Culvert end treatment	Ke
Box, reinforced concrete Headwall parallel to embankment (no wing walls)	
Square-edged on three edges	0.5
Rounded on three edges to radius of D/12 or B/12, or bevelled edges on three sides	0.2
Wing walls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of D/12 or bevelled top edge	0.2
Wing walls at 10°to 25° to barrel	
Square-edged at crown	0.5
Wing walls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2
*Note: "End sections conforming to fill slope," made of either metal or concrete, are the sections commonly available. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design, have a superior hydraulic performance. These latter sections can be designed using the information given for the bevelled inlet.	

e) Calculate outlet velocities:

a. If the controlling HW is based on inlet control, determine the normal depth and velocity in the culvert barrel. Velocities at normal depths are assumed to be the outlet velocity. This can be calculated by using Manning's equation.
b. If the controlling HW is in outlet control, the outlet velocity is the flow rate divided by the cross-sectional flow area. Determine the area of flow at the outlet based on the barrel geometry and the following:

   i. Critical depth, if the TWL is below critical depth;
   ii. TWL depth, if the TWL is between critical depth and the top of the barrel; and
   iii. Height of the barrel, if the TWL is above the top of the barrel.

c. Outlet flows shall closely match the velocity of the existing channel. If they do not, an alternate culvert design that reduces the outlet velocity or uses energy dissipaters shall be considered

f) Provide embankment slope protection at inlet and outlet of culvert:

a. Install rock riprap on inlet slope to a height equal to the design HW and width of 2D on each side of the culvert opening.
b. Install rock riprap on outlet slope to a height equal to 5D above the top of the culvert and width of 1D on each side of the culver opening.

g) Provide channel erosion protection at the inlet and outlet of culvert, if required.

A5.2.2. Wadi bridges

Bridge opening hydraulics will be used to design larger box culverts and bridges across Wadi's in (Al Ain). Bridges shall be considered when design flow is large and using multiple barrel culverts is not effective, or where located in channels with high-velocity flows with