Supplementary Materials

Section A

Table S1. SPHY model (see Section "Scale and scenario setting") input type and their values for the generation of the surface runoff for the river network in the considered case study area.

Map		**Source**
Dem		Cantabrian Government/EU-DEM
Latitude		European Space Agency (ESA)
Top soil	*Field capacity* ($SW_{1, fc}$) *Saturated water content* ($SW_{1, sat}$) *Wilting point* ($SW_{1, pF3}$) *Permanent wilting point* ($SW_{1, pF4.2}$) *Saturated conductivity* ($K_{sat, 1}$)	HiHydroSoil Database
Sub soil	*Field capacity* ($SW_{2, fc}$) *Saturated water content* ($SW_{2, sat}$) *Saturated conductivity* ($K_{sat, 2}$)	HiHydroSoil Database
Land use		IHCantabria
Climate	*Precipitation* *Temperature (min, mean, max)*	IHCantabria

Model parameter	**Physical meaning of model parameter**	**Initial value**
$SW_{3, sat}$	*Saturated water content in groundwater zone (mm)*	300
δ_{gw}	*Delay in groundwater recharge (days)*	119.697
BF_{tresh}	*Minimum value for baseflow to occur (mm)*	0
α_{gw}	*Parameter of baseflow days: alphaGw = 2.3/x (x = nr. Of baseflow days)*	0.051
μ	*Specific aquifer yield (m/m)*	0.05
kx	*Recession coefficient of routing*	0.5

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Table S2. Variation of the environmental parameters for the present (1980-2012) and future (2041-2070) time periods considered in the study.

Basin	**P** (mm/year)	T_{mean} (ºC)	**Kc**	**ETa** (mm/year)	Q_{mean} (m^3/s)
1980-2012	**1531**	**8.5**	**0.78**	**566**	**13.20**
2041-2070	**1387**	**10.1**	**0.84**	**614**	**9.90**
Variation	**-9%**	**1.6ºC**	**8%**	**9%**	**-25%**

The hydrological model's performance during calibration was analysed based on the Nash-Sutcliffe efficiency (LOG NSE) between observed and simulated flow. The performance of the SPHY model in the Pas catchment was done using the Puente Viesgo gauge station (period 01/01/1996 to 31/12/1998) and showed good calibration performance (log NSE =0.74). In addition, the model validation was assessed based on the LOG NSE and the percentage of Bias (PBIAS) from the observed mean flow. The validation analysis was done using the Puente Viesgo gauge station data for the period 01/01/1980 to 30/09/2007 and the results (LOG NSE = 0.75 and PBIAS = -7.28) confirmed the validity of the parameter values established through the calibration process.

Table S3. Percentage cover for each class and each scenario considered in the optimization simulation.

Land cover type	**PR Baseline**	**CC_BAU**	**CC_BGIN**
Broadleaf forest	16%	18%	25%
Coniferous forest	3%	3%	3%
Scrubs and Shrubs	45%	55%	48%
Pasture and grassland	29%	18%	19%
Agricultural land	4%	3%	2%
Denuded rock, bare land	0,5%	0,5%	0,5%
Urban areas & Human-derived activities	3%	3%	3%
Wetlands and water-associated ecosystems	0,5%	0,5	0,5%

Table S4. Summary of the e-flow requirements (EFR) considered in the study. The EFR define the hydrological conditions to be conserved in the river during the daily diversion operations throughout the year. The table shows the duration, the hydrological metric used and the month of the year relevant for each EFR. Legend: %MMF = percentage value of mean monthly flow; Qm7 = 7 times the median annual flow; Q75 = the flow value that is exceeded 25% of the time; %MYF = percentage value of the mean yearly flow.

Supporting ES		**EFR**	**Duration**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
Provision of habitat conditions for fish ES	*Migration*	R1a	Month	35% MMF											
		R1b	2 events (1 per month)	> Qm7											
	Spawning	R2	Month			50% MMF									
	Hatching	R3a	Month					55% MMF							
		R3b	27 days					< Qm7							
	Recruitment	R4	Month								55% MMF				
Life-supporting conditions for macroinvertebrates ES		R5	5 events	> Q75											
Primary productivity ES		R6	70 days							> 10% MYF					

Section B

S5. Human water supply objective

The aim of this objective O_S, is the maximization of the yearly water supplied for human use. No limitation to the water volume for human use has been set but rather the objective aims to identify the highest river water volume that can be extracted, meaning the delivery capacity of the river can be assessed.
The condition is valid for each point in the basin, hence accounting for the local volumetric capacity at each considered location in the basin. The objective function has hence been expressed as a minimization function of the difference between the total water volume provided by the river and the total diverted water from the river:

$$O_S: \quad \min\ f(y) = V_z^R - V_z^{\mathrm{D}} \tag{1}$$

Where:

V_z^{R}	total natural water volume per year that is available at a specific point z in the river, in m^3 per year;
V_z^{D}	total diverted water volume in m^3 per year, represents the maximum total abstraction volume per year at a specific point z (corresponding with a RS).

The total volume of natural flow and diverted flow is defined as follows:

$$V_z^R = \sum_{i=1}^{365} (x_i \cdot \tau) \tag{2}$$

$$V_z^D = \sum_{i=1}^{365} (y_i \cdot \tau) \tag{3}$$

Where:

$i \in \{1, \dots, 365\}$	days of the year;
x_i	natural flow (m^3/s) at day i of the year, $x_{\mathrm{i}} \in \mathbb{R}_0^+$. Represents the value of the natural flow (m^3/s) in the river at day i and is defined by the input scenario. This value doesn't change throughout the optimization process;
y_i	diverted flow (m^3/s) at day i of the year, $y_i \in \mathbb{R}_0^+$. Represents the portion of river flow (m^3/s) that is diverted from the river. It is randomly generated at each generation;
τ	constant, referring to the daily time-frame of diversion (considered 24 h);

Subject to:

Daily diverted discharge limit

$$0 \leq y_i \leq x_i \tag{4}$$

S6. Ecosystem services objectives

The ecosystem services (ES) objectives considered in this study: habitat conditions provisions for fish at different life-stages ES (O_{ES}^1), provision of conditions for macroinvertebrates taxa richness ES (O_{ES}^2) and primary productivity ES (O_{ES}^3) are represented by the aggregation of six optimization indicators (i.e. O_{R1}, O_{R2}, O_{R3}, O_{R4}, O_{R5}, O_{R6}). This section provides the description of the optimization functions defining the optimization indicators. The optimization equations presented below are expressed as minimization functions of the sum of the scores for each e-flow requirement. For modelling convenience each indicator has been fragmented in sub-equations, hence the equations are presented as they were incorporated in the optimization model.

Optimization objectives for habitat condition provision for fish life-stages ES (O_{ES}^1)

$$O_{ES}^1 = O_{R1} + O_{R2} + O_{R3} + O_{R4} \tag{5}$$

Let $q_i \coloneqq x_i - y_i$ be the residual water flow (m^3/s) in the river (the difference between x_i and y_i and represents the portion of the river flow that remains in the river after diversion), the O_{R1} optimization objective for fish migration is defined as follows:

$$O_{R1}: \quad \min\ f(q) = O_{R1}^1 + O_{R1}^2 + O_{R1}^3 \tag{6}$$

$$O_{R1}^1: \quad f_{1;1}(q) = \frac{\sum_{i=1}^{n} S_i^{R1;1}}{n} \qquad where\ i \in a_1 \tag{7}$$

$$S_i^{R1;1} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{35} > 0,\ i \in \mathscr{A}_1 \\ 1 - \frac{q_i}{\alpha_h^{35}}, & otherwise \end{cases} \tag{8}$$

Where:

$S_i^{R1;1}$	score value for the day i, when $i \in \mathscr{A}_1$;
$\mathscr{A}_1$	set of days of the year relevant for R1;1;
a_1	subset of $\mathscr{A}_1$, containing $S_i^{R1;1} > 0$ values;
n	number of days in the set a_1, $n \in \mathbb{N}^*$;
α_h^{35}	reference value for the discharge threshold (in m^3/s) corresponding to the 35% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R1}^2: \quad f_{1;2}(q) = \frac{\sum_{i=1}^{n} S_i^{R1;2}}{n} \qquad where\ i \in a_2 \tag{9}$$

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$$S_i^{R1;2} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{35} > 0,\ i \in \mathscr{A}_2 \\ 1 - \frac{q_i}{\alpha_h^{35}}, & otherwise \end{cases} \quad (10)$$

Where:

$S_i^{R1;2}$	score value for the day i, when $i \in \mathscr{A}_2$
$\mathscr{A}_2$	set of days of the year relevant for R1;2;
a_2	subset of $\mathscr{A}_2$, containing $S_i^{R1;2} > 0$ values
n	number of days in the set a_2, $n \in \mathbb{N}^*$;
α_h^{35}	reference value for the discharge threshold (in m^3/s) corresponding to the 35% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R1}^3: \quad f_{1;3}(q) = S^{R1;3} \quad (11)$$

$$S^{R1;3} = \begin{cases} 0, & \forall\, i,\ if\ N^{R1;3} \geq \beta_R, i \in a_3 \\ \beta_h - \omega, & otherwise \end{cases} \quad (12)$$

$$N^{R1;3} = \sum_i I_{q_i \geq \beta_h} \qquad i \in \mathscr{A}_3 \quad (13)$$

Where:

$S^{R1;3}$	score value for the R1;3 ;
$N^{R1;3}$	number of days i, resulting from the set $\mathscr{A}_3$, that satisfy the condition;
$\mathscr{A}_3$	set of days of the year relevant for R1;3 ;
a_3	subset of $\mathscr{A}_3$, containing $S_i^{R1;3}$ values;
ω	$\max f[\, a_3]$ is the maximum of the set a_3;
I	indicator function, takes the value of 1 or 0 respectively if the condition is satisfied or not;
β_h	reference value for the discharge threshold (in m^3/s) corresponding to seven times the median annual flow value for the given hydrograph h;
β_R	constant, number representing the optimal occurrence of events for the promotion of R1;3, $\beta_R \in \mathbb{N}^*$;

The O_{R2} optimization objective for fish spawning is defined as follows:

$$O_{R2}: \quad \min\ f(q) = O_{R2}^1 + O_{R2}^2 \quad (14)$$

$$O_{R2}^1: \quad f_{2;1}(q) = \frac{\sum_{i=1}^{n} S_i^{R2;1}}{n} \qquad where\ i \in b_1 \quad (15)$$

$$S_i^{R2;1} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{50} > 0,\ i \in \mathscr{B}_1 \\ 1 - \frac{q_i}{\alpha_h^{50}}, & otherwise \end{cases} \quad (16)$$

Where:

$S_i^{R2;1}$	score value for the day i, when $i \in \mathscr{B}_1$;
$\mathscr{B}_1$	set of days of the year relevant for R2;1;
b_1	subset of $\mathscr{B}_1$, containing $S_i^{R2;1} > 0$ values;
n	number of days in the set b_1, $n \in \mathbb{N}^*$;

α_h^{50}	reference value for the discharge threshold (in m^3/s) corresponding to the 50% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R2}^2: \quad f_{2;2}(q) = \frac{\sum_{i=1}^{n} S_i^{R2;2}}{n} \qquad where\ i \in b_2 \tag{17}$$

$$S_i^{R2;2} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{50} > 0,\ i \in \mathscr{B}_2 \\ 1 - \frac{q_i}{\alpha_h^{50}}, & otherwise \end{cases} \tag{18}$$

Where:

$S_i^{R2;2}$	score value for the day i, when $i \in \mathscr{B}_2$;
$\mathscr{B}_2$	set of days of the year relevant for R2;2;
b_2	subset of $\mathscr{B}_2$, containing $S_i^{R2;2} > 0$ values;
n	number of days in the set b_2, $n \in \mathbb{N}^*$;
α_h^{50}	reference value for the discharge threshold (in m^3/s) corresponding to the 50% of the *mean monthly flow* value for the given hydrograph h.

The O_{R3} optimization objective for fish hatching is defined as follows:

$$O_{R3}: \quad \min\ f(q) = O_{R3}^1 + O_{R3}^2 + O_{R3}^3 + O_{R3}^4 \tag{19}$$

$$O_{R3}^1: \quad f_{3;1}(q) = \frac{\sum_{i=1}^{n} S_i^{R3;1}}{n} \qquad where\ i \in c_1 \tag{20}$$

$$S_i^{R3;1} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{C}_1 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{21}$$

Where:

$S_i^{R3;1}$	score value for the day i, when $i \in \mathscr{C}_1$;
$\mathscr{C}_1$	set of days of the year relevant for R3;1;
c_1	subset of $\mathscr{C}_1$, containing $S_i^{R3;1} > 0$ values;
n	number of days in the set c_1, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R3}^2: \quad f_{3;2}(q) = \frac{\sum_{i=1}^{n} S_i^{R3;2}}{n} \qquad where\ i \in c_2 \tag{22}$$

$$S_i^{R3;2} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{C}_2 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{23}$$

Where:

$S_i^{R3;2}$	score value for the day i, when $i \in \mathscr{C}_2$;
$\mathscr{C}_2$	set of days of the year relevant for R3;2;
c_2	subset of $\mathscr{C}_2$, containing $S_i^{R3;2} > 0$ values;
n	number of days in the set c_2, $n \in \mathbb{N}^*$;

α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R3}^3: \quad f_{3;3}(q) = \frac{\sum_{i=1}^{n} S_i^{R3;3}}{n} \qquad where\ i \in c_3 \tag{24}$$

$$S_i^{R3;3} = \begin{cases} 0, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{C}_3 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{25}$$

Where:

$S_i^{R3;3}$	score value for the day i, when $i \in \mathscr{C}_3$;
$\mathscr{C}_3$	set of days of the year relevant for R3;3;
c_3	subset of $\mathscr{C}_3$, containing $S_i^{R3;3} > 0$ values;
n	number of days in the set c_3, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R3}^4: \quad f_{3;4}(q) = w_c - S_{i+w}^{R3;4} \qquad where\ i + w \in \mathscr{C}_4 \tag{26}$$

$$S_{i+w}^{R3;4} = \begin{cases} w_c, & if\ N^{R3;4} \geq w_c \\ N^{R3;4}, & otherwise \end{cases} \tag{27}$$

$$N^{R3;4} = \sum_{i+w} I_{q_{i+w} \geq \beta_h} \qquad i + w \in \mathscr{C}_4,\ w \in \{0, \dots, 27\} \tag{28}$$

Where:

$S_{i+w}^{R3;4}$	reference factor for fish hatching score;
$N_{i+w}^{R3;4}$	number of days i, when $i + w \in \mathscr{C}_4$, that satisfy the condition;
$\mathscr{C}_4$	set of days of the year relevant for R3;4 ;
I	indicator function, takes the value of 1 or 0 respectively if the condition is satisfied or not;
w	number of consecutive days representing the optimal time length for R3;4;
w_c	constant, target number of days for R3;4;
β_h	reference value for the discharge threshold (in m^3/s) corresponding to seven times the median annual flow (7mQ) for the given hydrograph h.

The O_{R4} optimization objective for fish recruitment is defined as follows:

$$O_{R4}: \quad \min\ f(q) = O_{R4}^1 + O_{R4}^2 + O_{R4}^3 + O_{R4}^4 + O_{R4}^5 \tag{29}$$

$$O_{R4}^1: \quad f_{4;1}(q) = \frac{\sum_{i=1}^{n} S_i^{R4;1}}{n} \qquad where\ i \in d_1 \tag{30}$$

$$S_i^{R4;1} = \begin{cases} 0, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{D}_1 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{31}$$

Where:

$S_i^{R4;1}$	score value for the day i, when $i \in \mathscr{D}_1$;

$\mathscr{D}_1$	set of days of the year relevant for R4;1;
d_1	subset of $\mathscr{D}_1$, containing $S_i^{R4;1} > 0$ values;
n	number of days in the set d_1, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R4}^2: \quad f_{4;2}(q) = \frac{\sum_{i=1}^{n} S_i^{R4;2}}{n} \qquad where\ i \in d_2 \tag{32}$$

$$S_i^{R4;2} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{D}_2 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{33}$$

Where:

$S_i^{R4;2}$	score value for the day i, when $i \in \mathscr{D}_2$;
$\mathscr{D}_2$	set of days of the year relevant for R4;2;
d_2	subset of $\mathscr{D}_2$, containing $S_i^{R4;2} > 0$ values;
n	number of days in the set d_2, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R4}^3: \quad f_{4;3}(q) = \frac{\sum_{i=1}^{n} S_i^{R4;3}}{n} \qquad where\ i \in d_3 \tag{34}$$

$$S_i^{R4;3} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{D}_3 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{35}$$

Where:

$S_i^{R4;3}$	score value for the day i, when $i \in \mathscr{D}_3$;
$\mathscr{D}_3$	set of days of the year relevant for R4;3;
d_3	subset of $\mathscr{D}_3$, containing $S_i^{R4;3} > 0$ values;
n	number of days in the set d_3, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R4}^4: \quad f_{4;4}(q) = \frac{\sum_{i=1}^{n} S_i^{R4;4}}{n} \qquad where\ i \in d_4 \tag{36}$$

$$S_i^{R4;4} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{D}_4 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \tag{37}$$

Where:

$S_i^{R4;4}$	score value for the day i, when $i \in \mathscr{D}_4$;
$\mathscr{D}_4$	set of days of the year relevant for R4;4;

d_4	subset of $\mathscr{D}_4$, containing $S_i^{R4;4} > 0$ values;
n	number of days in the set d_4, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

$$O_{R4}^5: \quad f_{4;5}(q) = \frac{\sum_{i=1}^{n} S_i^{R4;5}}{n} \qquad where\ i \in d_5 \qquad (38)$$

$$S_i^{R4;5} = \begin{cases} 0\,, & \forall\, i,\ if\ q_i - \alpha_h^{55} > 0,\ i \in \mathscr{D}_5 \\ 1 - \frac{q_i}{\alpha_h^{55}}, & otherwise \end{cases} \qquad (39)$$

Where:

$S_i^{R4;5}$	score value for the day i, when $i \in \mathscr{D}_5$;
$\mathscr{D}_5$	set of days of the year relevant for R4;5;
d_5	subset of $\mathscr{D}_5$, containing $S_i^{R4;5} > 0$ values;
n	number of days in the set d_5, $n \in \mathbb{N}^*$;
α_h^{55}	reference value for the discharge threshold (in m^3/s) corresponding to the 55% of the *mean monthly flow* value for the given hydrograph h.

Optimization objective for hydrological conditions for macroinvertebrates' taxa richness ES (O_{ES}^2)

The O_{ES}^2 corresponds to the value of the O_{R5}:

$$O_{R5}: \quad \min\ f(q) = 1 - \frac{S^{R5}}{\gamma_R} \qquad i \in \mathscr{E} \qquad (40)$$

$$S^{R5}: \quad f_5(q) = \begin{cases} \gamma_R, & if\ N^{R5} \geq \gamma_R, i \in \mathscr{E} \\ N^{R5}, & otherwise \end{cases} \qquad (41)$$

$$N^{R5} = \sum_i I_{q_i \geq \gamma_h} \qquad i \in \mathscr{E} \qquad (42)$$

Where:

S_i^{R5}	reference factor for R5;
N^{R5}	number of days i, when $i \in \mathscr{E}$ that satisfy the condition;
I	indicator function, takes the value of 1 or 0 respectively if the condition is satisfied or not;
$\mathscr{E}$	set of days of the year relevant for R5;
γ_R	constant, number representing the optimal occurrence of events for the promotion of R5, $\gamma_R \in \mathbb{N}^*$;
γ_h	reference value for the discharge threshold (in m^3/s) corresponding to the *75-percentile flow (Q25)* value for the given hydrograph h.

Optimization objective for primary productivity ES (O_{ES}^3)

The O_{ES}^3 corresponds to the value of the O_{R6}:

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$$O_{R6}: \quad \min\ f(q) = 1 - \frac{S_{i+u}^{R6}}{\sigma_R} \qquad i+u \in \mathscr{T} \tag{43}$$

$$S_{i+u}^{R6}: \quad f_6(q) = \begin{cases} \sigma_R, & \text{if } N^{R6} \geq \sigma_R, i+u \in \mathscr{T} \\ N^{R6}, & \text{otherwise} \end{cases} \tag{44}$$

$$N^{R6} = \sum_i I_{q_{i+u} \geq \sigma_h^{10}} \qquad i+u \in \mathscr{T},\ u \in \{0, \dots, 70\} \tag{45}$$

Where:

R_{i+u}^{R6}	reference factor for R6;
N^{R6}	total number of days i, when $i+u \in \mathscr{T}$, that satisfy the condition;
I	indicator function, takes the value of 1 or 0 respectively if the condition is satisfied or not;
u	range of days representing the optimal time length for R6;
$\mathscr{T}$	set of days of the year relevant for macrophytes seedling survival;
σ_R	constant, number representing the optimal number of days for the promotion of primary producers density and growth, $\sigma_R \in \mathbb{N}^*$;
σ_h^{10}	reference value for the discharge threshold (in m^3/s) corresponding to the *10% of the average yearly flow* calculated from the historical flow record.

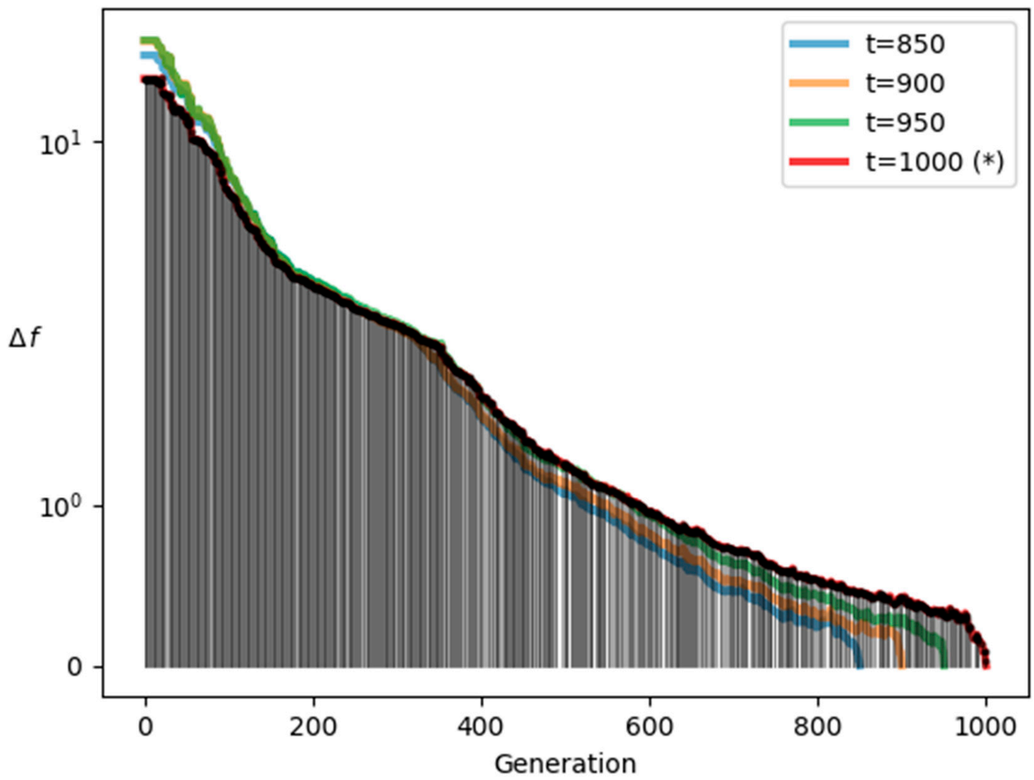

Figure S1. The Running Metric Indicator (Blank & Deb, 2020) for a test RS simulation. The Δf indicator measures the convergence of the objective space at each generation.

Section C

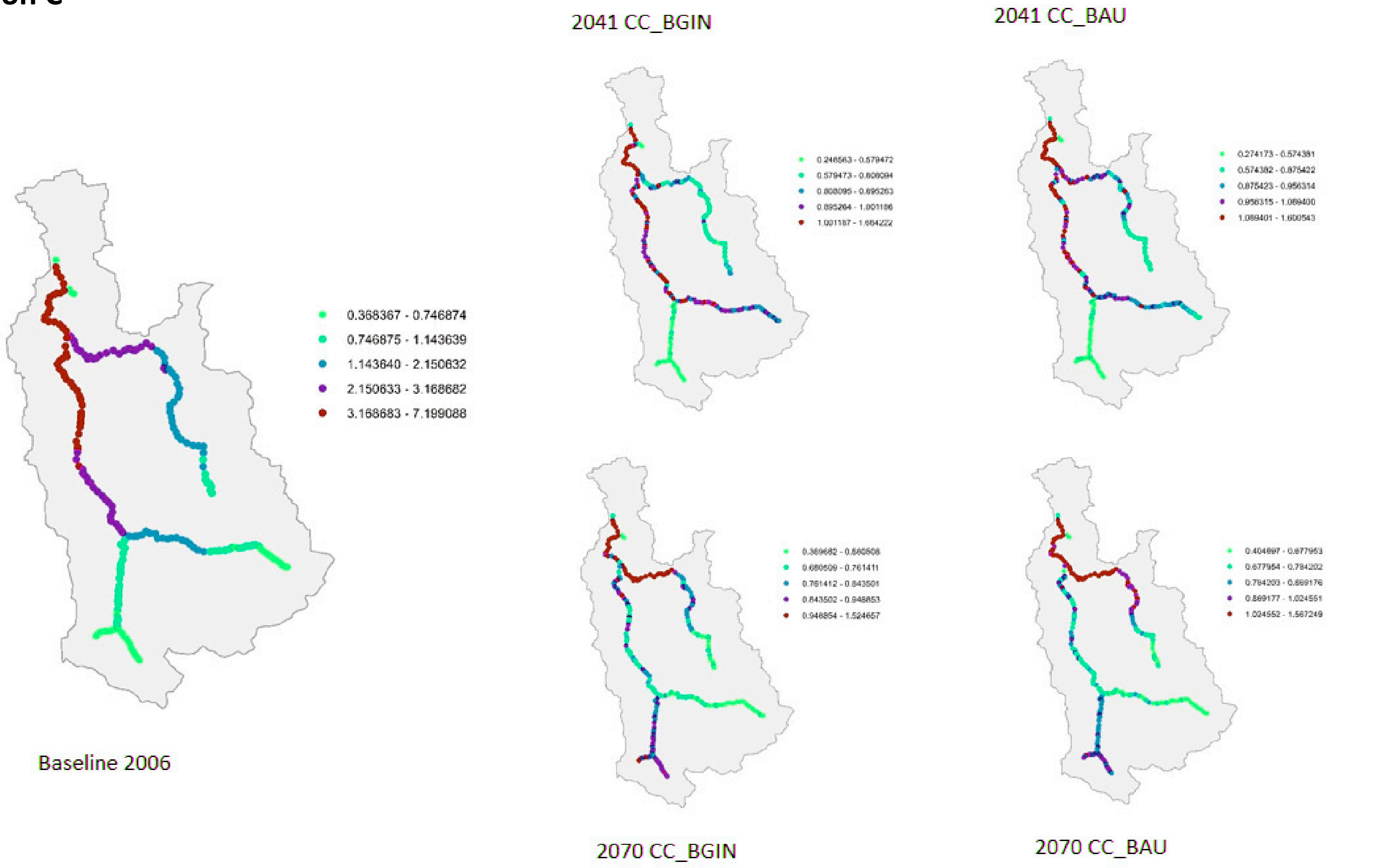

Figure S2. Maps showing the spatial distribution of the optimization objective scores for the *Habitat condition provision for fish life-stages ES* under each considered scenario. Values closest to zero indicate best achievement of the objective at a specific RS. The classification scheme follows the quantile chromatic classification approach: Red shades = highest scores (worst results), light-green shades = lowest scores (best results). Note: each map presents min-max values that differ from each other as figure aim is to highlight scenario-specific spatial variation of the scores.

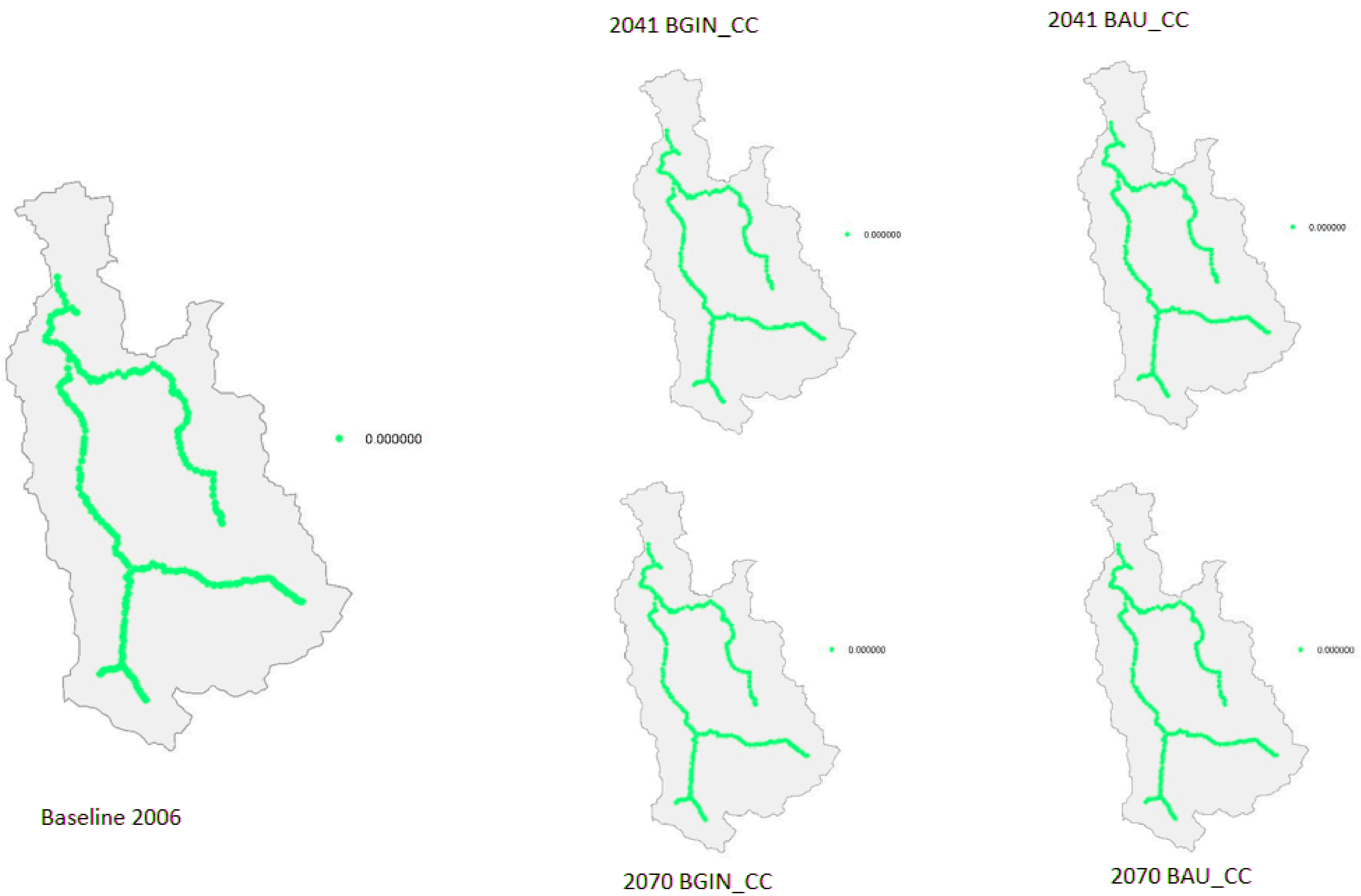

Figure S3. Maps showing the spatial distribution of the optimization objective scores for the life-supporting conditions for *Macroinvertebrate taxa richness ES* under each considered scenario. Values closest to zero indicate best achievement of the objective at a specific RS.

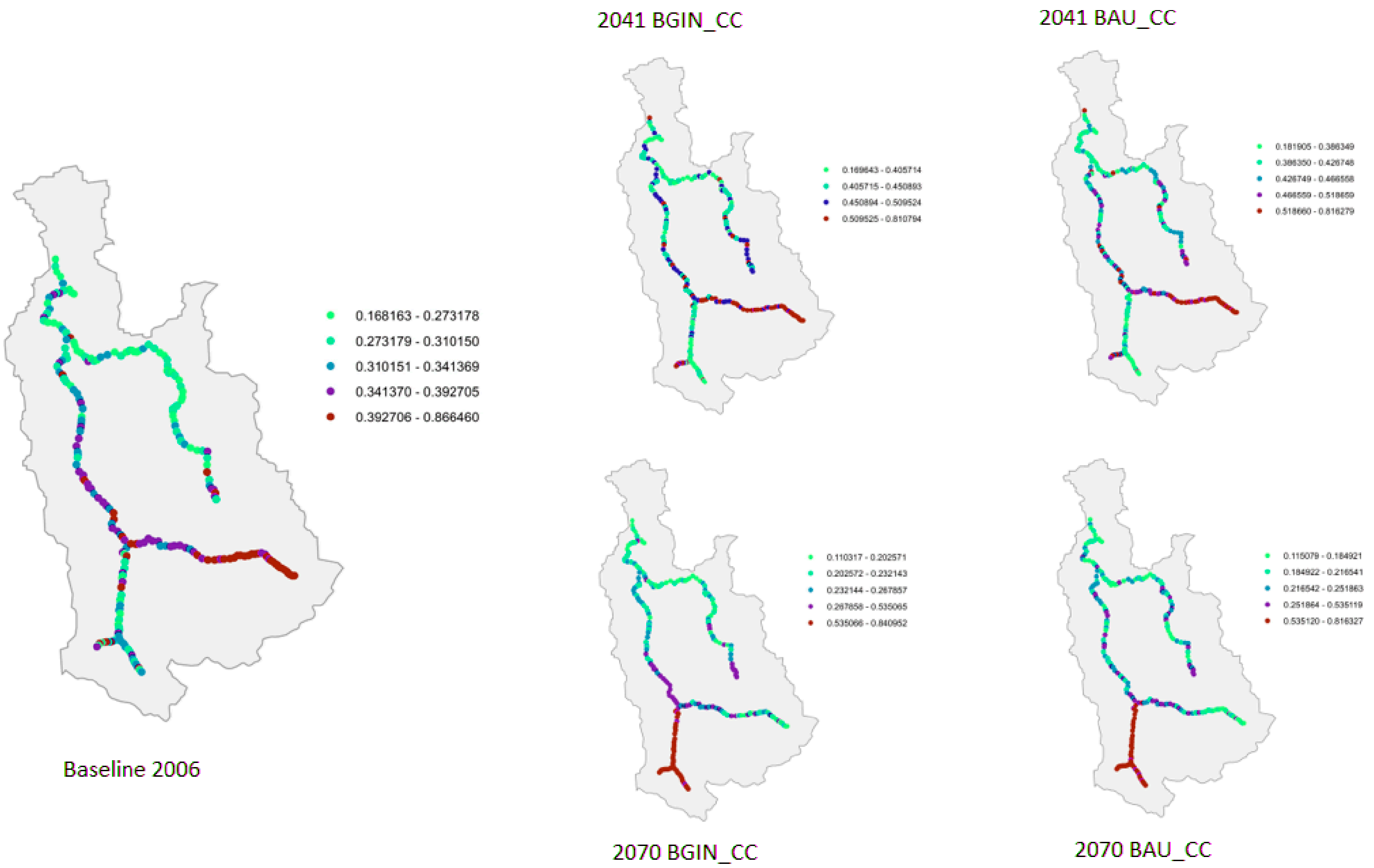

Figure S4. Maps showing the spatial distribution of the optimization objective scores for the *Primary productivity ES* under each considered scenario. Values closest to zero indicate best achievement of the objective at a specific RS. The classification scheme follows a quantile chromatic classification approach: Red shades = highest scores (worst results), light-green shades = lowest scores (best results). Note: each map presents min-max values that differ from each other as figure aim is to highlight scenario-specific spatial variation of the scores.

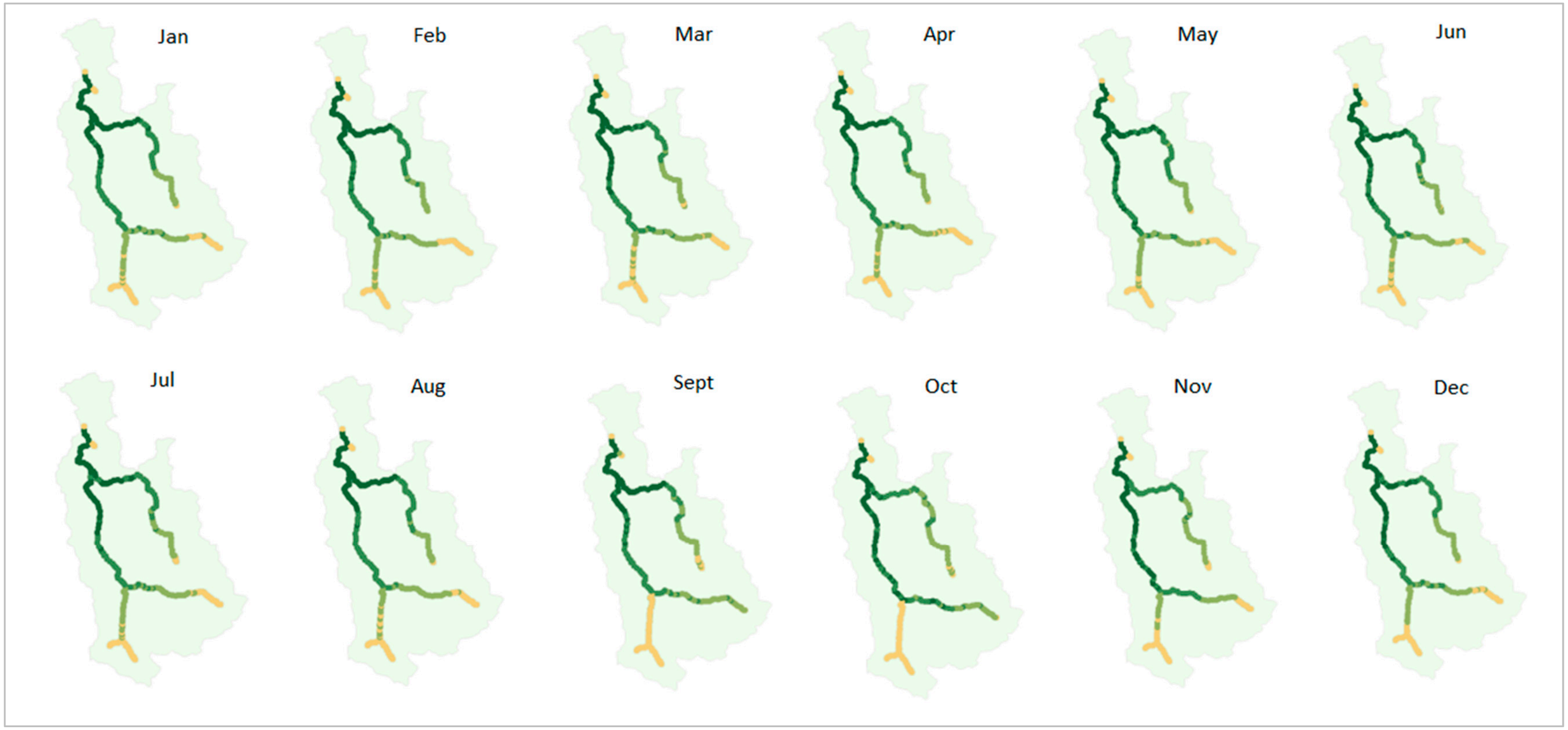

Figure S5. Monthly averaged optimized instream flow for the PR scenario (2006) using the quantile (25-100%) classification method: yellow=low discharge values; dark green=high discharge values).

Figure S6. Monthly averaged optimized instream flow for the CC_BAU 2041 scenario using the quantile (25-100%) classification method: yellow=low discharge values; dark green=high discharge values).

Figure S7. Monthly averaged optimized instream flow for the CC_BGIN 2041 scenario using the quantile (25-100%) classification method: yellow=low discharge values; dark green=high discharge values).

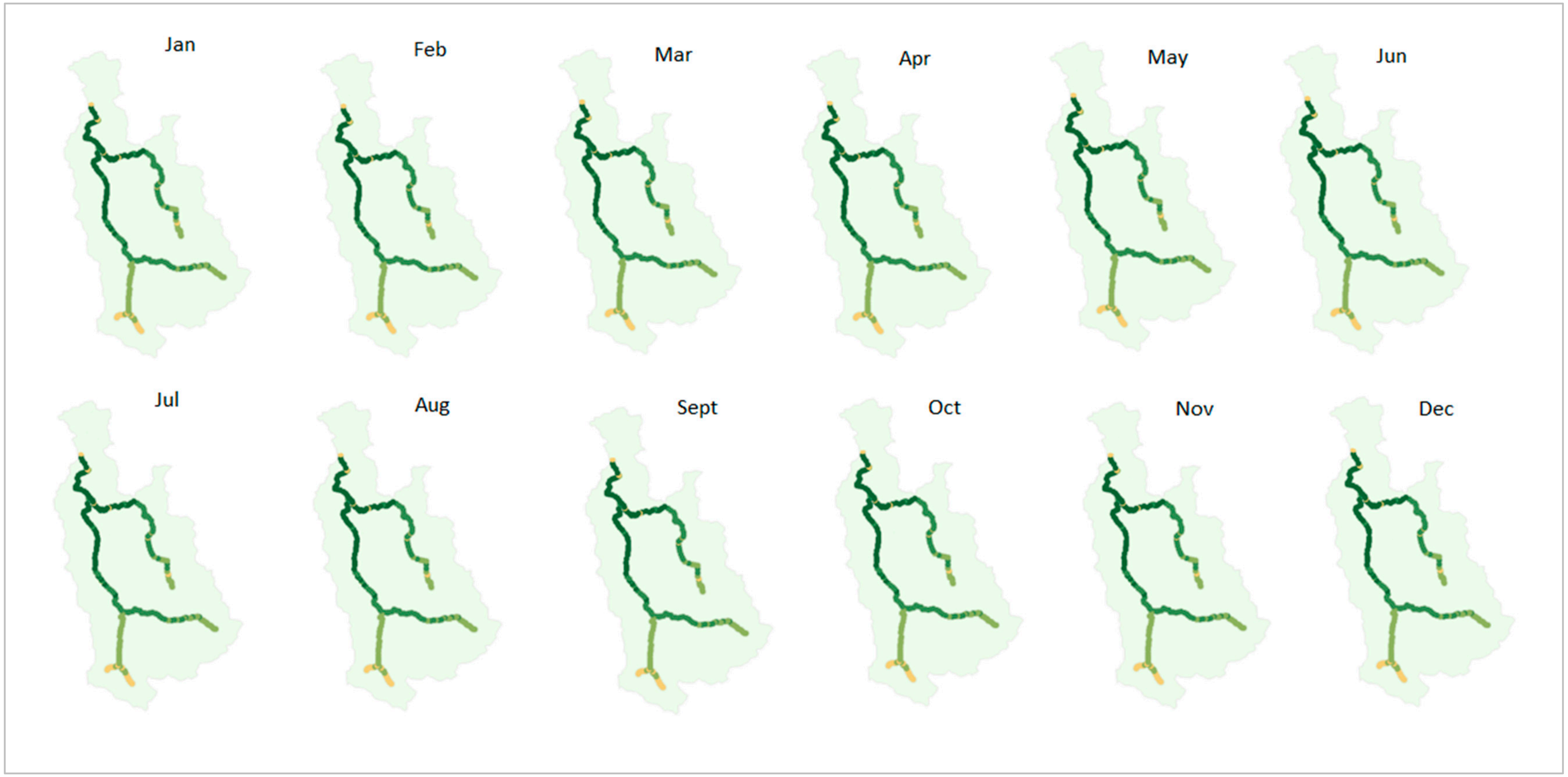

Figure S8. Monthly averaged optimized instream flow for the CC_BGIN 2070 scenario using the quantile (25-100%) classification method: yellow=low discharge values; dark green=high discharge values).

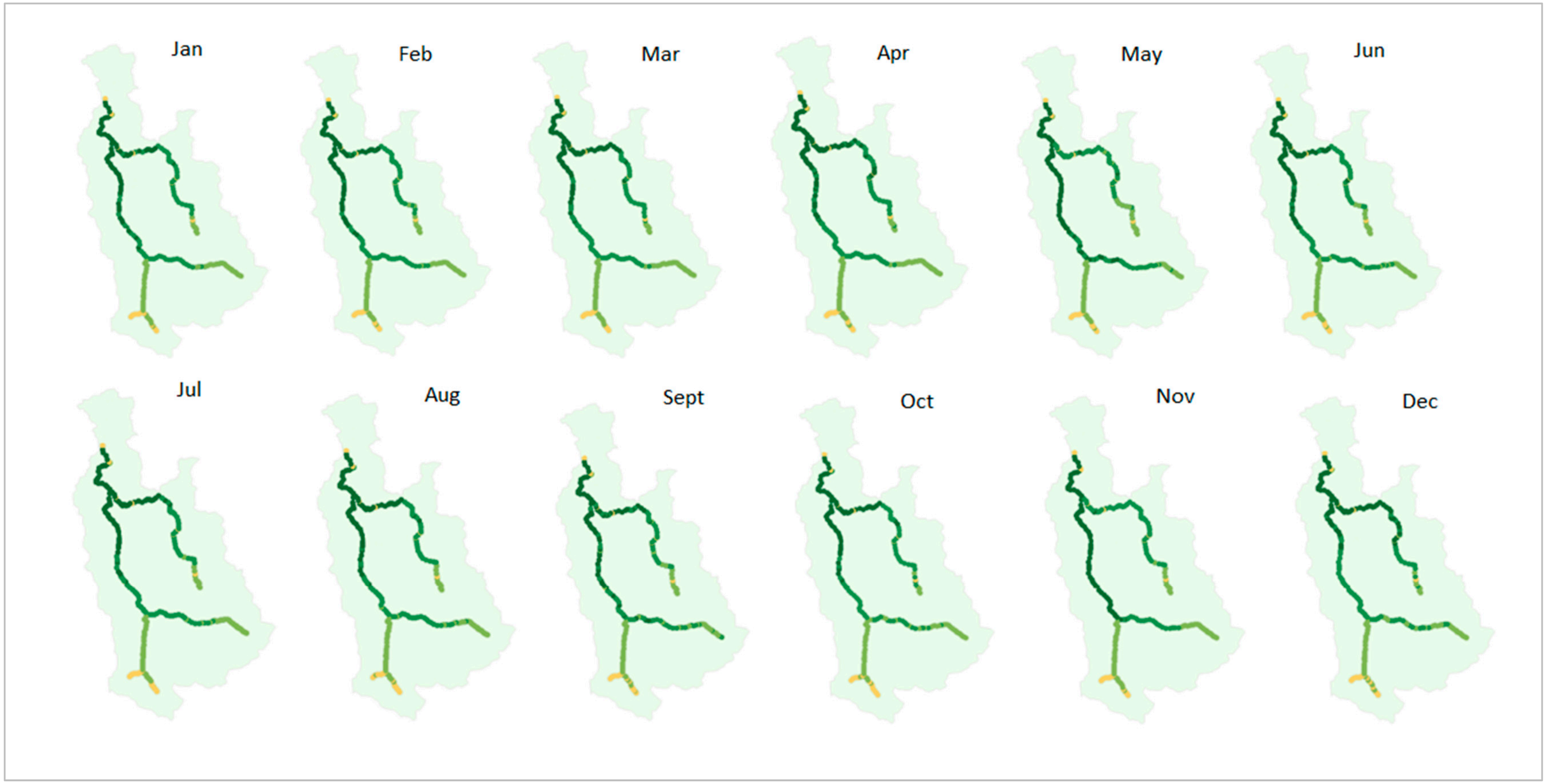

Figure S9. Monthly averaged optimized instream flow for the CC_BAU 2070 scenario using the quantile (25-100%) classification method: yellow=low discharge values; dark green=high discharge values).

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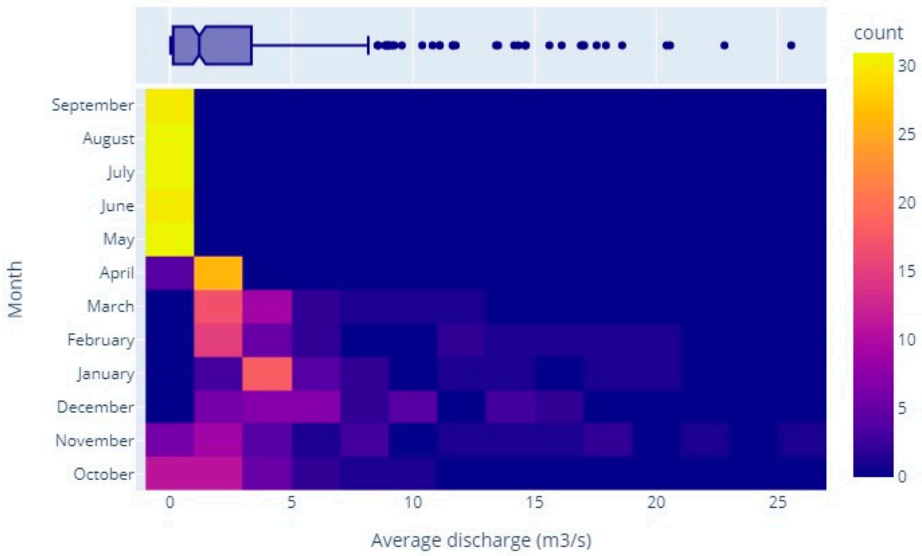

Figure S10. Heatmap showing the average optimized discharge (in m3/s) value (on the x-axis) for each month (on the y-axis) for the 2041 BGIN_CC scenario. On the right-hand side of the box a colour-based classification of the frequency of appearance of each value range; on top of the box a regular box-plot shows the yearly quartiles, extremes and outliers.

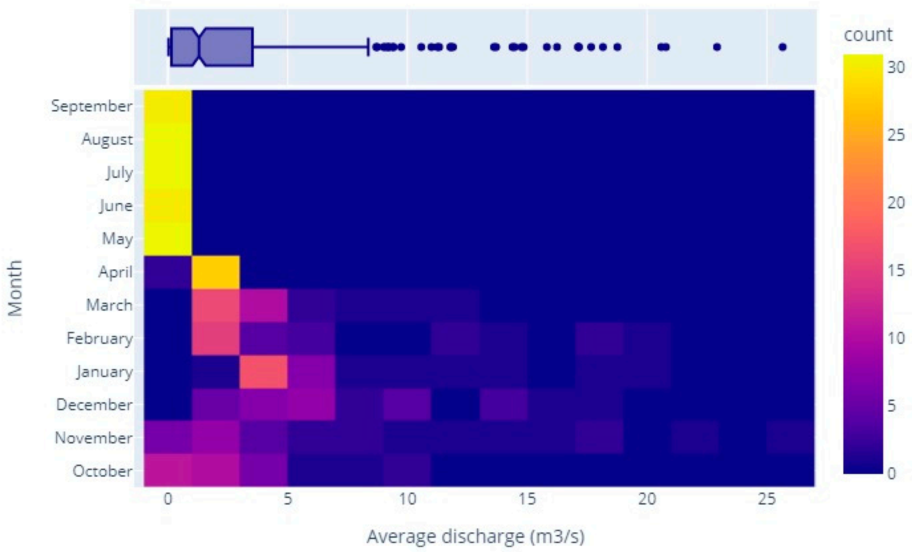

Figure S11. Heatmap showing the average optimized discharge (in m3/s) value (on the x-axis) for each month (on the y-axis) for the 2041 BAU_CC scenario. On the right-hand side of the box a colour-based classification of the frequency of appearance of each value range; on top of the box a regular box-plot shows the yearly quartiles, extremes and outliers.

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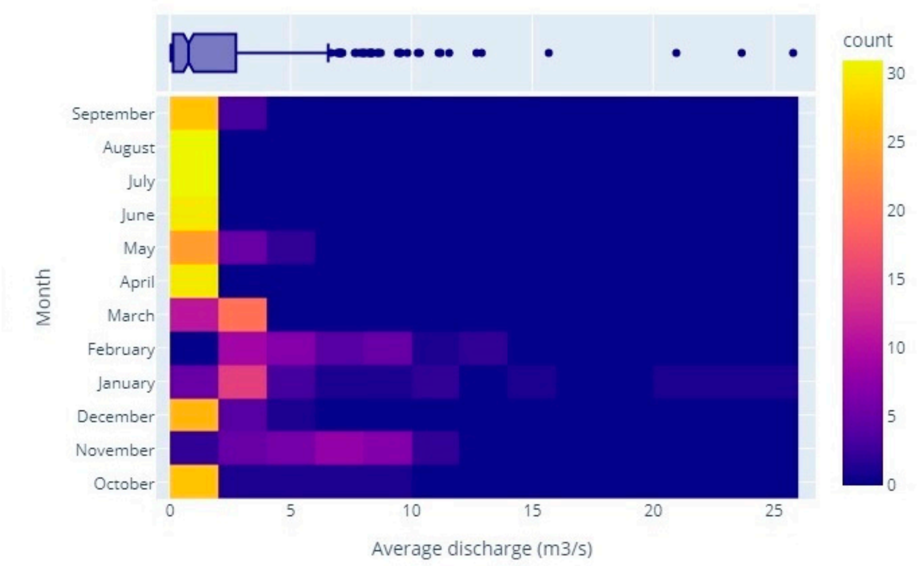

Figure S12. Heatmap showing the average optimized discharge (in m3/s) value (on the x-axis) for each month (on the y-axis) for the 2070 BGIN_CC scenario. On the right-hand side of the box a colour-based classification of the frequency of appearance of each value range; on top of the box a regular box-plot shows the yearly quartiles, extremes and outliers.

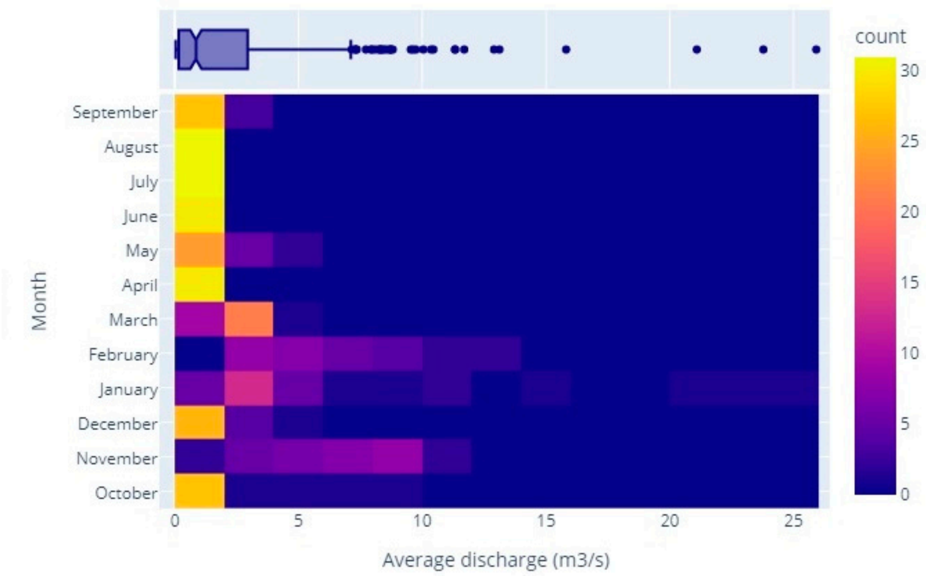

Figure S13. Heatmap showing the average optimized discharge (in m3/s) value (on the x-axis) for each month (on the y-axis) for the 2070 BAU_CC scenario. On the right-hand side of the box a colour-based classification of the frequency of appearance of each value range; on top of the box a regular box-plot shows the yearly quartiles, extremes and outliers.

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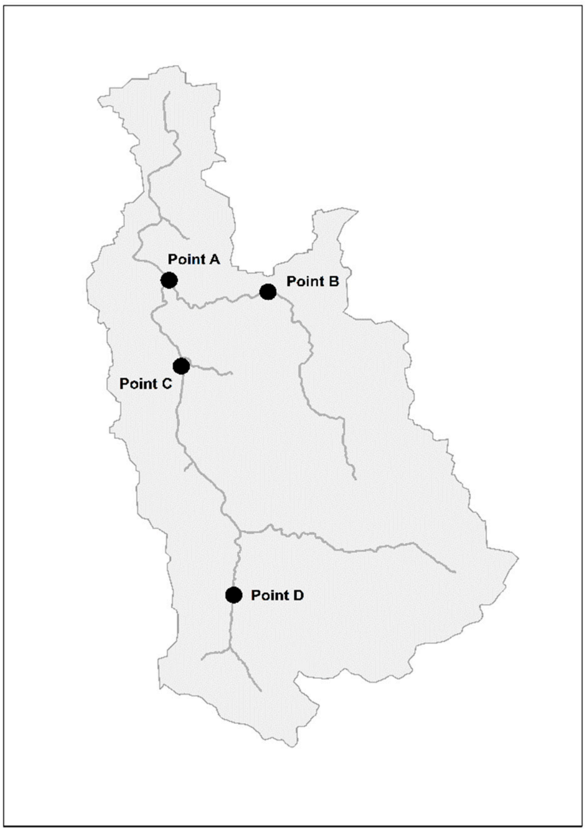
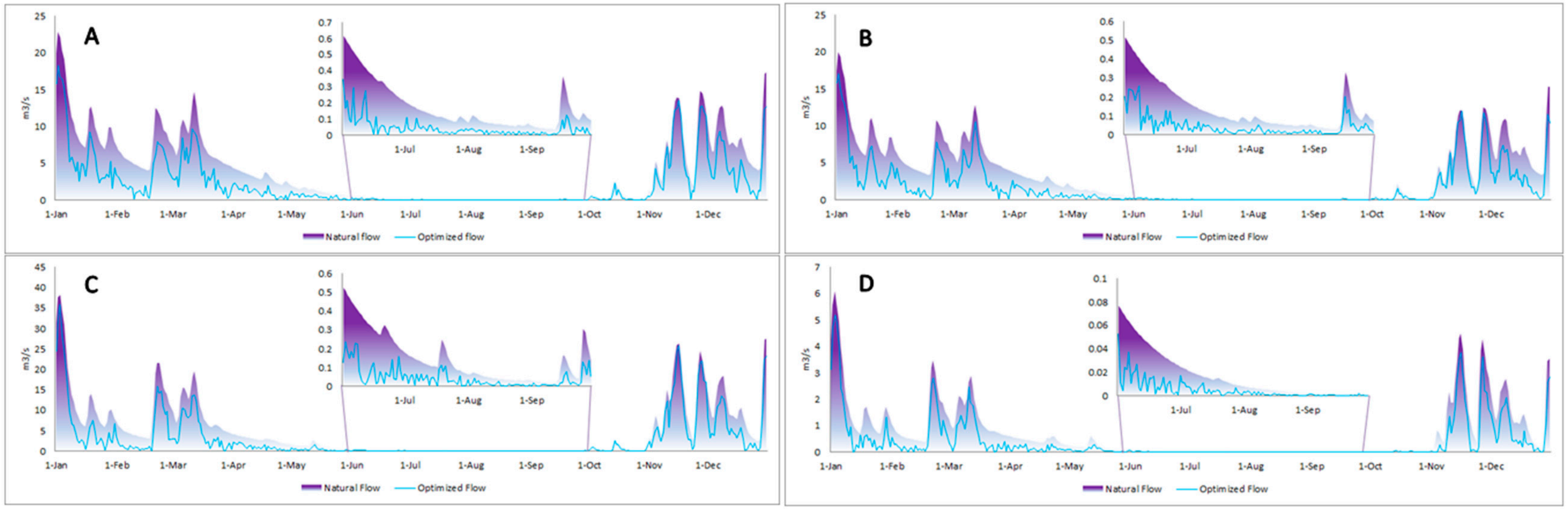
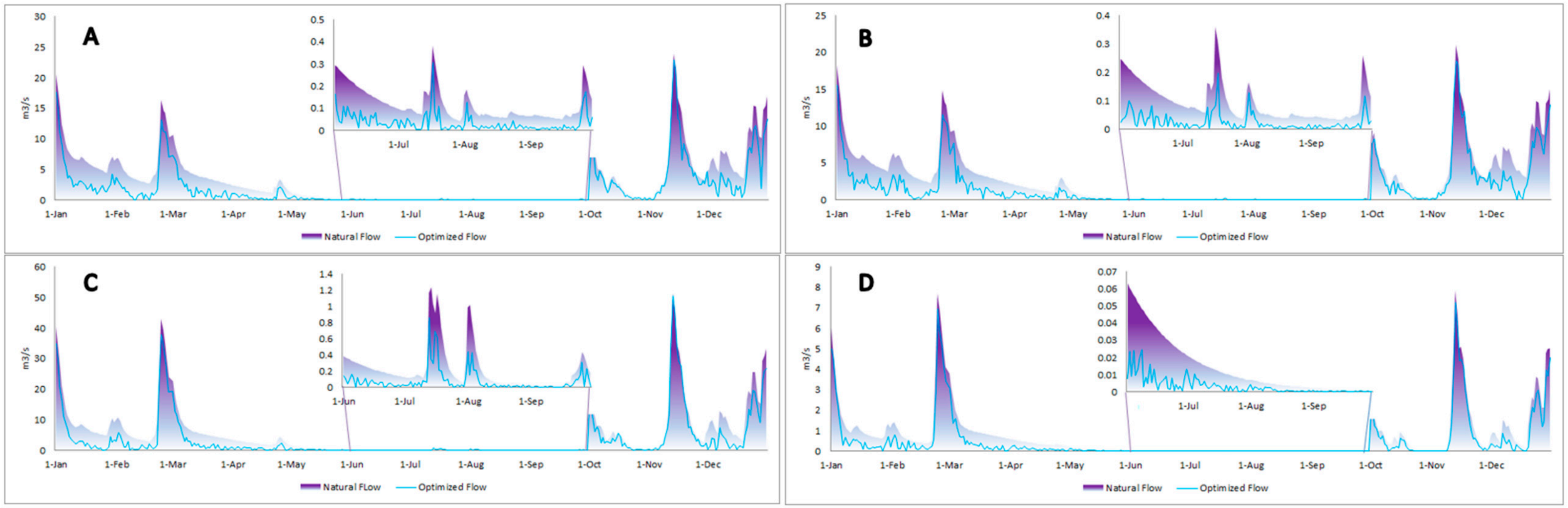


Figure S14. Location of the representative points in the basin elicited for results presentation and discussion. Complete optimization results available at : https://doi.org/10.6084/m9.figshare.19636449.v4



Figures S15-S16. Flow series showing the daily profile of the discharge (in m3/s) optimized for diversion (light blue thin line) plotted with respect to the river natural discharge (purple background shape) for the each of the four RS locations analyzed under the Baseline 2006 (PR) scenario (top) and 2041 BAU_CC scenario (bottom). More pronounced differences between the lines indicate the highest trade-off periods between the natural discharge and water for municipal use.



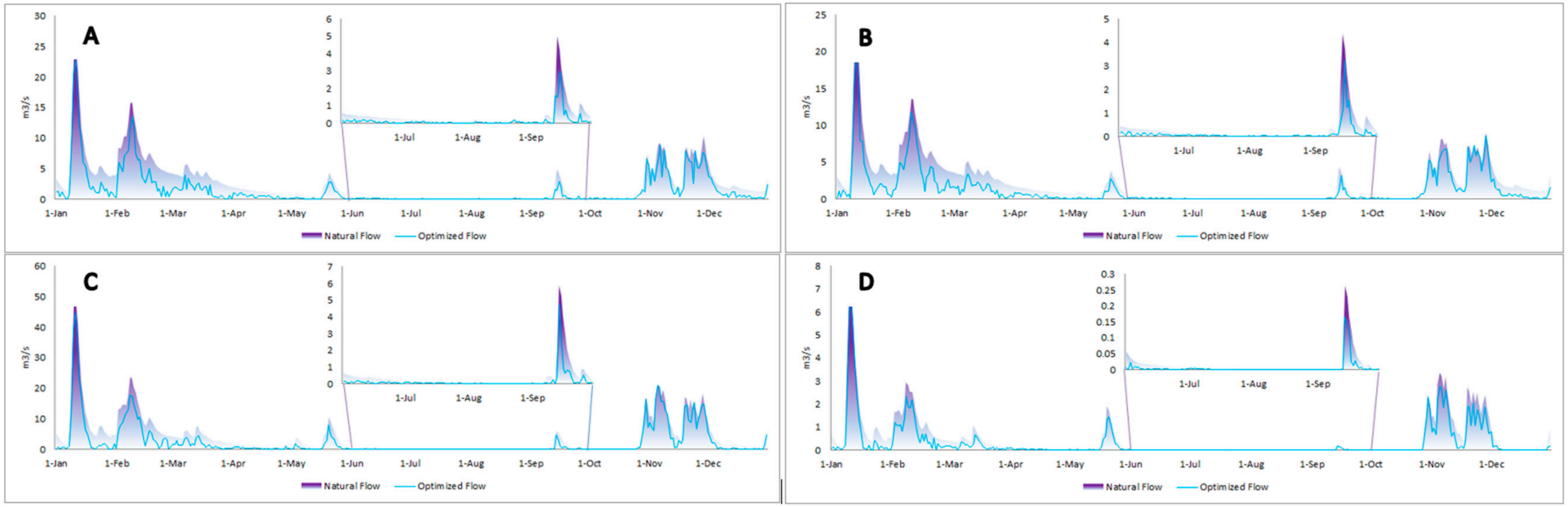


Figure S17-S18. Flow series showing the daily profile of the discharge (in m3/s) optimized for diversion (light blue thin line) plotted with respect to the river natural discharge (purple background shape) for the each of the four RS locations analyzed under the 2070 BGIN_CC (top) and 2070 BAU_CC scenario (bottom). More pronounced differences between the lines indicate the highest trade-off periods between the natural discharge and water for municipal use.