Plate 5.10 Water Withdrawal and Return

Introduction

Rivers and streams fulfil many different functions for the benefit of the ecosystem and society: they shape the landscape, they transport water and sediment, they replenish the groundwater and they provide a habitat for flora and fauna [3]. In Switzerland, these functions are restricted in around 10 % of rivers and streams – in some cases to a considerable extent – by the fact that the channel flow has been modified, and in particular through withdrawal of water from rivers [1].

Water is normally abstracted from a river or stream for a specific purpose and later returns to the same or a different river or stream, or seeps into the groundwater. In the intermediate stretch of residual water between the points where water is diverted and where used water returns to the river, the discharge regime (plate 5.2), the depth, the current, and natural fluctuations in water-level, as well as bed-load discharge and water temperature, are often greatly affected. This has adverse effects on aquatic and other sensitive habitats closely linked to the river, as well as on the replenishment of the groundwater. Plate 5.3 provides quantitative information about the extent of these different types of impact.

In the majority of cases where large quantities of water are taken from a river, the purpose is to provide energy. This concerns principally Alpine rivers. In the Central Lowlands and the Jura Mountains, low-pressure power stations, which do not necessitate water withdrawal, are more common. Switzerland has a total of some 1600 hydro-electric power stations. Water is also diverted to irrigate agricultural land, for cooling or cleaning industrial equipment or for other types of consumption [2].

Legislation concerning residual water flow rate

Since 1992, when the federal Law on the Protection of Waters of 24 January 1991 came into force, it has been compulsory to ensure appropriate residual flow rates in rivers and streams. The minimum residual water flow is based on the Q_{347} flow rate, which according to the federal law is defined as “rate of flow which, averaged over ten years, is reached or exceeded on an average of 347 days per year and which is not substantially affected by damming, withdrawal or supply of water” (cf. plate 5.8). The full significance of these stipulations in relation to residual water flow only becomes apparent when a new water withdrawal site is planned or when the permit for an existing withdrawal site is renewed. In the case of water withdrawal under a current permit, ecological enhancement of the intermediate stretch of water is compulsory only under certain circumstances.

According to the remediation regulations, the cantonal authorities are obliged to draw up an inventory of existing water withdrawal which they then have to pass on to the federal authorities. The contents of this inventory are defined by an ordinance and are accessible to the general public; they include only data which are relevant to water protection and which indicate the condition of the river or stream in question. As part of the implementation of the federal law, the federal and cantonal authorities are responsible for informing the public about these two aspects.

Database

Between 1994 and 2006 all cantons, with only one exception, submitted an inventory. The Federal Office for the Environment (FOEN) entered the data in a database and, after consulting the relevant cantonal offices, updated the information where necessary. At the end of 2004 the data included some 1700 cases of water withdrawal, of which roughly 1500 were used for the publication of the Residual Water Map of Switzerland. Withdrawal of water from rivers or streams that do not have a permanent channel flow (Q_{347} = 0 l/s), mobile water abstraction, withdrawal of water for military purposes, and cases where there is no operational abstraction device despite the existence of a valid permit were not included in the map. Water withdrawal for purposes other than hydro-electric power generation that involved less than 20 % of the Q_{347} flow rate and not more than 1 m^3/s was also omitted.

The quality of the data provided varies greatly, which can be explained by the difference in the collecting methods used from one canton to another. The cantonal authorities are solely responsible for the quality of the data they provide.

Mapping

As part of its duty to keep the general public informed, the FOEN published a large part of the data collected, with the consent of the cantonal authorities, in the form of the Residual Water Map of Switzerland; this work in fact consists of two maps at a scale of 1:200 000, an explanatory brochure and additional data in digital form [4]. Apart from the principal information, i.e. water withdrawal, the two maps include federal inventories that are pertinent to residual water (landscapes and natural monuments, alluvial zones and mire landscapes of national importance). Furthermore, they indicate whether, since the federal law came into force, a permit has been issued for withdrawal of a significant volume of water, and whether the corresponding minimum residual water flow rates are to be ensured.

The pattern of water withdrawal shown in this plate and the categories of use correspond to those used for the Residual Water Map of Switzerland. The 1:500 000 map shows firstly the geographical location of the withdrawal site and, wherever possible, the corresponding point where the water is returned and the pipework that is part of fixed installations in the categories “Wasserkraftnutzung” (hydro-electric power) and “Andere Nutzungen” (other uses, e.g. withdrawal for industrial purposes or for irrigation). Out of the 1500 water withdrawal sites on the map only 6 % are not connected with hydro-electric power generation. Withdrawal is differentiated according to its ecological relevance: water withdrawal operations which, according to their design capacity or right-of-use, divert more than 50 % of the natural Q_{347} flow rate from a river or stream with a constant channel flow (i.e. $Q_{347} > 0$ l/s) can be considered as significant for the environment. Around 86 % of all withdrawal systems fall into this category; they are indicated with a number which refers on the one hand to an entry in the list of withdrawal sites (see table) and on the other to the Residual Water Map of Switzerland [4]. When water that has been diverted is returned to a receiving river or stream, the point of return is indicated, as well as the pipework between the point of withdrawal and the point of return, either in summary form or as a section of the river network; this is the case for 94 % of the sites.

In 6 % of the cases the volume of water diverted is not known or not important from an environmental point of view (the operation being temporary or involving a drainage culvert along the stretch of residual water) or it was not possible to select a category.

With the help of the map and the information given in the table, it is possible on the one hand to locate the points where water is diverted and returned at present and on the other to estimate roughly the volume of water diverted. This provides, for example, preliminary information about human influence. The plate therefore gives an overview of the current situation with regard to water withdrawal and return for rivers and streams in Switzerland.

Case studies of water withdrawal

In addition to the mapping of water withdrawal sites, the situation at a number of selected locations is illustrated in the form of a bar chart (figs. 1,2,3). The columns are made up of the monthly mean value for residual water flow and the volume of water diverted, i.e. the height of the column shows the mean monthly flow above the point of withdrawal. The effective residual water flow at any given time may vary considerably from the mean value indicated, depending on the design capacity of the intake, the rate of flow at the time and any obligation to guarantee a minimum instream flow.

Figure 1 shows a broad selection of different types of water withdrawal from smaller and larger waterways in various parts of Switzerland which have varying hydrological and ecological consequences. The main aspect is the discharge regime. Many water intake operators try for economic reasons to use their design capacity to the full insofar as regulations concerning minimum instream flow and discharge conditions allow them to do so. In this type of residual water

reaches the discharge regime typical of that area often remains unchanged although discharge rates may be lower overall. Examples here are the water withdrawal sites on the Aabach (AG-028) and the R. Versoix (GE-003) and to a lesser extent that on the R. Doubs (JU-014), where on average less than the technically feasible volume of water is diverted only between July and September because of regulations concerning minimum instream flow. Water withdrawal from the R. Linth (GL-035) is an example of an installation that was issued a permit after 1992 and which uses its design capacity to the full while at the same time guaranteeing the minimum residual flow rate according to the federal Law on the Protection of Waters. In contrast, mean residual water flow rates from many withdrawal sites, particularly in the Alps and in the southern foothills of the Alps, as well as in the Central Lowlands, no longer reflect the natural discharge regime (e.g. BE-013, GR-132, TI-030, TI-104).

By reason of their potential capacity and the terms of the permit many water withdrawal sites that are important from an environmental point of view have on average an extremely small to zero stipulated minimum, at least during months when discharge is low. For example, at the withdrawal location on the R. Aare (SO-002) the residual amount of water represents only around 2 % of the monthly mean, despite a considerable discharge flow over the summer. For the relatively high withdrawal site on the Torrent de la Fouly (VS-224) there is no stipulated minimum instream flow for eight months of the year; the discharge in the residual water stretch is formed only by lateral tributaries which for their part also partially serve a water intake. The importance of the regulations concerning residual water flow set out in the federal law with regard to the various functions of a river or stream can be seen in the R. Birs, for example (BL-003): for around 4 months of the year the mean monthly discharge is lower than the design capacity of the withdrawal facility. Without the guarantee of a minimum instream flow, parts of the residual water stretch may run dry. The situation regarding water withdrawal on the R. Piumogna (TI-049) is similar, although on a much smaller scale.

Water withdrawal which is not considered important from an environmental point of view naturally has only a negligible influence on the discharge regime of the river, as seen in the case of SH-A (R. Rhine) as an example involving a large river, and OW-D (Gerisbach) where a small river is involved (fig. 2). The degree of impact of diverting water for purposes other than to generate hydro-electricity varies. Water is taken from the Gurschenbach (UR-043) to make artificial snow for ski slopes served by a ski-lift company. Measurements have been taken only for those months when the ski installations are in operation. Water is taken from the Sarbach (ZG-002) to wash gravel, and according to the federal law the gravel pit must ensure that there is a minimum instream flow of 50 l/s. This example illustrates the fact that, under the terms of the federal law, permitted water withdrawal from smaller rivers entails a high minimum instream flow in relation to the Q_{347} flow rate.

References

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