maximum allowable in accordance to natural or lining type) for bends, measured along the channel centreline, is two times the top width for design flow or a minimum radius of 7.5 m for roadside collector ditches, 15 m for low-velocity outfall ditches, and 30 m for high-velocity outfall channels, whichever is greater. For other radius or for higher velocities, the flow depth superelevation for determining the freeboard elevation can be calculated using Equation 1.2.

$$\Delta d = (v^2 T)/(g R_c)$$

Equation 1.2: Flow superelevation at channel bends

Where:

Δd = superelevation of the water surface profile due to the bend (depth above the water surface on the tangent section) (m)

v = average channel velocity in tangent section (m/second)

T = top width of flow (m)

g = acceleration of gravity (9.81 m/second^2)

R_c = centreline radius of the bend (m)

14. Bends cause additional flow turbulence and eddies that increase shear forces along the outside of the bend. For bends with radiuses greater than the minimum discussed in 5, no additional erosion protection is required, other than that required for the design tangent sections. If the radius is smaller than the minimum, or velocities exceed that allowable for the natural or lining type, then rock riprap revetment protection shall be installed. Recommended longitudinal extent of protection is 1.5 times the width of channel bottom from both ends of the bend.
15. If maximum bend flow velocity is required, the calculation involves adjustment factors based on empirical data for various channel conditions and radiuses. Use the procedure in Chapter 8 of Part 654 of the NRCS National Engineering Handbook.
16. Safety provisions for open diversion and outfall channels in public areas, not otherwise fenced, require side slopes no steeper then 3h:1v (easy for people to climb out of), design velocities within the allowable velocities for bare earth channels, and where in the vehicle clear zone along highways, design depths no deeper than 1.3 m.
17. Open channels in mountainous areas may require the following additional design considerations:

    a. Steep longitudinal slopes in bedrock. Due to high velocities with supercritical flows, provide extra SF freeboard at bends, transitions, and locations of hydraulic jumps. Develop designs based on water surface profiles starting from a definable control point upstream of the design section and calculating the energy loss/surface elevations in a downstream direction.
    b. Open channels in mountainous terrain usually have high bed loads in the flow, with the higher velocities moving large quantities of gravel, cobbles, and boulders (depending on velocity) along the bottom. Estimates of the bed load types and movements need to be made, and allowances in size, inverts, and scour protection provided at structures, in particular for channels crossing the roadway through culverts and bridges.

       Culverts require specific protection, larger sizes, or thicker walls to help withstand the abrasion effects of these bed loads. If the high velocity abruptly slows at a transitional drop, widening or outlet of a structure, these bed loads will accumulate and reduce the