Table 3-3
Comparative Flow Rates for Concrete Box Culvert lined with Snap-Tite®
Based on Manning's equation n=.00914 for Snap-Tite®, s=.001ft/ft

Existing Concrete Box Size	Manning's ``n´´ Factor	Snap-Tite® Liner Size	Box full-flow cfs	Snap-Tite® Flow cfs	% of Flow
3 ft. x 3 ft.	0.012	36"	29	25	86%
	0.015	36"	23	25	108%
4 ft. x 4 ft.	0.012	48"	63	54	86%
	0.015	48"	50	54	107%
5 ft. x 5 ft.	0.012	54"	114	74	65%
	0.015	54"	91	74	81%
6 ft. x 6 ft.	0.012	63"	186	111	60%
	0.015	63"	149	111	75%

3-4 Velocity

Velocity is the speed at which water flows through a culvert. When the velocity exceeds 3 feet per second (fps), sediment is normally entrained in the flow, and the culvert is considered self cleaning. If the velocity is less than 3 fps, sediment will usually buildup in the culvert. In evaluating sediment potential, factors such as particle size, specific gravity, cohesiveness, flow velocity and roughness of the pipe must also be considered.

Once the flow rate is determined using Manning's equation, then the velocity, V (ft/sec), can be approximated by using the equation below:

V = Q/A

Where:
Q= flow, cu ft per sec
A = area, ft sq

As the velocity increases, sediment is no longer a problem in most situations. It is considered high when velocities are over 12 feet per second. Solid-wall HDPE pipe has been used in slurry and dredging applications at velocities approaching 18 to 20 fps, with excellent wear resistance compared to most other materials. Short-term exposure to high velocity may cause long-term damage. As large rocks and debris strike the Snap-Tite® liner, damage can occur. Damage and wear is more likely at higher velocities.

When the velocity is known to be high, streambed scour and bank erosion may occur at the discharge of the outlet pipe. The high velocity and flow condition can erode a channel. An apron of formed concrete or riprap under the discharge is commonly used to prevent erosion and scour at the discharge.

High velocity in a liner can cause separation on the liner joints when the liner is not grouted in place. Grouting of the liner into the host culvert will solve separation concerns from velocity.

It should be noted that one of the anomalies associated with flow in circular pipes is that a partially full pipe will have higher discharge flow rates than a full pipe can carry, due to the increased friction along the wetted perimeter (Figure 3-1). Flow rates above 80% full will be higher than a pipe with full pipe flow, with a peak at 93%. Velocities above 50% will be higher than full pipe velocities with a peak at approximately 80% full mark.

Figure 3-1

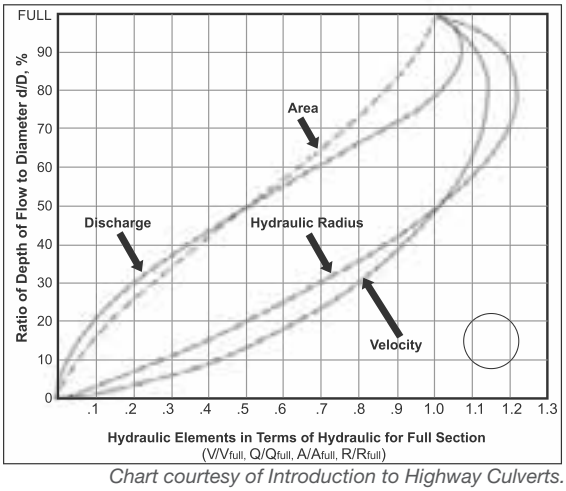

Chart courtesy of Introduction to Highway Culverts.