WP4.4 Pilot Case Studies indicators database for MCA

Structure of Bodendorf decisional tree

Date
17-07-2012

Report version
WP4 (action 4.4)

Author
Josef SCHNEIDER, Christopher SCHREIBER

Member number and name
PP6 – TUG – Graz Technical University

SHARE - Sustainable Hydropower in Alpine Rivers Ecosystems
http://www.sharealpinerivers.eu

Project reference number: 5-2-3-IT
Priority 3 – Environment and Risk Prevention
Project duration: 36 months – 1/08/2009 – 31/07/2012

Summary

SHORT DESCRIPTION
This document intends to describe the structure of the SESAMO tree and the MCA application of the Pilot Case Study of Bodendorf.

Document Control

Project	SHARE - Sustainable Hydropower in Alpine Rivers Ecosystems (ref. 5-2-3-IT)
Action	WP4 – action 4.4
Type	Report
Due date	
Dissemination	Internal
Origin	PP6
Author	Josef Schneider - schneider@tugraz.at, Christopher Schreiber - christopher.schreiber@tugraz.at

Version Control

VERSION	DATE	AUTHOR	AUTHOR'S ORGANIZATION	DESCRIPTION/CHANGES
v01.00				

Table of contents

Summary

The report summarizes the general methodological approach, the criteria and the indicators used to test the multi criteria analysis (MCA) on the Bodendorf pilot case study. The report highlights the progression of MCA model development. The main analyzed aspects are:

- MCA application
- Criteria, sub-criteria, & indicators evaluation
- Layout of the decision tree

This report is devoted to an explanation and the justification for each of the branches of the Bodendorf decisional tree model. We identified potential indicators useful to evaluate the chosen alternatives for the flushing of the reservoir of the hydropower plant.

Figure 1: Hydropower plant Bodendorf during a flushing of the reservoir in July 2012

Structure of the Bodendorf decisional tree

The HPP Bodendorf is heavily affected by sedimentation of its reservoir. The mean annual sediment input is stated with 53,000 m³, which is approximately 17% of the original reservoir volume (ALPRESERV Vol.5, 2008).

The HP-plant regarded in the MCA-tree is situated at the Mur river (Styria, Austria). During the last years and mainly within the Interreg IIIB project ALPRESERV a substantial amount of data has been collected for this area. Amongst others a flushing concept was developed, in order to reduce the negative ecological impacts of flushing. This concept consists of two main parts, in the first part, the conditions under which the flushing can be started are defined, whereas the second part describes the optimal coordination among the four HP plants concerning discharge velocity or temporally delayed flushing start.

Furthermore the flushing concept was an important input for the flushing permission of this HP plant chain, which is valid from 2007 till today. In Table 1, the legal conditions of flushing depending on seasonal issues and discharge values can be seen.

Table 1: Legal flushing conditions

	year 0	year 1	year 2	year 3	year 4+later
date of flushing	flushing	short time slot for flushing			extended time slot for flushing
spring (April-May)		--	>80/130 m^3/s	>80/130 m^3/s	>90/160 m^3/s
early sommer (June-July)		--	--	--	>90/160 m^3/s
late sommer (Aug.-Sept.)		>80/130 m^3/s	>80/130 m^3/s	>90/160 m^3/s	>90/160 m^3/s
		year-round flushing at major floods (>HQ_5 peak – 130/300m^3/s)			

This hydropower plant is the object of the Multi Criteria Analysis application to the Bodendorf river basin pilot case study. Huge sediment input makes flushing events necessary and ecological impacts of flushing events in the past should be considered for the future. The results will always be site specific and no standardization is possible apart from the principles on which the MCA application is based.

Figure 2: Head of the reservoir Bodendorf

Alternatives description

The alternatives that will be examined with the MCA concern the flushing of the reservoir. Based upon the present flushing duration, which can be considered as **Alternative 0**, the following alternatives are implemented in the MCA-tool:

ALTERNATIVE 1: maximizing the duration of flushing (3 day flushing)

pro: probably good sediment transport
con: large ecological impact of downstream ecosystem by decreased secondary flushing duration

ALTERNATIVE 2: reducing the duration of flooding (1 day flushing)

pro: longer secondary flushing with clear water reduces the ecological impact
con: probably insufficient sediment transport

MCA tree

- HPP_chain_upper_Mur
  - ENERGY
    - Annual_Energy_Production_[GWh] (F)
  - ECONOMY
    - Energy_Production_Lack_[€] (A) (F)
      - Duration_of_Flushing_[h]
      - Energy_Price_per_kWh_[€]
      - Power_Installed_[MW] (A)
        - Head_[m]
        - Design_Flow_[m^3s]
        - Efficiency_[%]
    - Flushing_efficiency_[%] (A) (F)
      - Original_Volume_[m^3]
      - Sediment_Output_[m^3]
      - Volume_before_Flushing_[m^3]
  - LANDSCAPE
    - Landscape
  - ENVIRONMENT
    - Abiotic_Indicators
      - Bed_Load_Transportation_out_res (F)
      - Suspended_sediment_concentration_average_[g_l] (F)
      - Suspended_sediment_concentration_peak_[g_l] (F)
    - biotic_indicators[reference_stretch_Gstuethof]
      - Substrat_conditions (F)
      - Fish_conditions (F)
  - TOURISM
    - Effects_on_tourism (F)
  - FISHING
    - Effects_of_fish_mortality
  - RISK
    - Flood_risk_reservoir_head_[m3] (F)

Figure 3: Bodendorf case study tree

Indicators description – Bodendorf River PCS

The following section contains the metadata of every indicator used in the Mur river reach example directly related to the MCA model of the Sesamo software.

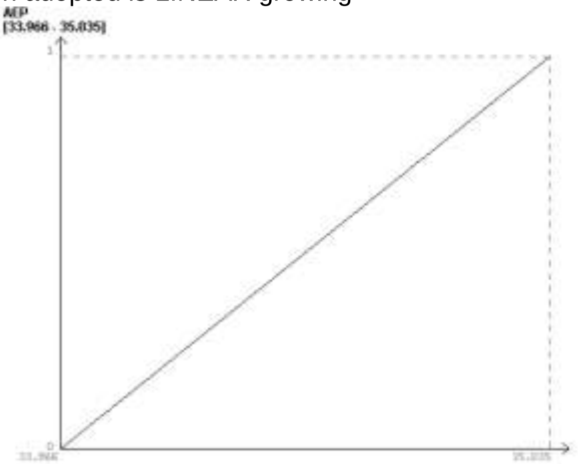
The structure of the decision tree for the pilot case of Bodendorf, considers 4 main branches:

1. **Energy;**
2. **Economy;**
3. **Environment;**
4. **Other criteria (Tourism, Landscape, Fishing, Risk)**

ENERGY

Bodendorf tree | ENERGY | Annual energy production

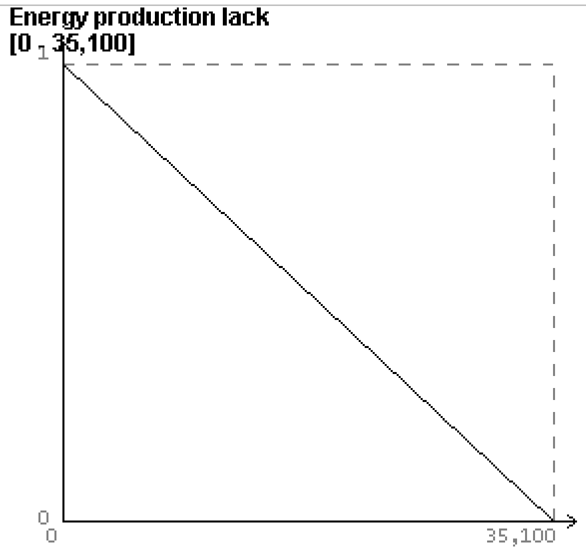
FIELD	DESCRIPTION
INDICATOR NAME	Annual energy production
ACRONYM	AEP
DPSIR	D (Driving Forces)
DESCRIPTION	The energy produced by the plant is intended as the total amount of energy sold to the consumers; it is the net energy produced by the HP plant. Depending on the flushing duration, the indicator will in- or decreases. The AEP was estimated through the Power (kWh) equation: $P = Q_m \cdot \Delta H \cdot g \cdot \eta$ Where P = energy power (kWh), Q_m the mean conceded discharge (m^3/s), DH the altitude difference between withdrawal and restitution points (m), g the gravity acceleration (m/s^2) and η the energy production performance/efficiency (equal to 0.85 - 0.95).
AIM	It furnishes an evaluation of the annual energy production which is the master aim of every HP plant manager.
KEY MESSAGE	The HP plant energy produced is the aim of every HP plant manager
MEASURE UNIT	GWh/year
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	The energy produced by the plant is intended as the total amount of energy sold to the network authority; it is the net energy produced by the HP plant
INDICATOR LIMITS	----
EVALUATION	The main parameters considered and evaluated for the Bodendorf power plant are: **DH** — **16.80** — **m** **Q max** — **50.0** — **m^3/s** **Installed power** — **7** — **MW**
AVAILABLE UF	YES

UF	The Utility Function adopted is LINEAR growing 
SHARE RELATED IND.	
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	HP producer
TIME COVER	1990-2011
UPDATE FREQUENCY	annual
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

ECONOMY

Bodendorf tree | ECONOMY | Energy production lack

FIELD	DESCRIPTION
INDICATOR NAME	Energy production lack
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	D (Driving Forces)
DESCRIPTION	This indicator describes the negative impact on the energy production caused by the flushing.
AIM	This indicator shows how much energy production is lost because of the flushing.
KEY MESSAGE	Flushing of the reservoir causes a lack of energy production. The higher this coefficient is, the less energy is produced because of the flushing.
MEASURE UNIT	€
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	This indicator is computed out of the threesub-indicators “duration of flushing”, “energy price per kWh” and “power installed”.
INDICATOR LIMITS	Only data which are provided by the HP plant owner can be used.
EVALUATION	----
AVAILABLE UF	YES
UF	The Utility Function adopted is LINEAR decreasing

	
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	HP producer
TIME COVER	1990-2011
UPDATE FREQUENCY	annual
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ECONOMY | Duration of flushing

FIELD	DESCRIPTION
INDICATOR NAME	Duration of flushing
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	----
DESCRIPTION	The duration of the flushing can have a great impact on energy production and river ecosystem.
AIM	This indicator shows the duration of the flushing of the reservoir.
KEY MESSAGE	The longer the flushing event lasts, the more negative impact on energy production happens. Value to calculate the flushing costs.
MEASURE UNIT	h (hours)
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Most of the flushings in the past lasted for 2 days. In the MCA implementation 3 different scenarios are given: duration of the flushing for one, two and three days.
INDICATOR LIMITS	The duration of flushings is also depending on hydrological conditions and cannot be freely decided by the operator of the HPP.
EVALUATION	Flushing duration of 1, 2 and 3 days = 24, 48 and 72 hours
AVAILABLE UF	NO
UF	---
SHARE RELATED IND.	---
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	HP producer
TIME COVER	2000 - 2012
UPDATE FREQUENCY	Single events

NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ECONOMY | Energy price per kWh

FIELD	DESCRIPTION
INDICATOR NAME	Energy price
ACRONYM	Price
DPSIR	D (Driving Forces)
DESCRIPTION	The actual electricity rate (unit cost per unit electricity) that a customer pays.
AIM	This indicator is used to calculate the energy production lack that is caused by the flushing of the reservoir of the HPP.
KEY MESSAGE	Unit cost per unit electricity
MEASURE UNIT	€
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Taken from the Austrian energy agency.
INDICATOR LIMITS	May vary significantly from locality to locality within a particular country.
EVALUATION	Amounts to 0.06 € at the time of this study.
AVAILABLE UF	NO
UF	----

SHARE RELATED IND.	-----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Austrian energy agency
TIME COVER	- 2012
UPDATE FREQUENCY	Frequently
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

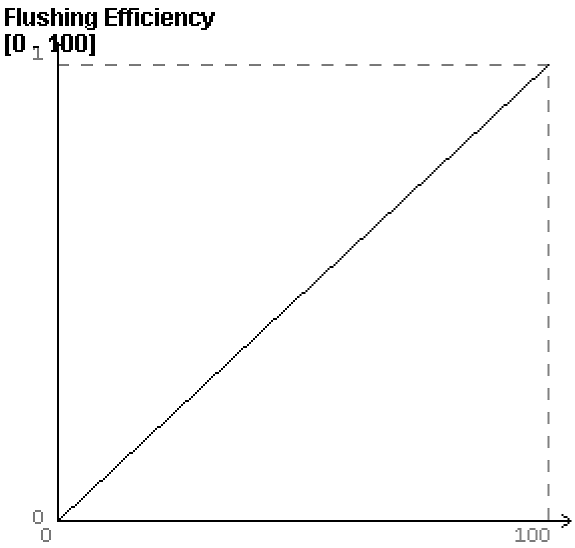
Bodendorf tree | ECONOMY | Power available

FIELD	**DESCRIPTION**
INDICATOR NAME	Power available
ACRONYM	Power
DPSIR	D (Driving Forces)
DESCRIPTION	This indicator refers to the intended output of the power plant and takes into account the discharge, altitude difference and efficiency of the turbines. It is an aggregation function of the three indicators “head”, “design flow” and “efficiency”.
AIM	This indicator is necessary to calculate the energy production lack (which is an aggregation function of this indicator, the duration of the flushing and the energy price.
KEY MESSAGE	Output of the hydropower plant.
MEASURE UNIT	MW
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Aggregation function of the three indicators “head”, “design flow” and “efficiency”.
INDICATOR LIMITS	---

EVALUATION	The installed power of the power plant Bodendorf amounts to 7.08 MW
AVAILABLE UF	NO
UF	----
SHARE RELATED IND.	-----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	HP producer
TIME COVER	1982 - 2012
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	----
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

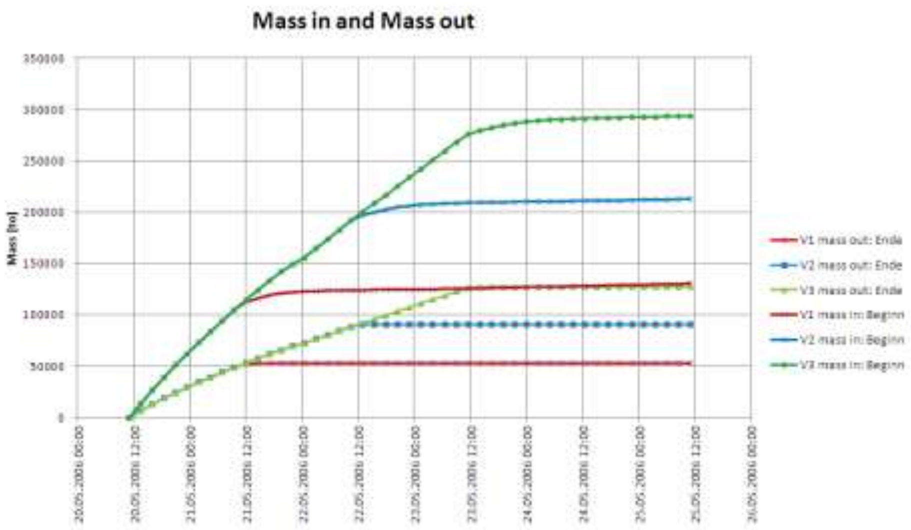
Bodendorf tree | ECONOMY | Flushing efficiency

FIELD	DESCRIPTION
INDICATOR NAME	Flushing efficiency
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	D (Driving Forces)
DESCRIPTION	This indicator is very important for the PCS Bodendorf because it describes how efficient the flushing of the reservoir was, considering the original volume, the sediment output and the volume before the flushing.
AIM	The purpose of the indicator is to assess the efficiency of the flushing.

KEY MESSAGE	Describes the efficiency of the flushing of the reservoir.
MEASURE UNIT	%
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	
INDICATOR LIMITS	----
EVALUATION	----
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is LINEAR (0 – 100%) growing 
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Literature, experiences from previous project (Alpreserv)
TIME COVER	2005 - 2012
UPDATE FREQUENCY	----

NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ECONOMY | Original volume/sediment output/volume before flushing

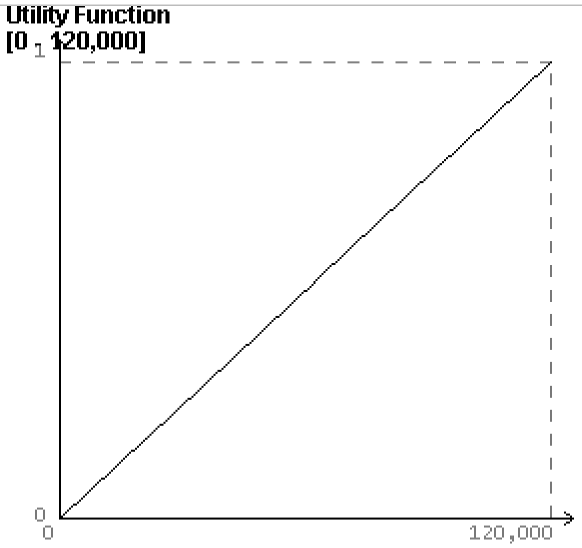
FIELD	DESCRIPTION
INDICATOR NAME	Original volume/sediment output/volume before flushing
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	----
DESCRIPTION	These three indicators are necessary to define the efficiency of the flushing. The original volume is the volume of the reservoir on the date of the start of operation. The sediment output is the amount of sediment removed by the flushing. The volume before the flushing defines how much volume of the reservoir is left at the time of the flushing.
AIM	The aim of these indicators is to calculate and evaluate the flushing efficiency.
KEY MESSAGE	These three sub-indicators are used to define the flushing efficiency.
MEASURE UNIT	m^3
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Taken from literature and measurements. Sediment output was also modelled with the software HEC-RAS. 

INDICATOR LIMITS	Application of numerical models in reservoir sedimentation studies would be needed to get more reliable data.
EVALUATION	----
AVAILABLE UF	NO
UF	----
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	PUBLIC: Research Institutes PRIVATE: Biology and Environmental Analysis Societies
TIME COVER	1982 (start of operation) - 2012
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

ENVIRONMENT – RIVER ECOSYSTEM

Bodendorf tree | ENVIRONMENT – RIVER ECOSYSTEM | Bed load transportation out

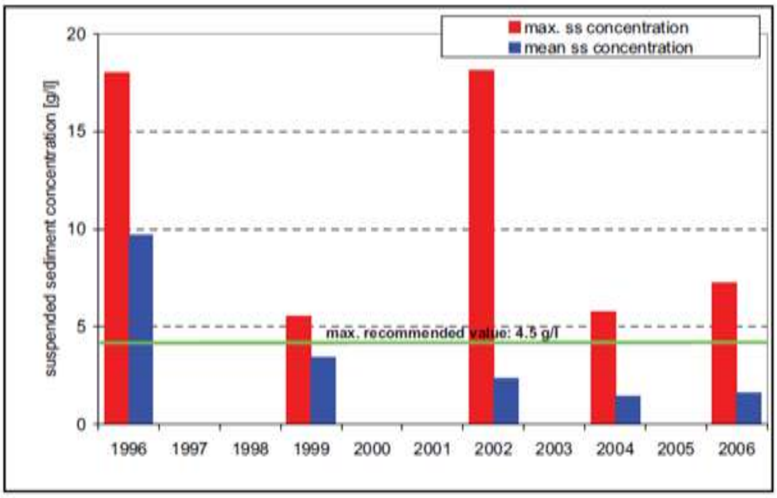
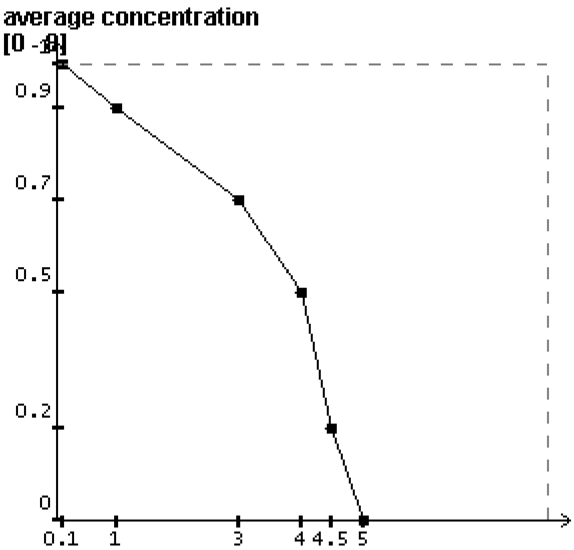
FIELD	DESCRIPTION
INDICATOR NAME	Bed load transportation out
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	----
DESCRIPTION	Reservoirs of hydropower plants are leading to a deficit of bed load downstream of the plant. Improving the bed load transport is desired and can be accomplished by flushings.
AIM	Increased bed load transport through the hydropower plant into the river section downstream.
KEY MESSAGE	This indicator describes how much bed load is transported out of the reservoir by the flushing.
MEASURE UNIT	m^3
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	The indicator consists of measurements, but also expert estimation is needed.
INDICATOR LIMITS	Application of numerical models in reservoir sedimentation studies would be needed to get more reliable data.
EVALUATION	----
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is LINEAR growing

	
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Literature, expert estimations
TIME COVER	2005 - 2012
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ENVIRONMENT – RIVER ECOSYSTEM | Suspended sediment concentration average

FIELD	DESCRIPTION
INDICATOR NAME	Suspended sediment concentration average
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	P - Pressures
DESCRIPTION	

	When the level of suspended sediment becomes too high, it can adversely impact fish and macroinvertebrates.
AIM	This indicator expresses an assessment of the effects of turbidity and suspended sediments on fish. The aim is to set thresholds to avoid harming the fish population during flushings.
KEY MESSAGE	The fish population is sensitive to the suspended sediment concentration in the water.
MEASURE UNIT	g/l (gram per litre)
REFERENCES	Newcombe & Jenson (1996) evaluated the severity of effects on fishes
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Expert talks, literature, suspended sediment measurements at flushing events 

	 Mean and max. suspended sediment concentrations during the flushings at HPP Bodendorf
INDICATOR LIMITS	Long-term effects are hard to quantify
EVALUATION	----
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is DOTS/DASHED decreasing 
SHARE RELATED IND.	---
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**

DATA SOURCE	Suspended sediment measurements at flushing events by TUG and operator of the HPP
TIME COVER	2005 - 2012
UPDATE FREQUENCY	Single events
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ENVIRONMENT – RIVER ECOSYSTEM | Suspended sediment concentration peak

FIELD	DESCRIPTION
INDICATOR NAME	Suspended sediment concentration peak
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	P - Pressures
DESCRIPTION	When the level of suspended sediment becomes too high, it can adversely impact fish and macroinvertebrates. This indicator shows the sediment concentration peak during the flushing.
AIM	This indicator expresses an assessment of the effects of turbidity and suspended sediments on fish. The aim is to set thresholds to avoid harming the fish population during flushings.
KEY MESSAGE	The fish population is sensitive to the suspended sediment concentration in the water.
MEASURE UNIT	g/l (gram per litre)
REFERENCES	Newcombe & Jenson (1996) evaluated the severity of effects on fishes
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Expert talks, literature, suspended sediment measurements at flushing events

Juvenile and Adult Salmonids

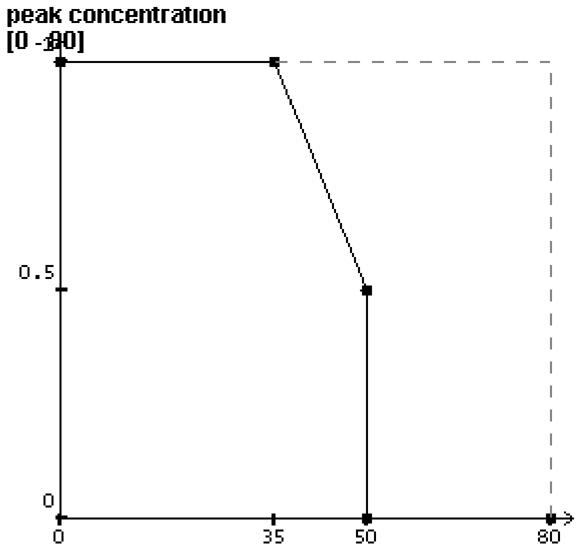
Duration of exposure to SS ($\log_e$ hours)

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	0	1	2	3	4	5	6	7	8	9	10	($\log_e$ mg SS/L)
162755	10	11	11	12	12	13	14	14	-	-	-	12
59874	9	10	10	11	12	12	13	13	14	-	-	11
22026	8	9	10	10	11	11	12	13	13	14	-	10
8103	8	8	9	10	10	11	11	12	13	13	14	9
2981	7	8	8	9	9	10	11	11	12	12	13	8
1097	6	7	7	8	9	9	10	10	11	12	12	7
403	5	6	7	7	8	9	9	10	10	11	12	6
148	5	5	6	7	7	8	8	9	10	10	11	5
55	4	5	5	6	6	7	8	8	9	9	10	4
20	3	4	4	5	6	6	7	8	8	9	9	3
7	3	3	4	4	5	6	6	7	7	8	9	2
3	2	2	3	4	4	5	5	6	7	7	8	1
1	1	2	2	3	3	4	5	5	6	7	7	0
	1	3	7	1	2	6	2	7	4	11	30	
	Hours			Days			Weeks		Months			

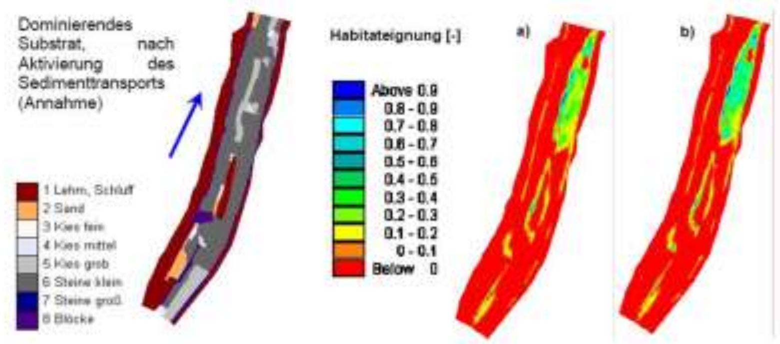
Half-95% confidence intervals (±)
around calculated severity-of-ill-effect scores (above)

INDICATOR LIMITS	Long-term effects are hard to quantify

EVALUATION	----
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is DOTS/DASHED decreasing 
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Suspended sediment measurements at flushing events by TUG and operator of the HPP
TIME COVER	2005 - 2012
UPDATE FREQUENCY	Single events
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ENVIRONMENT – RIVER ECOSYSTEM | Substrat conditions

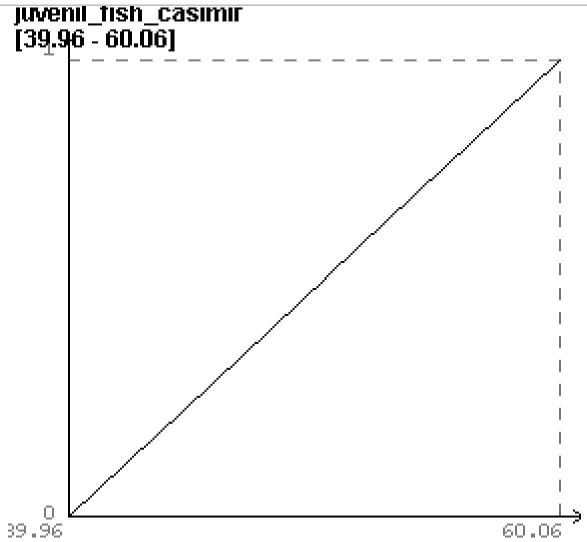
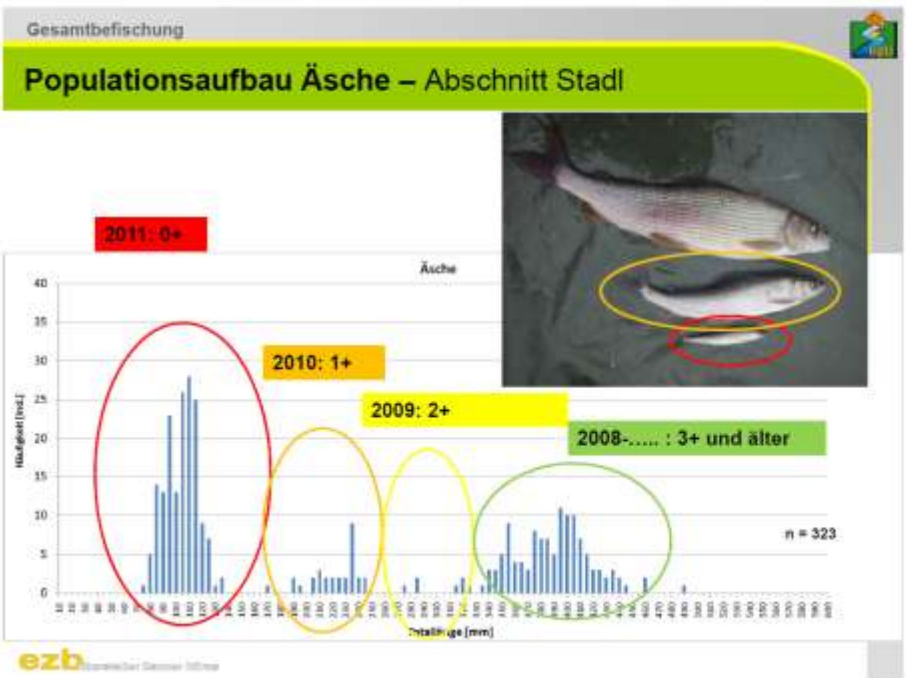
FIELD	DESCRIPTION

INDICATOR NAME	Substrat conditions
ACRONYM	n/a (there is no acronym scientifically documented)
DPSIR	S - State
DESCRIPTION	The aim of the indicator "substrat conditions" is to make a diagnosis of the substrat conditions in the river reach and their change because of the flushing. This diagnosis is based on the modeling of substrat conditions with the software CASiMiR.
AIM	This indicator expresses the substrat conditions at a reference stretch at the river Mur.
KEY MESSAGE	This indicator is designed to evaluate the impact of reservoir flushing on fish habitat and river substrate composition.
MEASURE UNIT	----
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	For calculation of the sediment transport of the river Mur between the HPP Bodendorf and the reach Gestuethof, which was investigated by the CASiMiR model, the software HEC-RAS 4.1.0 (US Army Corps of Engineers) was used. The results of HEC-RAS were fed into the CASiMiR model.  Abb. 7.5-2: Vergleich der Laichhabitateignungen, Annahme der Substratverteilung nach Aktivierung Sedimenttransport (Annahme: subdominierendes Substrat wird dominierend) (a) derzeitige Substratverteilung und (b) nach Aktivierung Sedimenttransport
INDICATOR LIMITS	----
EVALUATION	----
AVAILABLE UF	NO
UF	----
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS

FIELD	DATASOURCES
DATA SOURCE	Computer models and simulations (HEC-RAS, CASiMiR)
TIME COVER	2009 - 2012
UPDATE FREQUENCY	None
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Bodendorf tree | ENVIRONMENT – RIVER ECOSYSTEM | Fish conditions

FIELD	DESCRIPTION
INDICATOR NAME	Fish conditions
ACRONYM	Fish
DPSIR	
DESCRIPTION	Indicator giving the level pressure on water fishing uses due to HP activity
AIM	Fishing activity maintenance
KEY MESSAGE	----
MEASURE UNIT	
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	----
INDICATOR LIMITS	----
EVALUATION	
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is LINEAR growing

	
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Results of the fish monitoring programme by the technical bureau Eberstaller (TB Eberstaller) 
TIME COVER	NONE
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL

NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

LANDSCAPE

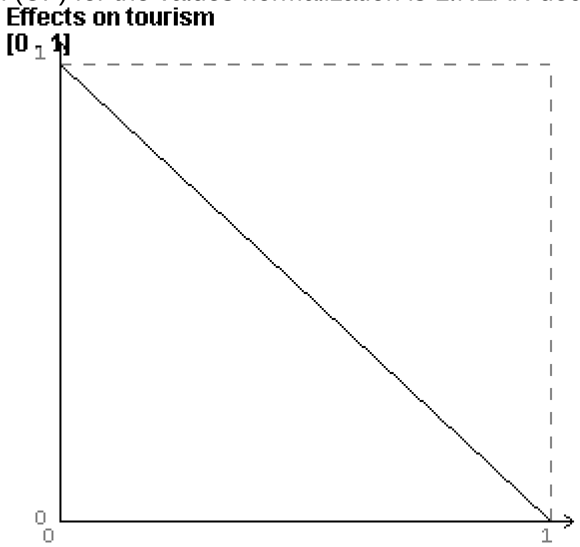
Bodendorf tree | LANDSCAPE | Landscape

FIELD	DESCRIPTION
INDICATOR NAME	Landscape
ACRONYM	L
DPSIR	S – States indicator
DESCRIPTION	This indicator evaluates the impact of flushings on landscape of the PCS area
AIM	Show the landscape and environmental impacts of the flushing
KEY MESSAGE	----
MEASURE UNIT	----
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Expert discussions, monitoring of effects on the landscape

	
INDICATOR LIMITS	Low pertinence
EVALUATION	----
AVAILABLE UF	NO
UF	----
SHARE RELATED IND.	----
COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Expert discussions
TIME COVER	NONE
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

TOURISM

Bodendorf tree | TOURISM | Effects on tourism

FIELD	DESCRIPTION
INDICATOR NAME	Effects on tourism
ACRONYM	---
DPSIR	Impact
DESCRIPTION	Indicator evaluating the impact of flushings on tourism at the area of Bodendorf.
AIM	This indicator should show the reduction of scenic attractiveness of the region due to the flushing of the reservoir.
KEY MESSAGE	Flushings are not very attractive for tourism
MEASURE UNIT	---
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Expert discussions
INDICATOR LIMITS	Tourism is not very important in the pilot case study area, low pertinence of the indicator
EVALUATION	----
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is LINEAR decreasing 
SHARE RELATED IND.	----
COUNTRY CODE	AT

WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Expert discussions
TIME COVER	2009 - 2012
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

FISHING

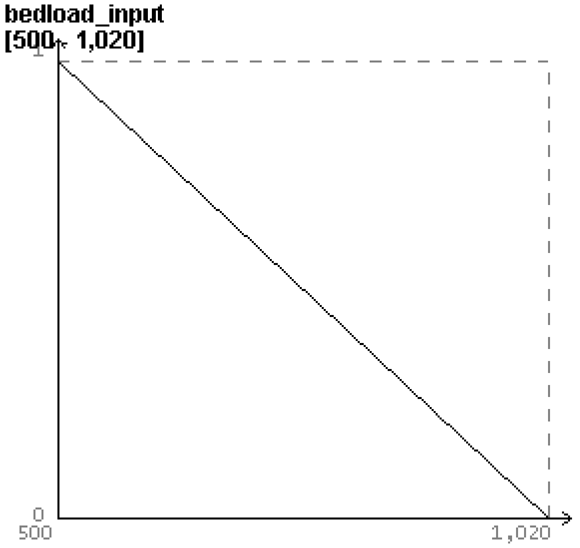
Bodendorf tree | FISHING | Effects of fish mortality

FIELD	DESCRIPTION
INDICATOR NAME	Effects of fish mortality
ACRONYM	---
DPSIR	I - Impacts
DESCRIPTION	The operator of the HPP has to pay compensation fees to the fishery for the fishes killed by the high concentration of suspended sediment during the flushing.
AIM	Indicator will take into account the costs of the fish mortality.
KEY MESSAGE	Indicator is evaluating the impact of fish mortality caused by the flushing.
MEASURE UNIT	€
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	Expert discussions
INDICATOR LIMITS	----
EVALUATION	----
AVAILABLE UF	NO
UF	----
SHARE RELATED IND.	----
COUNTRY CODE	AT

WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	Expert discussions
TIME COVER	NONE
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

RISK

Bodendorf tree | RISK | Flood risk reservoir head

FIELD	DESCRIPTION
INDICATOR NAME	Flood risk reservoir head
ACRONYM	*FLOOD*
DPSIR	D - Driving forces
DESCRIPTION	Sediments are trapped in the reservoir, thus increasing flood risk in the area at the head of the reservoir. Flushing the reservoir and mobilizing the sediment is therefore reducing the flood risk.
AIM	Reduce the risk of floods at the head of the reservoir and avoid severe damages.
KEY MESSAGE	River sediments are deposited in the reservoir, which is increasing the flood risk.
MEASURE UNIT	m^3
REFERENCES	–
FIELD	**METHODS AND MONITORING STANDARDS**
INDICATOR ELABORATION	----
INDICATOR LIMITS	Application of numerical models in reservoir sedimentation studies would be needed to get more reliable data.
EVALUATION	----
AVAILABLE UF	YES
UF	The utility function (UF) for the values normalization is LINEAR decreasing 
SHARE RELATED IND.	----

COUNTRY CODE	AT
WFD HER	STYRIAN ALPS
FIELD	**DATASOURCES**
DATA SOURCE	----
TIME COVER	2009 - 2012
UPDATE FREQUENCY	----
NUT III CODE	AT226
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Bodendorf

Weights assignment

The weights (W) assigned to the different criteria are shown in the following tables. There were made three weight assignments for the three stakeholder groups, concerned by the flushing of the reservoir (energy provider, ecologists, fishery). The last table is made from a neutral point of view, taking account of the needs and opinions of all interested parties.

Note that certain sub-indicators (head, design flow, ..) are part of aggregation functions and therefore are not considered in the calculation of the overall performance of the alternatives.

Energy provider, hydropower plant operators

CRITERIA	W	SUB-CRITERIA	W	INDICATORS	W	SUB-INDIC	W	SUB-INDIC	W
ENERGY	0.05			Annual energy production	1				
ECONOMY	0.25			Energy production lack	0.2	Duration of flushing	0.6		
						Energy Price	0.2		
						Power Installed	0.2	Head	0.5
								Design flow	0.3
								Efficiency	0.2
				Flushing efficiency	0.8	Original volume	0.1		
						Sediment output	0.8		
						Volume before flushing	0.1		
LANDSCAPE	0.05			Landscape	1				
ENVIRONMENT	0.4	ABIOTIC INDICATORS	0.7	Bed load transportation out res.	0.7				
				Suspended sediment concentration average	0.2				
				Suspended sediment concentration peak	0.1				
		BIOTIC INDICATORS	0.3	Substrat conditions	0.7				
				Fish conditions	0.3				
TOURISM	0.05			Effects on tourism	1				
FISHING	0.15			Effects of fish mortality	1				
RISK	0.05			Flood risk reservoir head	1				

Ecologists, environmentalists

CRITERIA	W	SUB-CRITERIA	W	INDICATORS	W	SUB-INDIC	W	SUB-INDIC	W
ENERGY	0.1			Annual energy production	1				
ECONOMY	0.2			Energy production lack	0.1	Duration of flushing	0.8		
						Energy Price	0.1		
						Power Installed	0.1	Head	0.3
								Design flow	0.3
								Efficiency	0.4
				Flushing efficiency	0.9	Original volume	0.1		
						Sediment output	0.8		
						Volume before flushing	0.1		
LANDSCAPE	0.1			Landscape	1				
ENVIRONMENT	0.4	ABIOTIC INDICATORS	0.5	Bed load transportation out res.	0.5				
				Suspended sediment concentration average	0.3				
				Suspended sediment concentration peak	0.2				
		BIOTIC INDICATORS	0.5	Substrat conditions	0.7				
				Fish conditions	0.3				
TOURISM	0.05			Effects on tourism	1				
FISHING	0.1			Effects of fish mortality	1				
RISK	0.05			Flood risk reservoir head	1				

Fishery

CRITERIA	W	SUB-CRITERIA	W	INDICATORS	W	SUB-INDIC	W	SUB-INDIC	W
ENERGY	0.05			Annual energy production	1				
ECONOMY	0.05			Energy production lack	0.1	Duration of flushing	0.8		
						Energy Price	0.1		
						Power Installed	0.1	Head	0.3
								Design flow	0.3
								Efficiency	0.4
				Flushing efficiency	0.9	Original volume	0.1		
						Sediment output	0.8		
						Volume before flushing	0.1		
LANDSCAPE	0.1			Landscape	1				
ENVIRONMENT	0.3	ABIOTIC INDICATORS	0.5	Bed load transportation out res.	0.2				
				Suspended sediment concentration average	0.4				
				Suspended sediment concentration peak	0.4				
		BIOTIC INDICATORS	0.5	Substrat conditions	0.3				
				Fish conditions	0.7				
TOURISM	0.05			Effects on tourism	1				
FISHING	0.4			Effects of fish mortality	1				
RISK	0.05			Flood risk reservoir head	1				

Neutral assessment

Table of weights assignment

CRITERIA	W	SUB-CRITERIA	W	INDICATORS	W	SUB-INDIC	W	SUB-INDIC	W
ENERGY	0.05			Annual energy production	1				
ECONOMY	0.35			Energy production lack	0.2	Duration of flushing	0.8		
						Energy Price	0.1		
						Power Installed	0.1	Head	0.5
								Design flow	0.3
								Efficiency	0.2
				Flushing efficiency	0.8	Original volume	0.1		
						Sediment output	0.8		
						Volume before flushing	0.1		
LANDSCAPE	0.05			Landscape	1				
ENVIRONMENT	0.35	ABIOTIC INDICATORS	0.5	Bed load transportation out res.	0.5				
				Suspended sediment concentration average	0.25				
				Suspended sediment concentration peak	0.25				
		BIOTIC INDICATORS	0.5	Substrat conditions	0.7				
				Fish conditions	0.3				
TOURISM	0.05			Effects on tourism	1				
FISHING	0.05			Effects of fish mortality	1				
RISK	0.1			Flood risk reservoir head	1				

Summary

The values were chosen according to many considerations and talks with experts from different stakeholder groups.
Energy criterion weighs only 5% of the whole tree, being not so relevant because the flushing only last for a short time. The downstream effects of flushing are a massive sediment transport (which is a desired effect) and possible damage to the ecological communities, considered in the criterion

"Enviroment". Interruption of the sediment transport is a big issue at the PCS area, so the indicators "sediment output" and "bedload transportation" have a higher significance for the tree.

High concentrations of suspended material during flushing events can damage the fish population; therefor the indicators of the suspended sediment concentration are also very important for this PCS.

Figure 4: Increased suspended sediment concentration during the flushing of the reservoir in July 2012

Flushing efficiency is the most important indicator (80%) inside the Environment criterion. Landscape and tourism criteria have a lower importance in the MCA, being the sum equal to 0.1. This is due to the characteristics of the river reach and the surrounding area, which is poor of touristic elements, with the exception of fishing activity. The same applies to the indicator risk, which also has only a partial importance and is weighted rather low with 10%.