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Ecological flow estimation in Latvian – Lithuanian trans-boundary river basins (ECOFLOW), LLI-249

METHODOLOGY OF E-FLOW EVALUATION

On the base of Venta and Lielupe Latvian-Lithuanian transboundary river basins

ECOflow

March 2019

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ABBREVIATIONS

EEA	European Environmental Agency
WFD	Water Framework Directive
CIS	Common Implementation Strategy
EU	European Union
NGO	Non-governmental organization
HPP	Hydropower Plant
CR	Cabinet Regulations
GU	Geomorphic Unit
QGIS	Quantum Geographic Information System
HyMo	Hydro-morphological
WGS	Water Gauging Station
e-flow	Ecological flow
$Q_{OPTIMUM}$	Optimum flow
ISH	Index of Spatial Habitat availability
ITN	Index of Temporal Habitat availability
IH	Index of Habitat Integrity
MesoHABSIM	Meso-scale Habitat Simulation
LEGMC	Latvian Environment, Geology and Meteorology Centre
BIOR	Latvian Institute of Food safety, Animal Health and Environment
Q_{ECOL}	Ecological water discharge (e-flow)
EC	European Commission

1. INTRODUCTION

According to the World Bank, ecological flows are “the quality, quantity, and timing of water flows required to maintain the components, functions, processes, and resilience of aquatic ecosystems”. Although concept of environmental flows exists more than 40 years, historically it was more understood as hydrological calculations and only in last couple of decades there are attempts to link these calculations with ecological processes and wellbeing of flora and fauna.

Water quantity and hydrological regime has critical role in quality of aquatic ecosystems, including available habitat area. According to EEA, about 40% of European water bodies are affected by hydromorphological degradation, including habitat alterations. About 100 small HPPs are installed within Latvian-Lithuanian (LV-LT) trans-boundary river basins, causing significant damage to river ecosystem.

Since adoption of WFD growing attention has been paid to freshwater ecological quality. Biological quality elements have largest impact on final ecological quality assessment and assessment methods must be developed primary taking into account wellbeing of biota. In the context of WFD environmental flows are “an hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies” (CIS guidance document No. 31). If there is poor hydromorphological quality (for example, altered hydrological regime), it is not possible to achieve at least good ecological quality, which is the main objective of the WFD. Indirectly ecological flows as component of hydrological regime are incorporated also in hydromorphological assessment which is important to determine rivers on high ecological status.

According to CIS Guidelines No. 31, each EU country must develop national methodologies for ecological flow implementation. It should provide a clear basis for issuing and regulating water use and permits. In this document proposed methodology to determine ecological flows in Latvia and Lithuania are described. This methodology can be used by institutions which are involved in issuing permits for the use of water resources, environmental NGOs and other interested stakeholders.

Methodology was developed using results of The Interreg V-A Latvia –Lithuania Programme 2014-2020 project LLI-249 “Ecological flow estimation in Latvian - Lithuanian trans-boundary river basins” (ECOFLOW). Data from 11 case studies in 10 rivers within Venta and Lielupe transboundary river basin districts were used. As both catchments belong to the same ecoregion (Baltic lowland province), one methodology for both countries can be developed.

2. ECOFLOW ISSUES TO BE ADDRESSED

2.1. Review of hydrological regime regulations problems in Lithuania and Latvia

Although Latvia and Lithuania have historically developed different traditions in the field of legislation and regulation, the main problem regarding ecological discharge is the same: too low flow and weak control authorities.

Many legislative documents related to use and maintenance of HPPs exist in both countries. Some of these regulations even describes ecological discharge in its most unclear way. In both countries ecological discharge is defined using hydrological calculations without any scientific justification. Some of these regulations (for example, CR No 736 in LV) describes also hypothetical wellbeing of aquatic ecosystems. Thinking about the ecological flow regime, not only the water quantity, but also dynamics (water level fluctuations) must be taken into account. Water level fluctuations (hydropeaking) in rivers cause as much damage as constantly low water levels (lack of ecological flow rate). At the moment hydropeaking is not regulated by the rules in Latvia or Lithuania.

There have not been any scientific researches how water level alterations caused by HPP affect in-stream biota in Latvia. Available reports and impact assessments are based mostly on expert opinion. Also, existing definitions are mostly based on theoretical assumptions about well-being of biota (mostly fish) and these assumptions/calculations in most cases are not scientifically proven.

In general, there is no clear definition of ecological flow in **Latvia** and sometimes ecological flow is mixed up with minimum guaranteed flow. It is stated in CR No. 329 that ecological flow has to be guaranteed downstream of hydrotechnical constructions and at the same time, CR No. 736 gives the same definition for the minimum guaranteed flow and specifies particular cases when ecological flow has to be ensured. Hydroelectric power plants and hydrological flow rates are described in three regulations in Latvia (CR No 736 and 1014, CR No 329 / Construction standard LBN 224-15), but two out of three regulations don't have instructions for calculations of ecological flow. Also, currently available instructions are less clear for ecological flow, e.g. "value up to minimum summer 30-days period low flow with 50% probability" is given just for the watercourses important for fishery. In other cases, ecological flow has to be estimated based on expert judgement.

In **Lithuania** the term *environmental discharge* came from the Soviet times when it was called *sanitary discharge* and used for estimation of dilution of wastewater coming from factories down to clean river water. Since the change of the term *sanitary* to *environmental* did not substantially change the essence of procedures, it was not correct to use it for hydro power plants that do not release polluted water, but significantly alter hydrological regime of the rivers. Although environmental discharge in the current edition/version of the Procedure is defined as the minimum water discharge required ensuring minimum conditions for ecosystem survival, such discharge is not environmentally friendly. The established environmental discharge is related to probability of multiannual runoff reoccurrence, whereas constant flow cannot fulfil requirements of river ecosystem.

2.2. Existing methods for e-flow evaluations

Flow regime has major role in structure and functions of aquatic ecosystems (Poff and Zimmerman 2010). According to newest intercalibration reports, Latvia doesn't have any biological method which is sensitive to hydromorphological alterations and therefore development of new monitoring methods is crucial for ecological quality assessment and determination of hydrological pressure. According to WFD, the quality of water bodies should be determined primarily by biological indicators. It means that in the context of the water body management, hydrological calculations alone are not enough, and the relevant biological indexes should also be used by the managers to calculate the ecological flow rate.

Historically simple hydrological methods (for example, a certain amount of the flow of the summer low-water period) focusing on flow data series were most widely used, but during last decades hydraulic-habitat methods become more popular. Hydraulic-habitat methods simulates how flow alterations interacts with biota, determining available habitats.

Most widely used bioindicators to assess flow alterations are benthic macroinvertebrates and fish, but other metrics, traditionally used in monitoring (macrophyte, phytobenthos), are less sensitive to hydromorphological alterations caused by HPP. During last decades several macroinvertebrate metrics which focuses on hydromorphological alterations have been developed in Europe (DSFI, MESH, LIFE), but with these metrics it is not possible to determinate connectivity disruption which is a critical factor for riverine biota. Fish are considered as better indicator because they are sensitive not only to discharge fluctuations, but also to connectivity disruptions caused by dams which limits availability of spawning areas. According to WFD CIS Guidance Document No. 31 “Ecological flows in the implementation of the Water Framework Directive”, to fulfill all WFD requirements, ecological flows must be calculated using hydraulic-habitat methods.

There are three widely used habitat simulation models: PHABSIM, MesoHABSIM and HARPHA (Parasiewicz and Walker, 2007). All three models use hydromorphological and biological data to create habitat-flow rating curves.

HARPHA (Hybrid Approach for Riverine Physical Habitat Assessment) is microscale model which uses multivariate criteria to predict available habitat for fish. From all three models, HARPHA is the least used.

PHABSM (Physical habitat simulation system) is the oldest of all models. It is microscale model. It integrates the hydraulic and morphological condition into one species specific habitat quality index. It uses biological model (fish) and hydrological model to quantify available habitat for selected flows. Hydromorphological measurements are done using regularly spacing transects. Relative weakness of this model is that it uses univariate habitat-use criteria and time-consuming conduction of hydrodynamic models (including field measurements).

Basically, **MesoHABSIM** (Mesohabitat Simulation Model**)** is more advanced version of PHABSIM. It focuses on river assessment in mesoscale. This model delineates river reach into geomorphic units and in each unit at least seven random point measurements are done (stream velocity, depth and substrate). Compared to PHABSIM, MesoHABSIM uses multivariate habitat suitably criteria. At the moment MesoHABSIM is one of the most popular methods for ecological flow calculations, at least in Europe. Results of MesoHABSIM are fully in line with requirements of WFD.

3. MESOHABSIM MODEL AS A TOOL FOR E-FLOW ESTIMATION

The mesohabitat simulation model (MesoHABSIM) refers to the requirements for the river management. It builds to predict the response of the aquatic fauna and flora to habitat changes. The variable spatial distribution of the physical characteristics of the river, resulting from flow fluctuations and biological reactions of the aquatic species to these changes, is the basis for simulating the effects of changes in the river ecosystem and, accordingly, justification for mitigation measures, particularly for ecological flow implementation.

The types of mesohabitat are determined by their geomorphic (hydro-morphological) units (GUs), such as pools and rapids, substrates, cover and other hydrological characteristics. Mesohabitats are mapped in multiple flow conditions (from minimum low flow to maximum flow) in extensive sites along the river. Fish data shall be collected by randomly distributed mesohabitats, where shall also be carried out habitat surveys.

Data of every fish species and life stages are used to build a presence/absence and a presence/abundance model.

These data are used to develop mathematical models that describe which mesohabitats are used by fish more frequently. It gives the possibility to assess the availability of habitats at the flow range.

The Rating curves represent the changes in the area of suitable habitat in response to the flow (Fig. 3.1). These Rating curves can be developed for river units of any size that is very useful for the assessment of river or some river stretches' suitability for various fish species.

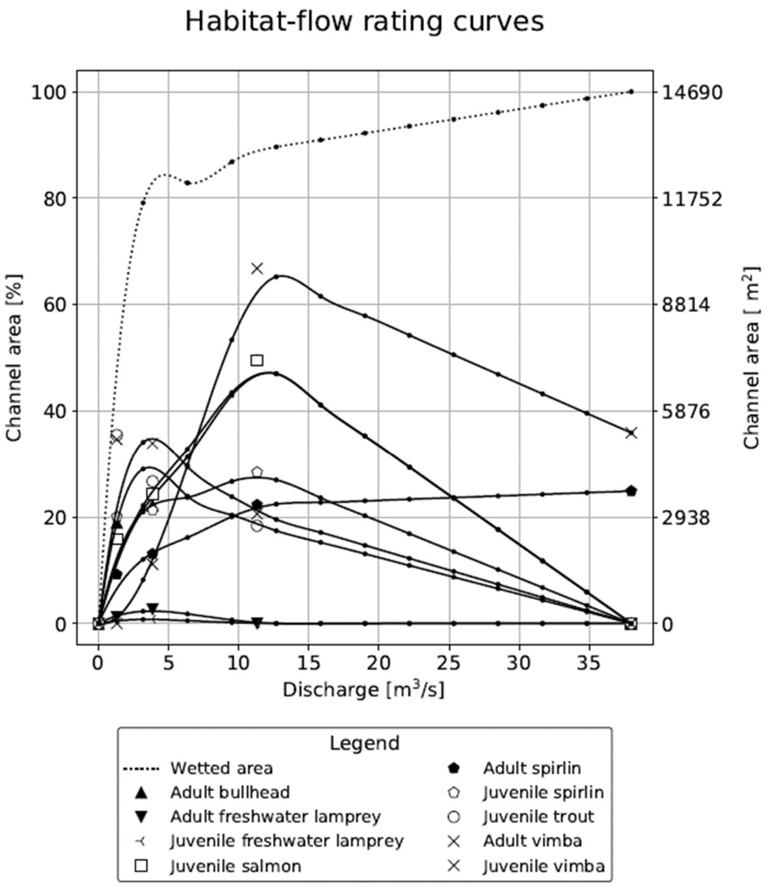

Figure 3.1. Habitat-flow rating curve of Venta River downstream Kuodžiai HPP

4. E-FLOW CALCULATION METHOD

4.1. Input data

Estimating ecological flow, the Sim-Stream tool of QGIS is used for implementation the Mesohabitat Simulation. The mentioned tools required different kind of information as input data, such as fish conditional models, hydro-morphological data and hydrological data.

4.1.1. Fish Conditional Model

The fish conditional models are developed according to the fish data, which is collected from the field surveys. These models are expressed as simplified mathematical models for evaluation of habitat suitability for different fish species.

Fish conditional models include the data of water depth, flow velocity, substrate of river bed and fish cover/shelter (e.g. woody debris, undercut banks, boulders, emergent & submerged vegetation); and evaluate how listed parameters influence the frequency of selected fish species in different geomorphic units (GUs). The fish conditional models are created for particular fish species of two different age groups (adults and juveniles) and they are adjusted to evaluate presence and abundance of specific fish species. The example of conditional models of *Alburnoides bipunctatus* is shown in Table 4.1.1.1.

Table 4.1.1.1.

Conditional models for prediction of presence and abundance of Alburnoides bipunctatus (adults and juveniles) in a river stretch (Lithuania and Latvia)

Alburnoides bipunctatus ADULTS Presence	*Alburnoides bipunctatus* ADULTS High abundance
IF (depth) [D30_45+D45_60+D60_75+D75_90+D90_105+ D105_120+D120_135+D135_D150]>0.4 AND (velocity) [CV15_30+CV30_45+CV45_60+CV60_75+ CV75_90+CV90_105]>0.3 AND (substrate) [MICROLITHAL + AKAL + PSAMMAL]>0.3	IF (depth) [D60_75+D75_90+D90_105+D105_120+D120_135+ D135_D150]>0.4 AND (velocity) [CV30_45+CV45_60+CV60_75+CV75_90]>0.4 AND (substrate) [MICROLITHAL + AKAL + PSAMMAL]>0.4
Alburnoides bipunctatus JUVENILES Presence	*Alburnoides bipunctatus* JUVENILES High abundance
IF (depth) [D_15+D15_30+D30_45+D45_60+D60_75] >0.3 AND (velocity)	IF (depth) [D15_30+D30_45+D45_60]>0.3 AND (velocity)

[CV15_30+CV30_45+CV45_60+CV60_75+ CV75_90+CV90_105]>0.3	[CV30_45+CV45_60+CV60_75+CV75_90]>0.3
AND (substrate)	AND (substrate)
[MICROLITHAL + AKAL + PSAMMAL]>0.3	[MESOLITHAL + MICROLITHAL + AKAL]>0.3

4.1.2. Geomorphic Unit maps

The GUs are mapped in the field surveys at multiple flow (discharge) conditions. Four different situations of the flow (from low flow minimum to low flow average, from low flow average to low flow maximum, from low flow maximum to annual mean and from annual mean to maximum flow) are selected as boundary conditions for creation of habitat-flow rating curves. These flow situations let us to assess all possible range of ecological flow.

The GUs are mapped four times with Map-Stream plugin of QGIS and ESRI ArcPad. The Map-Stream tool digitalised field measurements into necessary formats (.shp, .txt, etc.) for following modelling with Sim-Stream. The GUs mapping are updated by presence or absence of different natural attributes as follows: shading, roots, boulders, undercut banks, woody debris, and also submerged, emerged and overhanging vegetation.

The water depth, flow velocity and substrate of river bed are indicated at least in seven points of each GU. These measurements completed GUs approach in a river or river stretch. The examples of GU mapping results of two reaches are illustrated in Figure 4.1.2.1. The detailed description of different types of GUs can be found in Part 4 “Geomorphic Units Survey” of Deliverable 6.2 “Methods for HyMo Assessment” of REFORM project (4).

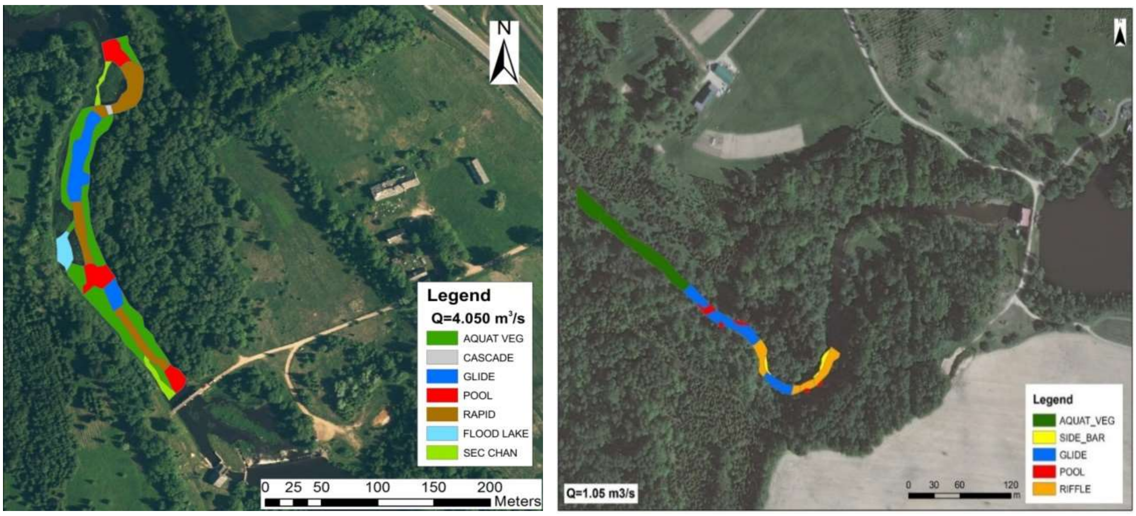

Figure 4.1.2.1. Geomorphic unit map of Venta river below Rudikiai HPP (left map) and Ciecere River below Pakuli HPP (right map) at situation of low flow maximum and low flow average

4.1.3. Flow data series

The data of hydrological scenarios of reference and altered conditions (time series of daily discharge) are necessary for hydrological simulations in particular case.

The reference conditions are represented by water gauging station (WGS) located upstream the selected HPP or modelled/calculated according to the method of analogue using river with natural flow; and altered conditions are represented by WGS in downstream of HPP or calculated according to the data series of energy production and technical specifications of turbines.

The daily discharge data series should be created for wet, normal and dry hydrological year (at least for one year of long-term average daily data) in order to evaluate the habitat suitability in all possible hydrological conditions. The example of reference and altered conditions are shown in Figure 4.1.3.1.

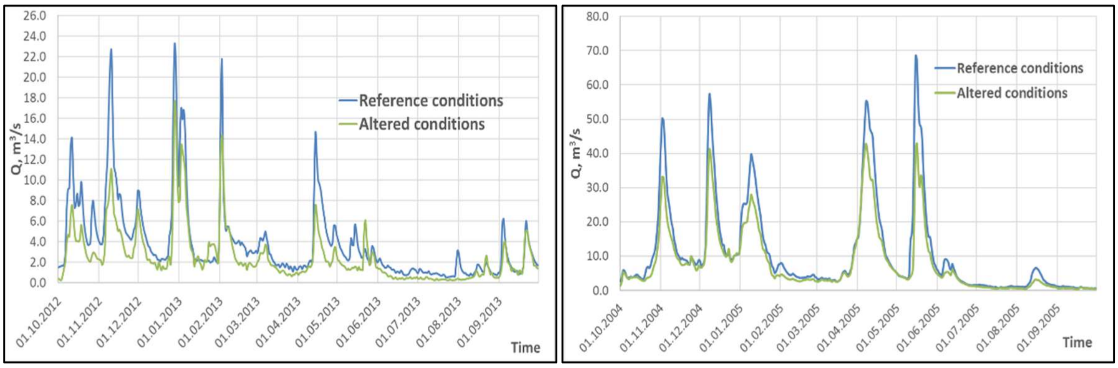

Figure 4.1.3.1. Hydrographs of normal year of Bartuva River at Skuodas HPP (left) and Levuo River at Akmeniai HPP (right) under reference and altered conditions

4.2. Modelling application

4.2.1. Modelling results

Sim-Stream Model is computer tool that supports the Mesohabitat Simulation approach. Sim-Stream describes river features that are relevant for aquatic species, calculates habitat suitability, and report on the actual and projected status of investigated river.

The software integrates hydro-morphological data collected during field surveys with fish data. This physical habitat simulation model describes the suitability of instream habitat conditions for aquatic fauna, allowing to simulate change in habitat quality and quantity in response to alterations of flow or river morphology.

Modelling results include number of maps, graphs and indices.

Since the distribution of GUs changes as a function of flow, the mesohabitats are mapped under multiple flow conditions at representative stretches of the river (Fig. 4.2.1.1.- 4.2.1.2).

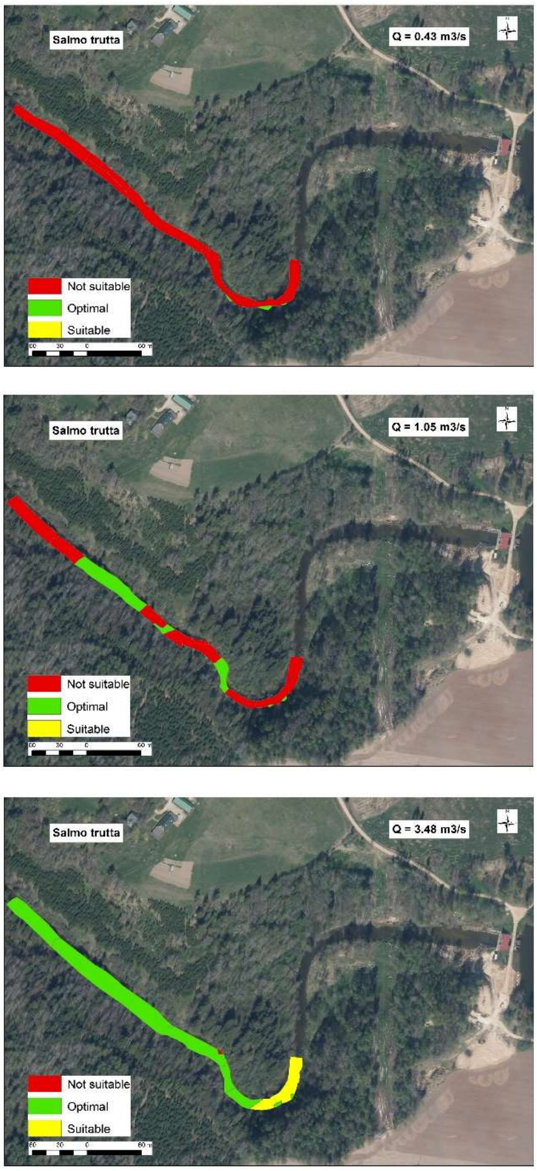

Figure 4.2.1.1. Habitat suitability maps for brown trout (adult) in presence of min low flow (above), average low flow (centre) and annual flow (below), Ciecere River downstream Pakuli HPP.

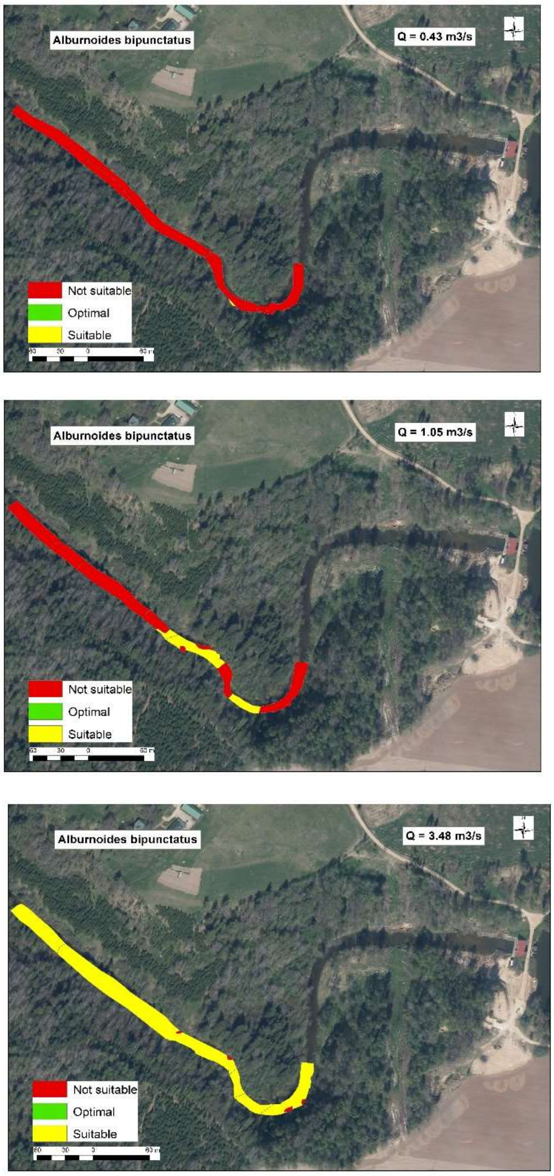

Figure 4.2.1.2. Habitat suitability maps for spirlin (adult) in presence of min low flow (above), average low flow (centre) and annual flow (below), Ciecere River downstream Pakuli HPP.

Graphs illustrate the significant increasing of habitat suitability with flow rising (e.g.1.5% of river stretch is suitable during minimum low flow for adult brown trout, 32.2% - during maximum low flow and 99% - in the annual flow' conditions).

The Habitat – Flow rating curve (Fig. 3.1) is developed for all species of interest, and to be used for the e-flow determination.

Habitat temporal distribution illustrate Habitat availability graphs (Fig. 4.2.1.3). These modelling results allow to calculate number of "stress days" for each fish species (Fig. 4.2.1.4), where habitat area is located below the threshold (>97% of probability).

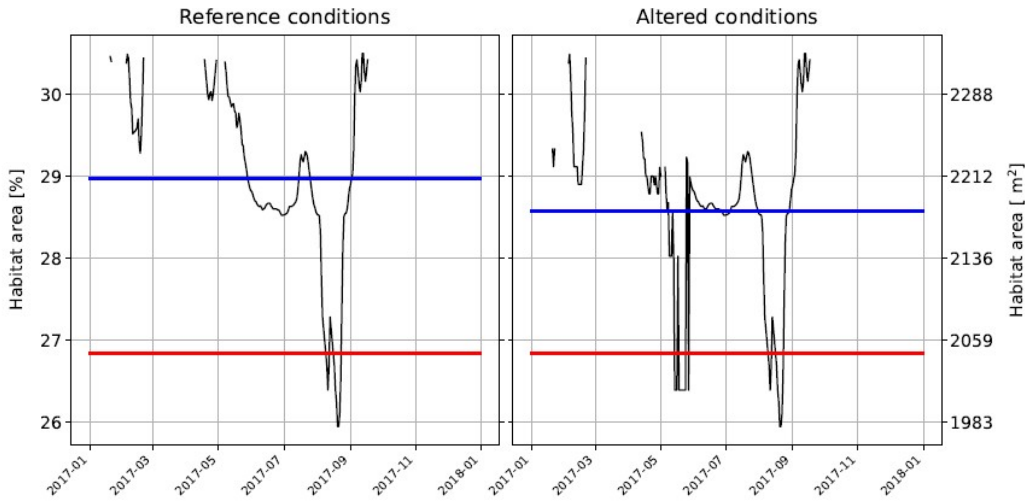

Figure 4.2.1.3. Habitat time series of the stone loach (adult) in reference and altered conditions, Islice River downstream Rundale HPP

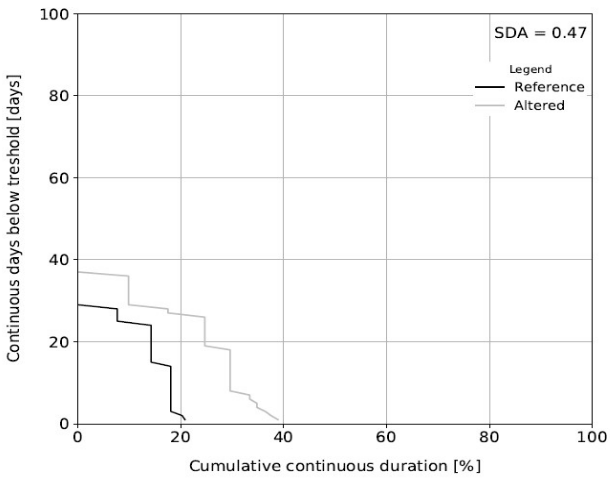

Figure. 4.2.1.4. Cumulative "stress days" duration of the adult common dace in reference and altered conditions, Islice River downstream Rundale HPP

To establish the e-flow in the modelled river stretches, the Optimum flow (thereafter $Q_{OPTIMUM}$) should be chosen as a baseline.

The $Q_{OPTIMUM}$ is a flow value, at which the area of suitable habitat reaches its maximum, or continues to increase, depending solely on the surface area of the water.

The optimum flow is determined using a modelled relationship between runoff and area of habitat suitable for certain fish species. The $Q_{OPTIMUM}$ values for different fish species, as well as adults and juveniles, are different in some cases.

First case is common for the cyprinid fish species. Herewith the maximum value of habitat area for juveniles is smaller than for adults and corresponds with smaller water discharge (Fig. 4.2.1.5).

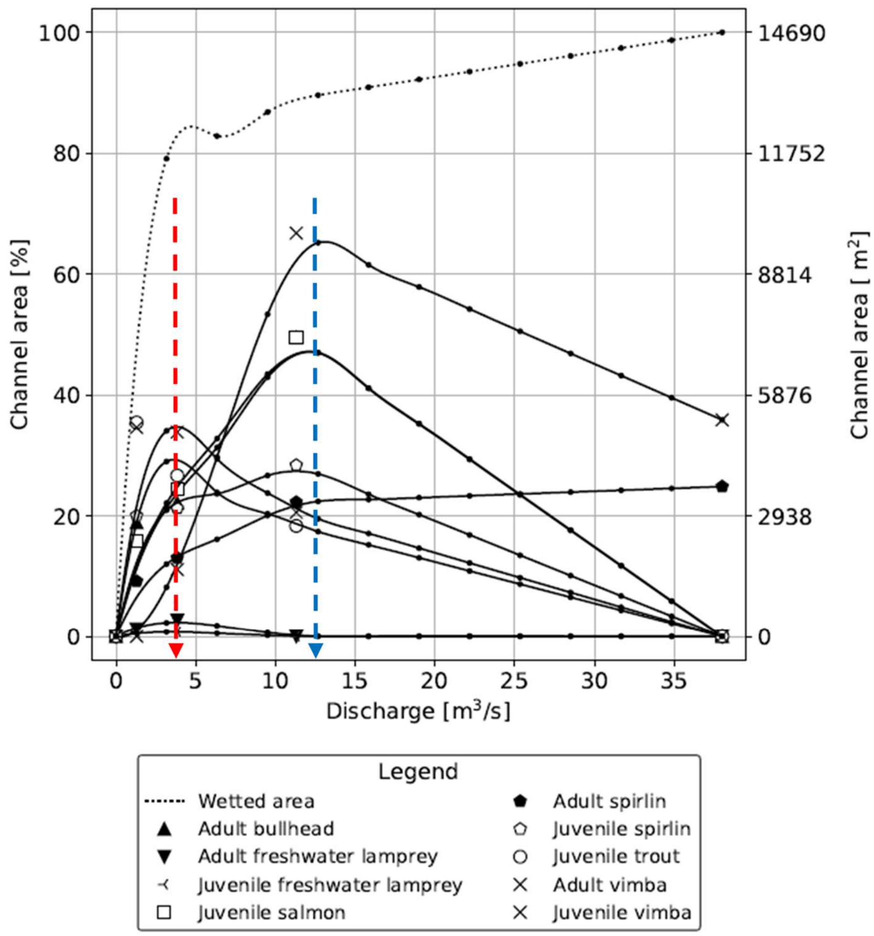

Figure 4.2.1.5. Habitat-Flow rating curve of Venta River downstream Kuodžiai HPP (red arrow shows the optimal water discharge for juveniles and blue arrow – for adults)

The second case is usual for the salmonid fish species. The conditional maximum value of habitat area might be corresponded with annual mean flow (Fig. 4.2.1.6).

Three indices are related to habitat' suitability: ISH – Index of Spatial Habitat availability, ITN – Index of Temporal Habitat availability and IH - Index of Habitat Integrity, that is a minimum value of two previous indices:

$$IH = \min (ISH, ITN)$$

There is a relationship between the Index of Habitat Integrity IH and ecological status of waterbody (Fig. 4.2.1.7)

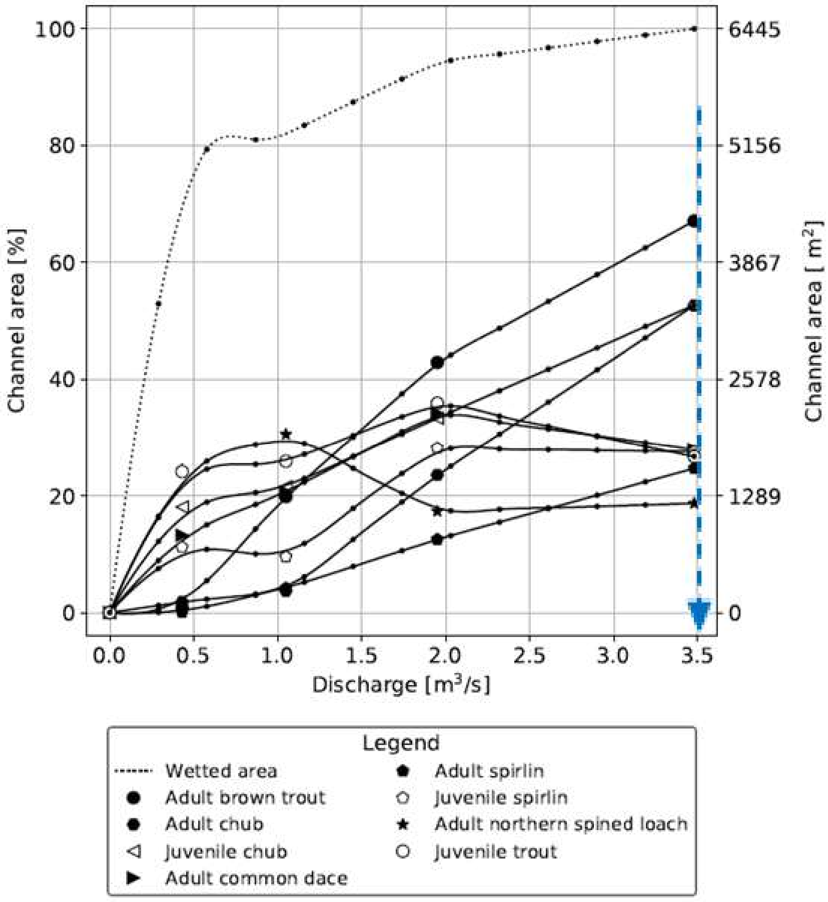

Figure 4.2.1.6. Habitat-Flow rating curve of Ciecere River downstream Pakuli HPP (blue arrow shows the optimal water discharge for adults' brown trout)

IH	Class
IH>0.80	High
0.60 < IH <0.80	Good
0.40 < IH <0.60	Moderate
0.20 < IH < 0.40	Poor
IH < 0.20	Bad

Figure 4.2.1.7. Index of Habitat Integrity IH and ecological status of waterbodies

Thus, overall results of modeling are meaningful and can be used for establishment of the e-flow.

4.2.2. E-flow estimation

The maximum habitat area and the water discharge related to this area (Fig. 4.2.1.5. – 4.2.1.6.) is a critical point for evaluation of e-flow.

In view of existing relations between habitat availability and water ecological quality, it is possible to conclude that 60% of the **$Q_{OPTIMUM}$** is sufficient value for presence and development of fish fauna during spawning and rearing period (mid October – June). For the rest of a year 30% of the **$Q_{OPTIMUM}$** is necessary to protect the aquatic fauna and flora during the dry season.

The Roadmap of e-flow evaluation include following major steps:

1. collecting of water flow data in reference and altered conditions;
2. collecting of fish (species of interest) data;
3. carrying out of field measurements and habitat mapping using the “Habitat Survey datasheet” (Annex I) and the “Geomorphic units and macro-units list” of REFORM Project (Annex II);
4. habitat modelling by Sim-Stream Model;
5. developing of $Q_{OPTIMUM}$ using Habitat – Flow Rating curve;

6. calculation of e-flow values.

4.3. E-Flow calculation simplification

The Methodology can be developed only if the e-flow can be calculated on the basis of variables, characterizing the annual runoff of the river. But for this, there should be some general patterns in the relationship between the e-flow and the metrics of annual runoff, so that the results of estimation of the e-flow in the studied river stretches can be extrapolated to other river stretches below HPPs.

There is a common agreement, that, if the status is classified from 0 to 1, the zero indicating bad status and 1 – high (or reference) status, than for classification to five status classes this interval can be subdivided into 5 equal subintervals (Fig. 4.3.1). Such approach of status classification is commonly accepted under European Water Framework Directive, and it is widely used in the classification of ecological status of water bodies based on biological quality elements. In addition, the same approach is used for division to status classes based on Index of spatial habitat availability, index of temporal habitat availability as well as overall index of habitat integrity. Consequently, it can be supposed, that, if the habitat area is the function of flow, than 0.6 of optimal flow should guarantee at least good status of fish species of concern (Fig. 4.3.1).

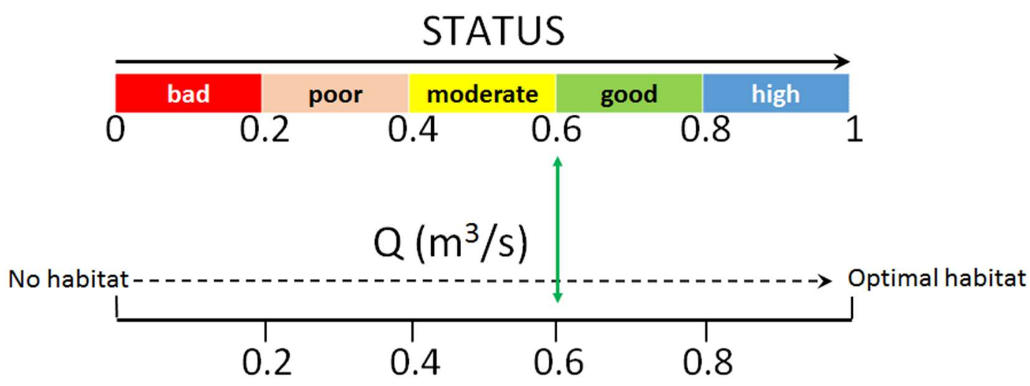

Figure 4.3.1. Schematic description of the identification of runoff, which corresponds ot at least minimally good conditions for fish.

Therefore, 0.6 of optimal flow (thereafter $Q_{OPTIMUM}$*0.6) were calculated in the studied rivers and compared with different indicators, describing annual characteristics of natural flow, which were calculated based on long term hydrological data before construction of HPP. It appeared that the modelled values of $Q_{OPTIMUM}$*0.6 are close to values of the median of minimum flow of the 30 driest days in winter, multiplied by 0.65 (min $Q_{50\%}$ winter*0.65). The average ratio of min $Q_{50\%}$ winter*0.65 / $Q_{OPTIMUM}$*0.6

in the studied river stretches is equal to 0.98 (±0.07), therefore the mismatch is relatively small. Therefore, min $Q_{50\%}$ winter*0.65 can be presumably considered as an e-flow, providing the fish with at least good conditions.

However, streams have natural regimes with seasonal fluctuations of flow. The low flow in the summer time is a natural phenomenon. Native species have evolved under such conditions, and are adapted to them. Discharge during summer period (~mid June – mid October) is naturally less than discharge during the spawning season (~April-mid of June for cyprinids and ~mid of October-November for salmonids) and during the wintering period (and rearing period for salmonids; December-April). An e-flow corresponding to min $Q_{50\%}$ winter*0.65 and providing at least good conditions was established for those fish for which optimum at higher flows is associated with natural runoff in the winter. In addition, for juveniles and some small fish species, optimal runoff is lower than for adults. The modeling results show that. Thus, different e-flow values should be established for low-flow season and for the rest part of the year

The low flow in the summer-early autumn is usually much less than in the winter-spring and strongly deviates from flow, which is optimal for many of species. Such conditions can be considered as poor, but not bad, because adult fish still manage to successfully survive during the low flow period. If the conditions would be really bad, they wouldn‘t survive. Therefore, following the same approach based on division to status classes, we have chosen the middle of poor status class ($Q_{OPTIMUM}$*0.3) to represent marginal conditions in summer (Fig. 4.3.2).

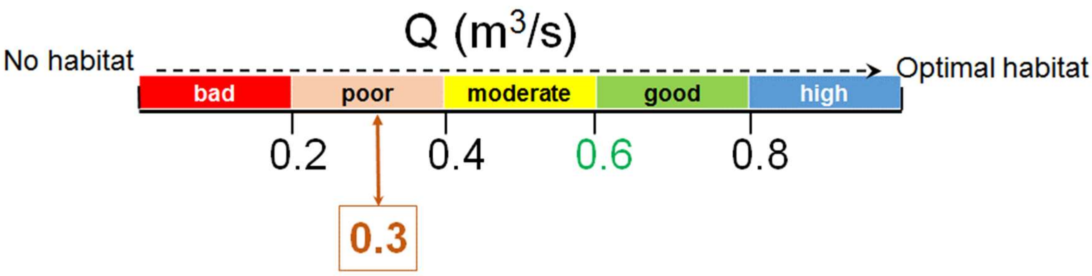

Figure 4.3.2. Schematic description of the identification of marginal conditions in summer.

Comparison of the $Q_{OPTIMUM}$*0.3 values with various indicators describing the annual characteristics of the natural flow showed that $Q_{OPTIMUM}$*0.3 are close to the median of minimum flow of the 30 driest days in summer (Fig. 4.3.3). The average ratio of min $Q_{50\%}$ summer / $Q_{OPTIMUM}$*0.3 in the studied river stretches is equal to 1.06 (±0.13), therefore the discrepancy is relatively small. Therefore, min $Q_{50\%}$ summer can presumably be considered as an e-flow for a low flow season.

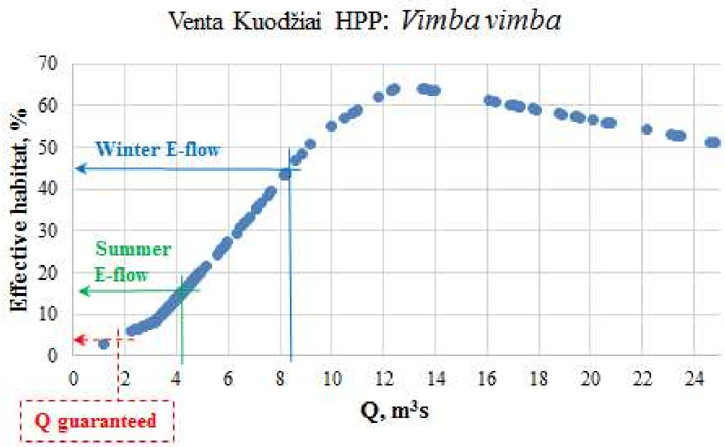

Figure 4.3.3. Proportion of effective habitat at the winter e-flow (blue line), summer e-flow (green line) and Q guaranteed (red line).

Comparison of the modelling results with annual characteristics of the studied rivers stretches indicates that to mitigate the impact of HPPs, different ecological flows should be used for the low flow season, and another part of the year. These e-flows are:

Winter e-flow = min $Q_{50\%}$ winter*0.65

Summer e-flow = min $Q_{50\%}$ summer

Application of higher e-flow during high flow season is of great importance, because late autumn, winter and spring are a critical period for fish. Fish are the cold blooded creatures therefore a sudden change in water temperature as well as zero temperature and ice cover is stressful for them. It is also crucial to provide fish with at least good conditions during spawning season. A significant reduction in habitat area in any of these periods can cause significant stress to the fish and/or seriously disturb fish reproduction, therefore at least marginal good conditions should be guaranteed.

Comparison of the availability of the suitable habitat for fish at summer and winter e-flows with the availability of habitat at Q guaranteed (30 driest days min $Q_{95\%}$ or $Q_{80\%}$ in summer-autumn) clearly shows that Q guaranteed, which is currently used as the minimum allowable flow in the HPP management, provides the fish with an extremely small proportion of suitable habitat (Fig. 4.3.3). This indicates that the current Q guaranteed cannot be considered environmentally friendly and should be changed.

The range of coefficient of regulation of natural flow in the rivers of different hydrological regions within Latvian – Lithuanian territory is different. Because of this, *e-flow* can only be established after applying habitat modelling and assessing the relationship between habitat area and flow. In the future, typical (pilot) river catchments should be selected for detailed studies in each hydrological region.

5. PRACTICAL APPLICATION OF METHODOLOGY

Latvia and Lithuania have different laws and regulations in the field of environmental protection. Therefore, the role of state authorities and other institutions involved in setting environmental requirements for water use is also different. For this reason, the recommendations on the approach for determining ecological flows are country specific.

5.1. Latvia

Currently there are several advantages and restrictions for practical application of method for calculation of ecological flow developed within this project. Significant advantage is that there is no need for knowledge transfer since institute BIOR which is one of the project partners is pointed out in legislation to be one of the competent authorities for calculation of ecological flow. However currently institute BIOR has a lack of expertise in hydrological and hydromorphological evaluation needed for implementation of both MesoHABSIM model and simplified method for calculation of ecological flow. Therefore, for practical implementation of conclusions of this project cooperation with LEGMC or other institutions will be needed, at least in a beginning.

One of significant restrictions for implementation of this project is also a great number of HPP operating in Latvia. Taking into account the capacity of both previously mentioned organisations even at a best scenario calculation of ecological flow for all HPP by using MesoHABSIM model would take at least a decade.

To minimise the impact of insufficient capacity following steps are suggested:

1. Compilation of all available information for all HPP operating in Latvia. This information should include not only requirements set in water use permit and data regarding equipment and operation regime of HPP but also information regarding type of river, fish fauna and other environmental data;

2. Development a method for listing all HPS in priority order for a calculation of ecological flow. Potentially most important criteria for prioritising HPP are allocation of a HPS, current requirements of water use permit, river quality below HPS and fish fauna below HPS;

3. List of all HPP in priority order. At this point listing in at least three groups are suggested however it is possible that after compilation of all available information number of groups can be larger or smaller;

4. Perform the calculation of ecological flow. At this point it is suggested that ecological flow for a HPPs with a largest adverse impact should be calculated by use of a MesoHABSIM model. For HPP with medium impact simplified methods can be

used and for HPP with a minor impact (for example HPP located directly above watercourse of another HPP) very simple calculations are acceptable.

Nevertheless it needs to be taken into account that following steps mentioned previously require additional effort and cooperation between institute BIOR, LEGMC, State Environmental Service, HPP owners and other. In accordance to that the local follow-up project for solving practical difficulties in implementation of conclusions of this project is suggested. It is also important that amendments of legislative acts suggested by ECOFLOW project (Recommendations for the amendment to national water legislations) will be implemented.

5.2. Lithuania

At present, the procedure for estimation of environmental flow is described in the relevant legal acts, and the practical application of the procedure can be carried out by any institution that has the appropriate qualifications. The results of the calculation can be applied in practice only after the approval of the Environmental Protection Agency. Changes in legal acts impose an obligation on institutions that calculate electronic flows to follow the amended calculation rules.

One of the limitations of applying the project results across the country is the difference in the annual flow characteristics in different hydrological regions. The coefficients of natural flow regulation (proportion of the base flow from the annual flow) of the rivers studied in the catchments of the Venta and Lielupe rivers are 0.5–0.6. For these rivers, according to the results of the simulation, Q_{ECOL} can determined by the formulas:

winter period (from the middle of October till the middle of March)

$Q_{ECOL}'=0.65\times Q(50\%)'$,

summer period (from the middle of March till the middle of October)

$Q_{ECOL}''=Q(50\%)''$, where

Q(50%)' - minimum thirty day runoff of 50% probability in winter,

Q(50%)'' - minimum thirty day runoff of 50% probability in summer-autumn.

The range of natural flow regulation coefficient in the range of 0.5-0.6 is typical for rivers in the hydrological region of Central Lithuania. Therefore, Q_{ECOL} for these rivers can be defined in the same way as for rivers modelled in the Venta and Lielupe catchments.

If the Q guaranteed currently specified in the national legislation will be replaced by Q_{ECOL}, the Rules for the use and maintenance of the reservoir have to be amended accordingly. When the inflow into the reservoir exceeds Q_{ECOL}, the flow passed through the HPP must be not less than Q_{ECOL}. When the inflow into the reservoir is less than Q_{ECOL}, all the inflow must be passed through the HPP, and in some cases, after coordination with the Environmental Protection Agency, pond water reserves can be used for the conservation of fish habitats below the HPP.

The range of coefficient of regulation of natural flow in the rivers of the Western and South-Eastern hydrological regions of Lithuania is different. Because of this, Q_{ECOL} can only be established after applying habitat modelling and assessing the relationship between habitat area and flow. In the future, typical (pilot) river catchments should be selected for detailed studies in the above-mentioned hydrological regions.

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ANNEX I

HABITAT SURVEY DATASHEET

Habitat survey datasheet

Date:_______ Time:______ Discharge:_______

Reach name/location:_______________________________________

Habitat #:______

Habitat type: pothole; cascade; rapid; riffle; step; pool; glide; backwater; aquatic vegetation; secondary channel; floodplain lake; artificial element

Choriotop categories: Check those that exist around the measurement point:

- Megalithal (>40cm, big boulders)
- Macrolithal (20-40cm, hand to head)
- Mesolithal (6-20cm, fist to hand)
- Microlithal (2-6cm, bird egg to sm fist)
- Akal (gravel)
- Psammal (sand)
- Pelal (silt, loam, sludge, clay)
- Detritus (organic matter)
- Xylal (tree trunks, branches, roots)
- Sapropel (sludge)
- Phytal (submerged plants, floating mats)

Depth [cm]:	Velocity [m/s]:	Substrate:
1:_______	1:_______	1:_______
2:_______	2:_______	2:_______
3:_______	3:_______	3:_______
4:_______	4:_______	4:_______
5:_______	5:_______	5:_______
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ANNEX II

Geomorphic units and macro-units list

Spatial setting	Macro-unit	Macro-unit type	Macro-unit sub-type
Bankfull channel ('submerged' units)	Baseflow or submerged channels (C/S)	Baseflow channel or main channel (C)	
		Secondary channel (within bankfull) (S)	Chute cut-off Two-way connected branch One-way connected branch Pond

Spatial setting	Macro-unit	Unit (type)	Unit sub-type
Bankfull channel ('submerged' units)	Baseflow or submerged channels (C/S)	Pothole (CH)	
		Cascade (CC)	
		Rapid (CR)	
		Riffle (CF)	Forced riffle
		Step (CT)	Rock step Waterfall Boulder step Log step
		Glide (CG)	Rock glide
		Pool (CP)	Forced pool Scour pool Plunge pool Dammed pool Meander pool
		Dune system (CD)	
Bankfull channel ('emergent' units)	Emergent sediment units (E)	Bank-attached bar (EA)	Side bar Point bar Counterpoint bar Junction bar Forced bank-attached bar
		Mid-channel bar (EC)	Longitudinal bar Transverse bar Diagonal bar Medial bar Bedrock core bar Forced mid-channel bar
		Bank attached high-bar (EAh)	
		Mid-channel high-bar (ECh)	
		Bank-attached boulder berm (EB)	
		Mid-channel boulder berm (EM)	
		Dry channel (ED)	
		Bedrock outcrop (EO)	
		Unvegetated bank (EK)	
	In-channel vegetation (V)	Island (VI)	Grassy island Young woody island Established/Adult woody island Mature woody island Complex woody island

	In-channel vegetation (V)	Large wood jam (VJ)	Meander jam Bench jam Bar apex jam Bar top jam Dam jam Bank input jam Flow deflection jam Landslide jam Vegetation-trapped jam
		Aquatic vegetation (VA)	Floating leaves Submerged leaves Emergent leaves
		Bench (VB)	Submerged shelf Berm Bench (sensu stricto) Ledge Point bench Concave bank bench Shelf Slump bench Ice abrasion and ice ploughing bench
		Vegetated bank (VK)	
Floodplain	Riparian zone (F)/ Human dominated areas (H)	Modern floodplain (FF/HF)	
		Recent terrace (FT/HT)	
		Scarp (FS/HS)	
		Levee (FL/HL)	
		Overbank deposits (FD/HD)	Crevasse splay Sand wedge Sand sheet
		Ridges and swales (FR/HR)	
		Floodplain island (FI/HI)	
		Terrace island (FN/HN)	
		Secondary channel (FC/HC)	Flood channel Abandoned channel Abandoned meander
	Floodplain aquatic zones (W/H)	Floodplain lake (WO/HO)	Oxbow lake
		Wetland (WW/HW)	Swamp Floodplain ponds

Spatial setting	**"Macro-units"**	**Feature types**
Floodplain	Human dominated areas (H)	Agriculture (HAg) Plantation (HPl) Urban (HUr)
All	Artificial features (A)	Dam (AA) Check-dam (AB) Weir A(C) Retention basin (AD) Diversion or spillway (AE) Culvert (AF) Ford (AG) Bridge (AH) Bed revetment (AI) Bed sill (AJ) Ramp (AK) Bank protection (AL) Artificial levee or embankment (AM) Mining sites / Sediment removal (AN)