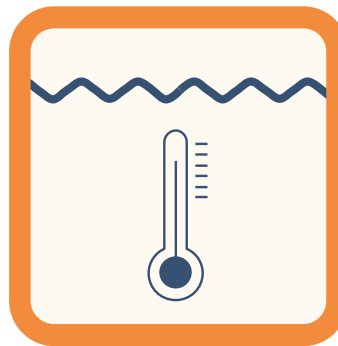




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Technical Sheet: Indicator Set 4 Temperature



Indicators: • 4.1 Temperature (Woolsey et al. 2005, no. 38)

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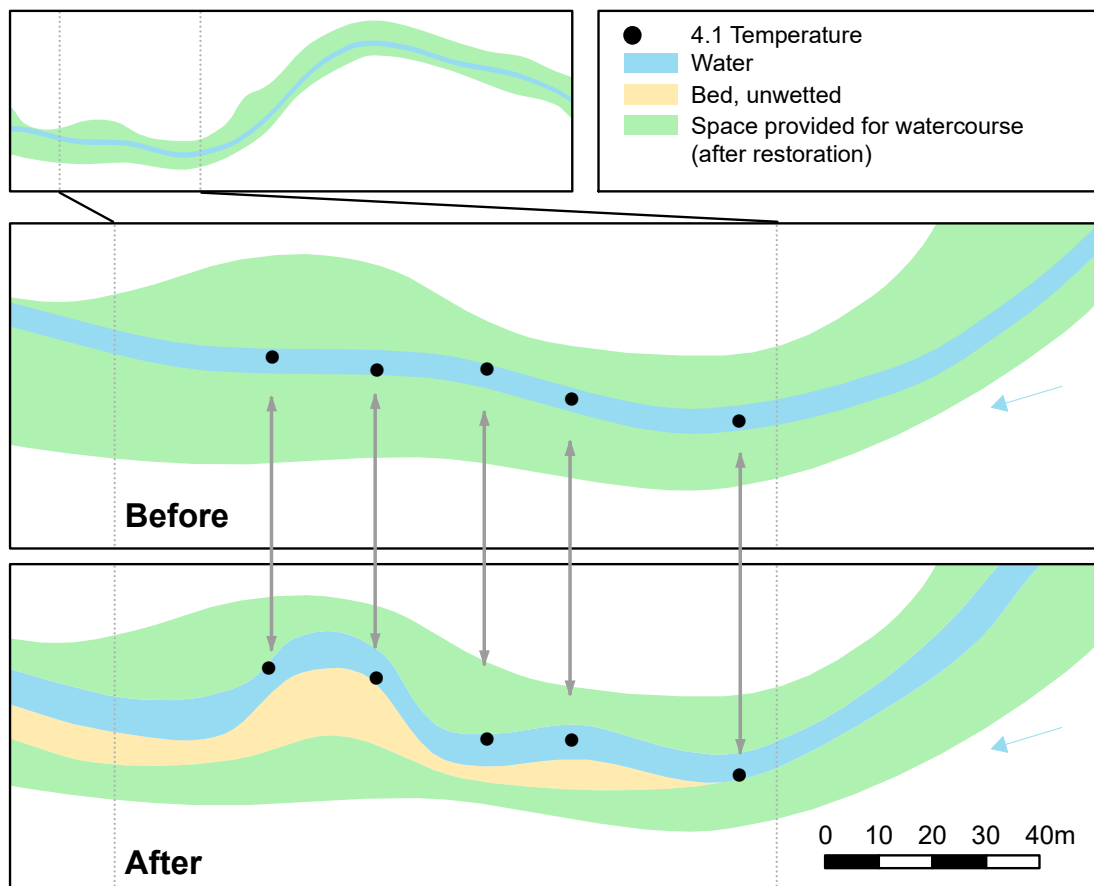
This Indicator Set forms part of the Swiss STANDARD outcome evaluation and is to be used in conjunction with the practice documentation "Evaluating the outcome of restoration projects – collaborative learning for the future" (FOEN 2019). The indicators included in the Indicator Set derive from various sources (e.g. Woolsey et al. 2005; Modular Stepwise Procedure) and, where appropriate, have been updated or adapted for the practice documentation. An overview of the most important modifications made can be found in Factsheet 7.

Principle

Water temperature is one of the key variables for aquatic ecosystems, determining the rate at which such fundamental processes occur as, for example, photosynthesis in aquatic and riparian plants; decomposition of leaf litter by invertebrates, fungi or microbes; or the metabolism of cold-blooded animals such as fish (e.g. respiration, digestion, growth). Many natural waters show spatial and temporal variation in water temperature, e.g. due to influx of groundwater, afforestation in the upper reaches, or meltwater. Indicator Set 4 describes the spatial and temporal distribution of surface temperature in watercourses, focusing on the summertime fair-weather, low-flow period.

Parameters	Five loggers are deployed along the subsection designated in Set 1, and 1–2 additional loggers in the upstream channelised section. To be determined is the variation in daily maxima between measurements in different habitats during a summertime fair-weather, low-flow period (2–3 weeks to 2 months).
Applicability	The Indicator Set can be used for all watercourse sizes (wadable/non-wadable). For the STANDARD outcome evaluation, it can be selected for medium-sized and large or for individual projects.
Special considerations	There is a risk of weather-related temperature changes being incorrectly attributed to restoration. Accordingly, caution is to be exercised in choosing the temperature data to be taken into consideration, e.g. for the before/after comparison. Essentially, only days which are similar in terms of key factors for water temperature are to be compared. These key factors are air temperature, solar radiation and discharge.
Survey site	Subsection, upstream channelised section
Timing	In this Indicator Set, water temperature is measured in summertime fair-weather, low-flow periods. If a project-specific interest exists, measurements may also be carried out in other seasons. Depending on the recording interval (hourly) and storage capacity of the loggers, data may need to be retrieved several times. The additional effort required should be taken into account when loggers are purchased. In channels with high bedload transport, monthly data retrieval is recommended so as to minimise potential data losses.
Material	Temperature loggers: a wide variety are available, ranging from low-cost loggers with limited memory and measurement accuracy (e.g. iButtons) to highly precise and rugged (e.g. Vemco) loggers. Ideally, accuracy should be 0.1°C and resolution 0.01°C. Protective cover for loggers, anchoring system.

Figure 4.1: Survey site for indicator 4.1 from Indicator Set 4.



Survey

The individual steps involved in the survey are explained below, in chronological order.

Step	Description	Indicator
Deployment of loggers before restoration	<ul style="list-style-type: none"> Restored section: 5 loggers to be deployed, based on the subsection mapping performed in Indicator Set 1: each permanently wetted bed structure type to be equipped with 1 logger. Loggers to be located on the bed or in the lower half of the water column. Upstream channelised section: 1–2 additional loggers to be deployed at the bank and midstream. Loggers to be securely anchored, so that they can remain in place and provide reliable measurements even under harsh conditions (e.g. high flows with bedload transport). Wherever possible, loggers should be attached to existing infrastructure (e.g. bridges, pipes, etc.). Loggers should be positioned in such a way as to be readily recoverable, but also protected, so as to minimise any risks of vandalism, tampering or theft. Logger locations are to be precisely recorded (e.g. GPS positioning, photos) Measurements are to be made at hourly intervals. Depending on the type of restoration measure, loggers may need to be removed before construction work begins. 	4.1
Deployment of loggers after restoration	<ul style="list-style-type: none"> The same number of loggers are to be deployed as far as possible in the same position as before the implementation of measures (position within the longitudinal profile and relative to the banks). 	4.1
Read-out	<ul style="list-style-type: none"> See “Timing” 	4.1

Alternative data source: drone-based thermal infrared remote sensing. This method is still labour-intensive, but it enables precise characterisation of spatiotemporal thermal heterogeneity in the upper centimetres of the water column (Tonolla et al. 2019).

Evaluation

The method for evaluation of temperature data has not yet been finalised. Various evaluation approaches can be found in the original indicator method sheets in the “Handbook for evaluating rehabilitation projects in rivers and streams” (Woolsey et al. 2005). These serve as a guide and will be discussed and revised in the coming months on the basis of the experience accumulated in the STANDARD and EXTENDED outcome evaluations.

Time required

Table 4.1: Estimated time required in person-hours for the determination and evaluation of Indicator Set 4. A rough cost estimate can be found in Table 2.1 of Factsheet 2.

Step	Specialists		Assistants	
	Persons	Time per person (h)	Persons	Time per person (h)
Preparation (deciding on logger sites)	1	2		
Deployment of loggers, recovery, data retrieval			1–2	8–16
Evaluation	1	12		
Total person-hours		14		8–32

Notes: Depending on the logger type and watercourse characteristics, more time may be required for data retrieval.

Further information

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| Data arising | <ul style="list-style-type: none"> • Data entry form for Indicator Set 4: KT_ProCode_ERHEBUNG_Set4_V#.xls <p>Elements of the file naming scheme (see Factsheet 5)</p> <ul style="list-style-type: none"> • KT = two-capital-letter cantonal abbreviation (e.g. BE) • ProCode = project code • ERHEBUNG = survey time point, i.e. VORHER (= before), NACHHER1 (= after 1), NACHHER2 (= after 2), or VERTIEFT (= EXTENDED) • V# = version number of the data entry form |
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Attachments	The field protocol, data entry form and other useful documents are available at: https://www.bafu.admin.ch/wirkungskontrolle-revit
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