Culvert Headwater under Inlet and Outlet Control

Headwater depth of a circular culvert for a design flow under inlet control (orifice) and outlet control (full-flow losses), and which control governs.

Method: Culvert hydraulics; inlet and outlet control

Input parameters

Unit system: SI

Parameter	Value	Unit
Design flow	9,000.0	m³/h
Pipe diameter	1,200.0	mm
Culvert length	30.000	m
Culvert slope	1.0000	%
Manning roughness	0.013000	
Entrance loss coefficient	0.50000	
Inlet orifice coefficient	0.60000	
Tailwater depth above outlet invert	0.80000	m

Calculated results

Parameter	Value	Unit
Full-pipe velocity	2.2105	m/s
Headwater, inlet control	1.2920	m
Headwater, outlet control	1.3970	m
Design headwater	1.3970	m
Headwater to diameter ratio	1.1642	

Notes for this case

- Inlet control: submerged orifice at mid-height; outlet control: full flow with entrance, friction and exit losses from max(TW, D) at the outlet. The larger headwater governs. Unsubmerged inlets (HW below about 1.2D) act as weirs; use the full charts for those.
- Outlet control governs.

Formula and method

$$HW_i = \frac{Q^2}{2gC_d^2A^2} + \frac{D}{2}, \quad HW_o = \max(TW, D) + \left(1 + k_e + \frac{2gn^2L}{R^{4/3}}\right)\frac{V^2}{2g} - S_0L$$

Variables

Q	Design flow	m³/s
D	Pipe diameter	m
L	Culvert length	m
S_0	Culvert slope	-
n	Manning roughness	-
k_e	Entrance loss coefficient	-
C_d	Inlet orifice coefficient	-
TW	Tailwater depth above outlet invert	m
V	Full-pipe velocity	m/s
HW_i	Headwater, inlet control	m

HW_o	Headwater, outlet control	m
HW	Design headwater	m
HW/D	Headwater to diameter ratio	-

Method and standards

Culvert control.

Assumptions and limits

- Circular pipe; submerged inlet; steady flow.

References

Culvert hydraulics, inlet and outlet control

Report details

Report reference	FCC-D4TT-0QAW (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/civil/hydraulics/culvert-headwater-inlet-outlet

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Reopens the calculator with the inputs of this report.