Chapter Four Sunken or Embedded Culverts

Table of Contents 1

Chapter 4: Sunken or Embedded Culverts 2
Preliminary Considerations 3
Condition I- **Culverts Placed Essentially Flat or up to 0.5 % Grade** 4
Condition II- **Culverts on Grades Between 0.5% to 4%** 5
Condition III- **Culverts on Grades Greater than 4% but Not More than 8%.** 6

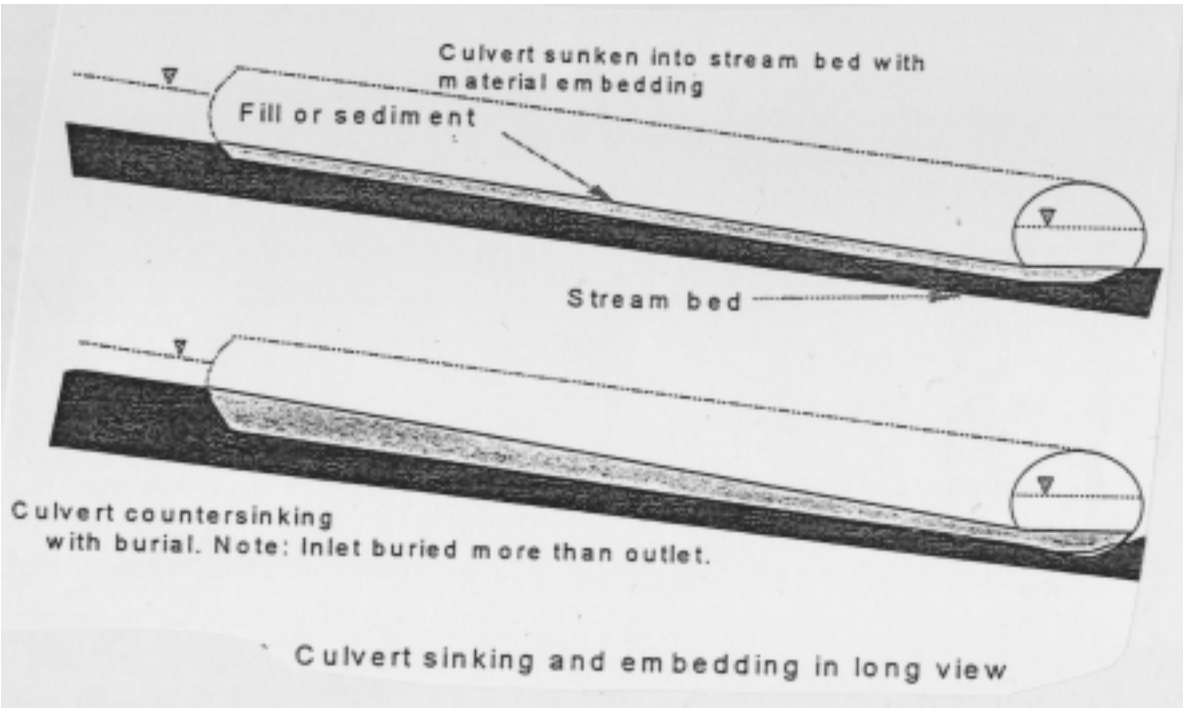
Chapter 4: Sunken or Embedded Culverts

George Robison formerly with The Oregon Dept. Of Forestry wrote a report "Road/Stream Crossing Restoration Guide." That report and a study done by Dale White are the basis for this chapter on Embedding culverts. George was involved in reviewing plans for the State of Oregon. This design is accepted for use on Forest Roads in the State of Oregon.

The following definitions were provided by George Robison in his report

> **Embedding a culvert** is to put in larger and smaller sediment in a continuous interlocking matter.
>
> **Seeding a culvert** is putting in scattered larger sized sediment in a discontinuous manner to increase roughness.

When properly installed, the culvert grade will be at the same slope as the stream with the stream sediment characteristics. For a migrating fish this would impose no changes or stress and no delay in upstream migration. Sediment transport would move through the culvert naturally and there would be no sediment buildup upstream or deprivation downstream. Because the width is similar to the stream width at the outlet there would be no flow concentration so there would be no increased scouring or damage at the outlet.



Three conditions are discussed by George in his report

a. Culverts on grades greater than 0% but less than 0.5%
b. Culverts on grades between .5% and 4%.
c. Culverts on grades between 4% and 8%

Preliminary Considerations (all designs)

1 Embedded culverts are used on low gradient crossings perhaps up to 8%. On grades greater than 5% designer the width of the structure may need to be excessive to retain substrates. Concern is that gravel will flush out during high flow events. This may not be an issue as that substrate will be replaced during lower flow events. Design calls for embedding the pipe with rocks. The use of embedding for culverts more than 5% is not very well documented at this time. In this author's opinion we need further review prior to exceeding 5%.

2. The width of the gravel or rock in the culvert should be at least the same width as the "active channel" to provide full stream simulation. If the stream is not the same width as the active channel, the velocities at the entrance are expected to be barriers to juvenile fish and other aquatic species in addition there is the potential for embedded rock to be washed out. If adult fish passage is the only issue then placing large rocks in a circular pipe appears to be an acceptable alternative design.

3. Culverts are buried deeper at the crossing then pipe arches of the same size or traditional culverts. Designer needs to check for bedrock. If bedrock is at a site it will need to be removed or another structure type selected. Installation assumes there is an adequate stream valley bottom fill available to sink the culvert into. Therefore this alternative would not work if the stream is predominately bedrock or has extremely large boulders that would prevent sinking the culvert.

5. The installer should embed the culvert with cobble-boulder sized material unless the stream is expected to fill the pipe without any embedment. As a minimum some seeding of the culvert is recommended. If the streambed near the culvert are dominated by sands and fines, there may not be adequate coarse material to make this alternative work without embedding. The only time embedding is not required by the State of Oregon are: When the channel upstream of the culvert has been incised by the newly placed culvert and plenty of material are expected to move into the culvert.

6. Circular Culverts: Sinking at inlet and outlet must comprise at least 40% of the culvert diameter or 2 feet whichever is greater.

7. Pipe Arch culverts: Sinking at inlet and outlet of at least 20% of the rise or two feet

whichever is greater.

8. Box Culverts: Sinking at the inlet 20% of the height or two feet whichever is greater. If the bottom is smooth or concrete, remedial measures may need to be taken to roughen up the bottom so it will collect bed material.

Condition I- Culverts Placed Essentially Flat or up to 0.5 % grade

1. This once was considered the best scenario for design and is the cheapest of all the alternatives. The culvert is still embedded below the stream gradient to allow substrates to build up in the pipe.

2. This option can be used on existing streams with stream gradients up to 2.5%. The inlet is buried deeper than the outlet in those conditions. Note depressing the inlet may cause degradation of the channel. Also, depressing the inlet will decrease the culvert's size, reinforcing the need to oversize the culvert, in proportion to the amount of embedment area.
3. Backwater pipes a minimum of 8 inches by sinking the outlet a minimum of 8 inches into the fill or using a downstream control weir.

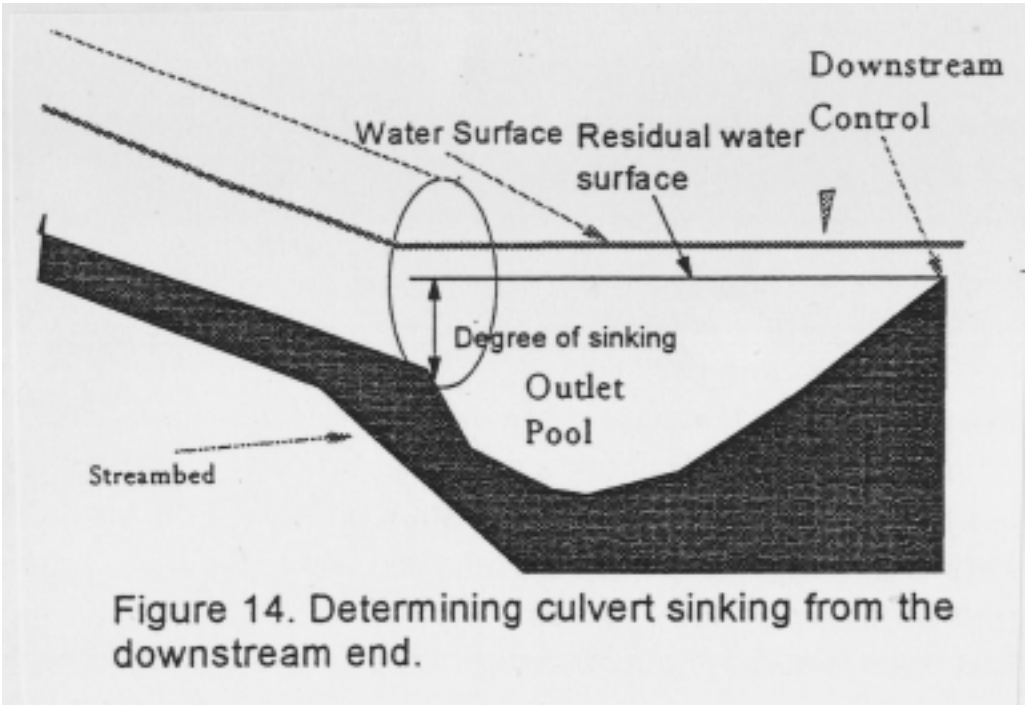


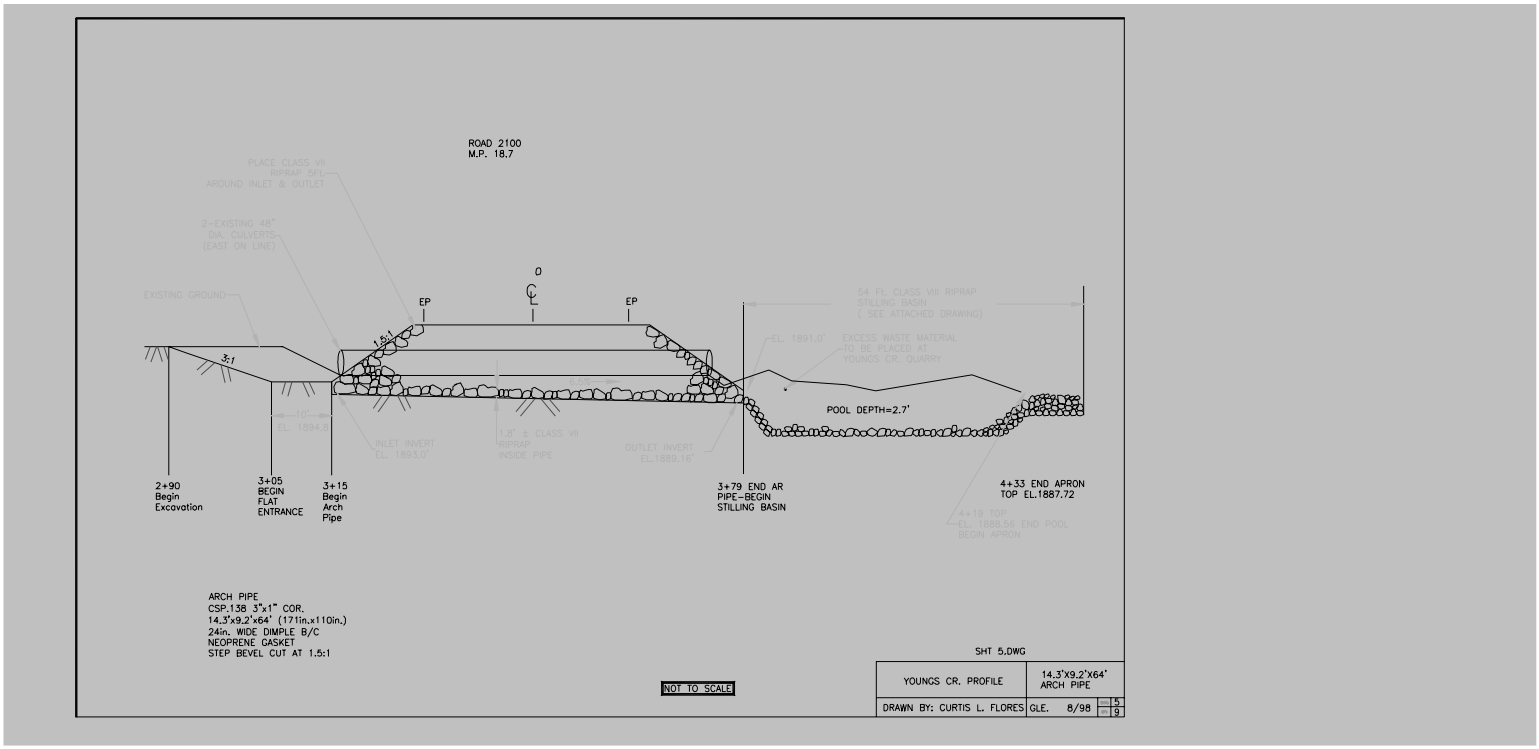
Figure 14. Determining culvert sinking from the downstream end.

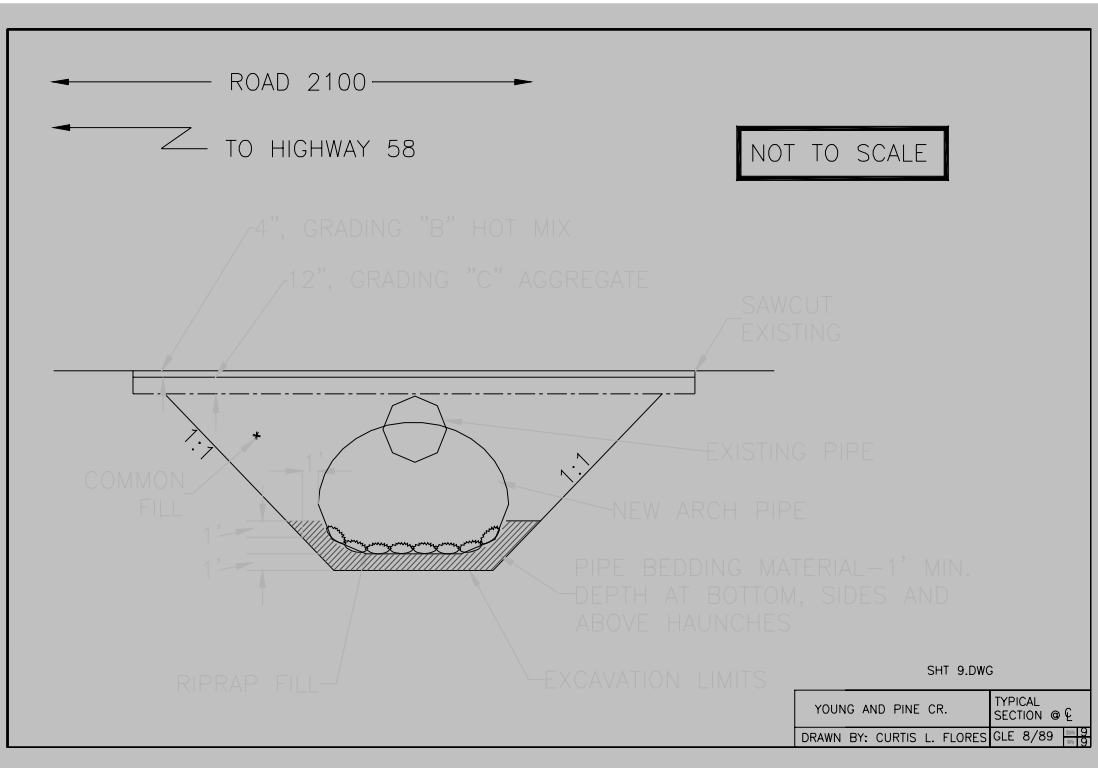
Condition II- Culverts on Grades between 0.5% to 4%

The design proposed is to sink the culvert as noted above equally at the inlet and outlet on the grade of the existing stream. The culvert width at the level of the stream should be at least equal to the active channel width if not the bankfull width.

1. Embedment can be equal at inlet and outlet.

2. Back watering can be used as an alternative to embedment. Back watering is done from a downstream control structure and should extend though the entire pipe. This is often a tricky calculation to get right and may require weir modifications in the future to fine tune to the design.
3. When designing for embedment check the capacity of the culvert for the design flow after eliminating the area taken up by the embedded material.
4. This design has worked well for grades up to 1.6% per White. See sample plans below developed on Willamette National Forest.
5. The following embedding procedure have been used or recommended.
    1. Placing a graded riprap inside the entire pipe. Size the riprap to prevent movement during the peak flow events.
    2. Seed rock in culvert assuming that natural bed load material will build up around it creating a natural substrate within the pipe.
    3. Place rock in a series of weirs in a culvert to create additional roughness and a step pool stream configuration.


ROAD 2100
M.P. 18.7
PLACE CLASS VII RIPRAP 5FT. AROUND INLET & OUTLET
2-EXISTING 48" DIA. CULVERTS (EAST ON LINE)
EXISTING GROUND
EP
EP
3:1
1.5:1
54 Ft. CLASS VIII RIPRAP STILLING BASIN (SEE ATTACHED DRAWING)
EL. 1891.0' EXCESS WASTE MATERIAL TO BE PLACED AT YOUNGS CR. QUARRY
POOL DEPTH=2.7'
EL. 1894.0'
INLET INVERT EL. 1893.0'
1.8' ± CLASS VII RIPRAP INSIDE PIPE
OUTLET INVERT EL.1889.16'
2+90 Begin Excavation
3+05 BEGIN FLAT ENTRANCE
3+15 Begin Arch Pipe
3+79 END AR PIPE-BEGIN STILLING BASIN
4+33 END APRON TOP EL.1887.72
4+19 TOP EL. 1888.56 END POOL BEGIN APRON
ARCH PIPE
CSP.138 3"x1" COR.
14.3"x9.2"x64' (171in.x110in.)
24in. WIDE DIMPLE B/C
NEOPRENE GASKET
STEP BEVEL CUT AT 1.5:1
NOT TO SCALE
SHT 5.DWG
YOUNGS CR. PROFILE
14.3'X9.2'X64' ARCH PIPE
DRAWN BY: CURTIS L. FLORES
GLE. 8/98
5
9


ROAD 2100
TO HIGHWAY 58
NOT TO SCALE
4", GRADING "B" HOT MIX
12", GRADING "C" AGGREGATE
SAWCUT EXISTING
1:1
1:1
EXISTING PIPE
COMMON FILL
NEW ARCH PIPE
1'
1'
1'
PIPE BEDDING MATERIAL-1' MIN. DEPTH AT BOTTOM, SIDES AND ABOVE HAUNCHES
RIPRAP FILL
EXCAVATION LIMITS
SHT 9.DWG
YOUNG AND PINE CR.
TYPICAL SECTION @ ℄
DRAWN BY: CURTIS L. FLORES
GLE 8/89
9
9

Condition III Culverts on Grades greater than 4% but not more than 8%.

" Countersunk Streambed Simulation Strategy": Bury the culvert deeper at the inlet-end than at the outlet-end such that the resulting culvert gradient is about 1.5 % less than the stream gradient. Lessening that gradient will help to hold substrates in the culvert.

1. Importance in design of having the culvert the proper width

2. Monitoring required may require retrofitting in future to hold substrates.