream crossing guide). Of key interest for this design is if the stream is moderate gradient about 1.5-8%. If the stream width at normal high water is greater than about 15 feet, a bridge may be a better option. The cost of a large diameter culvert may approach that of a bridge. The valley fill material should be ~~is~~ of adequate depth.

2. Design Assumptions:

3. Valley fill depth is deep enough sinking the culvert into streambed.

4. Culvert will be sunk into streambed minimum 20% of culvert rise or 18 inches (whichever is greater) for pipe-arch culverts and minimum 40% of the diameter or two feet (whichever is greater) for round culverts. For box shaped culverts the pipe-arch minimums apply.

5. Overall stream gradient is less than 8%.

6. Pick a culvert whose span or diameter matches the stream channels active channel width (see p. 36-37 on how to determine widths). Note the culvert cross-sectional area, given in table 6, page 59.

7. Determine countersink depth.

   Criteria

   A. circular culverts the greater of: 0.4 times diameter, or 2 feet.

   B. pipe-arch culverts the greater of 0.2 times rise, or 18 inches.

   C. Box culverts the greater of 0.2 times width or 18 inches.

   <u>For channel slopes 0 to <=4%:</u>

   Countersink as per criteria 4a, 4b or 4c. Outlet and inlet inverts are sunk to the same depth.

   <u>For channel slopes 4 to <=8%:</u>

   Start at culvert outlet, countersink as per criteria 4a or 4b. Determine outlet invert elevation relative to some datum.

   Determine depth to countersink at inlet

   Elevation inlet invert=(culvert length) * [(channel slope-1.5%)/100] + elevation outlet invert. Note use the inlet countersunk values for calculations in step 5.

8. Calculate "effective cross sectional area" (ECSA) and the flow capacity of the culvert

   ECSA= [(Culvert cross-sectional area for chosen culvert (step 3)] * [1-(percent loss in cross sectional area/100)]

   Note: The loss in cross-sectional area is determined using Table 7 on page 61. The cross-sectional area for given culvert sizes can be found in Table 6 (p. 59) or by using equations for cross-sectional area on page 60.

   Flow capacity is then determined by comparing the cross-sectional area determined with the corresponding max flow in culvert on Table 6. For instance an 84 inch round culvert has a cross-sectional area of 38.5 ft^2 and a maximum flow 262 cfs. To determine the flow of odd sizes simply interpolate between the given cross-sectional areas.

9. Check culvert size to make sure it passes the 50 year flow:

    1. Determine the watershed size in square miles (p. 58)

    2. Multiply the watershed size times the runoff factor from the runoff map (p. 56-57) to get the streamflow expected . Note a large scale version for the runoff map for western Oregon can be obtained from ODF state or local field offices.

    3. Check to see that the effective cross-sectional area found in step 5 and its flow capacity is equal to or greater than the 50 year peak flow determined in 6b.

10. If the flow capacity of the culvert is less than the 50 year event up-size the culvert and redo steps 4-6.