



Figure 6. The dimensionless water profiles

For a given water depth y_n , the distance of the fishway from the section (x_n) is analyzed as follows: Assume that all the pools are the same (all have the same ΔZ and L), and the distance from the section $X = PN * L$; map the figure to a coordinate system of y/y_0 and x/L_0 ; Obtain the XL corresponding to the given y_n by the method proposed by Rajaratnam et al. [3], and get the number of a pool $PN_n = X_L/L$. According to the Bakhmeteff-Chow method [4], the following equation can be obtained.

$$X = (y_0/s_0) * G(\eta, N, M, F_0)$$

where $X = PN * L$ is the longitudinal distance along the bottom (from the origin); y_0 is the normal (or uniform) flow depth; s_0 is the bed slope; G is the Bakmeteff-Chow varied-flow function; η is equal to y/y_0 with y being the depth at any x ; N and M are indexes for uniform and critical flows, respectively; F_0 is the Froude number of uniform flow.

Then, calculate the reality x_n by adding up the lengths of the n pools $x_n = PN_1 * L_1 + PN_2 * L_2 + PN_3 * L_3 \dots PN_n * L_n$. The water surface curves of the VSFs can be obtained based on Figure 6 and this formula.

In reality, it is very difficult to keep the water level constant at the upstream and the downstream [10, 11]. If the water is deeper in the downstream, the flow rate in the slots will fall below the designed burst speed, and the fish movement in the upstream will not be affected. If the water is deeper in the upstream, the flow rate in the slots will increase dramatically due to the falling water level of the pools at the end of the fishway. In several pools, the upstream movement of the fish will be impeded. The following measures should be taken to resolve the problem: 1) provide more inlets to reduce water depth variation gradient in each inlet across all scenarios; 2) control the flow rate under a reasonable value by widening the vertical slots in several pools at the end of the fishway

5. CONCLUSION

This paper introduces a new structure of VSF without central baffle. Based on the law of gravity similarity, three VSFs without central baffle are designed for experiments, in which the water surface curves are measured by a graduated scale. The water line in the VSF is associated with many factors, such as bottom slope, roughness, and form drag. It is proved that the fore-and-aft elevation difference in critical sections like small rest pool, large rest pool, turning pool and inlet section should be kept equal to that of the normal pools. Besides, all the small rest pools, turning pools and inlet sections act as normal pools. In order to maintain water depth, the ΔZ of the fore-and-aft in the adjoining pools

should be same. Instead of being uniform along the fishway, the water depth is affected by upstream and downstream water levels. The fluctuations of the water levels exert an impact to over a dozen pools at the end of the fishway. The water line characteristics are different when the downstream water depth is greater or smaller than the normal conditions. The results on M1 and M2 are plotted with the y/y_0 and the pool number, which are analyzed by the Bakhmeteff-Chow method. The water level variation mainly affects over a dozen pools at the end of the fishway, and the velocity in the slots increases dramatically due to the plunge of water level in these pools.

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