Installing a Vortex Rock Weir

On culverts assessed to have an outflow drop less than 30 cm, a vortex rock weir can be installed to increase the height of the existing plunge pool. By installing this type of structure water levels are raised in the plunge pool and the barrier outflow drop is effectively reduced or eliminated.

The size and volume of the rock weir is based upon the stream and culvert characteristics and can be calculated using data collected from the culvert assessment. To determine the volume of rock needed to build the weir, the outflow drop and the tailwater bankfull width of the barrier culvert are used in the following formula:

$$Volume = length\ x\ \frac{1}{2} width\ x\ height$$

Where:

$Volume = amount\ of\ rock\ required\ to\ build\ rock\ weir\ (m^3)$
$height = current\ outflow\ drop\ (m)$
$length = existing\ bankfull\ width\ at\ the\ current\ tailwater\ control\ (m)$
$width =$ *calculated width of the weir (using a height to base width ratio of 1:3*

$$Volume = length\ x\ \frac{1}{2} width\ x\ height$$

The size of the rocks within the weir must be able to withstand the force that water will exert upon it during Spring freshet and high flow periods. To determine the tractive force and incipient diameter the following equation is used:

$$\text{Ƭ}\ \left(\frac{\text{kg}}{m^2}\right) = Incipient\ Diameter\ (cm)$$

Where:

Ƭ = Tractive Force
$Incipient\ Diameter = 1000\ x\ d\ x\ s$
$d = average\ bankfull\ height\ at\ tailwater\ control$
$s = downstream\ channel\ slope.$

$$\text{Ƭ}\ \left(\frac{\text{kg}}{m^2}\right) = Incipient\ Diameter\ (cm)$$
$$\text{Ƭ}\ = 1000\ x\ d\ x\ s$$

Apply a safety factor of two for the rock size: For the large, flat footer stones that will make up the base of the weir, multiply the incipient diameter by four. Following CARP's methods, a vortex rock weir design was chosen to properly build-up the tailwater control of selected partial or full barrier culverts. The following tools were used:

- ☐ WAWA Permit

- ☐ Camera and GoPro
- ☐ Pencil and Notebook
- ☐ Survey Equipment (Tripod, Automatic Level, Staff)
- ☐ Measuring Tape
- ☐ Compass (GPS)
- ☐ 3 Stakes
- ☐ String

The apex or low flow notch (located at the center of the weir where water can flow during times of lower volume) has the lowest point of elevation and points upstream. The wings of the weirs were built at a 30° angle from the base of the weir (Figure 3).

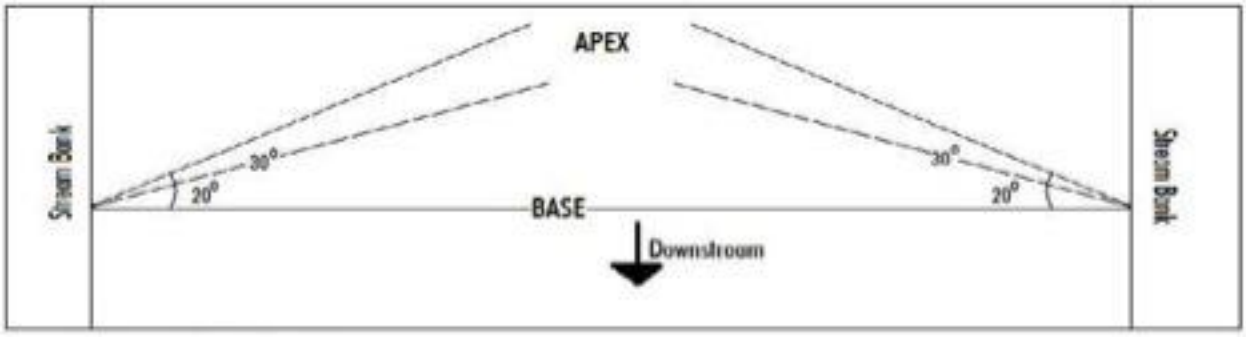

Figure 1: Vortex Rock Weir design

The large, flat stones called footer stones were used as the base layer of the weir. The remainder of the structure was built using weir stones (thicker than footer stones). Pebbles and cobbles were used as a filler. As recommended, the weir was tied 15 cm into the bank.

Table 1: Rock Weir design properties

Rock Weir Design Properties	
Rock Weir Placement	
Criteria	**Measurement**
Outflow Pool Width	2 x the culvert diameter (if multiple culverts, the sum of all diameters
Outflow Pool Length	3 x the Culvert Diameter
Recommended Pool Depth	~ 1 m
Rock Weir Dimensions	
Tie in Structure	at least 15 cm into each side of the bank
Length	Tailwater control bankfull width
Height	Outflow drop
Width	Height: Width Ratio of 1:3 (width is 3 x height)

The instructions below were followed to install rock weirs on selected partial or full barrier culverts (those with outflow drops <30 cm and/or slopes between 1-7%.

1. Before beginning construction, site photos were taken.
2. The base of the rock weir was located by measuring out the proper outflow pool length (3x culvert diameter, beginning at the culvert outflow and continuing downstream).
3. To designate the base of the rock weir, stakes were inserted at left bankfull and right bankfull. The compass, string and a third stake was then used to mark the apex of the structure, which was angled 30° upstream from the base and in the center of the stream.
4. The difference in elevation between the outflow and the streambed where the apex is located was measured and calculated using the survey equipment.
5. Weir rocks were used to build the apex higher than the outflow elevation, and if possible, as high as the inflow elevation. The survey equipment was used to verify the apex was built to the proper height.
6. With the height established, the base-width of the structure was measured and flagged off using the height:base ratio of 1:3.
7. The base area was cleared and footer stones were arranged.
8. Remembering that the apex (low-flow notch) must have the lowest elevation, the rock weir gradually became higher as it approached the stream banks. Pebbles and cobbles taken from the streambed were used as fill between larger rocks.
9. The weir was tied into the bank at least 15 cm.
10. Finally, photos of the completed rock weir were taken.

Over time, smaller rocks will be integrated into the rock weir and fortify the structure. Stream-crossing structures should be inspected and maintained on a regular basis, especially following high water flow season and large rainfall events.