MERLIN

Deliverable D1.7:

Revitalizing small streams – A practical guide for community action

www.project-merlin.eu

MERLIN

Imprint

The MERLIN project (https://project-merlin.eu) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036337.

Lead contractor: Friedrich-Schiller-Universität Jena

To be cited as: Bischof R., Danker S., von Gönner J., Friedrichs-Manthey M., Tent L., Bonn A. and Birk S., 2025. Revitalizing small streams – A practical guide for community action. EU H2020 research and innovation project MERLIN Deliverable 1.7. 32 pp. + Annexes. https://project-merlin.eu/outcomes/deliverables.html

Due date of deliverable: 28.02.2025

Actual submission date: 07.03.2025

MERLIN Key messages

1. Training material for the monitoring of small streams by citizen scientists according to FLOW project protocols is available in English language and was tested in Ghent (BE).
2. The ecological status of small streams is assessed before and after the implementation of citizen science (CS) restoration measures based on FLOW monitoring protocols for *hydromorphology* and *benthic invertebrates*.
3. A process description helps volunteers to check local conditions, to develop agreements between stakeholders and to implement site- and group specific measures.
4. We provide fact sheets on three different CS stream restoration measures: Installing wood structures, gravel micro-groins and planting alders.
5. We present approaches to monitor temporal changes in the benthic invertebrate community using the bioindicator EPT ratio.

MERLIN Executive Summary

Freshwater streams are fascinating ecosystems whose natural flow, substrate, and riparian dynamics support multiple ecosystem services. However, many streams have been heavily affected by human activities. This action guide provides volunteer groups and practitioners with hands-on instructions for improving the habitat quality of small streams.

The first section of this guide provides a brief overview of the current ecological conditions and major stressors of stream ecosystems. It also illustrates how the participation of volunteers or citizen scientists in stream monitoring and restoration can help conserve and restore stream health.

In the second part, we offer a detailed process description for volunteer groups on how to systematically plan and implement low-threshold stream restoration measures. As a first step, standardized citizen science monitoring protocols (for example from the FLOW project, www.flow-projekt.de) should be used to assess stream hydromorphology and benthic invertebrate communities. This evidence can then be used to identify structural deficiencies in the analysed stream section. Next, it is important to contact relevant stakeholders and supporters, to develop and discuss potential measures and finally, to agree on a suitable site-specific measure to improve the concerned stream's habitat quality. This section also provides tips for obtaining permissions, recruiting volunteers, mobilising supporters and implementing the stream restoration measure on site. Finally, a very important step is post-implementation monitoring to examine the ecological effects of the measure over time. In collaboration with the local stakeholders, the post-monitoring results can then be used to continue or adapt the respective stream restoration measures.

The third section provides practical knowledge on **well-tested, low-threshold stream restoration measures** to support volunteer groups and practitioners to plan and implement their own local measures. For this, we provide **fact sheets** on three stream restoration measures that can be implemented by volunteers in collaboration with relevant actors such as land owners and environmental agencies:

→ **Installing wood structures** to enhance substrate and flow diversity and stabilize stream banks
→ **Introducing gravel as micro-groins** to improve habitat quality, substrate and flow diversity
→ **Planting alders** to improve habitat quality and shading

For each of these measures, we summarize key information about the intended **ecological effects**, the **resources and materials** needed, **instructions, and illustrations for installing the measures** at the stream site.

In the fourth section, we present **approaches to monitor restoration-induced temporal changes** in the benthic invertebrate community, by using the **ratio of sensitive EPT taxa** (Ephemeroptera, Plecoptera, Trichoptera) as a bioindicator of stream habitat quality and hydromorphological status.

The action guide is complemented by a **glossary** of technical terms and **references** for further reading. The **appendix** contains relevant tables and fact sheets for printing and use in the field.

Content

1 Introduction

1.1 Introduction and objective

Europe is criss-crossed by a dense network of streams and rivers. Germany's river network, for example, has a total length of more than 500,000 kilometres. But only a small part of these rivers - in Germany: about 25% - is regularly monitored under the **EU Water Framework Directive**[1] (WFD). The remaining large part of the river network, i.e. **small streams** with catchment areas of **less than 10 km²**, is not systematically assessed by the official monitoring. Consequently, there is a lack of data on the ecological status of small streams in Europe.

Over centuries, people have impacted the natural morphology of streams: rivers and small streams have been **straightened, dammed**, or even **culverted**. In the second half of the 20th century, small streams were often degraded to drainage canals and confined to standardized, easy-to-maintain profiles. In addition, **pollutants** and **nutrients** from urban and rural areas, as well as a changing **climate**, affect the ecological functionality and biodiversity of streams and stream banks. Competing interests from agriculture, flood protection, construction and transport, recreation (leisure, angling), nature conservation, and heritage protection (e.g., historic weirs) lead to challenges for stream protection and restoration. These different drivers often lead to **land use conflicts**. As a result, many streams and small rivers have lost important habitat functions as a result of human land use and development activities. Their water quality is often impaired by the inputs of nutrients, pollutants such as pesticides, and sediments from adjacent areas. Due to the extensive loss of natural, (semi)shaded riparian strips of trees, shrubs and herbs, as well as semi-natural riparian forests, small streams are often overexposed to sunlight and 'overheated' during the summer months. These **multiple**, interacting **stressors** negatively affect stream ecological function and lead to drastic **declines in the biodiversity** of many streams, especially of specialized, pollution-sensitive, oxygen-dependent, and cold-adapted fish and insect species (Liess et al. 2021; Wolfram et al. 2021, BMUV/UBA 2022).

1.2 Importance of healthy streams

Small streams in good ecological status provide important **ecosystem functions**, including water purification, biodiversity conservation, natural flood protection, microclimate regulation, organic matter decomposition and nutrient cycling, and recreation.

These streams are characterized by a high flow diversity and their **natural dynamics** of erosion and sedimentation of substrates in the streambed, such as sand, gravel, and dead wood. This creates diverse, structurally rich, and constantly **changing habitats** for insects, fish and their larvae (Figure 1). Depending on the prevailing flow, nutrient and light conditions and substrate types, a wide variety of plant and animal species can be found in these diverse (semi)aquatic habitats. In well shaded streams, the water stays cool even in summer. The cooler the water, the more oxygen it can dissolve. Therefore, especially summer-cool streams provide a habitat for a unique and **species-rich community** of aquatic plants, invertebrates and fish.

[1] The term is explained in the glossary.

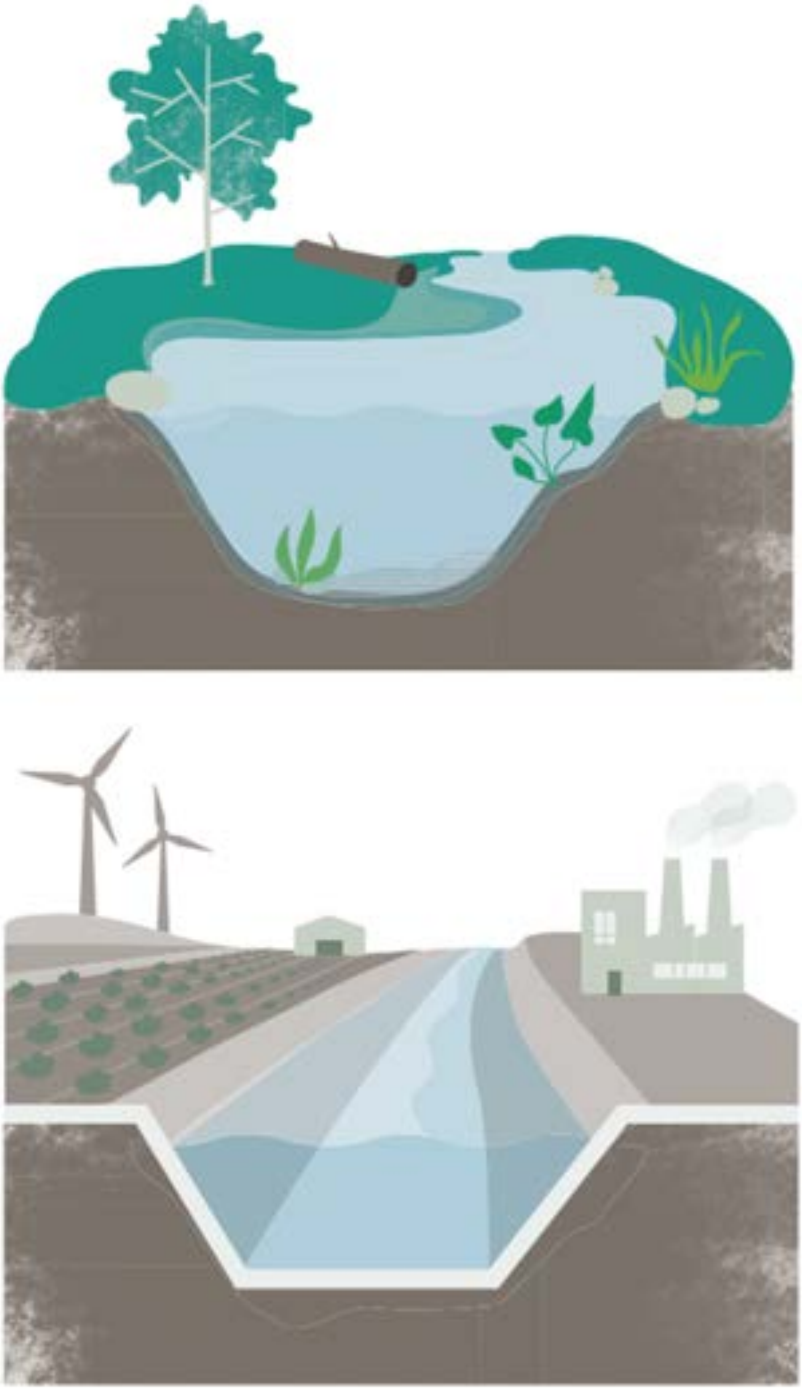


Figure 1: Near-natural, small stream with diverse habitat structures and intact riparian zone (top), versus a heavily modified, channelized stream with stabilized banks and detrimental adjacent land use (bottom).

1.1 How can citizen science monitoring help?

In citizen science projects, such as the **FLOW project** for freshwater monitoring, **trained volunteer groups**[2] collect standardized data on hydromorphological, physico-chemical and biological status of small streams across Germany. This citizen science approach encourages many people to observe their streams, contribute new knowledge about their ecological status, and help **fill existing data gaps** (von Gönner et al. 2024 a, b). The FLOW monitoring is based on the methodology of the Water Framework Directive and provides structured

[2] The term 'volunteer groups' is explained in the glossary.

citizen science protocols for the assessment of stream structure (hydromorphology) and benthic invertebrate[3] communities. The project also provides detailed and well-tested training materials for beginners to share practical knowledge on how to assess the ecological status of streams. In the FLOW project, a network of experienced group leaders and experts supports the volunteer groups during fieldwork. They ensure the **systematic implementation** of the monitoring methods and provide feedback on **species identification**. Volunteers are invited to analyze and interpret their results, investigate possible causes and discuss results and ideas for stream restoration with scientists at annual project conferences. The overall data quality and ecological results of the Germany-wide FLOW monitoring are also evaluated and analyzed by scientists. Therefore, citizen science monitoring is well suited to **prepare and evaluate low-threshold stream restoration measures by volunteer groups**.

1.2 How can volunteer groups contribute to stream restoration?

Citizen science monitoring data provide an important evidence base for **identifying deficiencies** in stream hydromorphology and benthic invertebrate communities. For example, the sampled stream sections may lack flow and substrate diversity, or may have little **riparian vegetation** that acts as a buffer strip and important habitat element.

In this situation, local practitioners and volunteers can choose several options to improve the local habitat conditions for flora and fauna through low-threshold measures. Even relatively simple, low-cost **stream maintenance measures** that do not require excavators or lengthy planning approval procedures can result in significant improvements in stream ecology and public perception of streams. This guidance document explains three **'instream'** measures that can be implemented within the current stream profile[4]. Their goal is to restore (at least partially) the natural dynamics of flow, substrate, and riparian structures.

This action guide aims to provide volunteer groups and practitioners with **hands-on instructions** for improving the **habitat quality** of small streams. The following sections describe the process of preparing, coordinating and implementing low-threshold stream restoration measures (Figure 2)

Figure 2:Process description. Color coding of arrows: green = successfully completed (process continues), yellow = in progress (adjustment needed), red = no / negative outcome (process ends / discontinues).

[3] These are organisms like insect larvae, gammarids, mussels and snails living on the stream bed.

[4] Tent, B. & Tent, L. (2016). Instream Restaurieren - jüngere Beispiele aus Hamburg-nahen Fließgewässern (see References).

Section 2 addresses the necessary **prerequisites** for volunteer groups to initiate low-threshold restoration measures in their local streams.

These include pre-monitoring, deficiency analysis, and a feasibility check. If the different steps are successfully completed (green arrows Figure 2), the group can move on to the next step. Yellow arrows indicate instances where adjustments are needed, and red arrows indicate that the process might have to be terminated at this point. Section 3 deals with the **coordination** of low-threshold stream restoration processes: Who needs to be involved? What agreements on measures, location and timing are needed? Which stakeholders need to provide necessary approvals? Section 4 describes the practical **implementation** of restoration measures. Here, we provide hands-on fact sheets for three well-tested, low-threshold restoration measures to guide volunteer groups how to improve the ecological condition of their local streams. The guide is completed by a description of **measure evaluation** (Section 5): How can post-monitoring assess progress on ecological effects of the stream restoration measures and inform adaptive management? Important technical terms are explained in the **glossary** (Section 6).

2 Prerequisites

Any stream restoration project undertaken by volunteer groups should begin with a **systematic preparation** to meet certain prerequisites. This will ensure that valuable resources are used efficiently, premature actions and conflicts are avoided, and that the ecological effects of stream restoration measures can be evaluated retrospectively.

As a first step, volunteer groups should select a specific **100m target section** of their stream. This stream section should be easily accessible and well representative of the entire stream.

2.1 Pre-Monitoring

The ecological status of each stream section is closely linked to its upstream and downstream sections. In order to understand the local situation, it is essential to first examine the **initial conditions**, i.e. the specific **stream type** (Table 1), and gain a detailed understanding of the catchment area including its unique characteristics by studying maps and other available information. Next, the volunteer group should conduct a **pre-monitoring** (see Figure 2) of their selected stream section to assess stream structure (hydromorphology) and benthic invertebrate community.

We suggest monitoring to be carried out according to the **FLOW protocols** and training materials.

Additional information on type and intensity of land use, and the presence of **point sources** of pollution upstream of the sampling site should be collected. This helps to assess the potential for the ecological enhancement of a stream section. Pre-monitoring represents an inventory and evaluation of the **current state** and is also essential for a successful evaluation of the suitability and effectiveness of the restoration measures to be carried out.

Table 1: Simplified stream type classification based on ecoregion and altitudinal zones

Stream type	Substrates	Surrounding landscape	Characteristics
Organic stream	High organic matter input (e.g., from leaves, wood, soil)	Often found in forested or peatland areas (lowland)	Typically, slow flowing and rich in nutrients.
Lowland stream	Fine sediments, deadwood and aquatic plants	Floodplain with meandering paths	Slow-flowing stream in flat terrain, often with warmer water, stable banks and abundant vegetation high nutrient levels.
Mid-mountain stream	Mix of gravel and cobble substrates	Hilly or lower mountain regions	Moderate-gradient stream, alternating riffles and pools, cooler water, and moderate flow variability.
Pre-alpine stream	Stony or rocky streambed	Transitional between mid-mountain and alpine zones	Steeper gradients, higher flow energy, often influenced by seasonal snowmelt and increased sediment transport.
Alpine stream	Rocky substrate	Mountainous regions	High-gradient, fast-flowing, cold water, low vegetation cover, strongly influenced by meltwater and seasonal flow fluctuations.

2.2 Deficiency Analysis

The analysis of **individual parameters** related to stream structure and the benthic invertebrate community provides important insights into the **habitat quality** of the studied stream section. Based on this information, a Deficiency Analysis assessed the stream structure in more detail (see Figure 2).

The identification of specific **morphological deficiencies** is the basis for the preparation and implementation of measures[5] to improve the stream structure (see Figure 3, red marking). At this stage, volunteer groups should check to which extent **individual parameters** like the stream's watercourse, the type of riverbed materials, or the condition of the banks (such as the width of the buffer strip, the type of plants, or bank reinforcements) have a negative effect on the **overall hydromorphological quality** of the stream section (see hydromorphology protocol in the Annex).

Rating	Parameter Index span	Stream course	Longitudinal section	Cross section	Bed structure	Bank structure	Surrounding	Mean (ø)
High	1.0 - 2.2							
Good	> 2.2 - 3.4							
Moderate	> 3.4 - 4.6							
Poor	> 4.6 - 5.8							
Bad	> 5.8							

Figure 3: Deficiency analysis. If individual parameters are rated "high" to "moderate" and the overall rating is "high" or "good" (blue box), no measures are needed. If any parameter is rated "poor" or "bad," or the overall rating is "moderate" to "bad" (red box), structural measures may be beneficial.

2.3 Feasibility check

A feasibility check helps to decide whether the volunteer group is able to address the **identified deficiencies** in the selected stream section by implementing low-threshold restoration measures. The group should critically **reflect and collectively assess** whether they feel capable of **successfully completing the process** described above at this stream section given the identified issues. Examples for small-scale and low-threshold measures, that can be implemented by volunteer groups are listed in Box 1.

Box 1. Examples for small-scale and low-threshold measures, that can be Implemented by volunteer groups.

- → Installation of structural elements
- → Planting of site-specific riparian vegetation
- → Introduction of natural substrates

In contrast, severe, anthropogenic disturbances (Box 2) can only be addressed through complex legal planning procedures and the involvement of professional stakeholders and authorities.

Box 2. Examples for severe anthropogenic disturbances, that involve stakeholders and authorities.

- → Severe modification of the river bed and/or bank areas (e.g. culverting or canalization)
- → Discharge of large amounts of wastewater or widespread, diffuse pollutant input in the catchment area (e.g., from agricultural, industrial, residential, or transportation areas)

[5] Depending on the region and section of the stream, previous studies may already exist, conducted by associations or nature conservation authorities. Consulting experts can help identify and access this information.

In the latter two situations, volunteer groups should not invest further time and effort into the process. Such extensive measures cannot be implemented by volunteer groups as part of water maintenance. Larger projects of this kind must be planned and approved by the relevant environment agencies and water authorities. They are considered to be '**stream modification or expansion measures**'[6] and therefore require a planning approval or permit procedure.

If small-scale measures, however, could realistically improve current stream structures in a given stream section, it is valuable for volunteer groups to initiate coordination and implementation efforts.

[6] Stream modification or expansion: see Section 6 (Glossary).

3 Coordination of the process

Next, in the Coordination phase (see Figure 2), it is advisable to establish direct contact with local authorities responsible for stream management and maintenance and to seek a joint discussion.

3.1 Who should be involved?

It is important to involve all related stakeholders as early as possible in the process - at the latest after the pre-monitoring, deficiency analysis and feasibility check by the volunteer group.

Responsibilities for stream management among local authorities and water maintenance agencies vary by region, depending on ownership, existing land use, flood protection measures, and state legislation. In any case, the relevant authorities, supervisory and maintenance bodies, as well as property owners must be included in the process. Depending on local conditions, it may also be necessary to involve or at least inform adjacent landowners and land managers (farmers, foresters), or associations as well as adjacent residents. If there are active environmental organizations or citizen initiatives, it is beneficial to contact them to gain support for the further process (see Table 2).

Table2: Responsible local institutions and relevant parties: Type of cooperation or involvement of the stakeholders

Responsible authority / party	Type of cooperation
Local water authority	(x) mandatory
Local nature conservation authority	(x) mandatory
Responsible authority for water maintenance (e.g., municipality, water maintenance association, etc.)	(x) mandatory
Landowners (if different from above)	(x) mandatory
Land managers (e.g., tenants, agriculture, forestry or fisheries, etc.)	(x) optional and recommended
Non-profit associations (e.g., WWF, Friends of the Earth, fishing clubs, etc.)	(x) optional and recommended

Early involvement of all relevant stakeholders can be critical in overcoming potential objections and working together to design adequate measures to improve stream structure.

If the stakeholders listed in points Table 2 are unwilling to cooperate or if property rights or conflicts oppose potential stream restoration measures, further efforts are unlikely to be successful and therefore not recommended.

In this case, it is advisable to focus on another stream or another stream section with less conflict potential.

⚠ In **consultation with the water authority**, it must be ensured to plan the proposed measure as part of **stream "maintenance".** Otherwise, the measure may be classified as "stream development", which would require complex planning approval procedures. Property rights or existing conflicts need to be clarified.

3.2 Agreement on restoration measures, site and timing

When all relevant stakeholders are willing to participate and cooperate, they should jointly discuss the objectives of the restoration measures, the specific type of measure and appropriate timing. The process can be guided following the key questions listed in Figure 4.

The groups' decisions should be based on the pre-monitoring results and the deficiencies identified (e.g., regarding the watercourse, flow and depth variability, or riparian vegetation). This process should take into account the diverse interests of all involved parties, including water management and flood control, ecologists and conservationists, land and forest users, fishers and anglers, and recreational users. Open, continuous and transparent communication about the project and a willingness to compromise increase the chances of successful implementation. It is therefore important to ensure a constant and trustful flow of information between the stakeholders.

For efficient cooperation with authorities (e.g., lower nature conservation or water authorities), it has proven effective to establish a designated contact person within the responsible authority.

3.3 Approval of involved parties and stakeholders

If all involved stakeholders reach an agreement based on the pre-monitoring and approve a specific measure that can be implemented by volunteer groups (stakeholder approval), there are no further obstacles to implementation.

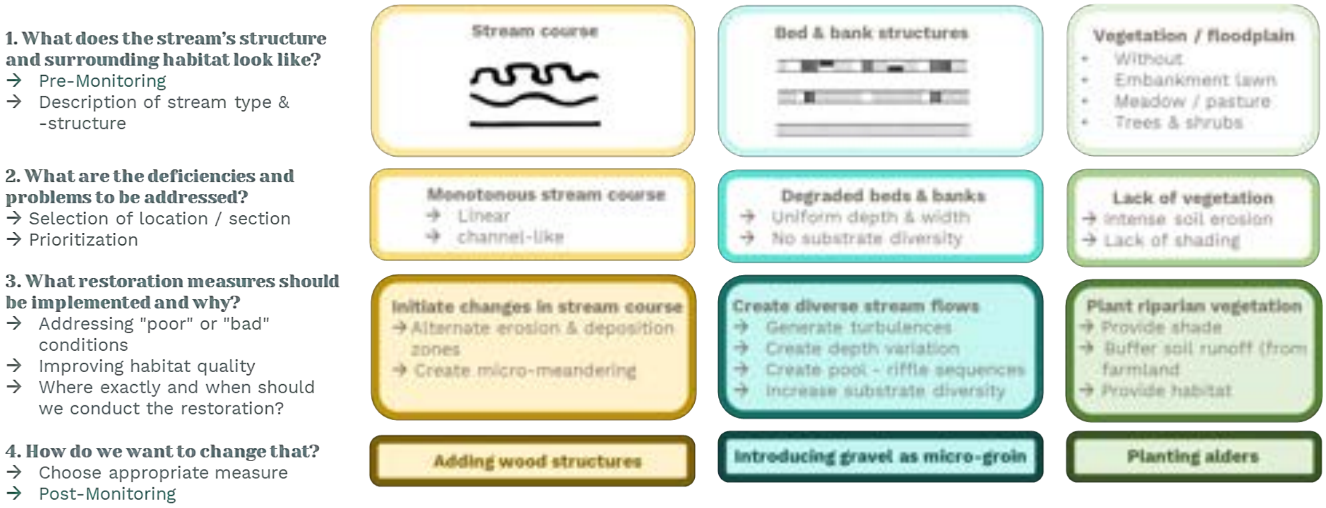


Figure 4: Key questions guiding the process to agree on type, location and timing of measures for the ecological enhancement of a stream section.

4 Implementation of measures

Good preparation is key for a successful organisation of the **implementation** of the selected stream restoration measure. This requires a collaborative approach based on cooperation, shared responsibility, and collective effort. The work is divided among the participants according to their skills, interests, or the needs of the restoration measure. The motivation to participate can be increased by organising it as a social event (Figure 5), e.g., with food and drink and **social activities**, like music, or a field trip.

Before the event, it is important to ensure that all necessary **equipment and materials** are available. Additionally, **responsibilities** within the volunteer group need to be clarified (Box 3).

Box 3. Responsibilities to be clarified within the volunteer group

- → Who will coordinate the group?
- → Who will coordinate the technical aspects?
- → Who cares for administrative or financial aspects?
- → Do we activate and coordinate a sufficient number of volunteers?
- → Do any social activities take place?
- → Who will document the campaign, e.g., with photos, reports, maps and posts for the organization´s website and social media?

On the restoration action day, it is important that the event is well structured and organized. Therefore, begin the event with a brief **introduction** (Figure 5) explaining why and how the measure will be carried out. Before starting, explain each necessary step clearly to all participants.

Everyone should follow these **instructions** to avoid unnecessary chaos or avoidable mistakes. A **rain shelter or shaded area**, such as a pavilion or tent with tables and benches, provides supportive infrastructure and is very helpful for fieldwork. As long as everyone is involved and the mood is right, fun is assured. To conclude the event, organize a **short debriefing** to review the day’s work, **thank all volunteers** for their participation, and wrap up the event.

⚠ The motivation to participate can be increased if the event is perceived as a **social occasion.** For example, providing drinks and food (a potluck is also a good idea), or combining the event with music or a small excursion, usually boosts participation (Figure 6).

Figure 5: Brief introduction (top) and potluck (bottom), photos from the FLOW event at Gembdenbach, April 2023: © Hannes Hoffmann

Figure 6 FLOW monitoring as social event with piano (top); drinks & food & shelter (shade, rain) (bottom); photos from the FLOW event at Gembdenbach, April 2023: © Hannes Hoffmann

In the next sections, we describe three very practical hands-on restoration measures. These are intended to **enhance the habitat structure** of the selected stream section.

They are designed to be implemented by a small group of volunteers within a few hours.

The restoration measures are modular in design and can therefore be adapted to local conditions, repeated, or scaled up as needed.

Depending on the identified deficiencies, different restoration measures are suitable (see Figure 4):

1 **Installing wood structures** to initiate meandering of the stream course,

2 **Installing gravel micro-groins** for the formation of bed and bank structures,

3 **Planting alders** to enrich the surrounding vegetation and buffer against external stressors.

The first two measures take place ‘in-stream’, while the third is carried out on the riparian stream bank. The following is a brief description of the purpose and effect of the restoration measures, its implementation, and effort involved.

4.1 Installing wood structures[7]

Which deficiencies can be addressed?

The **course** of the stream is monotonous, straight or even channel-like. The stream or respective stream section has an **overly wide, structureless** profile. The streambed is largely filled with **silt or sand** (Figure 7). If the streambed originally had a coarse material-rich structure with a gravel interstice system, as would be expected for mid-mountain or pre-alpine streams, this gravel is no longer visible.

What is the effect of the measure?

This 'in-stream method' is a cost-effective way to improve the stream structure. Depending on the implementation, adding wood structures can either promote a **dynamic development** of the streambed and the course of the stream or specifically stabilize bed and bank structures.

The installation of 'sticks and twigs' creates a **diverse flow** field with different flow velocities and water depths. This increases the **substrate diversity** in the streambed. These rake-like wood structures **trap debris** (leaves, twigs and branches, and sediment) carried by the current that gets caught and forms an obstruction to the flow. These wood structures also act as **flow deflectors**.

At the same time, they provide **habitat, food and shelter** for fish larvae and benthic invertebrates. This creates areas where material is eroded (**erosion**) and others where material is deposited (**sedimentation**), as well as a deep channel that ensures a continuous water flow.

Woody debris collectors consist of **sticks** driven into the stream bed **in a row, perpendicular to the direction of flow**. The sticks should ideally be driven into the stream bed for two-thirds of their length. They are **suitable for degraded streams with loose beds** (mud, sand, gravel), especially in lowland streams with gentle slopes and low water flows.

What materials and tools are needed?

- Dried sticks or branches of native shrubs (e.g. hazelnut, ash or alder) with a diameter of approx.. 3 to 7 cm, 50 - 150 cm long (Figure 6, right)
- Tools for shortening and, if necessary, sharpening the rods: pruning shears, hand saw
- Tools for installation: sledgehammer (5 kg)
- Personal protective equipment: gloves and rubber boots / waders

[7] based on measure A.10 in DWA guideline M527 (German Association of water, waste water and waste management)

Figure 7: sedimented stream section (top), installation of hazel rods as wood structures (bottom) © Benjamin Gottfried

How are wood structures installed?

1. **Prepare sticks:** use 10 to 30 sticks for each wood structure, shorten sticks if needed
2. **Place sticks:** place 3-5 cm apart near the bank, 10-15 cm apart towards the stream center
3. **Check streambed:** use a stick to measure sediment depth and identify gravel or stones below.
4. **Install sticks:** preposition & hammer sticks into ground up to average water level (Figure 8).
5. **Align sticks** at a right angle to the bank, sloping toward the center at water level (Figure 8 & 9).
6. **Maintain** spacing in the stream center to ensure continuous flow.
7. **Monitor**: observe sticks over the following months.
8. **Adjust:** adjust, remove, or replace as needed.

⚠ When positioning the wood structure, ensure they cover about one-third (to one-half maximum) of the stream width (Figure 9). For multiple wood structures in sequence, it is recommended to arrange them alternately. The spacing between two elements on the same side should be approximately 8 (to 12) times the stream width (Figure 10).

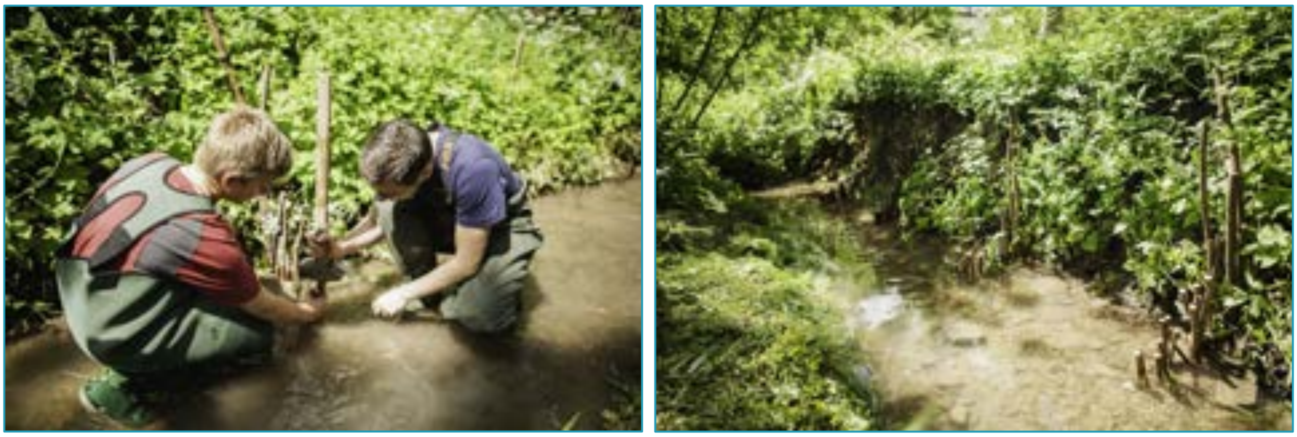


Figure 8: Installation of the sticks with the hammer (left) at low water level, arrangement of the sticks (sloping towards the middle of the stream); photos: © Peter Runkewitz

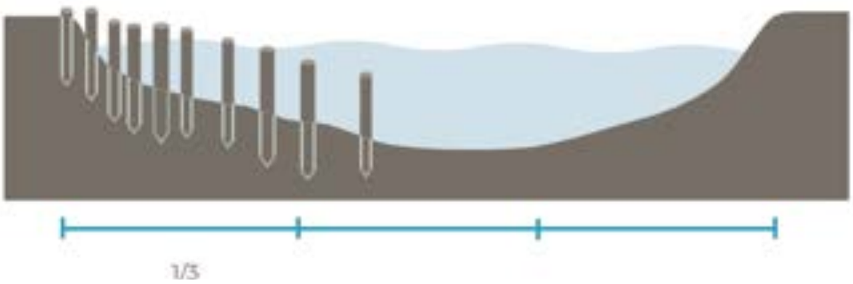


Figure 9: Added wood structure at mean water level in the stream cross-section. © Luise Schumann

Figure 10: Added wood structures in top view, spacing between two elements on the same stream bank equals eight times the width; top: initial state, below: stimulated development.

When should the measure be implemented?

Jan	Feb	Mar	Apr	May	Jun
Jul	Aug	Sep	Oct	Nov	Dec

Late summer / early autumn (before brown trout spawning season); reproduction of sensitive invertebrates (indicator species) is complete and juvenile fish are developed enough to be unaffected; ideally, install during low water.

Workload

Time required for a 100 m stream section is about 10 - 30 person-hours, depending on the number of elements (in teams of three to four, plan about 30 minutes per element)

4.2 Installing gravel micro-groins[8]

Which deficiencies can be addressed?

The selected stream section is characterized by coarse material (gravel or larger stones) with local areas of gravel and a monotonous, straight or channel-like watercourse. The streambed lacks gravel or it has an overly wide profile, the gravel bed is covered with sand or silt. If the current stream profile is deeply incised - meaning that the stream has 'dug itself into' the substrate, for example as a result of straightening - there is sufficient room for the introduction of gravel (Figure 11). The stream profile is often deeper than officially authorized[9]. This might be confirmed by the responsible water authority.

What is the effect of the measure?

Installing micro-groins aims to structure the streambed and banks and provides near-natural bank protection. Gravel deposits can create turbulence and accelerate the flow. This benefits flow-preferring (rheophilic) organisms. The measure can increase the number of species and population density of benthic invertebrates living in the gravel bed system and serves as an opportunity for fish species to lay their eggs in the gravel. A better connection between water and land is created, with a more diverse cross- and longitudinal profile. Additionally, ecological niches are created for organisms of different feeding types (shredders, substrate and filter feeders, grazers and predators). The lack in sediment (bed load[10]) can be reduced at least locally and temporarily, by gravel fills and deposits (Figure 12).

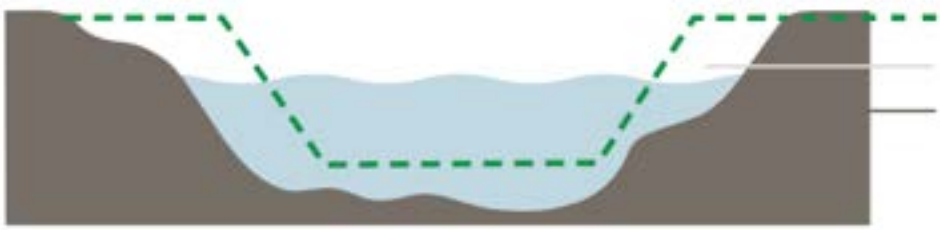


Figure 11: Initial situation

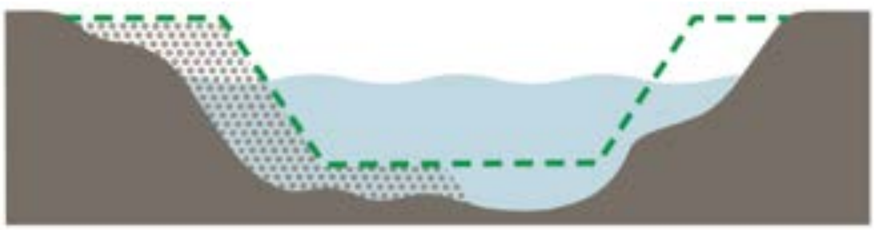


Figure 12: Gravel micro-groin in cross profile

Newly placed gravel should not be not washed away during the next high-water flow, e.g., due to heavy rainfall or smaller flood events. To prevent this, the gravel should have a broad mix of grain sizes (Figure 13, left). The gravel deposits should not be considered static structures, but rather dynamic ones that should be checked at least annually and replenished if necessary.

What materials and tools are needed?

- → Gravel of local origin, grain size (ø) (8) 16 - 32 mm; in low mountain ranges / if needed: 64 mm
- → Possibly cobbles ranging from 64 mm to 100 mm in diameter for increased hydraulic load
- → Excavator / front loader or wheelbarrow and shovels
- → Personal protective equipment: gloves and rubber boots / waders

[8] Based on measure A.3 of DWA guideline M527

[9] Officially approved stream profile: The term is explained in more detail in the Glossary.

[10] Bed load: The term is explained in more detail in the Glossary.

How are wood structures installed?

1 **Place gravel:** use a dumper, excavator, wheelbarrow, or hand shovel (Figure 13)

2 **Extend gravel:** distribute gravel up to half the stream width (or more if needed)

3 **Build micro-groin**: shape with a gentle slope from bed to bank to prevent erosion, maintain a stable angle of repose to keep gravel in place.

4 **Ensure overtopping:** construct a permanently overtopped groin at mean water level[11] (Figure 14) or below mean water level if necessary.

5 **Stabilize micro-groin:** Orient micro-groin against flow to enhance stability & effectiveness (Figure 15)

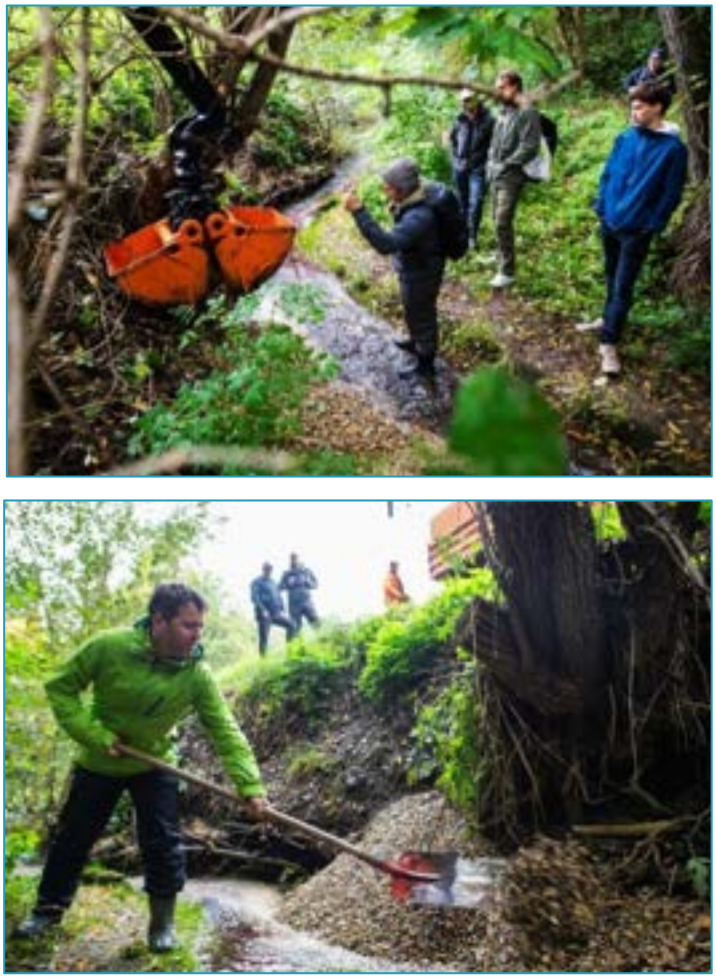


Figure 13: Gravel placement with excavator (top), and with hand shovel (bottom); images from gravel deposits: © Peter Runkewitz

[11] Mean water level: The term is explained in more detail in the Glossary.

Figure 14: Gravel micro-groin and bank protection made of coarse gravel and cobbles, with finer gravel piled upstream as a spawning substrate (left); gravel micro-groin with bank protection on both sides (right); Photos: L. Tent

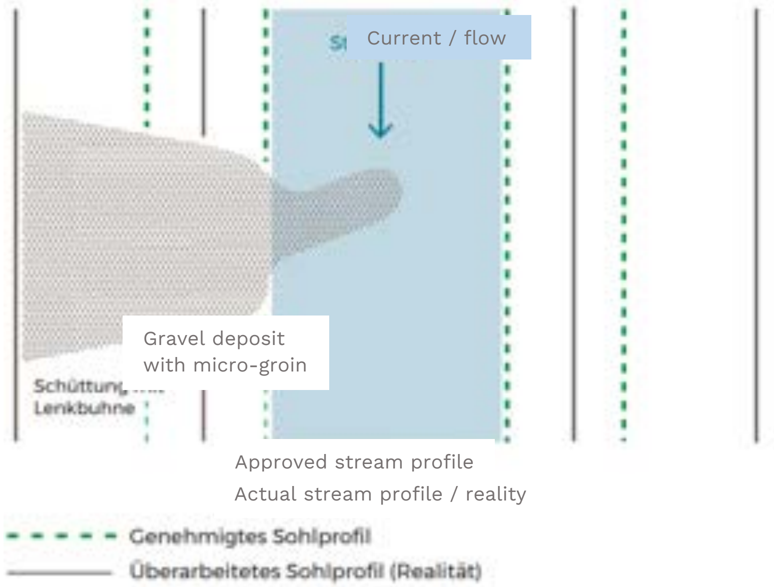


Figure 15: Gravel micro-groin in top view as a measure to restructure the overly wide, overly deep profile[12]

When should the measure be implemented?

Jan	Feb	Mar	Apr	May	Jun
Jul	Aug	Sep	Oct	Nov	Dec

Late summer to early autumn (before the brown trout spawning season) is the ideal installation period. Then sensitive invertebrate reproduction (indicator species) is complete and juvenile fish are sufficiently developed to avoid disturbance. Ideally, carry out the installation during low water conditions.

Workload

The time required depends on the number of deposits and the available equipment used to distribute the gravel, and is approximately 5 – 20 person-hours (in teams of three to four: plan 1.5 – 6 hours).

[12] The concept is based on Tent & Tent (2016).

4.3 Planting alder trees on stream banks

Which deficiencies can be addressed?

The river bank lacks a protective strip of trees and shrubs that would shade the stream section, buffer against pollutant and nutrient input from surrounding areas, and protect the bank from erosion. Often, there is also a very sun-exposed section of the stream that heats up during summer months. The stream may also be cutting deeper into the landscape due to a lack of vegetation. This measure can help increase shading, provide habitat for wildlife and enhance the surrounding landscape, and protect against detrimental run-off of pollutants, nutrients and fine sediments into the stream.

What is the effect of the measure?

A naturally structured, wide riparian zone with trees and shrubs at various growth stages provides habitats and food for fish and benthic invertebrates through deadwood and leaf litter. Shaded banks or riparian forests offer protection and act as migration corridors for many species. Even moderate shading can prevent aquatic and herbaceous overgrowth (algae, herbs and grasses) and reduce maintenance costs. Alder roots extend below the water level (Figure 16). They grow densely and can penetrate the streambed. Alders tolerate waterlogging and grow in saturated soils. Their lower branches break off more easily and offer less surface area to floodwaters than willows. They are also capable of sprouting from stumps. Their roots provide shelter for fish, and their leaves decompose quickly, serving as an important food source for benthic invertebrates.

Figure 16: Alder roots grow down to the streambed (left), staked young tree with planting hole (centre), alder sapling on waterlogged meadow (right). Sketches: © Luise Schumann, photo: © Roland Bischof

What materials and tools are needed?

- → Local plant material: seedlings or young plants of black alder, max. 100-150 cm high
- → Spade and shovel
- → Stake and hammer
- → Watering can for initial watering
- → Personal protective equipment: gloves and rubber boots / work shoes

How are wood structures installed?

1 **Choose local stock:** Prefer regionally sourced alder seedlings for resilience. Example prices: Annual seedlings (≤ 50 cm): < 1 €, transplanted saplings (2–3 years, ≤ 150 cm): 1–5 €

2 **Transplanting wild alders:** Plant 20 cm above mean water level in permanently wet areas for best growth (Figure 15, centre).

3 **Planting steps:**
- Dig a hole twice as wide as the root ball
- Plant at the same depth as before, adding soil to allow for settling.
- Press soil gently, ensuring root contact and forming a shallow basin.
- Water well. Space 1 m apart in rows for natural self-regulation.

4 **Staking larger trees:**

- stake diagonally upstream, tie loosely with coconut rope/rubber loop.
- check binding after a few months; remove after 1–2 years.
- if mowing occurs, stakes serve as planting markers.

When should the measure be implemented?

Jan	Feb	Mar	Apr	May	Jun
Jul	Aug	Sep	Oct	Nov	Dec

On frost-free days during vegetative dormancy, in the case of severe spring drought prefer late autumn.

Workload

Time required for a 100 m section depending on the number of trees is approx. 5 - 20 hours (in teams of three to four: plan 1.5 – 6 hours).

⚠ If **wildlife browsing** is likely, use plastic guards or wire mesh (Figure 16, right).

Protection against beaver damage: A wide vegetation strip provides enough food, and most riparian trees regenerate. Beavers prefer willows over alders. In high-risk areas, protect young or valuable trees with 1 m high wire mesh.

5 Evaluating the ecological effectiveness of restoration measures

A key part of implementing stream restoration measures by volunteer groups is documentation and follow-up. It is vital to record what restoration measures have been conducted where and how. This is easily forgotten - map and document well and also pass this information on to relevant agencies.

A before-and-after comparison of monitoring results on stream structure and benthic invertebrate communities allows an evaluation of the measure's success. To ensure this, FLOW monitoring should be conducted at the project site before implementation and at least once after implementation (Table 3).

The optimal timing for post-implementation monitoring depends on the type of measure. For planting projects, at least five years may be needed to detect measurable effects, whereas changes from adding gravel or wood structures can often be documented within one to two years. Ideally, multiple FLOW assessments after implementation will track and document long-term changes over time.

Table 1: Overview of the Types and Timing of FLOW Monitoring Surveys for Evaluating the Success of Restoration Measures in Small Streams by Citizen Scientists (based on LAWA Handbook on Monitoring Success, 2020); X = mandatory, (x) = optional

Timing \ type of measure	Wood structures	Gravel micro-groins	Planting alders
Before implementation	X	X	X
1 Year after implementation	(x)	(x)	(x)
2 Years after implementation	X	X	(x)
5 Years after implementation	(x)	(x)	X

A suitable bioindicator to measure and evaluate an improvement in the quality of habitats for benthic invertebrates is the EPT ratio (abbreviated as EPT%, see Box). An ecological assessment of the observed EPT proportion in the total number of individuals depends on the specific ecoregion of the stream, i.e., the geographical characteristics (Figure 17)[13].

For lowland streams, a well-functioning benthic invertebrate community (ecological status: at least 'good') can be assumed with an EPT proportion of about one-third to less than half (35 - 45%)[14]. In contrast, for alpine streams, this assessment requires an EPT proportion of more than half (55%).

[13] These values provide only a rough guideline and should be interpreted with caution.

[14] Pottgießer (2008)

Bioindicator EPT% for habitat quality

For EPT%, the proportion of individuals of mayfly (E = Ephemeroptera), stonefly (P = Plecoptera) and caddisfly (T = Trichoptera) larvae in the total number of the benthic invertebrate individuals is recorded. These insect orders consist of numerous demanding and pollutant-sensitive representatives. They have high water quality requirements, and their diverse representatives inhabit a wide range of habitat structures. The individual representatives of these benthic invertebrate orders and their number of individuals (abundance) are documented in the FLOW taxa list at family level (or, if possible, more precisely at genus or species level).
Their proportion in the total number of invertebrate individuals in the sample is suitable for evaluating the success of restoration measures in terms of water quality and habitat structure.

$$EPT\ Ratio\ (\%) = \left(\frac{Number\ of\ EPT\ individuals}{Total\ number\ of\ benthic\ invertebrates}\right) * 100$$

This formula expresses the percentage of Ephemeroptera (E), Plecoptera (P), and Trichoptera (T) individuals relative to the total number of benthic invertebrates in a sample. A higher EPT ratio generally indicates better water quality, while a lower ratio suggests environmental stress or pollution.

However, the exact EPT value is less important for assessing the effect of a restoration measure than the overall trend. If the before-after comparison over a relevant period (two to five years) shows an improvement in habitat quality and in the proportion of % EPT, the development can be considered successful. If no measurable success is observed, the volunteer group and involved stakeholders can meet again to discuss possible adjustments with regional experts, such as authorities or environmental organizations. Based on this, a new attempt can be made, for example, by modifying the type or implementation of the measure.

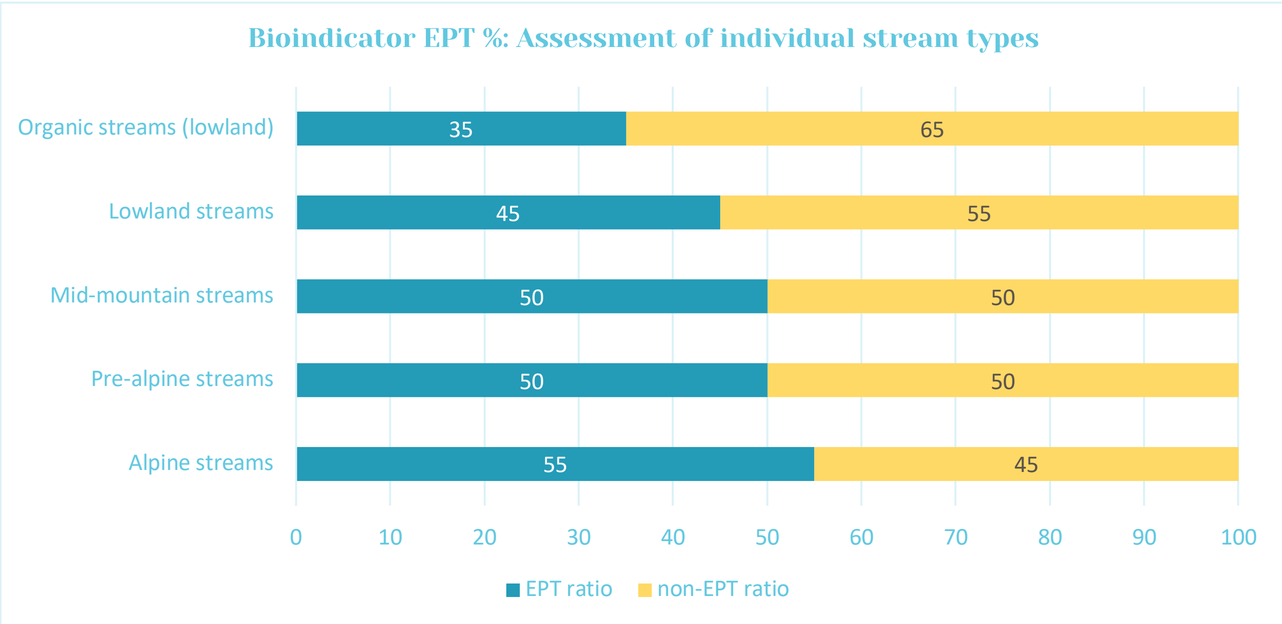


Figure 17: Minimum proportion of individuals of EPT taxa (blue bar) and maximum proportion of individuals of non-EPT taxa (yellow bar) required to achieve a good ecological status (class 'high' or 'good') in the surveyed stream section, sorted by ecoregions. Classification based on Pottgießer (2008).

6 Conclusion and outlook

Many streams have been straightened, reinforced, and deprived of their natural dynamics. To restore natural processes such as erosion, sedimentation and the formation of diverse structures, structural restoration measures can help reactivate these natural processes. This action guide describes the process of how to plan restoration and provides step-by-step guidance for three straight-forward and effective restoration measures, that, relatively easily implemented by volunteer groups. This will allow the streams to develop a dynamic of natural change, contributing to the creation of new habitats with diverse, self-sustaining structures and increased biodiversity.

Finally, once you have completed the restoration, celebrate your success with everyone involved. Share your stories and experience in the local media, and pass on your expertise to other volunteer groups. Work with the local fishing clubs and other organisations to maintain the momentum for restoration also of other stream sections. We wish all river enthusiasts and local restoration groups much success and fun!

Healthy streams for healthy landscapes and healthy people!

7 Glossary

Bedload: Mineral solids such as gravel, sand, stones or debris that are transported by the flow of a stream. It plays a crucial role in the dynamics and structural development of streams and rivers.

European Water Framework Directive (EC WFD): European regulatory framework that came into force at the end of 2000. It mandates a systematic, holistic, and catchment-based management approach to achieving at least a "good" ecological status for water bodies ("improvement obligation"). This status is assessed based on three key quality criteria: physical structure and external appearance of a waterbody (hydromorphology), chemical-physical water quality and biotic communities (biology). The status of the biotic community is the decisive factor for classifying a river section's ecological status, following the "one-out-all-out" principle. For entire river catchments, management plans and programs of measures have been established within a defined implementation period. More info: http://data.europa.eu/eli/dir/2000/60/oj.

Mean water level: Hydrological term describing the average water level or discharge of a stream over a longer period of time. The mean water level (MW): is the average water level of a stream, a statistical measure used to assess water level fluctuations, calculated from long-term measurements over several years. Mean discharge (MQ) refers to the average volume of water that flows through a specific stream cross-section per unit of time (e.g., per second), often given in cubic meters per second (m^3/s) and is based on long-term measurements.

Responsible Parties for Stream Maintenance: Legal or natural person responsible for the maintenance of a stream. Ensuring proper water flow, preserving ecological functions of a stream, and maintaining and developing its structure. Responsibilities are defined by National Water Acts and respective state water laws and vary depending on stream type and regional regulations. For state-owned water bodies and smaller rivers or streams, responsibility typically lies with federal states, municipalities, water and soil associations, or private owners.

Revitalization: Reviving and restoring rivers and streams that have often been affected by human interventions (e.g., straightening or damming), to a more natural state. This improves water quality, biodiversity, and habitat conditions. Key measures include restoring natural flow, adding natural elements like gravel, deadwood, and plants to create diverse habitats and improve riverbanks by planting vegetation and reconnecting floodplains. This involves improving streams through various actions (e.g., widening riverbanks, creating meanders, adding habitats) to enhance biodiversity and hydrological processes. The goal is not necessarily to return the stream to its original state but to significantly improve its ecological quality.

Renaturation: Restoring rivers and streams that were historically shaped by natural processes but have been altered by human interventions, to a more natural state by reversing human impacts. Renaturation seeks a more complete restoration of natural river courses and streambank structures. This includes both the revitalization as well as removing dams, barriers or artificial reinforcements, straightening and negative effects of hydropower.

Self-dynamic development: Reactivating or allowing natural, intrinsically occurring flow processes driven by the energy of flowing water. Changes and dynamic processes are often hindered by regular mowing of embankments, removal of deadwood, renewal of bank reinforcements, or prevention of bank erosion. Allowing self-dynamic development is cost-effective and can often be applied on a large scale, gradually leading to more natural conditions.

Spring-fed streams: Streams and rivers primarily fed by underground springs. The springs can be natural groundwater outlets, typically maintaining a consistent water temperature year-round. They provide habitats for specialized plants and animals that depend on cold, oxygen-rich water. These ecosystems are highly sensitive to changes such as drought or pollution (see BML 2012).

Stream maintenance: Minor maintenance and development measures affecting the riverbed, banks, or surrounding areas. Stream maintenance measures do not require official approval (as long as no chemical substances are used). They are considered straightforward, flexible, and adaptable without the need for complex procedures.

Stream modification or expansion: Implementing certain stream restoration measures requires a planning approval or permit procedure (in Germany, according to § 31 of the German Federal Water Act - WHG). These modifications (e.g., removal, creation, or significant alteration of streams or banks) impact the water profile and can significantly affect the water balance (e.g., water level, discharge), navigation, fisheries, or interfere with third-party rights (e.g., land ownership). The distinction between stream modification and maintenance is often unclear and requires case-by-case assessment.

Volunteer group: Active group of citizen scientists who come together on a voluntary basis to monitor and enhance the ecological quality of small streams. In this action guide, they are the initiators of restoration measures.

8 References

8.1 Cited literature

BMUV/UBA. (2022). Die Wasserrahmenrichtlinie – Gewässer in Deutschland 2021: Fortschritte und Herausforderungen. Umweltbundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/221010_uba_fb_wasserrichtlinie_bf.pdf

LAWA (Bund-/Länder-Arbeitsgemeinschaft Wasser) (Ed.). (2020). Handbuch „Erfolgskontrolle hydromorphologischer Maßnahmen in und an Fließgewässern“. LAWA.

Liess, M., Liebmann, L., Vormeier, P., Weisner, O., & Reemtsma, T. (2021). Pesticides are the dominant stressors for vulnerable insects in lowland streams. Water Research, 201, 117262. https://doi.org/10.1016/j.watres.2021.117262

Pottgießer, T. (2008). Anhang der Steckbriefe der deutschen Fließgewässertypen – Bewertungsverfahren und Klassengrenzen. Retrieved from https://wasserblick.net/servlet/is/18727/99_Anhang_gesamt_April2008.pdf?command=downloadContent&filename=99_Anhang_gesamt_April2008.pdf

Tent, B., & Tent, L. (2016). Instream restaurieren – Jüngere Beispiele aus Hamburg-nahen Fließgewässern. In Gewässerentwicklung & Hochwasserrisikomanagement. Wasserbauliche Mitteilungen der TU Dresden, 57, 319–330. ISBN 978-3-86780-475-2.

von Gönner, J., Masson, T., Köhler, S., Fritsche, I., & Bonn, A. (2024a). Citizen science promotes knowledge, skills and collective action to monitor and protect freshwater streams. People and Nature, 6, 2357–2373. https://doi.org/10.1002/pan3.10714

von Gönner, J., Gröning, J., Grescho, V., Neuer, L., Gottfried, B., Hänsch, V. G., & Bonn, A. (2024b). Citizen science shows that small agricultural streams in Germany are in a poor ecological status. Science of The Total Environment, 171, 183. https://www.sciencedirect.com/science/article/pii/S0048969724013226

Wolfram, J., Stehle, S., Bub, S., Petschick, L. L., & Schulz, R. (2021). Water quality and ecological risks in European surface waters – Monitoring improves while water quality decreases. Environment International, 152, 106479. https://doi.org/10.1016/j.envint.2021.106479

Zeh, H. (2010). Ingenieurbiologische Bauweisen im naturnahen Wasserbau: Praxishilfe. Umwelt-Wissen Nr. 1004. Bundesamt für Umwelt.

Zerbe, S., & Wiegleb, G. (2009). Renaturierung von Ökosystemen in Mitteleuropa. Spektrum Akademischer Verlag.

8.2 References for further reading

Baur, W. H. (2020). Renaturierung kleiner Fließgewässer mit ökologischen Methoden im Berg- und Hügelland. Anleitung zum konkreten Handeln (3. Auflage). Landesfischereiverband Baden-Württemberg.

Deutscher Verband für Landschaftspflege (DVL) e.V. (2010). Kleine Fließgewässer kooperativ entwickeln. Erfolgsmodelle für die Umsetzung der Wasserrahmenrichtlinie. DVL-Schriftenreihe „Landschaft als Lebensraum“, Heft 17.

Kail, J., Palt, M., Hund, K., Olberg, S., Hering, D., & Jünger, W. (2022). Ökologische Funktionen von Gewässerrandstreifen für die Wasserrahmenrichtlinie. Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG).

Madsen, B. L., & Tent, L. (2000). Lebendige Bäche und Flüsse: Praxistipps zur Gewässerunterhaltung und Revitalisierung von Tieflandgewässern. Edmund Siemers Stiftung.

Schüller, R., & Krop-Benesch, A. (2022). Beschattung an Fließgewässern – Funktionen, Auswirkungen und Bedeutung von Ufergehölzen an naturnahen Bächen und Flüssen. Gemeinnützige Fortbildungsgesellschaft für Wasserwirtschaft und Landschaftsentwicklung (GFG) mbH der Deutschen Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA).

Schweizerischer Fischerei-Verband. (2020). Fischer schaffen Lebensraum (2. Auflage). Schweizerischer Fischerei-Verband.

Tent, L. (2022). Lebendigere Bäche und kleine Flüsse – Restaurieren in Zeiten des Klimawandels. In Technische Universität Dresden, Institut für Wasserbau und technische Hydromechanik (Hg.), Nachhaltigkeit im Wasserbau - Umwelt, Transport, Energie (Dresdner Wasserbauliche Mitteilungen 68, S. 209-220). Technische Universität Dresden, Institut für Wasserbau und technische Hydromechanik.

Umweltbundesamt. (2010). Kleine Fließgewässer pflegen und entwickeln – Neue Wege bei der Gewässerunterhaltung. https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3747.pdf

Umweltbundesamt. (2014). Hydromorphologische Steckbriefe der deutschen Fließgewässertypen - Anhang 1 von „Strategien zur Optimierung von Fließgewässer-Renaturierungsmaßnahmen und ihrer Erfolgskontrolle“. https://www.umweltbundesamt.de/publikationen/strategien-zur-optimierung-von-fliessgewaesser

Umweltbundesamt. (2020). Unsere Bäche und Flüsse: Renaturieren, entwickeln, naturnah unterhalten. Redaktion: G. Lamberty, M. Kemper, & S. Naumann. Umweltbundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/421/publikationen/unserefluesse_online_04e.pdf

WBW Fortbildungsgesellschaft für Gewässerentwicklung mbH, & LUBW Landesanstalt für Umwelt Baden-Württemberg. (2021). Ingenieurbiologische Bauweisen an Fließgewässern, Teil 1: Leitfaden für die Praxis (Überarbeitete Ausgabe). Karlsruhe.

WBW Fortbildungsgesellschaft für Gewässerentwicklung mbH, & LUBW Landesanstalt für Umwelt Baden-Württemberg. (2021). Ingenieurbiologische Bauweisen an Fließgewässern, Teil 2: Steckbriefe aus der Praxis (Überarbeitete Ausgabe). Karlsruhe.

WBW Fortbildungsgesellschaft für Gewässerentwicklung mbH, & LUBW Landesanstalt für Umwelt Baden-Württemberg. (2021). Ingenieurbiologische Bauweisen an Fließgewässern, Teil 3: Arbeitsblätter für die Baustelle (Überarbeitete Ausgabe). Karlsruhe.

WBW Fortbildungsgesellschaft für Gewässerentwicklung mbH, & LUBW Landesanstalt für Umwelt Baden-Württemberg. (2021). Bausteckbrief 1: Vitale Gewässer in Baden-Württemberg – Kiesstrukturen einbringen.

8.3 Weblinks

LUBW-Information sheets for stream restoration measures and guidance: https://pudi.lubw.de/detailseite/-/publication/10270

Website Ludwig Tent for stream protection and restoration: http://www.salmonidenfreund.de/

Field protocol Hydromorphology (stream structure) (comp. LAWA, 2019. Supporting material: picture collection Hydromorph.)

0. General Stream Information

Name of the stream: ______________________ **GPS-Coordinates:**______________________

Short description of the sampling site (next place / village, path / trail / street, Landscape element):______________________

Date & Time:______________________ **Type of stream** (according to map):______________________

Weather during the past 24 hours (estimated air temperature, precipitation/dry?):______________________

Present weather (precipitation/dry? Sunny / cloudy?):______________________

Stream use *(Several boxes can be checked!)*

- Hydropower ☐
- Fish farming ☐
- Water extraction (e.g. farming or power plant) ☐
- Flood protection ☐
- Settlement/developement ☐
- Leisure & recreation (e.g. canoeing, fishing) ☐
- Agricultural use ☐
- Superstructure (e.g. bridge) ☐
- Other kinds of use:______________________

Air temperature

(°C):______________________

Size class *(Please check only one box!)*

Width of stream		Length of the sampled stream section
< 1 m	☐	100m
1-5 m	☐	100m
>5-10 m	☐	200m
>10 -20m	☐	500m

Location of sampling site

(Please check only one box!)

- Settlement ☐
- Rural area ☐

Special case

(Several boxes can be checked!)

- Dried out ☐
- Piped ☐
- Other case: ______________________

Photo documentation

(4 pics, check if done. Left/Right stream bank depending on flowing direction!)

- Left bank upstream ☐
- Left bank downstream ☐
- Right bank upstream ☐
- Right bank downstream ☐

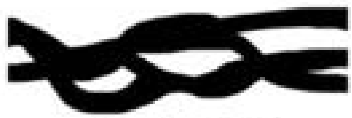
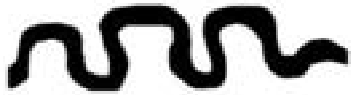
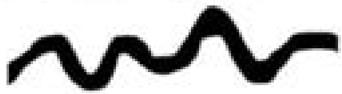
Page 1

Stream type (In situ assessment, *please check only one out of the 10 white boxes!*)

Please note: choose one out of the 10 white boxes, grey boxes show impossible combinations!		**Predominant bed substrate (material at bottom of stream)**				
		organic: aquatic plants, deadwood peat, detritus,	Enriched with fine material: silt	Enriched with fine material: loess loam	Enriched with fine material: sand	Enriched with coarse material: gravel, stones …
Valley type	V-shaped Valley					
	V-shaped Trough-V.					
	Meander valley					
	Trough-/Floodplain-V.					
	Stream without Valley					

1. CURRENT DEVELOPEMENT *(Please check only one box at a time!)*

1.1. Stream Curvation

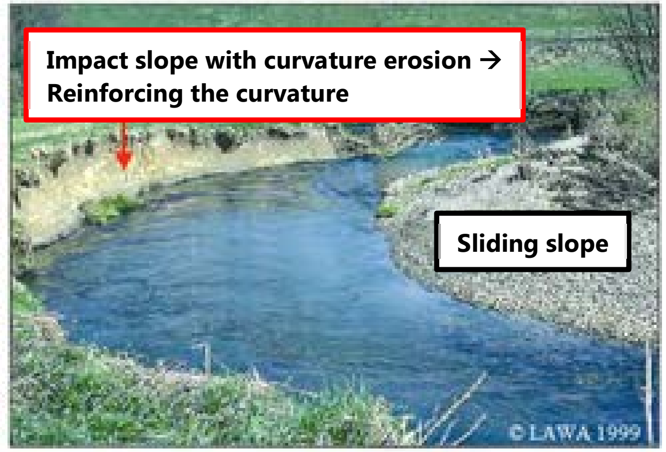
Curved	**Multi-bed channel** (the water flows permanently in several watercourses)		
	Strongly meandering (very intense & irregularly curved course throughout)		
	Meandering (continuously intensive & irregularly curved)		
	Curved (continuously regular and intensively curved)		
Uncurved	**Slightly curved** (continuous slight and elongated curvature)		
	Stretched (straight or slightly curved watercourse without major bends)		
	Straight (canal-like, completely straightened, dead straight)		

1.3. Longitudinal banks **(e.g. shore banks, island banks of gravel, sand ...)**

Many (> 3)	
Three	
Two	
One	
Rudimentary (of small size)	
None	

1.2. Curvature erosion (Bank erosion on the impact slope)

	Curved	Uncurved
By nature none		
By human intervention none		
In many places, strong		
Scattered, strong		
In many places, weak		
Scattered, weak		



1.4. Special river course structures

Many (> 3)	
Three	
Two	
One	
Rudimentary *	
None	

Special stream course structures include (see pic collection)

- **Accumulations of driftwood** (wedged driftwood / timber)
- **Plunged trees** (trees fallen into the water)
- **Formation of islands** (flowed around, overgrown land area)
- **Expanded stream course** (local widening of stream bed)
- **Constricted stream course** (local narrowing of stream bed)
- **Bifurcation** – stream bifurcates into two branches
- **Oxbow / Cut-off** (Section cut-off from main stream)
- **Beaver dam**

Rudimentary special stream course structures: small size, remains, easily overlooked, continued existence uncertain

2. The Stream in Longitudinal Profile 1

2.1. Cross structures (artificial steps / dams in the river bed)

If there are transverse structures in the test section, please enter the exact number in the respective boxes. It is possible to fill in several boxes.

No transverse structure	
Bottom sill (low artificial sill in the stream bed	
Smooth glides / ramp (developed sloping section of the stream bed without sediments)	
Rough glide / ramp (developed, sloping section of the stream bed with stony, rough subsoil and sediments)	
Transverse structure with near-bottom outlet (vertical gate valve to regulate water flow, water runs off near stream bottom)	
Tide gate (to channel a body of water through the dike)	
Causeway / dike, e.g. from soil, stones	
Barrage / river dam (structure that encompasses and closes off the entire width of the valley)	
Pumping station (pumping water from a low to a higher level)	

Type of Construction \ Height	< 0,3 m	0,3 - 1 m	> 1 m
Fixed weir (without movable gate valve), **Fall** (artificial step in the riverbed), **Stairway** (several successive artificial steps in the stream bed			
Weir (with movable gate valve			

Additionally: Fish migration aid (fish ladder, fish pass)	
Aditionally: Bypass channel (part of the water continuously flows around the structure, this section is passable for fish)	

Fall, below rough ramp

Fall, below smooth glide / ramp

2.2. Backwater

If available, please enter the number of backwater sections in the respective box

	technical	natural
No backwater		
Backwater section comprises **less than 10 %** of the test section		
Backwater section comprises **10 to 50 %** of the test section		
Backwater section comprises **more than 50 %** of the test section		

Technical backwater caused by a transverse structure. Natural backwater is caused, for example, by wood accumulations or beaver dams.

Page 3

2.3. Piping / pipework

If available, please enter the number of pipings in the respective box

	without sediment	with sediment
No piping		
Piping comprises **10 to 20 %** of the test section		
Piping comprises **20 to 50 %** of the test section		

Piping of a stream with sediment.

2.4. Crossbenches (Elevation of the river bed, shallow water zones, e.g. fords, natural sediment banks)

Check one box!

Many (> 3)	
Three	
Two	
One	
Rudimentary	
None	
Not detectable	

Transverse bank created by a shallow water zone (ford)

2. THE STREAM IN LONGITUDINAL PROFILE 2

2.5. Flow diversity (*Please check one box!*)

Very large (alternation of slow and fast flowing areas)		
Large (clear change in flow velocity recognizable)		
Moderate (flow differences mostly small, multiple changes recognizable)		
Low (occasional, minor flow differences)		
None (uniform flow in the entire test section)		
In addition: Artificially increased flow diversity (e.g. through transverse structure, discharge, introduced & fixed deadwood)		

2.6. Depth diversity (*Please check one box!*)

Very large (strong change in water depth throughout)		
Large (Several clear changes in depth)		
Moderate (multiple but small depth changes recognizable)		
Low (occasional und small depth differences)		
None (water depth totally uniform)		
In addition: Depth diversity artificially increased (e.g. cross structures, stream bed changes)		
Not detectable (deep and murky waters, use measuring rod)		

Stream with **very high flow diversity** (top) and **stream without flow diversity** (bottom).

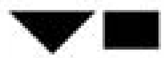
2.7. Water abstraction

Temporary or permanent withdrawal (abstraction) of water from the stream, e.g. by hydropower plants. Please check one box!

No abstraction	
Section affected by water abstraction comprises **less than 50%** of the sample section	
Section affected by water abstraction comprises **more than 50%** of the sample section	

3. THE STREAM IN CROSS-SECTION *(please check one box each, several answers are possible in section 3.5.)*

3.1. Profile type (Cross-Section of the stream bed)

Natural profile (very shallow to shallow, naturally vegetated embankment, no human intervention)		
Almost natural profile (flat, embankments mostly natural, few near-natural development measures)		
Varying erosion profile (deep river bed, banks characterized by erosion and slopes, little to no bank vegetation, irregular river bed due to erosion)		
Derelicted standard profile (former bank reinforcement broken up and overgrown, banks partially or completely overgrown with woody plants)		
Deep erosion profile (deep, almost rectangular cross profile, steep, vegetation-free banks, strong bank erosion)		
Trapezoidal profile (artificially developed water bed, paved banks, trapezoidal)		
V or box profile (artificially developed water bed, paved banks, V- or box-shaped)		

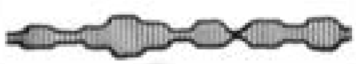
3.2. Profile depth (Ratio of water depth and width)

Very shallow (Depth-width ratio < 1:10, more than ten times as wide as deep)		
Shallow (Depth-width ratio 1:6 to 1:10)		
Moderately deep (Depth-width ratio 1:4 to 1:6)		
Deep (Depth-width ratio 1:3 to 1:4)		
Very deep (Depth-width ratio > 1:3, less than three times as wide as deep)		
Not detectable (deep and murky waters, use measuring rod)		

3.3. Profile depth (Bank breaks on both sides, leading to widening of the river bed. Check one box either under 'Profile deep' or under 'Profile less deep-shallow')

	Profile deep	**less deep-shallow**
Strong (Severe erosion on both sides, embankments very steep & unstable		
Weak (week erosion on both sides, embankments very steep & unstable		
No (eventually erosion limited to one side, the impact slope		

3.4. Variation of width (Change of different stream widths)

Very large (Very frequent, clear differences in width)		
Large (frequent, clear differences in width)		
Moderate (occasional, clear differences in width)		
Small (occasional, small differences in width)		
No (constant stream width)		

3.5. Bridges and superstructures *(If present, please insert the number of constructions into the respective box. Multiple answers possible.)*

Watercourse narrowed by bridge / superstructure		
Natural shore interrupted by bridge / superstructure		
No bride / superstructure within the test section		
Construction, which is **not damaging natural shore structure** (no narrowing of the watercourse, no interruption of the bank		

4. Structure of the Stream Bed

4.1. Substrates of the stream bed

Please record the substrates of the stream bed (compare photo collection substrate mapping). Natural (= typical) substrates: select a dominant substrate and check all other subordinate substrates that are less frequently present. In addition, record all unnatural (untypical) substrates (several crosses possible). Gray boxes indicate combinations that are impossible.

	Natural		Unnatural
	dominant	subordinate	
Mineral substrates			
Silt, mud			
Clay, loam, silt			
Sand			
Gravel (stones between 0,2 and 6 cm)			
Stone fragments between 6 & 20 cm			
Stone blocks (> 20 cm)			
Rock in place			
No mineral substrates present			
Not detectable (due to depth or turbidity)			
Organic substrates			
Deadwood			
Aquatic plants			
Peat			
No organic substrates present			
Not detectable (due to depth or turbidity)			

4.2. Substrate diversity (Diversity of the stream bed substrates, compare 4.1. Please check only one box!)

Very large (at least 4 different substrate types, each with large shares of area present)		
Large (3 different substrate types, each with large shares of area present)		
Moderate (3 different substrate types, two with small shares of area present)		
Low (2 different substrate types, one with small share of area)		
No (substrate in sampled section completely uniform)		
Substrate diversity not detectable (due to depth or turbidity)		

4.3. Stream bed shoring (artificial sealing)

Set a maximum of one cross for a shoring that covers more than 50 % of the sample section. Several crosses are possible for forms of shoring that cover 10-50% of the sample section.

	> 50%	10 -50%
Rockfill		
Solid concrete base with sediment		
Solid concrete base without sediment		
No stream bed lining		
Not detectable (deep, murky streams)		

Bed made of concrete / grid stones with sediment

4.4. Special stream bed structures

(Please check only one box!)

Many (> 3)	
Three	
Two	
One	
Rudimentary*	
None	
Not detectable	

Special stream bed structures include (see pic collection)

- **Blocks of rock, deep water pools** (pothole/kolk)
- **Rapids** (very fast flowing sections) or **cascades**
- **Shallow stream areas** (with turbulences)
- **Stagnant water pools** (Deepening in the water bed with low current)
- **Deadwood or Fine roots** (e.g. elder, growing on river bed)

* Rudimentary special stream course structures: small size, remains, easily overlooked, continued existence uncertain

5. Bank Structure

5.1. Bank vegetation

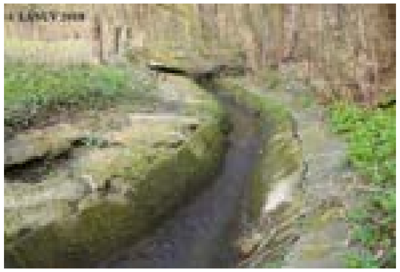
Select one dominant type of vegetation per bank that covers more than 50 % of the bank. Please select left / right bank based on the direction of flow

	left	right
Site-appropriate trees and shrubs		
Due to nature: none (e.g. due to steep wall, fluctuating water levels/flooding)		
Due to nature none (e.g. due to shoring)		
Forrest (closed deciduous forest of native, site-appropriate species such as alder, elm, willow, ash)		
Gallery (closed row of native trees growing on the bank such as		
Partly forrest and row of native trees		
Bushes, individual trees (Individual native trees and bushes on the banks)		
Young trees and shrubs (still small, recently planted trees and bushes)		
Non-native woody plants		
Forest or gallery, e.g. from conifers or hybrid poplars *Populus x canadensis*		
Bushes, individual trees (e.g. conifers or hybrid poplars)		
Young trees and shrubs (still small, recently planted trees and bushes)		
Herbaceous vegetation		
Due to nature: none (e.g. due to steep wall, fluctuating water levels/flooding)		
Due to nature none (e.g. due to shoring)		
Natural herbaceous vegetation e.g. reed beds, gravel or pioneer meadows, early flowering plants, grasses		
Herbaceous vegetation caused by human activities, tall herbaceous plants e.g. closed nettle meadows, other nitrophytes		
Neophytes (alien plants such as himalayan balsam, asian knotweed, Canadian goldenrod, giant hogweed)		
Meadow (grassland, pasture)		
Embankment lawn (lawn that is mowed regularly)		

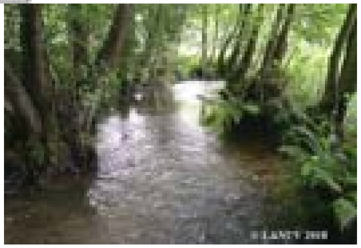
5.2. Bank shoring

If available, mark one dominant form each for the left and right bank (over 50% area). Several subordinate forms (with 10-50% area share) can be marked for left and right.

	left 10-50%	left >50%	right 10-50%	right >50%
No bank shoring				
Flow diverters (armature stones or logs placed on the bank that protrude into the water to change the direction of flow)				
Dilapidated bank stabilization (former bank stabilization, allows natural bank development)				
Living bank stabilization (bank stabilization with dense row or mat-like vegetation, e.g. willow/alder or mown cultivated lawn)				
Wooden shoring (planks, stakes, beams for bank stabilization)				
Stone fill / stone throw (banks covered with 30-50 cm large stones)				
Wild shoring (from waste wood, building rubble, scrap)				
Massive shoring (banks partially or completely covered by paving or stone setts, grid stones, concrete parts, sheet piling)				



Dilapidated bank shoring with wooden planks (above) and solid bank shoring with concrete slabs (below).



page 7

Fig. center left: Riparian vegetation: embankment turf, center right: riparian vegetation: site-appropriate gallery.

5.3. Special bank structures

Check one box each for left and right bank

	left	right
Many (> 3)		
Three		
Two		
One		
Rudimentary *		
None		

Special bank structures include (see pic collection)

- **Tree circulation** (water flows around a tree standing on a bank)
- **Root shelter** (undercut rootstock protruding above the water), **wood accumulation** in the bank area
- **Fallen tree** (tree that has fallen into the bank area)
- **Nesting wall** (stable, natural demolition bank made of clay, fine sand as a nesting site for kingfishers or sand martins)
- **Bank spur** (bank bay protruding into water made of artificially placed stones)
- <u>* Rudimentary special stream course structures:</u> small size, remains, easily overlooked, continued existence uncertain

6. Riparian environment

6.1. Land use

*Select **one** dominant category with >50% area share in the 100m vicinity for each bank side; for subordinate categories with 10-50% area share, several crosses are possible in each case.*

	left		right	
Area share of the types of land use	10-50%	>50%	10-50%	>50%
Site-appropriate forest (alder, ash, willow, hornbeam, English oak				
Near-natural floodplain biotopes (oxbow lakes, reedbeds)				
Fallow land (shrubs, hedges, perennials)				
Grassland (meadow, pasture, orchard)				
Non-site-typical forest (conifers, hybrid poplars)				
Fields, special crops (vegetables, fruit, tree nurseries, vineyards)				
Garden, park, green area				
Development with open, unsealed areas				
Development without open spaces (with complete soil sealing, settlement)				
Other surrounding cultures (compare 6.3.)				

Fig. top left: Riparian vegetation = site-appropriate forest,
Fig. top right: riparian vegetation = natural herbaceous vegetation.

6.2. Riparian strips

*Select **one** dominant category (>50% area share)for each bank side; for subordinate categories (10-50% area share), several crosses are possible.*

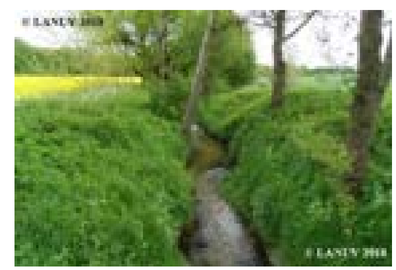
Share of bank area	10-50%	>50%	10-50%	>50%
Near-natural forest or bushes line the stream (> 20 m width)				
Riparian strips (near-natural shrubs or bushes bordering the stream, with a width of >5-20m)				
Edge strips (near-natural shrubs or bushes bordering the stream, with a width of 2-5m)				
Narrow edge strips (<2m) or missing edge strip, instead use as field, path, border, garden				

6.3. Pollution of the riparian area

(in 100m surroundings, several crosses possible for left and right bank)

Distance of the surrounding structures to stream	low (<10m)	moderate (10-40m)	large (>40m)	low (<10m)	moderate (10-40m)	large (>40m)
No harming surrounding structure						
Soil excavation (e.g. gravel pit)						
Fish pond with inlet/outlet to the stream						
Stream-incompatible plants & installations (Sewage treatment plant, stormwater overflow basin, sports field, farmstead, warehouse)						
Unpaved traffic routes (foot / field paths parallel to the stream)						
Paved traffic routes (road running parallel to the stream, railway tracks, sealed surface)						
Waste dumping (waste from home, garden, agriculture, industry)						
Flood protection structure (dam, dike, flood retention basin)						

Fig. left: Riparian strip less than 2 m wide or not present.
Fig. right: Riparian strips between 2 m and 5 m wide.



Determination of structural quality grades

After entering the data in the Excel spreadsheet (*for determination in the field, offline*) and in the web application (*online*), the result is entered here for evaluation.

Structural quality grade (with color-code)	**Index range**	**Degree of impairment**	**Short description**	**Overall result** (check one quality grade)	**6 Partial results** (Check one quality class each for the course of the stream, longitudinal profile, transverse profile, bed structure, bank structure and stream surrounding)
1	1 – 2,2	unaltered	The stream structure corresponds to the natural state		
2	>2,2 – 3,4	Slightly altered	The stream structure is near-natural and only slightly altered by individual, small-scale interventions.		
3	>3,4 – 4,6	Moderately altered	The stream structure is influenced by various interventions, e.g. in the bed and banks, by backwater and/or land use.		
4	>4,6 – 5,8	Strongly altered	The stream structure is severely impaired by a combination of interventions, e.g. in the course of the stream, bank stabilization, transverse structures, dam regulation and/or the use of the floodplain.		
5	>5,8	Completely altered	The stream structure has been completely altered by interventions in the course of the stream, bank stabilization, transverse structures, dam regulation, flood protection facilities and/or uses in the floodplain.		

3.3. Assessment of the macrozoobenthos community

In the FLOW project, the community of macrozoobenthos is being investigated for the biological assessment. Macrozoobenthos (synonym macroinvertebrates) is the name given to the community of invertebrates at the bottom of watercourses, including insects (larvae), mussels, snails, crustaceans, leeches and worms. Macroinvertebrates are established as bioindicators in stream ecology. They react sensitively to changes in chemical water quality and stream structure and thus provide important information on the health and functionality of fluvial ecosystems.
The Helmholtz-Centre for Environmental Research (UFZ) has developed the ***SPEciesAtRisk* „SPEAR“[1] biological indicator**, which shows the ecological effects of pesticides (especially insecticides and fungicides) on macrozoobenthos.
The SPEAR index determines the relative proportion of macroinvertebrates at a sampling site that are very sensitive to pesticides due to their **functional ecological characteristics** (so-called *SPEcies At Risk*, "SPEAR species").
The higher the proportion of these pesticide-sensitive species, the lower the pesticide contamination of the sampling site. If many SPEAR species are found during the water analysis, this is a good sign for the water quality!

The sampling of macrozoobenthos consists of five steps:

1. mapping the substrates (i.e. materials at the bottom of the watercourse such as gravel, sand, leaves, etc.) and distributing the 20 net samples to the substrates
2. 20x netting of the macrozoobenthos (kick sampling) based on the determined substrate distribution
3. sorting the macrozoobenthos into main taxa using the column sieve
4. taxonomic identification of the macrozoobenthos
5. determination of the SPEAR index

3.3.1. Substrate mapping

Team size: 2–3 people
Material: Field protocol substrate mapping and photo collection substrate mapping, clipboard and pens

The invertebrates (macrozoobenthos) are sampled a total of 20 times in the marked sampling section of the stream. This means that **20 samples** are **taken** from the stream **with a landing net**. This is called "kick sampling" because for each of the 20 net samples, the bottom of the stream is carefully stirred up with the foot to flush the bottom-dwelling animals into the net in the direction of flow.
For this purpose, the **substrates (various bottom materials on the river bed such as gravel, sand, pieces of wood, etc.)** in the sampling section are first documented in the field protocol in order to systematically search for macrozoobenthos on each important substrate with the landing net.

Procedure:

- The **proportions** of the **substrates** listed in the field protocol (1. mineral substrates and 2. organic substrates) are estimated **in 5% increments** in the sample section and noted in the protocol column "Degree of coverage" (**example**: 55% gravel, 25% sand, 15% CPOM and 5% fine and medium gravel)
- The coverage of all substrates should total **100%.**
- On this basis, the total of **20 net samples** are **distributed to the individual substrates**: **one net sample** is taken **for every 5% coverage** by a substrate (e. g. gravel). For the above example, this would result in 11 subsamples on gravel, 5x sand, 3x CPOM and 1x fine and medium gravel (compare FigFig. **2**, aus: Meier et al., 2006).

[1] https://www.ufz.de/index.php?de=38122

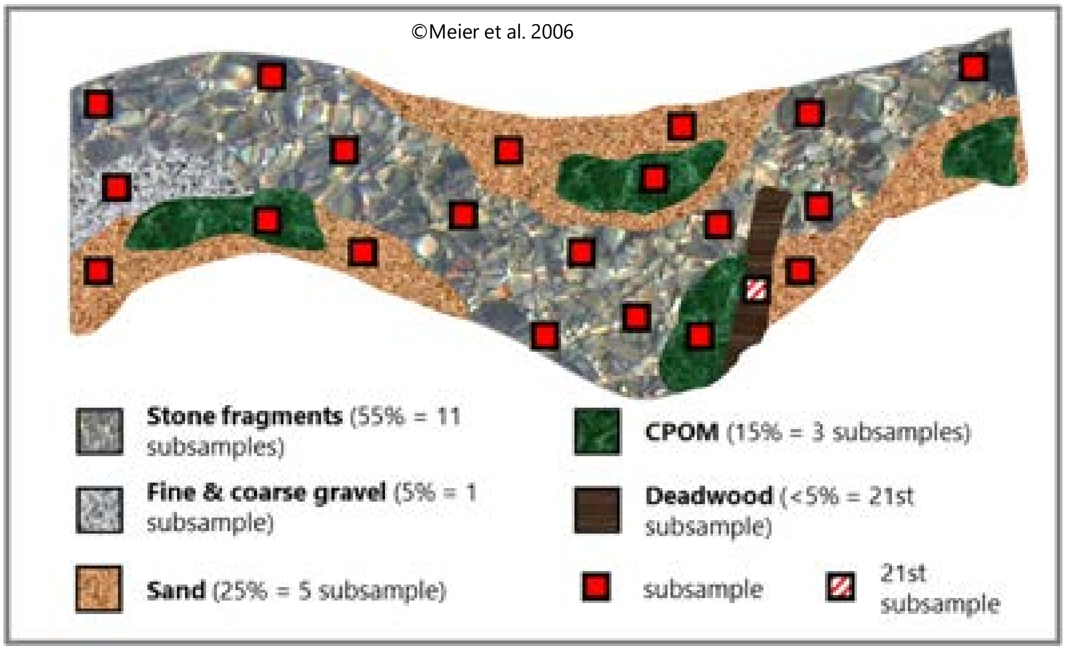


Fig. 2: That is how the 20 landing net samples are distributed among the substrates recorded. Substrates that only have a very low proportion of less than 5% coverage can be taken into account with a 21st subsample. Adapted from Meier, 2006.

Important:

- Map the substrates from the bank so that the animals are not stirred up before the nets are used.
- The landing net samples should cover both bank areas and the middle of the watercourse, as well as deep and shallow areas. (see Fig. from: Meier et al., 2006).
- If mineral substrate (e. g. stones) is covered by organic substrate (e. g. leaves), the covering substrate is decisive for mapping.
- The **'Remarks' column** in the protocol provides space for special features of the sampling site. For example, you can enter here which mineral substrate is covered by organic substrates.

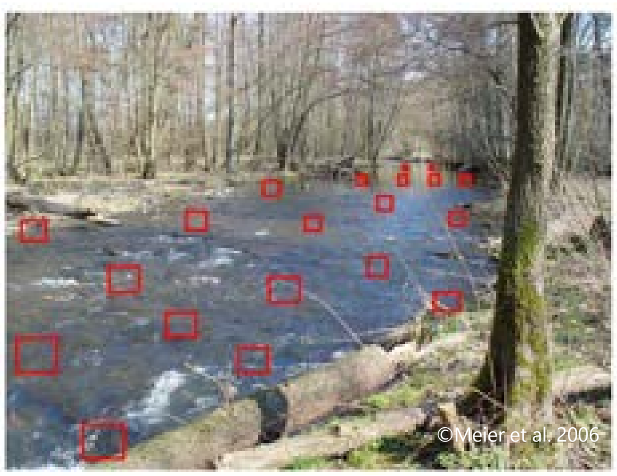


Fig. 3: Distribution of the 20 net samples over the sample section so that both bank and edge areas are covered during netting.

3.3.2. Netting the macrozoobenthos (Kick-Sampling)

Team: at least two people
Material:

- A long-handled landing net (rectangular frame 25x25cm, net width 500 µm, net depth 70cm)
- Field protocol substrate mapping with allocation of the landing net samples to the substrates
- Old toothbrushes for scraping off stones, possibly rubber gloves
  Rubber boots / waders

Procedure *see Short video about Kick-Sampling*

- One person (equipped with rubber boots or waders) goes into the stream to net the fish
- An assistant tells the person in the stream from the bank, based on the "Substrate mapping" protocol, how many landing net samples are to be taken on which substrates
- Sampling is carried out **against the direction of flow, starting at the lowest end of the sampled section**
- To take a landing net sample, place the landing net perpendicular to the bottom of the stream **against the direction of flow**
- **Use your foot to stir up** (carefully 'kick') the bottom of the water in the direction of flow so that as many organisms as possible are washed into the landing net by the current ('kick sampling', about 10 'kicks' per subsample).
- Use your foot to work on an area roughly the size of the landing net frame (25x25cm)
- Aquatic plants, large stones and dead wood are lifted and searched for macroinvertebrates with your hands (use rubber gloves or a toothbrush to scrape off stones if necessary). Position the landing net in such a way that any animals that come loose are caught. Place any animals collected from the stones in the landing net.

Fig. 3: Taking a landing net sample in a stream using 'kick sampling'.

Important: When kick-sampling, always hold the landing net in the water against the direction of flow so that animals that have already been caught cannot escape again!
Accidentally caught fish or crayfish are returned directly to the water (according to the protocol).
All dragonfly species are protected by law and should be handled with particular care.

3.3.3. Sorting the macrozoobenthos

Material

- 2–3 10-Liter bucket, column strainers
- White trays with water for sorting the macrozoobenthos into large taxonomic groups
- Spring steel tweezers and Petri dishes, possibly a magnifying glass
- Macrozoobenthos poster and identification aid for sorting

After all 20 landing net samples have been taken from the water, the sample material is placed **directly onto the column sieve** (Fig. 5) together with the animals from the landing net.
To do this, set up the **column sieve** (finest sieve at the bottom, coarsest sieve at the top) and place it in a large white bowl. The contents of the landing net are now placed on top of the column sieve (in small portions if necessary) and rinsed through with water. The animals can now be picked out of the sieve sections and placed in a white tray.

Abb. 4: The macrozoobenthos sample is rinsed through the column strainer (left). Three differently fine sieve parts of the column sieve (right).

Now the animals are sorted according to large groups (orders) into the appropriately labeled **white trays filled with water**:

1. Caddisfly larvae (Trichoptera)
2. Mayfly larvae (Ephemeroptera)
3. Stonefly larvae (Plecoptera) and if present: Alder-, Dobson- or Fishfly larvae (Megaloptera)
4. Beetles and beetle larvae (Coleoptera)
5. Two-winged / True fly larvae (Diptera)
6. Snails and mussels / clams (Gastropoda and Bivalvia)
7. True bugs / waterbugse (Heteroptera)
8. Crayfish, shrimps & isopods (Crustaceae, especially freshwater shrimps)
9. Oligochaetes (Oligochaeta), flatworms (Turbellaria) and leeches (Hirudinea) → they roll up in ethanol, so it is best to take photos while they are still alive.
10. Dragonfly & damselfly larvae (Odonata)

Notes on implementation:

- **Large and particularly muddy samples** with a lot of organic material are **transferred to a 10-liter bucket for rinsing** before screening and sorting:
  - To do this, fill the bucket up to approx. ¾ full with water and carefully stir or swirl up the contents by hand
  - the light organic material including the animals is stirred up, heavy stones, mud and sand settle to the bottom of the bucket
  - now pour the material floating on top out of the bucket through an empty landing net so that the plant material and animals end up in the landing net
  - repeatedly fill the bucket with water and continue 'stirring' & pouring until only stones & sediment and no more organisms remain at the bottom of the bucket (check again for shells etc., then the rest in the bucket can be thrown away)
- **Use spring steel tweezers** to pick out the animals!
- **To sort** the macrozoobenthos into the large taxonomic groups: Use the FLOW identification aid and macrozoobenthos poster

Note on killing and preserving macrozoobenthos in ethanol: The identification of animals in the living state is sometimes difficult. To ensure the quality of the data, some participating participating groups check the macrozoobenthos in the laboratory. If this applies to your group, you will be contacted by the FLOW team. In this case, 5-10 specimens of each species will be transferred to ethanol for preservation. In this case, the killing of the animals for the purpose of data collection is justified from a conservation point of view. Dragonfly larvae are the only animal group that are not preserved in ethanol, but are identified alive and photographed as accurately as possible! (→ especially protected species).

Fig. 5: From left to right: white trays, ethanol spray bottles and collection bottles.

3.3.4. Identification of Macrozoobenthos

Material:

- Petri dishes and spring steel tweezers
- Taxa list (printout) and pens
- Binoculars (with LED lights)
- FLOW identification guide, FLOW poster (can be supplemented with own literature and Kosmos guide)
- Laptop with Excel tables and SPEAR calculator
- (90%, denatured ethanol in spray bottles)

Team size for species identification: up to ten people

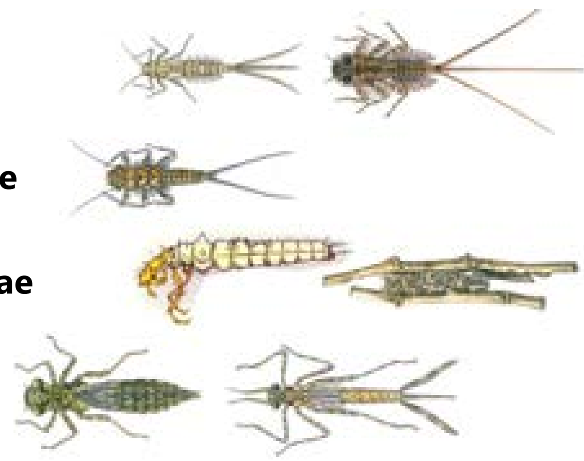
To determine the SPEAR index, all macroinvertebrates found are determined as precisely as possible (aim: at least down to family level).

Each team of two or three takes on a large group for the determination:

1. Fill a Petri dish with a little water and place it under the binoculars. Illuminate the Petri dish with the LED lights.
2. Place the animals in the Petri dish for identification using a pair of spring steel tweezers (one at a time or a few similar-looking animals).
3. Animals that have been identified are returned to the white dish and counted.
4. After identification, the frequency of individuals is counted for each taxon (up to 50 individuals); in the case of very numerous occurrences (> 50 individuals), the frequency is estimated.
5. Species and frequency data are transferred to the field protocol
6. All taxa lists are collected and data are entered into corresponding prepared Excel spreadsheet
7. 3-5 specimens of each species are preserved in collection bottles with ethanol, the rest are released back into the stream. Preserved animals are sometimes easier to identify.

Important: In order to obtain the most meaningful SPEAR index possible for the sampling site, it is important to determine the following groups as precisely as possible, i.e. down to family level or more precisely (see Fig. 6 from Engelhardt et al., 2015).

- **Mayfly larvae**
- **Stonefly larvae**
- **Caddisfly larvae**
- **Dragonfly & damselfly larvae**
- **Alder-, Dobson- & Fishfly larvae**



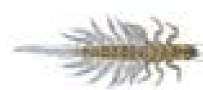


Fig. 6: Orders of macrozoobenthos that are particularly important for determining the SPEAR index. They should be in focus of the determination.

Instructions for photographing macrozoobenthos: A photo is taken of each specific animal. Note the following:

- Save with name of the taxon, date & sampling site (e. g. 'Limnephilus_lunatus15042022_SN_Rohrgraben')
- Upload photos to the web application
- only one animal per photo
- as good a resolution as possible
- photograph in front of a white background, colors & patterns should be clearly visible (a little sediment in the picture does not matter)

Tip: At the beginning, appoint a photographer to take photos of all the animals with a digital camera. Place numbered, small pieces of paper next to the animals so that the animals can be assigned to the taxa list afterwards. Also helpful: use a very small Petri dish to restrict the animals' range of movement; use a white or black background; use a cell phone attachment/mobile phone microscope.

Sending the samples: To check for data quality, 20 % of the participating groups are randomly selected and asked to send their samples soaked in ethanol to the UFZ.

Field protocol for mapping the substrates at the stream bottom

Cf. Photo collection for substrate mapping **Macrozoobenthos team (Name):**	**Sampling site:** **Datue:**		
Mineral substrates	**Coverage ratio (in 5% steps)**	**Number of subsamples**	**Remarks**
Very large stones and stone blocks > 40cm, rock (Megalithal)			
Stones of head size > 20cm - 40cm, with variable proportion of smaller grain sizes (Makrolithal)			
Crushed stone, fist-sized stones > 6cm - 20cm, with variable proportion of smaller grain sizes (Mesolithal)			
Coarse gravel from the size of a pigeon's egg to the size of a child's fist, grain size > 2 cm - 6 cm, with a variable proportion of smaller grain sizes (Mikrolithal)			
Fine to medium gravel, grain size > 0.2 cm - 2 cm (Akal)			
Sand and/or mineral sludge (grain size > 6µm - 2mm, Psammal)			
Loam and clay, cohesive material, e. g. alluvial loam grain size < 6µm (Argyllal)			
Artificial substrate: rock fills (Technolithal 1)			
Artificial substrate: closed river bed protection e.g. concreted river bed (Technolithal 2)			
Organic Substrates	**Coverage ratio (in 5% steps)**	**Number of subsamples**	**Remarks**
Algae (threaded algae, clumps of algae)			
Submerged macrophytes: aquatic plants that grow completely submerged			
Emersed macrophytes: Plants growing partly above the water such as cattails, sedges, reeds			
Living parts of terrestrial plants (fine roots, floating riparian vegetation)			
Wood and deadwood, i.e. tree trunks, branches, larger roots (Xylal)			
CPOM (coarse particulate organic material, > 2mm)			
FPOM (fine particulate organic material, < 1mm)			
Wastewater-related growth of bacteria such as Sphaerotilus (Saprobal)			
Debris (organic and inorganic material deposited in the shore zone by currents)			
Sum	**100%**	**20**	

Macrozoobenthos sampling: taxa list

Date:___________________________________

Project group:__________________________

Stream:__________________________________

Tips: The aim is to identify the animals down to the family, if possible also more precisely (genus, species). Please try to fill in at least the first two columns (order & family). For **beetles** (Coleoptera) please mark larvae with **Lv.** and adults with **Ad.** (adult). Please take a **photo** of each animal listed and then upload it to the web app.

Order (e.g. Caddisfly, *Trichoptera*)	**Family** (e.g. *Limnephilidae*)	**Genus** (e.g. *Limnephilus* sp.), **Species** (e.g. *Limnephilus lunatus*)	**Frequency** Please mark: estimated: * counted: ~