# MINIMUM WATER REQUIREMENT INVESTIGATION WITH THE SIMULATION MODEL CASiMiR

The computer model CASiMiR (Computer Aided Simulation Model for Instream Flow Requirements) was developed at the University of Stuttgart's Institute of Hydraulic Engineering. It is a surface water habitat model, in which – among other things – fish habitats can be investigated. The model uses additional information for the regulation of hydraulic parameters. This enables the assessment of, for example, water depth, flow velocity or sediment transport as conditions are modified.

The basic principal guiding habitat-modelling is that the majority of water organisms have specific demands for the suitability of their environment. For example, spawning brown trout generally prefer zones with middle to high water depths, clear currents and gravel to blocky river bottom surfaces. In contrast to the spawning stage, juveniles prefer to be on flat areas with low flow and depend less on high cover when they find themselves in open systems of a river bed. Such dependencies and behaviours have already been known by fish biologists for many different fish species and they can be implemented on the CASiMiR model using simple expert defined behaviour rules.

The water depth and flow relations normally change clearly with discharge. It is then quite obvious that the environmental requirements described above are also strongly dependent on discharge. Therefore often donation-investigations for the minimum water requirement are carried out, in which different discharges are adjusted and then the relevant sections are visually evaluated by experts. The sufficient discharge for each type of fish species will be estimated based on visual impressions. It can, however, be problematic to reach an agreement on specific numerical values when there are small changes in the discharge, because they can look very similar. Also it is often the case that two experts come up with different recommendations because their evaluations are very subjective.

This problem can be avoided with the application of a simulation model. For the description of the water body in a computer model and the evaluation of flow velocities and water depths clearly defined input data are available. With this quantitative input information an evaluation of the influence of discharge on the hydraulic conditions and therefore fish habitats can be carried out. Based on the results of the hydraulic model and the hydrological character of the river, it is possible to devise qualitative statements to describe the dynamics of sedimentation and hydraulic parameters, parameters important for morphologic development.

The following are the principal steps for a CASiMiR-study:

1) One or more investigation stretches – that are representative for the longer water body – are chosen.
2) For each investigation stretch surveying measurements should be carried out (principally for cross sections) and additional information like substrate distribution and grain size in the river bed or the location of fish covers should be mapped.
3) The next step is to reproduce the investigation stretches with small elements in a computer model. For the model's hydraulic calibration the water surface and flow velocity measures for different discharges are used (approximately 1-3 discharges are used for each).
4) With help of this digital model the local flow velocity, water depth and wetted area for each river section are calculated in each model element for a wide spectrum of discharges. These are important and limiting factors in respect of ecological constraints, or for other uses such as ship navigation or rafting.
5) Reduced shear stress caused by decreased discharges has often had a significant affect on the balance of soil material. The hydraulic calculations can be used to predict potential sedimentation and/or erosion areas. It is possible to formulate the expected future morphodynamic situation in the channel and in the diverted river reach.
6) After the linkage of hydraulic properties with mapped substrate and cover conditions the most important fish revelant parameters from each individual element of the computer model are known.

7) The special habitat requirements formulated by the fish experts for each of the fish species in the observed water body (brown trout, salmon, etc.) are imported in the CASiMiR simulation model (Figure 1 middle).

8) For each element it will be checked to what extent these needs are fulfilled at a specific discharge.

   (Example: Are the corresponding flow velocity, waterdepth and substrate for a discharge of 1 m³/s suitable for a spawning brown trout?)

9) As a result a suitability index is calculated which represents the habitat quality (0 = not qualified, 1 = optimal qualified, Figure 1 right).

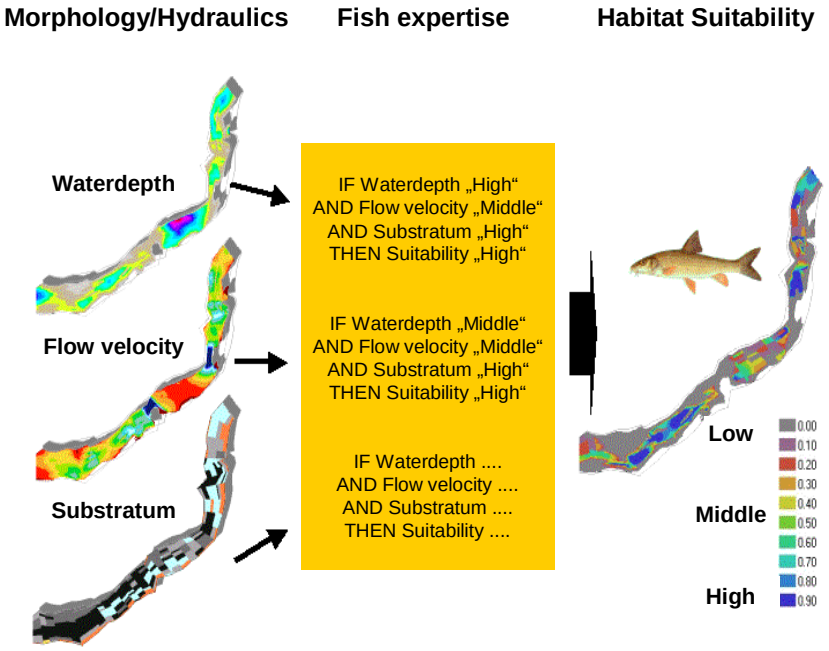


**Fig 1:** Principal mode of operation of the fish-habitat model in the model system CASiMiR

10) Now a comparison as to how the habitat suitability changes with the discharge can be made. Normally fish habitats will clearly improve when the discharge increases. However for a specific discharge the habitat suitability gets a maximum value, for higher discharges it will decrease. Additionally, the minimum water depth which is required for fish migration can be checked in CASiMiR.

11) From the simulation results, a minimum flow requirement is to be developed for the different fish types and their age stages (spawning, juvenile, adult). This requirement should guarantee that at any time in the year there exists the necessary vital habitat space and appropriate spawning conditions.

12) For the final determination of minimum flow conditions other aspects such as the natural discharge events during the year and the significance of the investigated water stretches for the total river are to be considered. At the end there is a minimum flow regulation which defines what minimum discharges must remain in the diverted river reach throughout the year in order to meet ecological needs. Figure 2 gives an example of the minimum water requirements for salmon's spawning season in the late autum and winter and a dynamic adaptation to the natural summer months' regime.

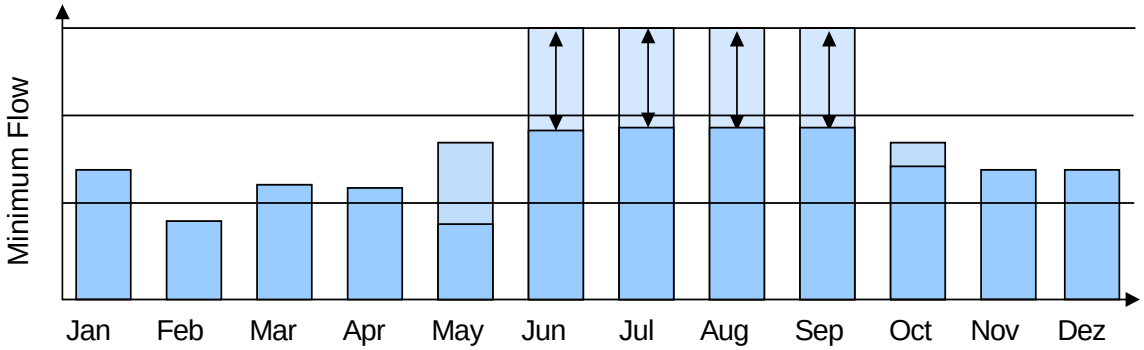


**Fig 2:** Example of a staged minimum water requirement rule catalogue with dynamics in summer

The model system CASiMiR has been applied within the scope of many projects with different investigation focuses and with different types and levels of flow as well as on different river types and dimensions reaching form high alpine creeks to large lowland rivers. Same as for conventional hydraulic modeling information on river bathymetrie and bottom roughness is required for the application of the habitat model. Therefore it is supposed that cross section survey can be performed either by wading the river during low flow, by crossing it with a boat or by installing any other device to detect river geometry and morphology.

Diverted Reach, River Danube: Backwater, waterdepth up tu 3 m, low flow velocity

Diverted Reach, River Gutach, Black forest: high blocky substratum

Upper Part of River Rhine, „Isteiner Schwellen“: Diverted Reach of Grand Canal d’Alsace

Inn, downstream of Martina, current hydropeaking - , future minimum flow section

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