BENEFITS OF HEADWALL WITH WEHOLITE PIPE

TECHNICAL BULLETIN

OBJECTIVE:

The objective of this Technical Bulletin (TB) is to demonstrate the benefits of a ‘headwall’ with Weholite pipe in submerged inlet operating conditions. The head-discharge curve for Weholite pipe with a ‘projecting at inlet’ end, has been compared with the curve for the same pipe but with a ‘headwall’. This TB concludes that the ‘headwall’ increases the flow capacity in a Weholite culvert pipe.

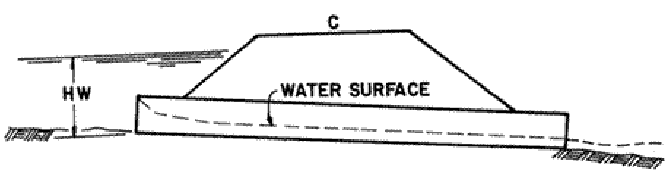
INTRODUCTION:

The primary purpose of a culvert is to convey run-off from one side of embankment to the other. Flow through a culvert is either inlet or outlet controlled. The hydraulic capacity of a culvert depends upon a different combination of factors for each type of control as shown in the FHWA HDS-5 Table 1.1.

Factor	Inlet Control	Outlet Control
Headwater	X	X
Area	X	X
Shape	X	X
Inlet Configuration	X	X
Barrel Roughness	--	X
Barrel Length	--	X
Barrel Slope	X	X
Tailwater	--	X
Note: For inlet control the area and shape factors relate to the inlet area and shape. For outlet control they relate to the barrel area and shape.		

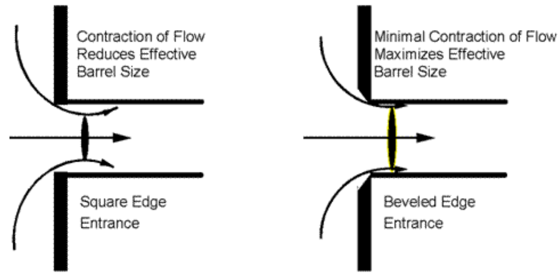
Factors influencing culvert design (from FHWA HDS-5)

The figure below illustrates typical inlet control conditions. The inlet end is submerged and the outlet end flows freely. Flow approaches normal depth at the downstream end.



Typical Inlet Control (from FHWA HDS-5)

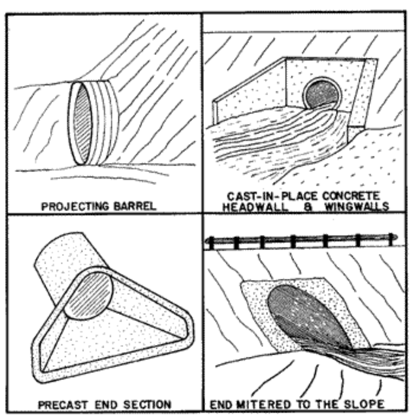
The capacity of an existing culvert operating under inlet control can be increased by providing a more efficient inlet to reduce the flow contraction at the entrance and increase the flow depth (and flow rate) in the barrel.



Entrance contraction (from FHWA HDS-5)

When existing culverts reach the end of their useful service life, the slip-lining culvert rehabilitation technique represents a cost effective alternative to culvert replacement. In order to minimize the loss of flow capacity, the slip-liner pipe can be fitted with an improved inlet headwall.

According to FHWA '*Hydraulic Design of Culverts'* commonly used inlet configurations include projecting ends, headwalls with wing-walls and prefabricated end sections. Since the headwall is curved, it gently redirects the flow into the culvert pipe. Uponor Infra regards the design to be most appropriately modeled using the Oregon Department of Transportation (ODOT) developed curves for prefabricated end sections.



Four standard inlet types

(from FHWA HDS-5)

Weholite Headwall

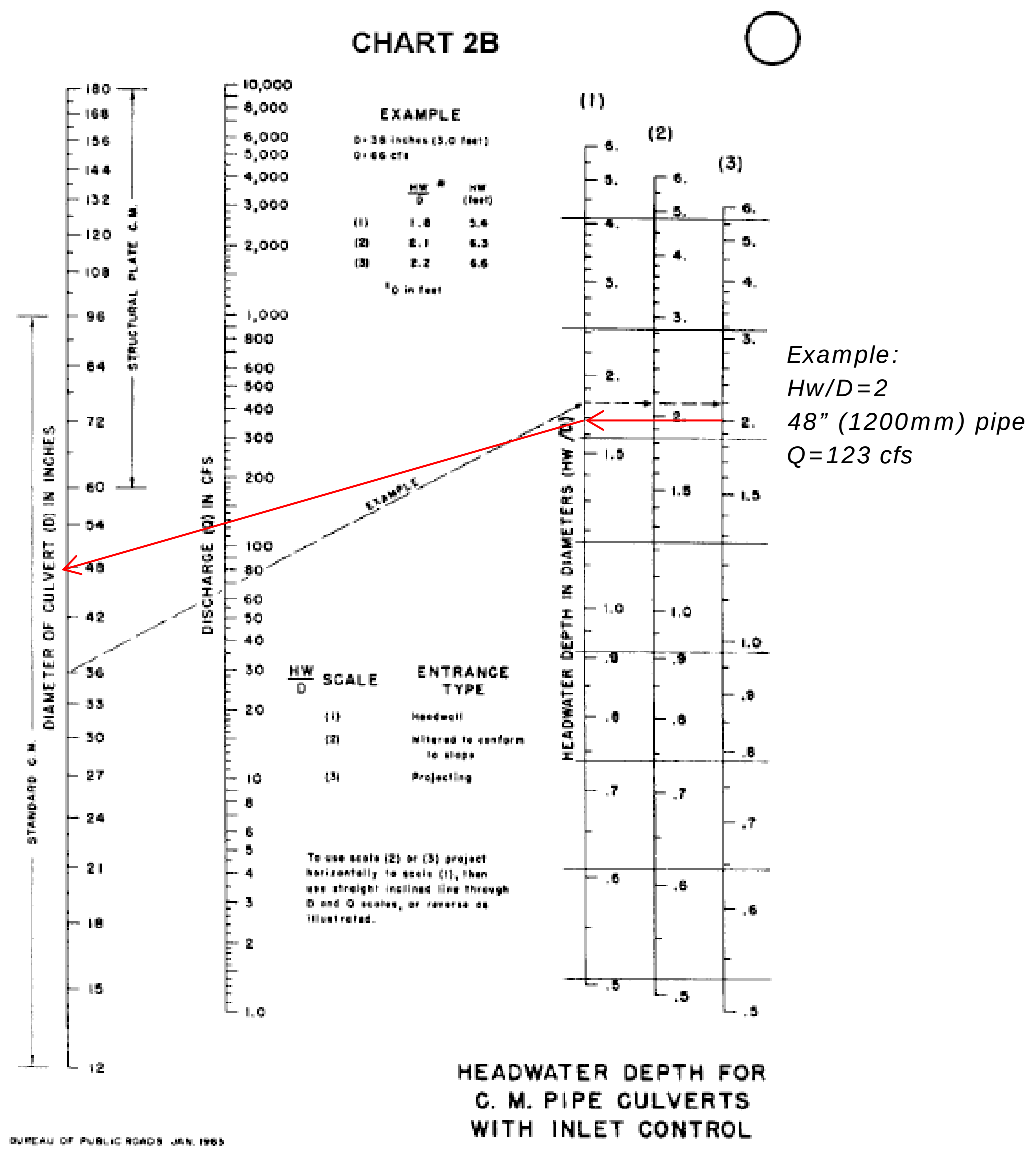
Weholite headwalls are made of lightweight material and are intended for use with Weholite culverts (both direct bury and reline). They provide embankment stability, and increase the efficiency of the inlet.

INLET CONTROL NOMOGRAPHS:

The Division of Hydraulic Research, Bureau of Public Roads developed nomographs for determining culvert capacity. Nomographs are available in FHWA Hydraulic Design Series No.5 *‘ Hydraulic Design of Culverts* ‘.

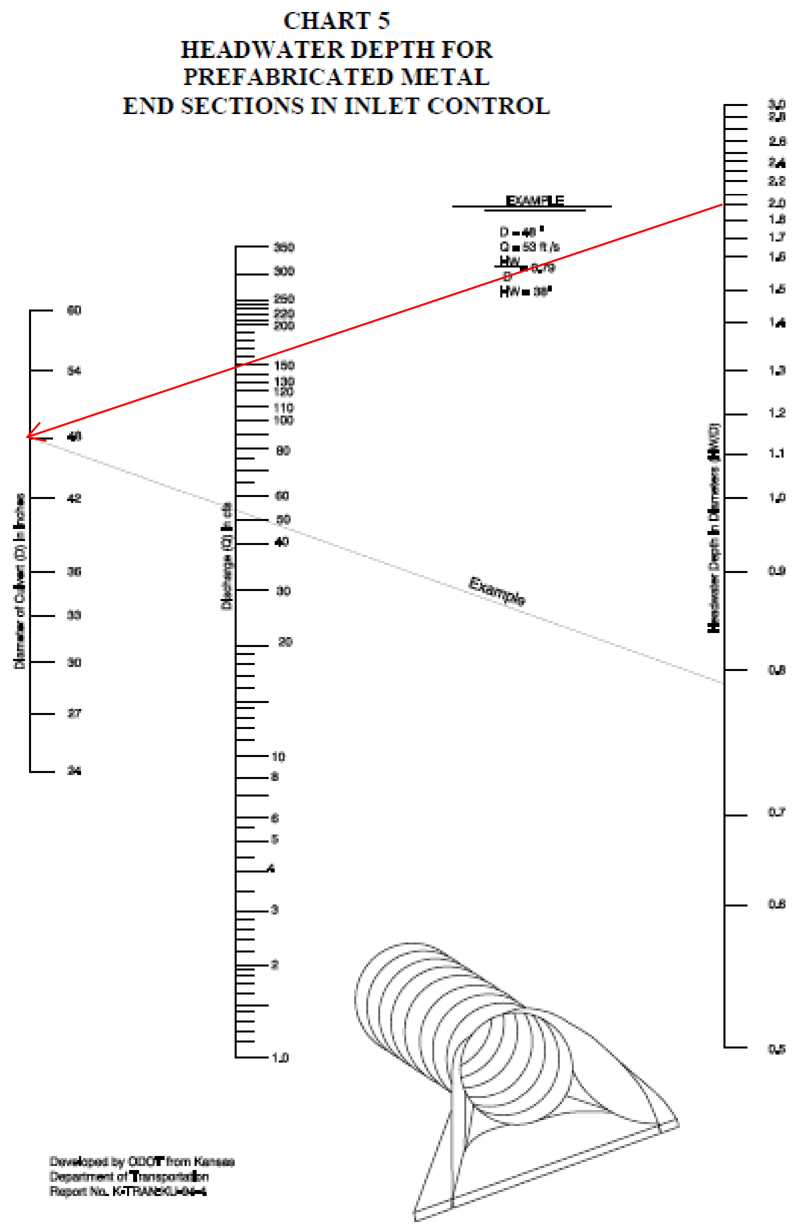
As stated by FHWA ‘*HY-8 Culvert Analysis Program’* the most suitable nomograph for smooth HDPE (Weholite) pipe with ‘*projecting at inlet’ end is HDS-5 Chart Number 2B-3.* To determine discharge (Q) of Weholite pipe for assumed Hw/D in a range of 1.25-3 the procedure is as follows:

Locate Hw/D on scale (3), extend Hw/D point horizontally to scale (1). Connect point on Hw/D scale (1) and the size of the culvert on the left scale. Read (Q) on the discharge scale.



ODOT developed nomographs for prefabricated end sections. The '*Chart -5'* from Appendix A, Chapter 5 of the ODOT Hydraulics Manual is most applicable for Weholite pipe with a '*headwall'.* To determine the discharge (Q) of the Weholite pipe for an assumed Hw/D in the range 1.25-3 the procedure is as follows:

Connect with a straightedge the given Hw/D, and the culvert diameter. Read (Q) on the discharge scale.

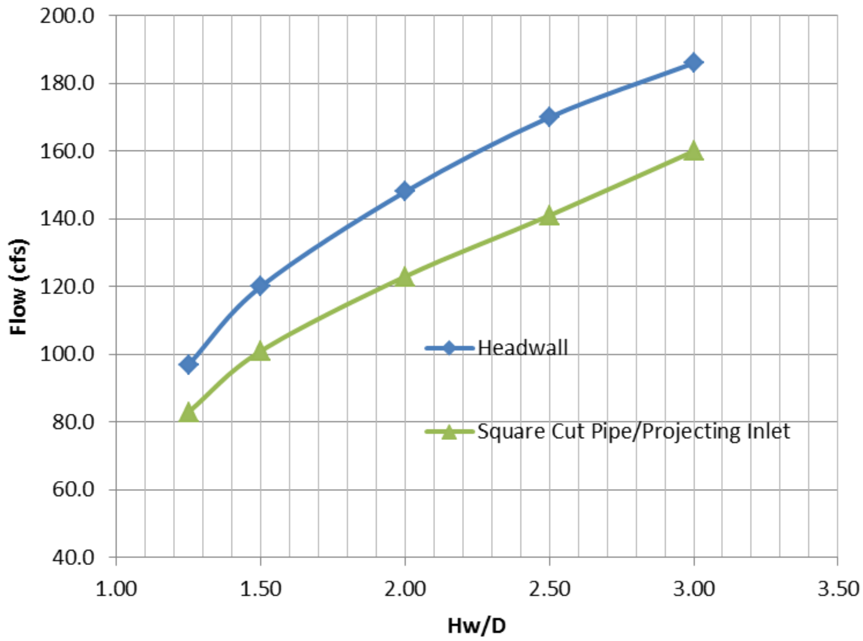


Example:
Hw/D=2
48" (1200mm) pipe
Q=148 cfs

HEAD-DISCHARGE COMPARISON CURVES FOR DIRECT BURIAL APPLICATIONS:

The inlet control, '*end projecting'* and '*headwall'* Weholite pipe head-discharge data determined using nomographs, are plotted in the figure below.

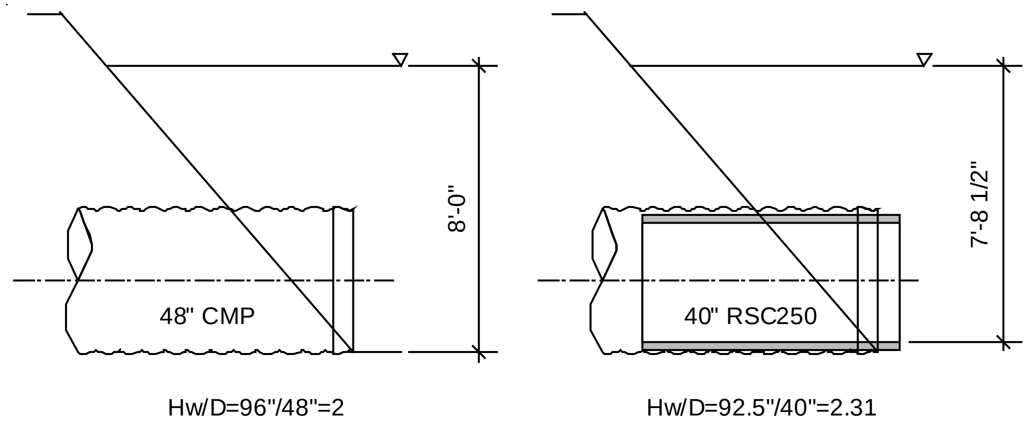
For example, as shown, the flow rate of a 48" '*end projecting'* Weholite and Hw/D=2.5 is approx. 141 cfs. The flow rate of a Weholite with a '*headwall'* with the same ratio of Hw/D is about 170cfs…… an increase of 20%.



This exercise has been repeated for several other sizes. In some cases the improvement is slightly less than 20% while in others, improvements are significantly greater than 20%.

HEAD-DISCHARGE COMPARISON CURVES FOR RELINE APPLICATIONS:

In reline applications the user is interested in determining the capacity after relining. For example, a 48" CMP might be relined with a 40" RSC250 Weholite pipe. When the Hw/D of the host pipe is 2, the Hw/D for the same water elevation on the inlet side would be 2.31 as shown in the accompanying figure.



Reline application

From the HDS-5 Chart Number 2B-3, (end projecting, Hw/D=2)	Q48"CMP=123 cfs
From the same chart, (end projecting, Hw/D=2.31)	Q40"WEHO=80 cfs
From the ODOT Chart 5, (headwall, Hw/D=2.31)	Q40"WEHO=100 cfs

CONCLUSION:

This TB illustrates that the '*headwall'* increases the flow capacity in a culvert pipe. Flow improvement is conservatively 20% for Weholite pipe of a given size with Hw/D values between 1.25 and 3.0.

For reline applications using the headwall, the flow calculation is based on improved entrance conditions and a small increase in Hw/D. As Hw/D increases the flow of the reline pipe with a headwall will more closely approximate the original flows in the host pipe.

REFERENCES:

- FHWA, Hydraulic Design Of Highway Culverts , HDS No.5
- ODOT, Hydraulics Manual, Chapter 9-Culverts
- FHWA, Hydraulic Design of Improved Inlets for Culverts, HEC-13
- FHWA, HY-8 Manual

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