RESOURCE NOTES

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HYDROLOGY

An Evaluation of Water Velocities in Culverts Designed with Weirs and/or Roughening Baffle

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Background

Recently, a great deal of time and money has been spent, especially in the Pacific Northwest, installing culverts to provide passage to adult and juvenile salmonids. Conversely, little has been done to evaluate the success of these culverts. There is a good deal of discussion as to what constitutes a passable culvert. Many specialist agree that if a natural substrate is retained through stream simulation, the culvert is passable. However, in many situations, stream simulation is not an option due to site conditions that result in prohibitive water velocities. In these cases, alternative designs must be utilized. Weirs and/or roughening baffles have been installed in many culverts but it has been difficult to evaluate the ability of these culverts to pass fish, especially juveniles.

Since water velocity is a quantifiable parameter that is easily measured and is a limiting factor when designing culverts for fish passage it seemed to be a logical place to start. Most of the guidance that is readily available to designers is based on average velocities with no reference as to how or where the velocity is actually determined. Many programs and equations have been developed to estimate average velocities in channels and culverts. However, most are based on conditions that rarely occur in natural channels or are for culverts that are extremely low gradient and do not contain structures, such as weirs and/or roughening baffles.

Discussion

A Marsh-McBirney Flowmate (Model 2000) flow meter was used to determine point velocities. Due to the turbulent flow conditions encountered in the culverts it was not possible to use a cup-type meter (Pygmy or Price AA). Velocity measurements were taken at various depths in the water column at cross sections through the entire length of three culverts and at key locations (ie. notches in weirs and baffles) to determine the extent of low velocity water in the culvert. The assumption is that the adults and especially the juveniles will locate the slower water and move up through the culvert. An extra effort was made to obtain velocities at or near the maximum design discharge, which is defined as the highest, mean monthly flow. The design flows are 55 cfs and 10 cfs for Marlow Creek and Cherry Creek respectively. Velocities were also taken over a range of flows to help determine if and/or when a culvert is no longer passable. A flow duration curve is then consulted to help determine the percentage of time a culvert is passable.

Conclusion

To date, velocity measurements have been mapped in three culverts on gradients ranging from 3.5% to 7.5%. Two of the culverts contain roughening baffles and the third contains both roughening baffles and weirs. The roughening baffles are 8 inch high, steel plates that are welded vertically to the culvert bottoms. The weirs are 18 inch high, steel plates that slope downstream with a V-notch in the center. See Figure 1 for a typical installation pattern. A pool is created between each set of baffles or weirs and Tables 1 and 2 list the average velocities by pools from inlet to outlet.

The point velocities have ranged from -2.8 ft/s to 8.5. ft/s However, the average velocities taken 0.2 feet above the culvert bottom have been in the range of 1-2 ft/s with rather extensive areas of zero or eddy flow. It is not surprising that the velocities increase rapidly as measurements are taken higher in the water column. This is very apparent in Lower Marlow Creek as the average velocity at 0.2 feet from the culvert bottom is 1.2 ft/s at 55 cfs. While at the same discharge, but at a depth of 0.6 feet from the water surface, the average velocity increased to 2.5 ft/s.

Since the assumption is that the fish are moving near the culvert bottom and velocities under 2 ft/s are not a problem for most salmonids it is our conclusion, at this time, that these culverts are passable to both adult and juvenile salmonids up to and probably slightly exceeding the design flows. This evaluation is ongoing and will be continually updated as more data is collected. For further information please feel free to contact either.

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Table 1. Lower Marlow Creek - Weirs and Baffles - 7.5%

Average Water Velocities (ft/s)

	Flow (cfs)	Depth (ft)	Pool 1	Pool 2	Pool 3	Pool 4	Pool 5	Pool 6	Pool 7	Total Average
Lower Marlow Creek	55	0.2	1.3	2.2	1.3	1.5	0.75	1.1	0.5	1.2
	55	0.6	2.9	2.9	2.7	2	2	2.5	26	2.5
	36	0.5	2.4	2.4	2.3	1.9	1.4	1.6	2.3	2
	14	0.5	1.3	0.6	1	0.7	1.1	0.8	0.8	0.9

Table 2. Upper Marlow Creek - 3.5% and Cherry Creek - 7.5% - Baffles only in both culverts

Average Water Velocities in pools (ft/s)

	Flow (cfs)	Depth (ft)	Pool1	Pool2	Pool3	Pool4	Pool5	Pool6	Pool7	Pool8	Pool9	Pool10	Pool11	Pool12	Total Average
Upper Marlow Creek	46	0.2	2.2	1.8	1.7	1.2	1.9	1.8	2.5	3	1.9	2.1	2.3	2.8	2.1
	12	0.2	1.3	1.4	1.2	1.3	1.4	1.1	1.2	2.3	2.6	1.1	1.4	2.5	1.6
Cherry Creek	11	0.2	2.2	1.3	1.4	2	1.8	2.5	1.9	1.6	0.7	1.7	1		1.6

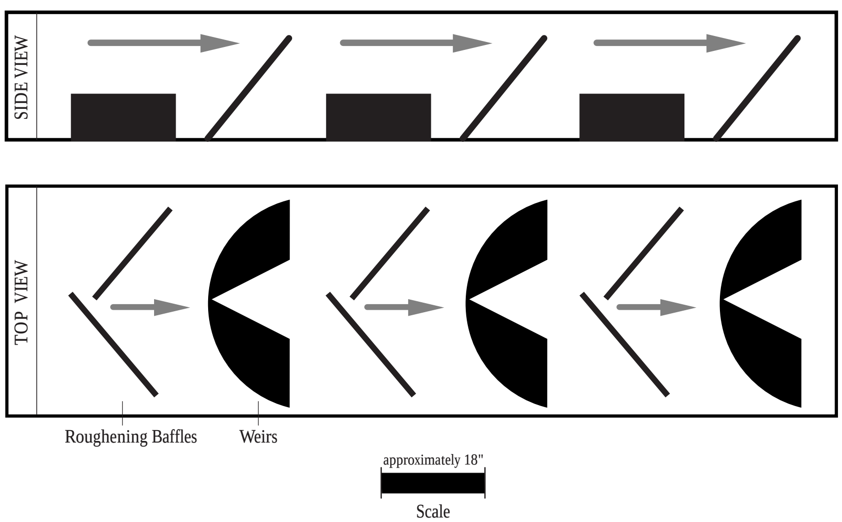

Figure 1. Typical installation pattern of roughening baffles and wiers.
(-> Direction of flow)

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