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# CARAŞ RIVER GORGE ASPECTS OF SALMONIDS' COMMUNITIES MANAGEMENT – TECHNICAL SOLUTIONS

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**ABSTRACT:** There are many obstacles in rivers that prevent or hinder passage of fish past barriers. Here, we present a specially designed solution for juvenile and adult brown trout so that they may to swim past discharge-regulating weirs in the upper Caraş River in both the upstream and downstream directions. The proposed solution relies on gravity flow and will have current velocities that will not inhibit weak swimmers swimming upstream to pass the weirs. Corrosion-resistant materials and the absence of components that could potentially injure the fish will be used in the construction of these technical solutions. Although testing of the functionality of this solutions for upstream - downstream and downstream - upstream passage of weirs is needed, we believe that if implemented, it should improve connectivity especially for brown trout and consequently conserve within-stream genetic diversity in the Caraş River and where appropriate in alike other Carpathian lotic systems with similar types of weirs.
**KEY WORDS:** Brown trout, Caraş River, Banat, discharge-regulating weirs, habitats fragmentation, fish passages.

## 1. INTRODUCTION

To characterize the ecological status of a lotic system and its need for remedial measures, one should not only consider the ecology of the organisms living in the system, but one should also take into account the geomorphology, hydrology, connectivity and water quality of the system. All of these factors are tightly interlinked and neglect or exclusion of one of them may lead to erroneous conclusions about the status of the system or the remedial measures that are needed (Aadland 1993, 2010).

Most effective remedial measures need to be carefully evaluated, and subsequently adapted to the local conditions, in terms of environmental potential response (Brittain, 1996).

Human-made obstacles in lotic systems (culverts, weirs, and dams) generally have environmental impact, often affecting freshwater fish species, many of which are of economic importance (Gumpinger and Scheder, 2008; Trichkova *et al*., 2009; Jeeva *et al*., 2011; Rumana *et al*., 2015; Curtean-Bănăduc *et al*., 2015; Weis, 2018). The fish populations in Carpathian streams and rivers of Romania are no exception in this respect, with numerous reports of impacted populations (Curtean-Bănăduc *et al*., 2014, 2018; Costiniuc and Davideanu, 2006; Bănăduc *et al*., 2002, 2010, 2013; Voicu *et al*., 2016).

Various types of protected areas in the Carpathians were established to preserve their ecological status, and their preservation strategies include in numerous cases the fish. The proposals for these protected areas took into consideration several different criteria such as natural or nearly natural habitats, persistent and healthy fish populations, ecologically and economically important species and low levels of human impacts. (Bănăduc 2011; Bănăduc *et al*. 2012)

*Salmo trutta fario*, resident in many Carpathian rivers and streams, is an economically very valuable fish species used both for fishing and aquaculture (Hard *et al.* 2008; Pomeroy *et al.* 2008; Kruzhylina and Didenko, 2011).

This species uses a broad range of different types of habitats in streams (for shelter, feed, rest, spawn, nursery, etc.) and habitat use differs with age of the fish (Bănărescu 1964; Elliott 1994; Crisp 2000). In addition to habitat, the species often relies on an intact connectivity between habitats to complete their life cycles (Schwartz *et al.* 2007). Connectivity is also relevant if one is interested in preserving genetic diversity, thereby maintaining a high adaptive potential for the fish populations. Admixture is one potential process that preserves genetic diversity, which occurs when spawners migrate back and forth from one part of a watershed to another and/or among different watersheds (Ostergren *et al*. 2012). This phenomenon often plays a large role when tributaries are spatially close (Carlsson and Nilsson, 2000). All age classes of salmonids can be negatively affected by changes in flow conditions, both natural and anthropogenically-induced (Warren *et al.* 2015; Bănăduc, 2008; Bănăduc *et al*., 2013). Anthropogenic activities and/or catastrophic natural events that induce lotic fragmentation in a basin may hinder fish from reaching spawning grounds as well as isolate populations, leading to inbreeding or genetic drift (Cunjak and Power, 1986).

Many dams, culverts and weirs are barriers to migration of native fish. Many fish passage solutions have been constructed to facilitate fish migration, but not all of them are functional or as effective as one would like (Bowman and Rowe, 2002, Gillian O'Doherty, 2009). Reasons for poor functionality often have had to deal with the fact that fish have trouble locating the fishway entrance (Rivinoja et al. 2001), or because the hydraulic conditions are not amenable to the fish's swimming ability and behavior (Aaerstrup et al. 2003). Even for fishways with high passage, there may be substantial delays (Calles and Greenberg 2009).

The causes of passage problems are numerous, with much focus given to hydropower and riverbeds hidrotechnical works. There are many other types of obstacles that fish need to overcome, such as culverts and weirs, and passage solutions for these are needed.

Our proposed specific technical solution is expected to provide fish passage for native fish without impeding water flow, to survive future flood events, and to show that fish-friendly hydrological weirs can be constructed based on low-tech approach.

The purpose of this study is to offer passage solutions for brown trout at three weirs in the lower Caraş River Gorge area. The Caraş River originates on the western part of the Semenic Mountains at about 700 m a.s.l. and flows 110 km before emptying into the Danube River. In Romania, the river flows for 80 km and the basin has a surface area of 1,118 $km^2$. The upper Caraş Basin is characterized by limestone formations and spectacular gorges. The annual average flow fluctuates between 20 l/s in the high elevation areas to below 7.0 l/s in low elevation areas. There are periods with relatively high flows, which can move fish downstream over existing human-made barriers. (Posea, 1982; Ghinea, 2002)

The Caraş River ichthyofauna was studied by Bănărescu (1964) over 50 years ago, but has changed since then, mainly due to reductions in the range of some of the indigenous fish species, including brown trout.

The numerous weirs and dams lacking fish passage solutions contribute to this situation.

The specific technical solution proposed in this paper work will allow brown trout individuals to move freely past three weirs in the lower part of the gorges. These solutions will reduce the slope at the obstructions (Voicu and Dominguez, 2016), thereby improving conditions for salmonids movements in this section of the river.

## 2. OBSTACLES FOR FISH

The three discharge weirs are situated upstream of Caraşova locality (Fig. 1).

These are located in the Semenic-Caraş Gorge National Park, designated as an IUCN management category II.


**Figure 1.** The location of the three discharge weirs in the Caraş River.

The proposed solutions in this paper for restoring longitudinal connectivity in the upper Caraş River sustain the conservation of fish species too, in particular all that fish species present in the studied area and mentioned in the Semenic - Cheile Caraşului protected area management plan, but especially the brown trout.

We propose to be built fish migration systems for the spillways (weirs) at sites 1-3.

Here we present our design for the weir at site 2, situated about 103 m downstream of site 1 (Fig. 1).

The weir at this site is 12.3 m wide, has a crown thickness of 1.31 m, and water spills approximately 1.6 m from the top of the weir (Fig. 2).

Before being able to construct the proposed fish migration system centrally-located concrete separator needed to be repaired (Fig. 3).


**Figure 2.** The weir at site 2 in the Caraş River.


**Figure 3.** The discharge weir at site 2, showing the existing concrete separator - indicative figure.

## 3. RESULTS AND DISCUSSIONS

The concrete separator (concrete wall), with a maximum height of 50 cm, a length of 10 m and a thickness of 46 cm, has an inclined irregular upper surface (Fig. 4). We propose to smoothen the upper surface so that it forms a smooth plane (linear in cross-section). To do this we will raise the maximum height by 5 cm (Fig. 5). The length (10 m) and the slope will remain the same as at present.

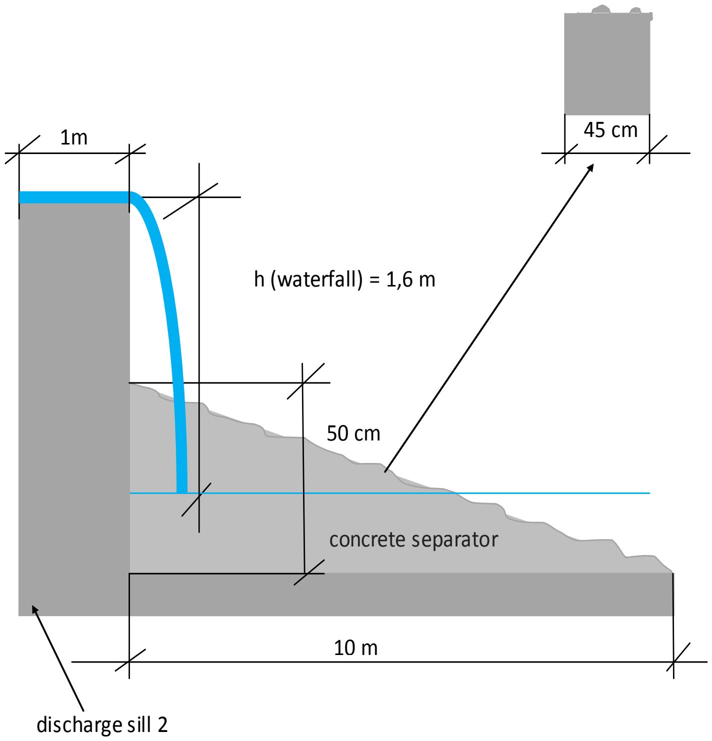


**Figure 4.** A longitudinal cross-section of the existing concrete separator - indicative scheme.

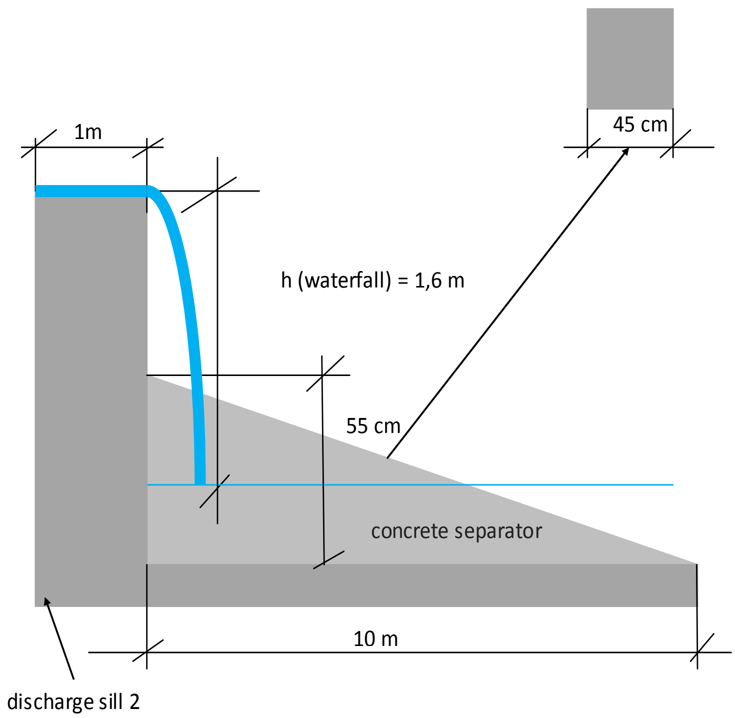


**Figure 5.** A longitudinal cross-section of the concrete separator after proposed repairs - indicative figure.

After modifying the concrete separator, a concrete basin, referred to as the water catchment basin, will be constructed so it will exceed the height of the weir by approx. 40 cm on three sides (Fig. 6).

Two concrete sheet piles of equal height (approximately 40 cm) will be attached perpendicular to the concrete basin and extend along the entire width of the weir (Fig. 6). The collector basin will also be attached to the concrete separator and will have a height of approximately 1.4 m.

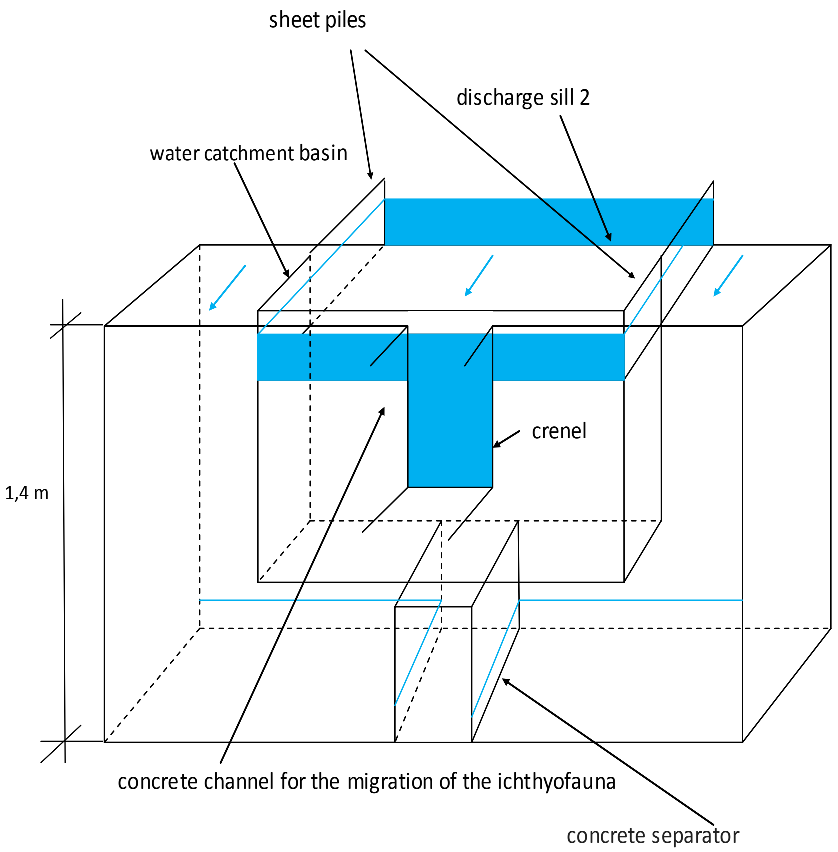


**Figure 6.** A schematic drawing showing the concrete basin and how it is attached to the concrete separator (the blue depicts the water) - indicative figure.

The water will flow through the receiving basin, through its crenellation, which is directly connected to the fish migration channel (the length of the channel is 8 meters, width 46 cm and height 44 cm, with 42 cm water blade), and fish will use this system to go over the spill threshold (Fig. 7).

The channel will be inclined with a slope of approx. 10 m/km. The average water current flowing through this channel will be approx. 0.5 m/s, about half the mean current velocity calculated for the study reach.

Four concrete pillars in the concrete separator will be used to support the channel (Fig. 7). The pillars will be attached to the channel with stainless steel dowels (Fig. 7).

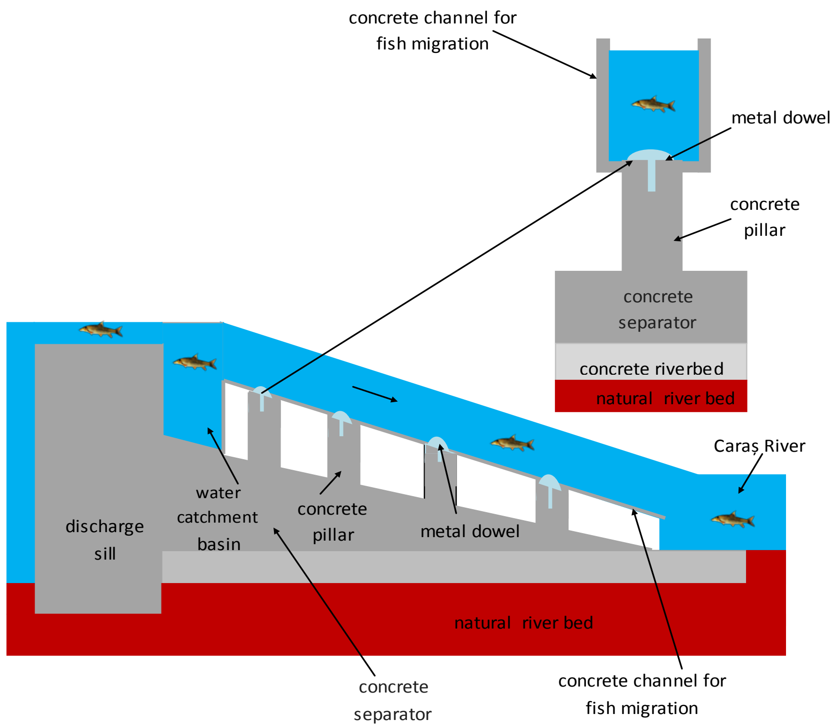


**Figure 7.** Schematic diagram showing the channel and how the pillars support and are attached to channel.

The channel will have the following approximate dimensions: 40 cm width, 45 cm height and 8 meters long. Besides water coming directly from the river, a side channel will support the system with extra water if needed (outlet Tyrol) (Fig. 8). 20 cm water high flows enter continuously over the weir in the water capture basin. The lateral flow from the side channel is stored in a concrete basin attached to a concrete stream bank. This water enters the water catchment basin via a metal pipe (Fig. 7), equipped with a regulating valve at the upstream end. On the fish migrating channel, four sides (two by two) pockets like structures (parallelepiped-resistant glass resting areas for fish), (Figure 8). The fish can rest in this 30 cm deep and 35 cm wide structure made entirely of glass resistant, which allow the fish to be able to have the required light to enter this space (Figure 8). Upstream of the spillway a semicircular metal grid is attached, which redirects the floating plastic bottles, this grid has about 40 cm and is half in the water half outside, symmetrical to the average river level (Figure 8). The grid will be 40 cm high, with half of it below the water surface and thus approaching fish should be able to swim under it. The depth of the water upstream of the weir is approximately 1 meter. The fish cannot get out from the channel because there is a concrete grid on top. When this system should to be repaired, a galvanized structure will be fixed on the semi-circular grid which redirects the floating plastic bottle, so all the water that reaches the basin for water capture is redirected over the weir threshold. Within this context the pipe that feeds the basin for water capture closes with the tap situated on it. (Figure 9).

The water coming from the river flows continuously over the discharge sill and will arrive in water catchment basin. In order for the catchment basin to be full and to feed the fish migration channel with a flow corresponding to the migration, it must be fed by a metal pipe equipped with a regulating valve at the upstream end. In front of each concrete pillar supporting the migratory channel of the fish will be fixed fish resting tanks. These resting tanks for fish are made of highly resistant transparent sheet piles and looks like rectangular parallelepipeds. We can also call them fish pockets. The fish can enter in these resting rectangular parallelepipeds by some crenels made in the fish migration channel. The floats to not block the fish migration channel, a metal grid is attached on the discharge sill. This grid will be partly in the water partially out but with its size and positioning it allows the fish to easily pass under it and to get upstream of the spillway. For system repairs, we can fix a metal semicircular metal sheet pile to the existing metallic grid to redirect the water that penetrates the fish migration channel over the discharge sill.

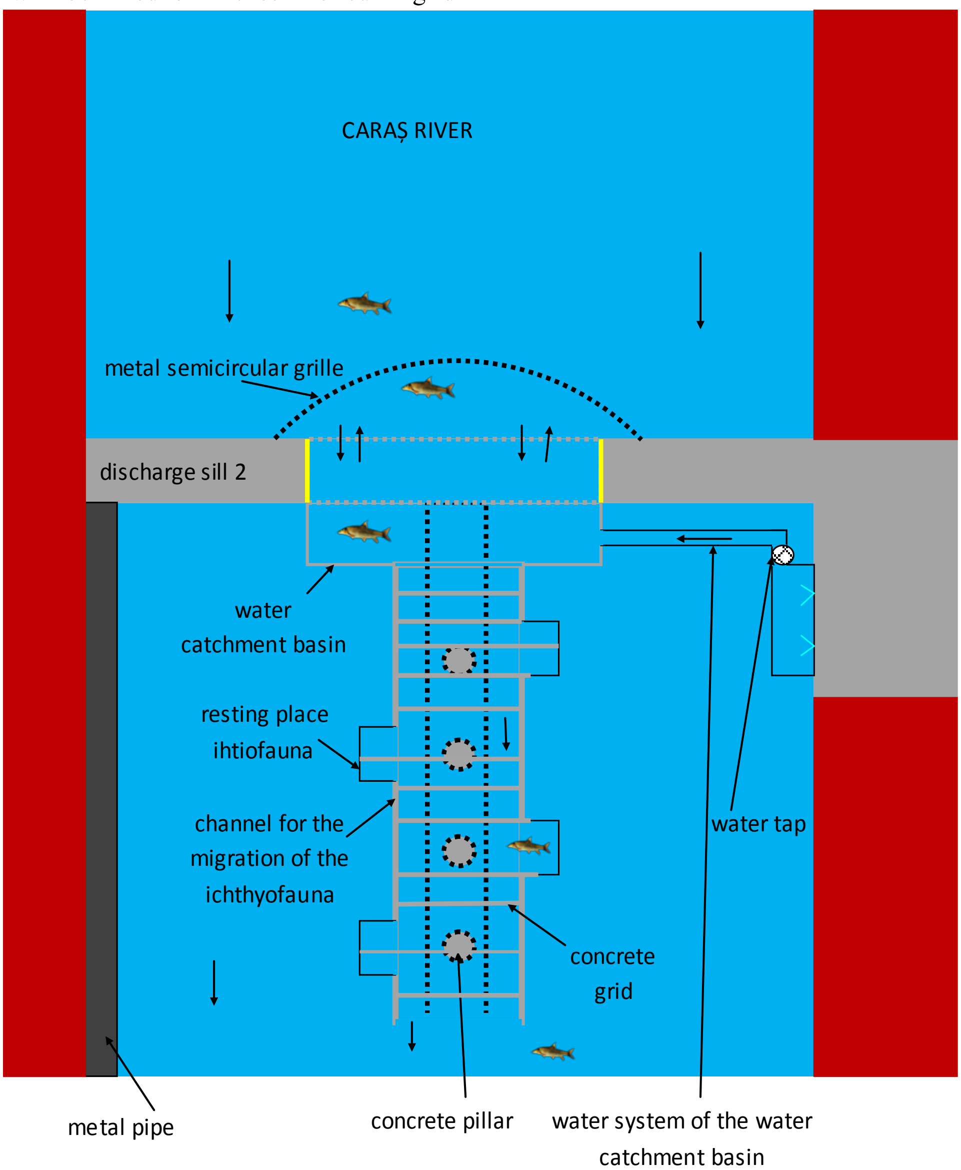


**Figure 8.** Schematic drawing showing a bird's eye view of the collector basin water system - indicative figure.

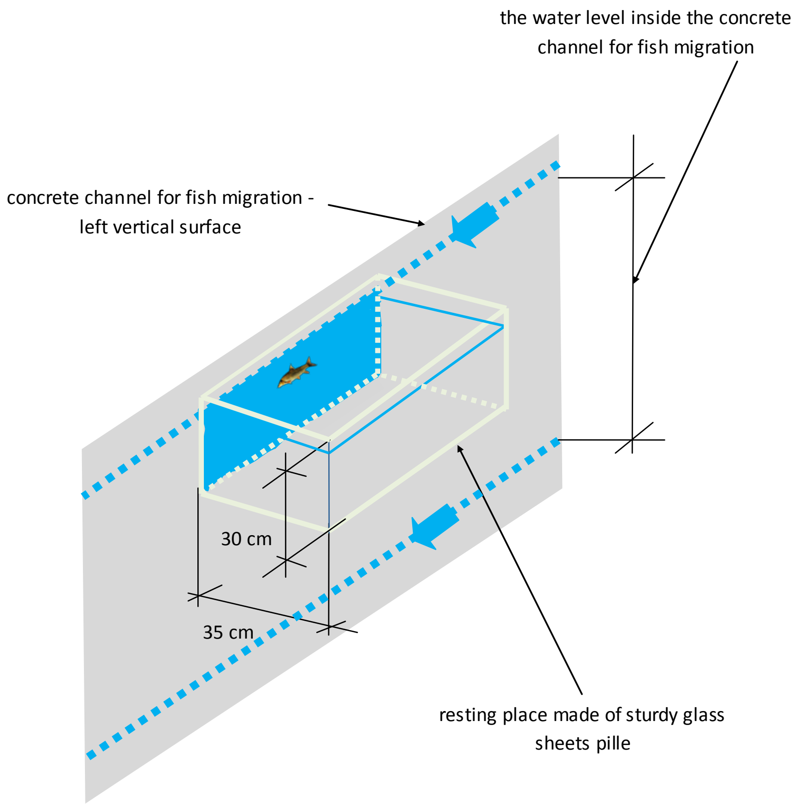


**Figure 9.** Schematic drawing showing a resting space for fish - indicative figure.

# 4. CONCLUSIONS

All components of the fish migration system are made of resistant and non-corrosive materials. The system is attached to the weir and does not affect the weir's structure and functionality. The water speed in the channel will be low enough so that weak swimmers and juveniles can pass. This system can easily be removed and placed at another location. The proposed system is entirely based on the gravity flow of the water. Corrosion-resistant materials and lack of components that can injure fish make this a user-friendly system. This system can operate at all spill thresholds with heights of up to 2.5 m where downstream of the spill way is enough length needed to the construction of a concrete separator. There where is not present a concrete wall (separator) with a sloping plan of the upper edge, it can be done relatively easy.

This system should contribute to the conservation of genetic diversity and a high adaptive potential for salmonids valuable populations.

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