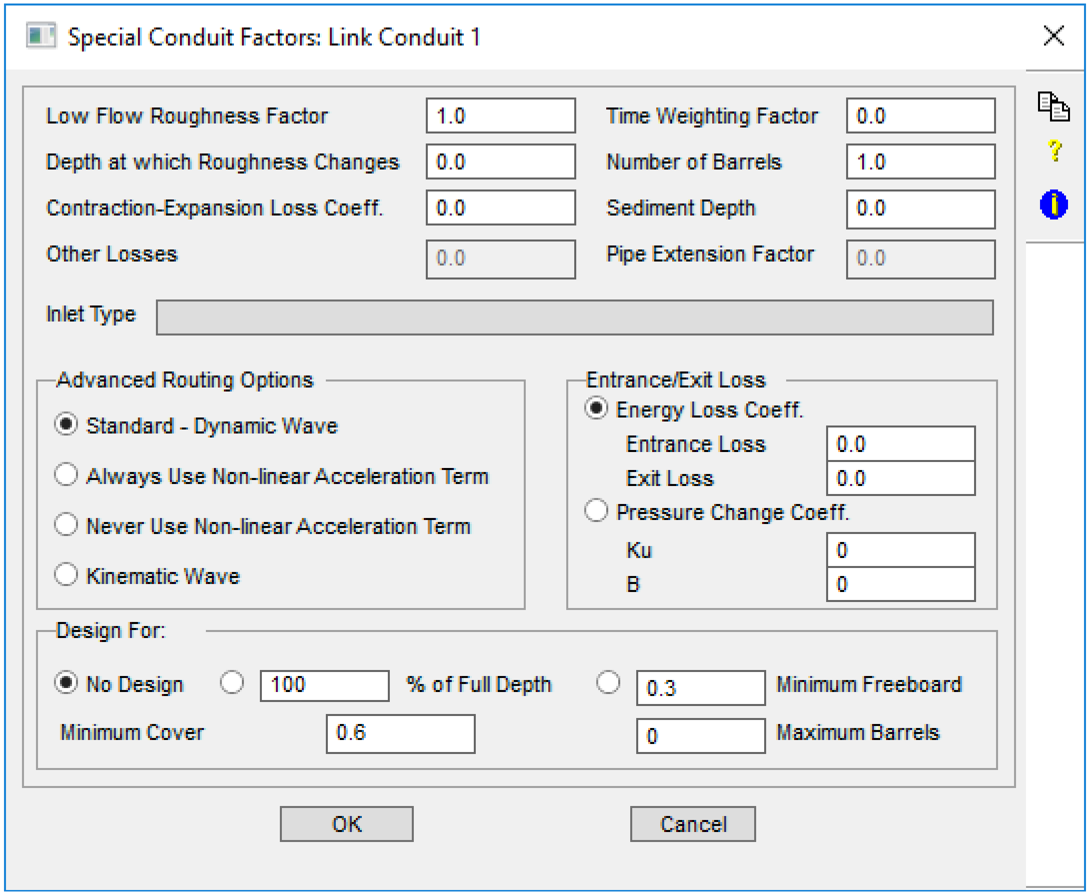
Special Conduit Factors (XPSWMM online manual printout)

Data entered in this dialog may be used to override the global Job Control Information. Information not available in a particular mode is shown greyed out.



Low Flow Roughness Factor: 1.0
Depth at which Roughness Changes: 0.0
Contraction-Expansion Loss Coeff.: 0.0
Other Losses: 0.0
Time Weighting Factor: 0.0
Number of Barrels: 1.0
Sediment Depth: 0.0
Pipe Extension Factor: 0.0
Inlet Type:

Advanced Routing Options
● Standard - Dynamic Wave
○ Always Use Non-linear Acceleration Term
○ Never Use Non-linear Acceleration Term
○ Kinematic Wave

Entrance/Exit Loss
● Energy Loss Coeff.
Entrance Loss: 0.0
Exit Loss: 0.0
○ Pressure Change Coeff.
Ku: 0
B: 0

Design For:
● No Design ○ 100 % of Full Depth ○ 0.3 Minimum Freeboard
Minimum Cover: 0.6
Maximum Barrels: 0

Note that the entrance loss is calculated for the upstream node (end of conduit with higher invert) and exit loss is calculated for the downstream node (with lower invert) regardless of flow direction.

Low Flow Roughness Factor

Multiplier for the lowest vertical roughness level, when vertical roughness discretization is being used in the model. The roughness in the lowest level is increased by the factor (Hydraulics layer only).

Depth at which Roughness Changes

The depth in the conduit at which the vertical discretization changes in the conduit. This may be 0.0 for no vertical discretization. There are only two levels of vertical roughness (Hydraulics layer only).

Contract-Expansion Loss Coefficient

The abrupt cross section shape changes from one conduit to the next creating turbulence. The loss in velocity from this change can be modeled by using a contraction/expansion loss coefficient. This coefficient is conduit specific (Hydraulics layer only).

Inlet Types (Inlet Control Theory)

Inlet Control Theory

The design equations used to develop the inlet control nomographs are based on the research conducted by the National Bureau of Standards (NBS) under the sponsorship of the Bureau of Public Roads (now the Federal Highway Administration). Seven progress reports were produced as a result of this research. Of these, the first and fourth through seventh reports dealt with the hydraulics of pipe and box culvert entrances, with and without tapered inlets (4,7 to 10) These reports were one source of the equation coefficients and exponents, along with other references and unpublished FHWA notes on the development of the nomographs. (56,57)

The two basic conditions of the inlet control depend upon whether the inlet end of the culvert is or is not submerged by the upstream headwater. If the inlet is not submerged, the inlet performs as a weir. If the inlet is submerged, the inlet performs as an orifice. Equations are available for each of the above conditions.

Between the unsubmerged and the submerged conditions there is a transition zone for which the NBS research provided by drawing a curve between and tangent to the curves defined by the unsubmerged and submerged equations. In most cases, the transition zone is the short and the curve is easily constructed.

Table I1 contains the unsubmerged and submerged inlet control design equations. Note that there are two forms of the unsubmerged equation. Form (1) is based on the specific head at critical depth, adjusted with two correction factors, Form (2) is an exponential equation similar to a weir equation. Form (1) is preferable from a theoretical standpoint, but form (2) is easier to apply and is the only documented form of equation for some of the inlet control nomographs. Either form of unsubmerged inlet control equation will produce adequate results.

Table I1: Inlet Control Design Equations.

UNSUBMERGED

Form (1)

$$\frac{HW_i}{D} = \frac{H_o}{D} + K\left[\frac{Q}{AD^{0.5}}\right] - 0.55^2$$

Form (2)

$$\frac{HW_i}{D} = K\left[\frac{Q}{AD^{0.5}}\right]^M$$

SUBMERGED

$$\frac{HW_i}{D} = c\left[\frac{Q}{AD^{0.5}}\right]^2 + Y - 0.55$$

Definitions:

HWi = Headwater depth above inlet control section invert, metres or feet

D = Interior height of culvert barrel, metres or feet

Hc = Specific height of culvert barrel, metres or feet

Q = Discharge, m3/s or ft3/s

A = Full cross sectional area of culvert barrel, metres2 or feet2

S = Culvert barrel slope m/m or ft/ft

K, M, c, Y = Constants from Inlet Nomograph Data table below

1. Equations for unsubmerged apply up to about Q/AD0.5 = 3.5
2. For mitered inlets use + 0.75 instead of – 0.55 as the slope correction factor.
3. Equation for submerged applies above about Q/AD0.5 = 4.0.

Constants for inlet control design equations

Inlet Nomograph Data

Shape and Material	Inlet Description	Equation Form	Unubmerged		Submerged	
			K	M	c	Y
Circular Concrete	Square edge w/ headwall	1	0.0098	2	0.0398	0.67
Circular Concrete	Groove end w/ headwall	1	0.0018	2	0.0292	0.74
Circular Concrete	Groove end projecting	1	0.0045	2	0.0317	0.69
Circular CMP	Headwall	1	0.0078	2	0.0379	0.69
Circular CMP	Mitered to slope	1	0.021	1.33	0.0463	0.75
Circular CMP	Projecting	1	0.034	1.5	0.0553	0.54
Circular	Beveled ring, 45° bevels	1	0.0018	2.5	0.03	0.74
Circular	Beveled ring, 33.7° bevels*	1	0.0018	2.5	0.0243	0.83

Rect. Box Concrete	30° to 75° wingwall flares	1	0.026	1	0.0347	0.81
Rect. Box Concrete	90° and 15° wingwall flares	1	0.061	0.75	0.04	0.8
Rect. Box Concrete	0° wingwall flares	1	0.061	0.75	0.0423	0.82
Rect. Box Concrete	45° wingwall flare d = .043D	2	0.51	0.667	0.0309	0.8
Rect. Box Concrete	18° to 33.7° wingwall flare d = .083D	2	0.486	0.667	0.0249	0.83
Rect. Box Concrete	90° headwall w/3/4" chamfers	2	0.515	0.667	0.0375	0.79
Rect. Box Concrete	90° headwall w/45° bevels	2	0.495	0.667	0.0314	0.82
Rect. Box Concrete	90° headwall w/33.7° bevels	2	0.486	0.667	0.0252	0.865
Rect. Box Concrete	3/4" chamfers; 45° skewed headwall	2	0.545	0.667	0.04505	0.73
Rect. Box Concrete	3/4" chamfers; 30° skewed headwall	2	0.533	0.667	0.0425	0.705
Rect. Box Concrete	3/4" chamfers; 15° skewed headwall	2	0.522	0.667	0.0402	0.68
Rect. Box Concrete	45° bevels; 10°-45° skewed headwall	2	0.498	0.667	0.0327	0.75
Rect. Box 3/4" chamf. Conc.	45° non-offset wingwall flares	2	0.497	0.667	0.0339	0.803
Rect. Box 3/4" chamf. Conc.	18.4° non-offset wingwall flares	2	0.493	0.667	0.0361	0.806
Rect. Box 3/4" chamf. Conc.	18.4° non-offset wingwall flares 30° skewed barrel	2	0.495	0.667	0.0386	0.71
Rec. Box Top Bev. Conc.	45° wingwall flares - offset	2	0.497	0.667	0.0302	0.835
Rec. Box Top Bev. Conc.	33.7° wingwall flares - offset	2	0.495	0.667	0.0252	0.881
Rec. Box Top Bev. Conc.	18.4° wingwall flares - offset	2	0.493	0.667	0.0227	0.887

Circular	Smooth tapered inlet throat	2	0.534	0.555	0.0196	0.9
Circular	Rough tapered inlet throat	2	0.519	0.64	0.021	0.9
Elliptical Face	Tapered inlet - beveled edges	2	0.536	0.622	0.0368	0.83
Elliptical Face	Tapered inlet - square edges	2	0.5035	0.719	0.0478	0.8
Elliptical Face	Tapered inlet - thin edge projecting	2	0.547	0.8	0.0598	0.75
Rectangular Concrete	Tapered inlet throat	2	0.475	0.667	0.0179	0.97
Rectangular Concrete	Side tapered - less favorable edges	2	0.56	0.667	0.0446	0.85
Rectangular Concrete	Side tapered - more favorable edges	2	0.56	0.667	0.0378	0.87
Rectangular Concrete	Slope tapered - less favorable edges	2	0.5	0.667	0.0446	0.65
Rectangular Concrete	Slope tapered - more favorable edges	2	0.5	0.667	0.0378	0.71

Constants for Inlet Control Equations for Discontinued Charts (FHWA - Hydraulic Design Series Number 5)

Shape and Material	Inlet Configuration	Equation Form	Unsubmerged		Submerged	
			K	M	c	Y
Boxes CM	90° headwall	1	0.0083	2	0.0379	0.69
Boxes CM	Thick wall projecting	1	0.0145	1.75	0.0419	0.64
Boxes CM	Thin wall projecting	1	0.034	1.5	0.0496	0.57
Horizontal Ellipse Concrete	Square edge w/ headwall	1	0.01	2	0.0398	0.67

Horizontal Ellipse Concrete	Groove end w/ headwall	1	0.0018	2.5	0.0292	0.74
Horizontal Ellipse Concrete	Groove end projecting	1	0.0045	2	0.0317	0.69
Vertical Ellipse Concrete	Square edge w/ headwall	1	0.01	2	0.0398	0.67
Vertical Ellipse Concrete	Groove end w/ headwall	1	0.0018	2.5	0.0292	0.74
Vertical Ellipse Concrete	Groove end projecting	1	0.0095	2	0.0317	0.69
Pipe Arch 18" Corner radius CM	90° headwall	1	0.0083	2	0.0379	0.69
Pipe Arch 18" Corner radius CM	Mitered to slope	1	0.03	1	0.0463	0.75
Pipe Arch 18" Corner radius CM	Projecting	1	0.034	1.5	0.0496	0.57
Pipe Arch 18" Corner radius CM	Projecting	1	0.03	1.5	0.0496	0.57
Pipe Arch 18" Corner radius CM	No Bevels	1	0.0088	2	0.0368	0.68
Pipe Arch 18" Corner radius CM	33.7° Bevels	1	0.003	2	0.0269	0.77
Pipe Arch 31" Corner radius CM	Projecting	1	0.03	1.5	0.0496	0.57
Pipe Arch 31" Corner radius CM	No Bevels	1	0.0088	2	0.0368	0.68
Pipe Arch 31" Corner radius CM	33.7° Bevels	1	0.003	2	0.0269	0.77
Arch CM	90° headwall	1	0.0083	2	0.0379	0.69
Arch CM	Mitered to slope	1	0.03	1	0.0463	0.75
Arch CM	Thin wall projecting	1	0.034	1.5	0.0496	0.57

The HDS-5 document can be viewed at https://www.fhwa.dot.gov/engineering/hydraulics/pubs/12026/hif12026.pdf.

Constants for Inlet Control Equations for South Dakota Concrete Box (Refer to HY-8 User Manual and Table 11 of FHWA 2006)

Wingwall Flare	Top Bevel	Top Radius	Corner Fillet	RCB Inlet Configuration	Equation Form	Unsubmerged		Submerged	Submerged
						K	M	c	Y
30°	45°	-	-	Single barrel	2	0.44	0.74	0.04	0.48
30°	45°	-	6"	Multiple barrel (2, 3, and 4 cells)	2	0.47	0.68	0.04	0.62
30°	45°	-	-	Single barrel (2:1 to 4:1 span-to-rise ratio)	2	0.48	0.65	0.041	0.57
30°	45°	-	-	Multiple barrels (15°skewed headwall)	2	0.69	0.49	0.029	0.95
30°	45°	-	-	Multiple barrels (30° to 45° skewed headwall)	2	0.69	0.49	0.027	1.02
0°	none	-	-	Single barrel, top edge 90°	2	0.55	0.64	0.047	0.55
0°	45°	-	6"	Single barrel, (0 and 6-inch corner fillets)	2	0.56	0.62	0.045	0.55
0°	45°	-	6"	Multiple barrels (2, 3, and 4 cells)	2	0.55	0.59	0.038	0.69
0°	45°	-	-	Single barrels 2:1 to 4:1 span-to-rise ratio)	2	0.61	0.57	0.041	0.67
0°	-	8"	6"	Single barrel (0 and 6-inch fillets)	2	0.56	0.62	0.038	0.67

0°	-	8"	12"	Single barrel (12-inch corner fillets)	2	0.56	0.62	0.038	0.67
0°	-	8"	12"	Multiple barrels (2, 3, and 4 cells)	2	0.55	0.6	0.023	0.96
0°	-	8"	12"	Single barrel (2:1 to 4:1 span-to-rise ratio)	2	0.61	0.57	0.033	0.79

Constants for Inlet Control Equations for Concrete Open-Bottom Arch (Chase 1999)

Span to Rise	Wingwall Flare	Top Edge	Inlet Configuration	Equation Form	Unsubmerged		Submerged	
					K	M	c	Y
2:1	0°	90°	Mitered to conform to slope	2	0.44	0.74	0.04	0.48
2:1	45°	90°	Headwall with wingwalls	2	0.47	0.68	0.04	0.62
2:1	90°	90°	Headwall	2	0.48	0.65	0.041	0.57
4:1	0°	90°	Mitered to conform to slope	2	0.69	0.49	0.029	0.95
4:1	45°	90°	Headwall with wingwalls	2	0.69	0.49	0.027	1.02
4:1	90°	90°	Headwall	2	0.56	0.62	0.045	0.55

The 2:1 constants above are used for ratios less than or equal to 3:1 and the 4:1 constants for ratios greater than 3:1

Constants for Inlet Control Equations for Embedded Circular Shapes (NCHRP 15-24)

Embedded	Top Edge	Inlet Configuration	Unsubmerged				Submerged	
			K Form 1	M Form 1	K Form 2	M Form 2	c	Y
0.2D	thin	Projecting End, Ponded	0.086	0.58	0.4293	0.64	0.0303	0.58
0.2D	thin	Projecting End, Channelized	0.0737	0.45	0.4175	0.62	0.025	0.63
0.2D	--	Mitered End 1.5H:1V	0.0431	0.58	0.4002	0.63	0.0235	0.61
0.2D	90°	Square Headwall	0.0566	0.44	0.4001	0.63	0.0198	0.69
0.2D	45°	Beveled End	0.0292	0.57	0.3869	0.63	0.0161	0.73
0.4D	thin	Projecting End, Ponded	0.084	0.76	0.4706	0.69	0.0453	0.69
0.4D	thin	Projecting End, Channelized	0.0927	0.59	0.4789	0.66	0.0441	0.52
0.4D	--	Mitered End 1.5H:1V	0.0317	0.77	0.4185	0.68	0.0363	0.65
0.4D	90°	Square Headwall	0.049	0.71	0.4354	0.68	0.0332	0.67
0.4D	45°	Beveled End	0.0358	0.62	0.4223	0.67	0.0245	0.75
0.5D	thin	Projecting End, Ponded	0.1057	0.69	0.4955	0.71	0.0606	0.54
0.5D	thin	Projecting End, Channelized	0.1055	0.59	0.4955	0.69	0.057	0.48
0.5D	--	Mitered End 1.5H:1V	0.0351	0.59	0.4419	0.68	0.0504	0.44
0.5D	90°	Square Headwall	0.0595	0.59	0.0595	0.59	0.0402	0.65
0.5D	45°	Beveled End	0.0464	0.46	0.4364	0.69	0.0324	0.67

Constants for Inlet Control Equations for Embedded Elliptical Shape (NCHRP 15-24)

Embedded	Top Edge	Inlet Configuration	Unsubmerged				Submerged	
			K Form1	M Form 1	K Form 2	M Form 2	c	Y
0.5D	thin	Projecting End, Ponded	0.1231	0.51	0.5261	0.65	0.0643	0.5
0.5D	thin	Projecting End, Channelized	0.0928	0.54	0.4937	0.67	0.0649	0.12
0.5D	--	Mitered End 1.5H:1V	0.0599	0.6	0.482	0.67	0.0541	0.5
0.5D	90°	Square Headwall	0.0819	0.45	0.4867	0.66	0.0431	0.61
0.5D	45°	Beveled End	0.0551	0.52	0.4663	0.63	0.0318	0.68

Conduit Time Weighting

The implicit time weighting for this conduit alone. This replaces the global time weight parameter. Typically, this parameter should have a value between 0.55 and 1.0. This parameter is used to decrease the oscillations in “hunting and seeking” mode (Hydraulics layer only).

Number of Barrels

Number of barrels for this conduit. This parameter is used to model multiple culverts as one computational link. This increases the numerical stability of the model by substituting a single computational link for multiple computational links. The total flow in the conduit is Q*Number of barrels, where Q is the flow in the single computational link. The default is one barrel. Non integer values can be used. For example, a value of 1.9 might represent the effective flow of 2 conduit barells.

Sediment Depth

The sediment depth represents a restriction in the conduit and changes the hydraulic properties of the conduit based on the amount of silt buildup.

Pipe Extension Factor

Lengthening a conduit can also mimic minor losses. This field holds a multiplier to be used on the conduit length. The additional friction losses from this added length should equal the expected minor losses from bends, misalignment and entrance/exit losses. This field has been added for compatibility with imports from Hillsborough County SWMM. This coefficient is both conduit and layer specific (Hydraulics Mode (HDR) only). It currently does not have any computational effect.

Design Undersized Conduits

This flag controls whether a conduit will be resized automatically by the model if it has insufficient flow carrying capacity. When a surcharge condition is encountered (flow exceeds full flow capacity), the conduit is increased in size in fixed increments of diameter (for circular pipes, or width for rectangular conduits), until capacity exists to accept the flow. Conduits that are neither circular nor rectangular will be converted to circular if they need to be resized. A message is printed indicating the resizing, and a table of final conduit dimension is printed at the end of the simulation.

The design operation will effectively eliminate surcharging but will also minimize in-system storage within manholes, etc. The net effect is to increase hydrograph peaks at the downstream end of the system. This can create a conflict between controls aimed at curing in-system hydraulic problems, and controls aimed at pollution abatement procedures at the outfall that make use of in-system storage.

Design parameters include: Percent of Full [conduit] Depth (%), Minimum Freeboard (ft, m), Minimum Cover (ft, m) and Maximum number of Barrels [i.e. duplicate conduits]

Advanced Routing Options

By default the Hydraulics layer uses the widely accepted procedure of ignoring the Non-linear acceleration term in the St Venant equation (or simply using normal flow) when the flow becomes super-critical. However, this approach is not always valid. This flag should be enabled when there is an abrupt change in area between adjacent conduits or when the friction slope approaches zero. Refer to the discussion in the SWMM theory Section for further information (Hydraulics layer only).

Entrance/Exit Loss

Energy Loss Coefficient. The Entrance and Exit Loss Coefficients are the multipliers of the squared velocity ($k*V^2/2g$) applied to entrance and exit of the conduit. The loss is actually modelled in the conduit momentum equation since only a continuity equation is used at the junctions. This coefficient is both conduit and layer specific (Hydraulics layer (HDR) only).

Pressure Change Coefficient. The Pressure Change Coefficient (Ku) is converted to and Energy Loss and modelled using the conduit Momentum equation as follows:

B = Vu/Vo *where Vu and Vo are upstream and downstream velocities respectively.*

K′ = Ku – 1 + $\mathbf{B^2}$ *where K′ is the equivalent energy loss*

Other Losses

This field allows the inclusion of additional loss coefficients as the multipliers of the squared velocity (k*V^^{2}/2g) applied to the of the conduit. The loss is actually modelled in the conduit momentum equation since only a continuity equation is used at the junctions. This coefficient is both conduit and layer specific (Hydraulics layer (HDR) only). This field is for compatibilty when importing Hillsborough County SWMM and plays no hydrulic role currently.

Pipe Extension Factor

Lengthening a conduit can also mimic minor losses. This field holds a multiplier to be used on the conduit length. The additional friction losses from this added length should equal the expected minor losses from bends, misalignment and entrance/exit losses. This field has been added for compatibility with developments in EPA SWMM. This coefficient is both conduit and layer specific (Hydraulics Mode (HDR) only).