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ReBioClim

D1.2.1 Report

Ecological goals for restoration of the study streams

Version 2

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Content

EXECUTIVE SUMMARY

The ecological perspective led by TU Dresden, Institute for Hydrobiology, assesses and evaluates the current ecological status and carries out deficit analysis to identify hydro-morphological pressures and establish ecological goals for restoration to enhance connectivity and foster biodiversity. Defining goals for restoration is an important step towards appropriate restoration attempts and in order to evaluate the success or effect of restoration measures.

A. Purpose and Objectives

A core question of restoration ecology is the definition of success. Urban streams face a wide range of ecological challenges. Functional restoration to reach good ecological reference conditions is often not possible due to chemical contamination, strongly fluctuating hydrological condition, a lack of space for natural dynamics, a limited species pool for recolonization and many instream migration barriers. On the other hand, it is a missed opportunity for the increase of biodiversity or functional species richness to capitulate and only enhance urban streams in terms of human aesthetic norms. Within ReBioClim we work on these conflicts in urban stream restoration. The international research project identifies and analyses the current urban challenges and opportunities for river restoration from different perspectives in four different countries and extract the trade-offs between social and ecological requirements in the context of urban planning and institutional settings. This enables the project team to develop socio-ecologically integrated solutions for urban multifunctional areas that provide ecosystem services and climate adaptation, promote biodiversity and take into account urban planning.

From an ecological perspective, the following questions arise: What are the ecological possibilities for urban stream restoration? What could be a biological reference system for urban streams?

We have developed a comprehensible method for setting ecological restoration goals for urban streams. These are based on chemical, geomorphological and biological data collection and stressor analysis. This allows to prioritise urban stressors and set restoration targets. We consider spatial and administrative constraints to formulate ecological targets that are understandable, measurable and achievable.

These criteria are particularly important as ecological restoration targets are combined with urban-spatial analysis and socio-economic objectives as the basis for stakeholder co-design workshops, and are made available to communities as projects are implemented in our stream sites.

B. Methods

1. Literature Research

ReBioClim aims to restore urban streams in a community-based approach based on scientific metrics. To get an overview over scientific based approaches literature search in Web of Science (WOS) was conducted to get an overview of methods to identify urban stream ecology restoration goals. The aim was to identify publications that deal with the setting of goals for a socio-ecological urban stream restoration project. The following search string was used in WOS:

TS=((stream OR freshwater OR running water OR flowing water) AND (restorat OR renature* OR enhance) AND (goals OR goal OR objective* OR success Or target*) AND (urban OR cit*) NOT (marine OR ocean OR energy))*

The query resulted in 776 Results (27.02.2025) which were filtered by adjusting the timespan of publication date for the last ten years (2025-2015) to consider current mode of conduct and applying the research question: Does the study elaborate on goals for urban stream restoration? One older study (Palmer et al., 2005) was considered as it dealt with setting of standards for ecologically successful river restoration. The majority of studies dealt with various questions on (urban) stream restoration. Only eight studies, were extracted which dealt with setting of restoration goals specifically.

Additionally, the AI Research Assistant Elicit was applied with the research question: "What is the best method to identify urban stream ecology restoration goals". The AI based search assistant scanned 126 million academic papers from the Semantic Scholar corpus and provided ten studies that described five distinct methods for identifying urban stream restoration goal. Deleting double hits and applying the set publication time frame resulted in another two studies. The literature research resulted in eleven studies, which dealt with the setting of urban stream restoration goals.

2. Data acquisition

In ReBioClim, a multiperspective approach on urban stream restoration was conducted for all four partner cities and streams. To gain an understanding of the ecological status of the project stream data acquisition through our local partners and web resources was necessary.

Table 1 Overview of ReBioClim partner cities and streams

Country	County/Region	City	Project Stream
Slovakia	Trnavský kraj	Senica	Teplica
Germany	Sachsen	Dresden	Geberbach
Poland	Wielkopolskie	Poznań	Piaśnica
Czech Republic	Liberecký kraj	Jablonec nad Nisou	Bílá Nisa

2.1. Public Resources

To obtain a data basis for ecological monitoring data that is comparable between the project cities and that can be used in other European locations a first step was to obtain open access monitoring data of stream morphology, benthic invertebrates and fishes. The first resource to conduct was data from the Water Framework Directive (WFD) (2000/60/EC), since all partner countries are subject to it. Here is a list of identified open access web resources:

- European level:
  - WDF Results: https://discomap.eea.europa.eu/wise-freshwaterviewer/?page=Page&views=Ecological-Status%2CLayer (12.06.2025) Jurisdiction: European Commission and the European Environment Agency (EEA).
  - https://water.europa.eu/freshwater/europe-freshwater/water-framework-directive/ecological-status-of-surface-water

ESA WorldCover: https://doi.org/10.5281/zenodo.7254221,(10.06.2025), Jurisdiction: European Space Agency

- National Level:
  - Czech Republic
    - Geomorphological Type: https://vuv.maps.arcgis.com/apps/webappviewer/index.html?id=6a6a8ec85cc9452bba069147ecd9ada4 (12.06.2025), Jurisdiction: CUZK
    - Hydromorphology: https://hydro.chmi.cz/hpps/?id=act&key=map&sx=1691250.3976558652&sy=6575027.318561342&sz=8 (12.06.2025), Jurisdiction: Český hydrometeorologický ústav (Czech Hydrometeorological Institute)
  - Germany
    - WFD Results, geomorphological type, stream/river fact sheets: https://geoportal.bafg.de/wfdmaps2017/# (12.06.2025), Jurisdiction: Bundesanstalt für Gewässerkunde (BfG)
    - Saxony:

    Morphological, chemical, biological data stream data, fact sheets, : https://www.umwelt.sachsen.de/umwelt/infosysteme/ida/ (12.06.2025), Jurisdiction: Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)

    Discharge and in-stream barriers: https://www.umwelt.sachsen.de/umwelt/infosysteme/mnqhq-regio/website/?whereClause=AKZ%20IN(%2705113%27) (12.06.2025), Jurisdiction: Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)

    Nutrient inputs into Saxon waters: https://www.viewer.stoffbilanz.de/start/ (12.06.2025), Jurisdiction: Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)

  - Poland
    - Status of surface water bodies and additional data: https://wody.gios.gov.pl/pjwp/publication/367 (12.06.2025), Jurisdiction: Department of Environmental Monitoring of the Chief Inspectorate for Environmental Protection (GIOS)
  - Slovakia:
    - No public resources found

As the obtained data was insufficient for ecological analysis local partners were asked to obtain data on hydro morphological features such as discharge, geomorphological type, stream velocity and chemical pollution. Local partners were able to provide further non-public data and collect specific data for the project streams:

- Jablonec nad Nisou: Biological report for the Bílá Nisa project site (Michal Pravec, 2024)
- Poznań: Monitoring data on aquatic macrophytes and benthic macroinvertebrates (mzb)
- Senica: Results of WFD, In-stream barriers, overview illegal discharges

2.2. Data collection

As the data availability was inconsistent in the four project cities, further data on stream morphology and biology needed to be collected within the project.

2.2.1.1. Morphology Data

To collect consistent stream morphology data the application of one common methodology was agreed upon: Applied procedural methodology for small urban watercourses (Renner et al., 2018). Since the usual mapping methods are based on reference conditions, they place particular emphasis on urban impact and pollution. The method used is based on the perception that morphological conditions are changed in urban areas and ecological reference state cannot be reached. The procedure can therefore evaluate the morphology of urban streams in a more differentiated manner. In addition to substrate, embankment and stream bed characteristics other parameters relevant to urban spaces are considered as well (f.ex. reachability of the area and peculiarity of the site). The method calculates indexes which lead to five structure classes. Each class rates urban stream morphology from “Unimpaired” (class 1) to “Completely anthropogenically impaired” (class 5). The methodology was translated from German into English language and provided to local partners to map the stream structure in 50 m segments.

2.2.1.2. Composition of benthic invertebrates

To increase the knowledge on stream biology the biological quality class of benthic invertebrates (mzb) were chosen. Monitoring mzb in small streams is necessary because their community composition integrates the effects of multiple environmental stressors over time and thus reflects the overall ecological condition of the stream better than momentary chemical measurements. They are a key trophic link in stream food webs, contributing to organic matter breakdown, nutrient cycling, and energy transfer to higher trophic levels such as fish. Their varying sensitivities to pollution and habitat alteration make them reliable bioindicators of water quality and ecological integrity. Because many benthic taxa have life cycles spanning several months (to years), changes in their communities indicate both recent and cumulative impacts. This makes them indispensable for assessing both current status and trends in stream ecosystem health.

Regional partners in Sencia and Poznan agreed on sampling campaigns for mzb according standardised WFD procedure (PERLODES protocol) (WFD 2001):

- Multihabitat sampling (20 Habitats +1 optional, on a 100m stream stretch, with a 0,25*0,25 m area)
- BACI Design (Before, After, Control, Impact)
- One sampling campaign/year (spring sample)
- Three samples in each campaign:
    - 1 at beginning of project site
    - 1 at end of project site
    - 1 urban reference above project site
- determination to lowest possible taxonomic level (genus or species)

Figure 4 City of Senica with project stream Teplica (red) and 3 sampling sites (green)

Figure 3 Sampling procedure of benthic invertebrates kick-sampling method.

Figure 1 Sampling procedure of benthic invertebrates pre-picking delicate organisms

Figure 2: Sampling procedure of benthic invertebrates fixation in 80% Ethanol.

Three sampling campaigns were conducted by LP (TU Dresden) and Mgr. Igor Kokavec, PhD. (Sk) according the aboved mentioned procedure:

- Jablonec nad Nisou (Bílá Nisa), 29.04.2025
- Dresden (Geberbach), 15.04 and 16.04.2025
- Senica (Teplica), 24.04.2025

Sampling of the open section of Piaśnica was conducted by Szymon Jusik (Uniwersytet Przyrodniczy w Poznaniu) by Polish standart protocol (determination to family level):

- Poznan (Piaśnica), 24.09.2025

The monitoring sites are displayed in Figures 1-3. The samples were pre picked and conserved in 80 % Enthanol for conservation (Figures 5-7). The taxonomic determination was conducted by Maja Reukauf (TU Dresden), Povodni Ohre (Teplica) and Mgr. Igor Kokavec, PhD.. A detailed site description was created for each waterbody based on the data described in 2.1 and 2.2 (attached files). The site descriptions contain information on stream geo-hydraulics, physico-chemics and biology. This was intended to provide a quick overview of the water ecology parameters and assessments according to the WFD. The site descriptions can be used by the responsible partners in the cities in the further planning and implementation process.

To interpret and compare the ecological quality of the project streams different core metrics calculated from the taxa lists within the PERLODES evaluation scheme were combined. The indicators were chosen for their relevance in (urban) stream environments (Table 2). All indicators were standardized (0-1) and an overall index as the mean value of all standardized values per site was calculated. In addition to monitoring the pilot sites and upstream site in each river was chosen to serve as urban reference. The parameters of these sites accounted for urban reference mean values which served as overall reference.

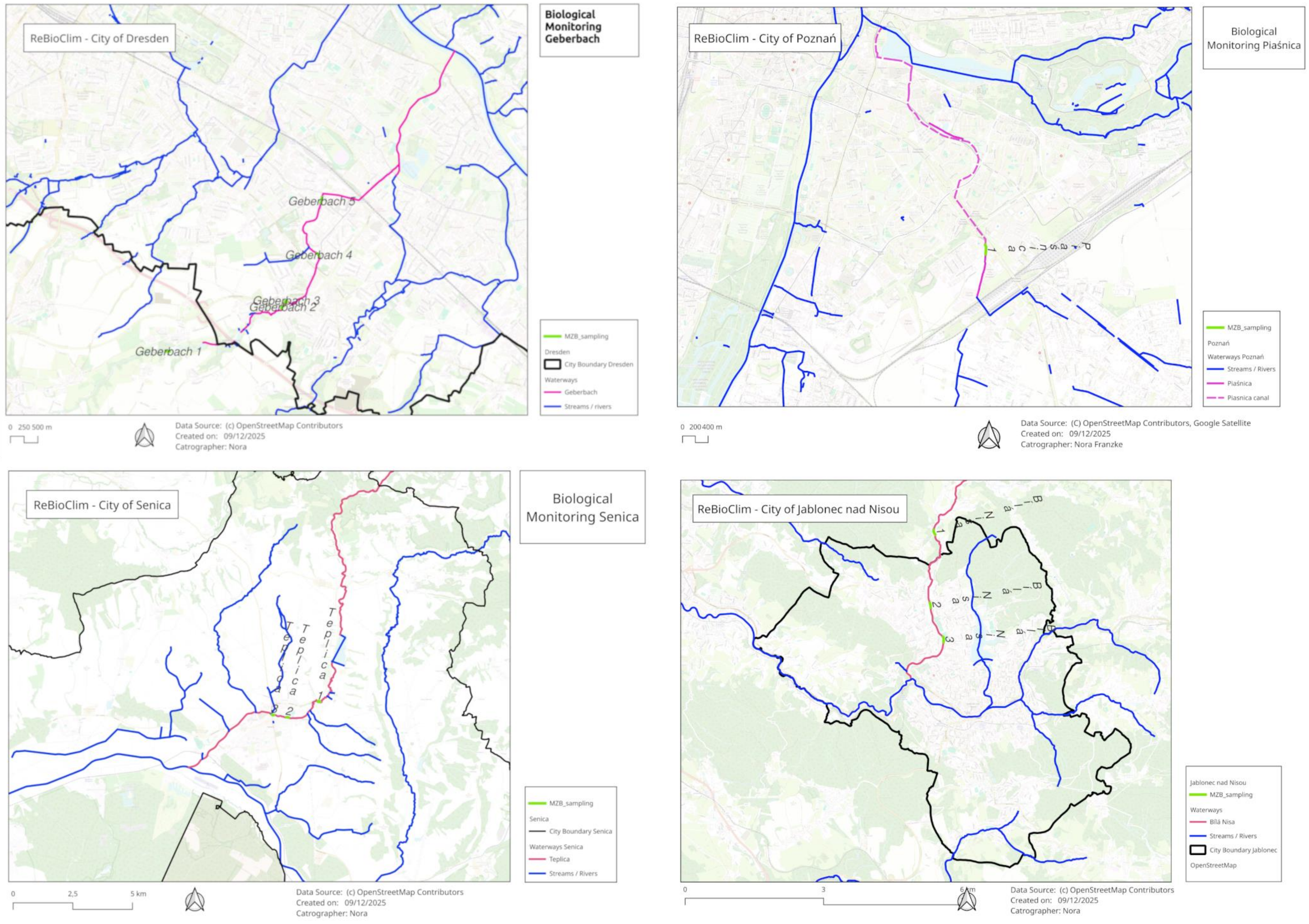

Figure 4: MZB sampling sites in the four pilot sites

Table 2 Metrics of biodiversity

Indicator	Description
Shannon-Wiener-Index	The Shannon-Wiener-Index is a measure of biodiversity that considers both the number of species (richness) and how evenly they are distributed (evenness). A high index value indicates greater diversity, which is associated with more species and a more even distribution of individuals among those species.
Evenness	Evenness is a measure of how evenly the individuals in a community are distributed among the different species.
1-German Saprobial Index	The type-specific saprobic index assesses the effects of organic pollution on macrozoobenthos. The higher the index, the greater the intensity of organic pollution. increased decomposition of pollution activity is inevitably associated with a decrease in dissolved oxygen content. As saprobity increases, the biocoenosis shifts towards taxa that can tolerate deficits in oxygen content. These taxa predominantly belong to the ecological guilds of detritus feeders, fine sediment dwellers, and profundal and potamal dwellers, while the proportion of rheophilic taxa decreases.
German Fauna index (specified for coarse substrate mountain streams)	The index describes the effects of morphological degradation on the macrozoobenthos community of a river section based on water type-specific indicator lists. A high metric value indicates a large proportion of taxa with high morphological requirements in the water body type under consideration and thus also a largely type-specific and near-natural macrozoobenthos community.
Rheo index based on abundances (according to Banning)	This index indicates the ratio of rheophilic and rheobiont taxa to still water species and ubiquists, and highlights disturbances in the biocoenosis of streams caused by changes in flow patterns.
% Feeding type shredder	The metric describes the percentage of individuals that feed on coarse organic matter (e.g. leaf litter, wood). It relates to the functional feeding type of stream organisms. High proportions of shredder organisms are based on the availability of coarse organic matter, e.g. provided by sufficient tree cover along the stream.
SPEAR-Index	SPEAR (Species At Risk) is a trait based biological indicator that determines the contamination of a stream based on the composition of macroinvertebrate communities. A high SPEAR (pesticides) index indicates low pesticide contamination — meaning that many pesticide-sensitive (“at-risk”) macrozoobenthos taxa are still present.
% EPT-Taxa	The metric calculates the relative abundance of Ephemeroptera, Plecoptera, and Trichoptera taxa based on individuals per square meter. These insect orders mainly

	comprise species that are intolerant to pollution and have relatively high habitat requirements, both in aquatic and terrestrial environments. The metric primarily indicates the undisturbed nature of the dominant sub-habitats and therefore generally responds to impairments in water quality and water morphology. A high metric value usually indicates undisturbed, structurally rich water bodies.
% Pelal Microhabitas	The metric calculates the relative abundance of species that prefer pelal (mud, slik) habitats. A high number of pelal dwellers is a sign of degradation in a mountainous stream environment, as mountain stream have rapid currents and therefore a shift towards coarse substrates.

C. Results

3. Urban Stream Restoration Goals: A Methodology

Effective goal-setting in urban stream restoration requires the integration of scientific, ecological, and societal dimensions, supported by clear, measurable, and adaptable objectives (Asnake et al., 2021). Ecological indicators such as macroinvertebrate communities, riparian vegetation, habitat conditions, and water chemistry provide a valuable basis for defining restoration targets, although the recovery of aquatic communities may be constrained by landscape connectivity and the distance to source populations (Feio et al., 2015).

Context-specificity is another critical consideration. In urban environments, where space is limited, restoration often involves balancing flood defence infrastructure with the reestablishment of ecological functions and the provision of recreational opportunities—a trade-off that is recognized as challenging to achieve (Guimarães et al., 2021). Sustainability-oriented perspectives further highlight that long-term ecological integrity depends not only on natural processes but also on socioeconomic dimensions, such as safe public access and the integration of streams into neighbourhood aesthetics (Hawley, 2018). Conceptual tools such as the Stream Function Pyramid (**Fehler! Verweisquelle konnte nicht gefunden werden.**) provide a hierarchical framework for identifying foundational hydrological and geomorphic processes that support higher-level ecological functions, emphasizing the interdependence of system components (Harman et al., 2012).

Another recurring theme is the need to incorporate community values and diverse knowledge systems into restoration planning (Murphy et al., 2022). Flexible frameworks, such as Urban Stream Renovation, align restoration goals with plausible future scenarios rather than attempting to replicate historical reference conditions, which are often unattainable in urban contexts. By linking short-term societal benefits to long-term ecological outcomes through feedback loops, such approaches can enhance public support and improve the overall success of restoration initiatives (Smith et al., 2016).

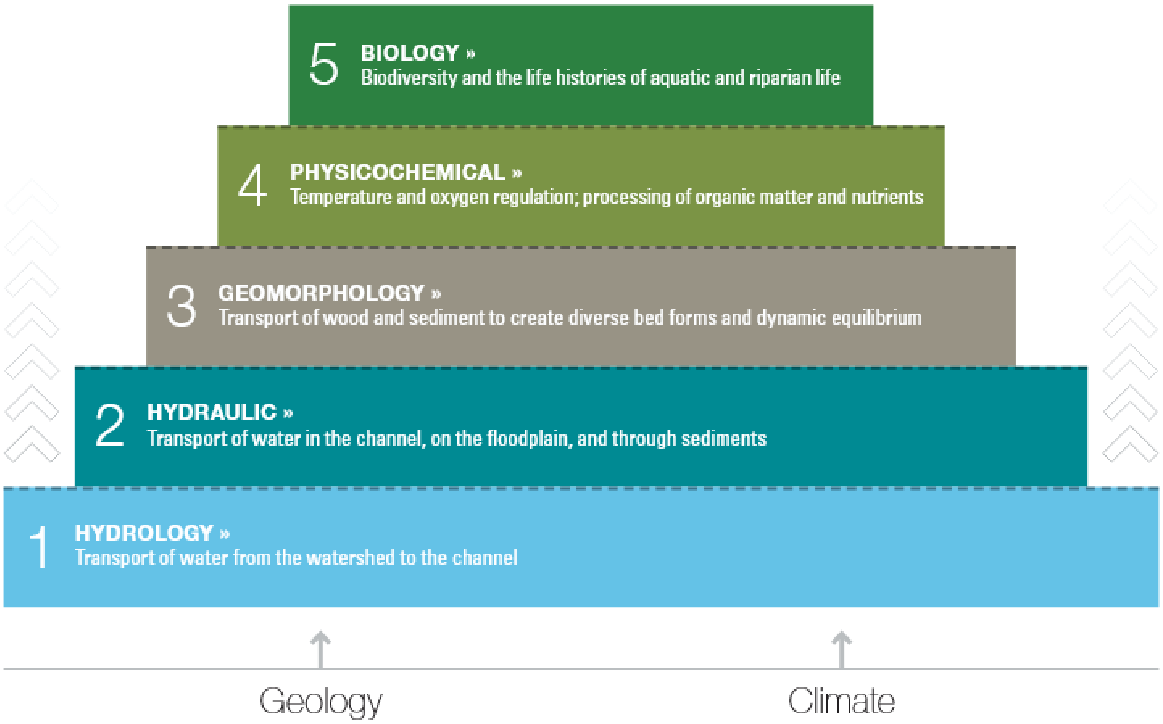

Figure 8 The Stream Functions Pyramid, developed by (Harman et al., 2012), provides a framework that organizes stream functions in a pyramid form. It illustrates that stream functions are supported by lower-level functions in a hierarchical structure.

From the above summarized findings in recent publications on urban stream restoration goals, the following methodology was derived:

1. **Stressor Identification:** Identification of stressors in urban streams, assess specific biological, physico-chemical and morphological conditions at every stream site
2. **Scale Definition:** Define Scale of Restoration (Historical-, Functional- or Ecological Restoration, Enhancement)
3. **Stressor Priorisation**: Which stressors are relevant for specific site and project scale? And is there an ecological priority between stressors? What is the primary ecological issue at the site?
4. **Goal Formulation**: Formulate ecological restoration goals which are comprehensible, measurable and reachable

The formulated goals and measures feed into the further multiperspective process where stakeholder and community interests and spatial constrains and possibilities are incorporated to assess synergies and conflicts.

4. Project Streams: An Overview

Figure 5: ReBioClim project streams Geberbach site 2 (Prohlis) and Bílá Nisa 1 (upper section)

Figure 6: ReBioClim project streams Piaśnica (piped) and Teplica

The partner cities varied in area and population size (Table 3). Dresden is the city with the largest area and number of inhabitants, followed by Poznań. Jablonec nad Nisou has the smallest city area but more than double the number of inhabitants compared to Senica, which is smaller in size. All cities are located in low mountain ranges, the streams in reference conditions would be typically rich in coarse substrates, have a rapid flow velocity, a high stream dynamic due to slope and precipitation, a high variety of substrates, riparian trees/forest in the riparian zone and a high species variety of benthic invertebrates. Even though the cities and streams differed in catchment size and discharge, they all shared the influence of urban space on their biology, physico-chemistry and geohydraulics. The streams have been confined to regulated channel (or even piped) and are disconnected from its floodplain and former meanders. In all streams there were several migration barriers that impair ecological connectivity. Furthermore, all streams were degraded by chemical pollution due to agriculture, industry and urban run-off. In the following chapters urban stream morphology, stream ecology and physico-chemistry are described to assess the pressing stressors on stream health.

Table 3 Overview over the four project cities and site with selected criteria

	Senica	Dresden		Poznań	Jablonec nad Nisou
Population [inhabitants]	19 000	560 000		530 000	46 000
Area [km²]	50	328		262	32
Project Stream	Teplica	**Geberbach 1** Nickern	**Geberbach 2** Prohlis	Piaśnica	Bílá Nisa
Catchment area [km²]	47	18		15	22

5. Project Streams: Urban Morphology

Project Stream	Teplica	Geberbach 1 Nickern	Geberbach 2 Prohlis	Piaśnica	Bílá Nisa 1 Upper section	Bílá Nisa 2 Lower section:
Site length [m]	750	320	1090	250	1030	200
Structure index	3	3.2	2.8	5	3.5	2.1

The site length of ReBioClim pilot sites varied from 1090 m (Geberbach 2) to 250 m (Piaśnica). The structure classes ranged from class 2.1 (Slightly anthropogenically impaired) to 5.0 (Completely anthropogenically impaired).

Table 4: Description of structure classes (Martina Renner et al., 2018)

Structure Class	*Description*	*Index Range*
1	*Unimpaired*	*1.0 - 1.6*
2	*Slightly anthropogenically impaired*	*> 1.6 - 2.5*
3	*Moderately anthropogenically impaired*	*> 2.5 - 3.5*
4	*Strongly anthropogenically impaired*	*> 3.5 - 4.4*
5	*Completely anthropogenically impaired*	*> 4.4 - 5.0*

Piaśnica pilot site reached the worst index of 5, as it is fully underground. The other sites were scored with index 3 “moderately anthropogenically affected”, due to few special bed structures, concrete river bed construction, technical embankments and visible pollution. The sites in Teplica, Geberbach 2 and Bílá Nisa

1 had parks with urban greenery, trees in the riparian zone or valuable socio-cultural characteristics that increased the overall index. The Bílá Nisa 1 in Jablonec nad Nisou had the best overall structure class (index 2.1, “slightly anthropogenically affected”), as the profile, river bed and base of embankment was less fortified and had more diverse substrates. The overall mean of Bílá Nisa resulted in index/ structure class 3 (Moderately anthropogenically impaired). In Dresden the lower section (Geberbach 2) scores slightly better than the upper section (Geberbach 1), although both lie in the range of Index 3 (Table 3).

6. Project Streams: Stream Ecology

Urban morphology results are partly supported by the assessment results of WFD (Table 5) for Geberbach (Dresden) and Teplica (Senica). The classification of the ecological status or potential of rivers is based on so-called biological quality components of the aquatic flora and fauna. The fish, invertebrates, phytoplankton and other flora living in the water are good indicators of the quality of the waters. The evaluation is divided into five categories: Class 1 = very good, Class 2 = good, Class 3 = moderate, Class 4 = poor and Class 5 = bad. The classification is based on how much the current quality of a body of water differs from the quality of a body of water that is not affected by human influences. (UBA, 2025)

The results show a bad to poor ecological potential. For Piaśnica and Bílá Nisa there are no monitoring results under WFD as they are not subject to reporting according (European Environment Agency (EEA), 2021). For Bílá Nisa our own data showed “poor” ecological quality of the Biological Quality Class (QC) macroinvertebrates (mzb).

Table 5 Results of biological and chemical assessment based on WFD for the four project streams.

Rating under WFD	Teplica	Geberbach	Piaśnica	Bílá Nisa
Ecological status/ potential (total)	Poor	Bad	No data	No data
Biological QC: Fishes	Good	Bad	No data	No data
Biological QC: mzb	Bad	Poor	No data	Poor
Chemical condition (total)	Not Good	Not Good	No data	No data

Further results on in-stream biodiversity were based on field measurements of benthic invertebrates in the pilot reaches of Geberbach, Teplica and Bila Nisa according to PERLODES protocol (WFD 2001).

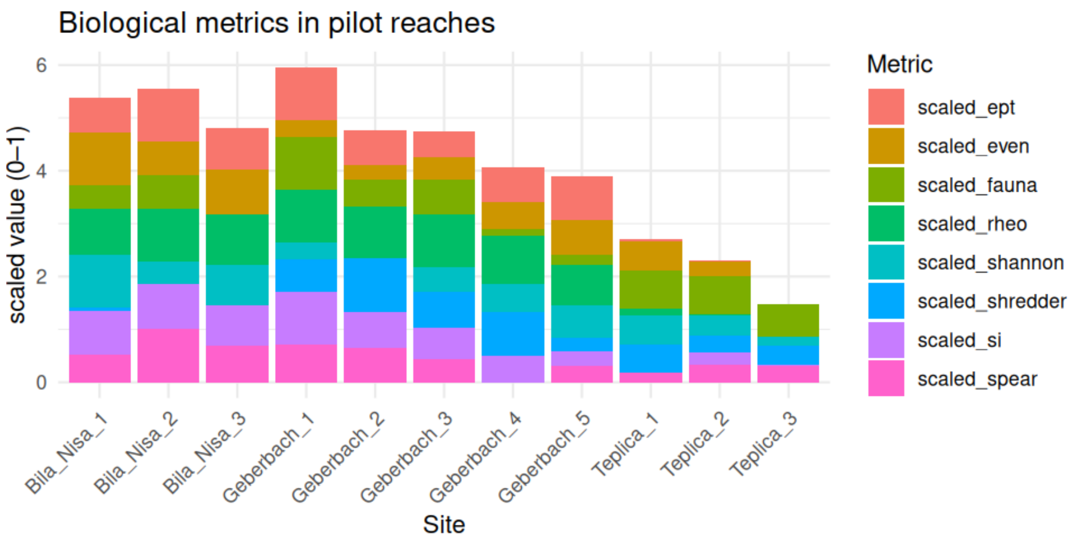

Figure 8: Selected normalized biological metrics in Teplica, Bila Nisa and Geberbach pilot sites, The first site of each stream is the urban reference site

The results of the mzb monitoring showed a gradient from Bílá Nisa, to Geberbach, to Teplica, in terms of diversity (Shannon-Wiener-Index), sensitive species (EPT-Taxa, Fauna-Index, Rheo-Index) and pollution (Saprobic-Index and SPEAR-Index) (The urban reference sites (Bílá Nisa 1 and Geberbach 1) reached the highest overall index (mean of all scaled indexes).

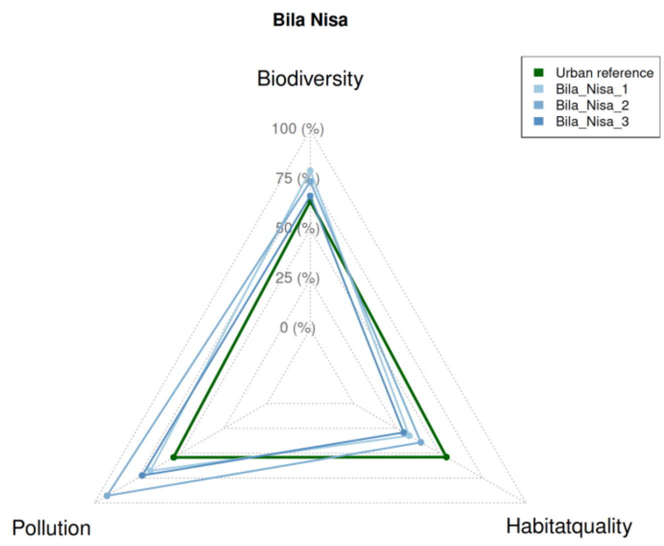

Figure 7: Spider plot with scaled ecological indexes for Biodiversity (mean percentage of EPT- Taxa, Shannon Index, Rheo Index, Fauna Index and Evenness), Habitatquality (mean percentage of shredders, percentage pela/mud habitats) and Pollution (mean SPEAR -Index, Saprobic Index) for Bila Nisa in three different sites and the urban reference site (as weighted mean)

Bílá Nisa had the lowest and Teplica the highest overall levels of pollution. The overall index shows a gradient from better to worse ecological condition in relation to distance to source, from urban reference sites to downstream (more urban sites) for all streams, which can be explained by increasing levels of pollution and increasing degradation of habitats.

The monitoring results of Bílá Nisa showed a relatively good ecological basis of sensitive, cold-water loving species that prefer rapid currents. The highest in-stream biodiversity was found at Bílá Nisa 1 (urban reference- Figure 7). Their abundance decreases from pilot site 1 to pilot site 2, even though morphological alteration of the pilot section is higher upstream than downstream. Possibly the upstream pilot site is influenced by the more diverse urban reference sites above. The abundance of rheophilic and rheobiotic species is high, due to stream slope (mountainous character of the stream) but also the anthropogenically narrowed stream corridor, that increases the current (*rithralization)*. The effect of *rithralization* is especially apparent in section Bílá Nisa 2, where the concrete trapezoid channel offers almost no substrate, but supports hundreds of strong currents loving Baetidae (Mayfly-Larvae), that increase the ecological indexes. Due to rapid currents, there are almost no mud or slick loving species present, which would be a sign of degradation. The Fauna-Index is below average and shows a depletion of mountainous indicator species. The taxonomic composition of benthic invertebrates in Bílá Nisa shows almost no shredders, species that prefer coarse organic substrates, like leaves or dead wood. This might be due to missing trees in the riparian zone of almost the whole stream. The monitoring of benthic invertebrates showed the disruption of species composition from highly specialized sensitive mountain dwellers to more insensitive generalists. The indicators that display organic pollution (Saprobic-Index) and the influence of pesticides (SPEAR-Index) are above average for all sites.

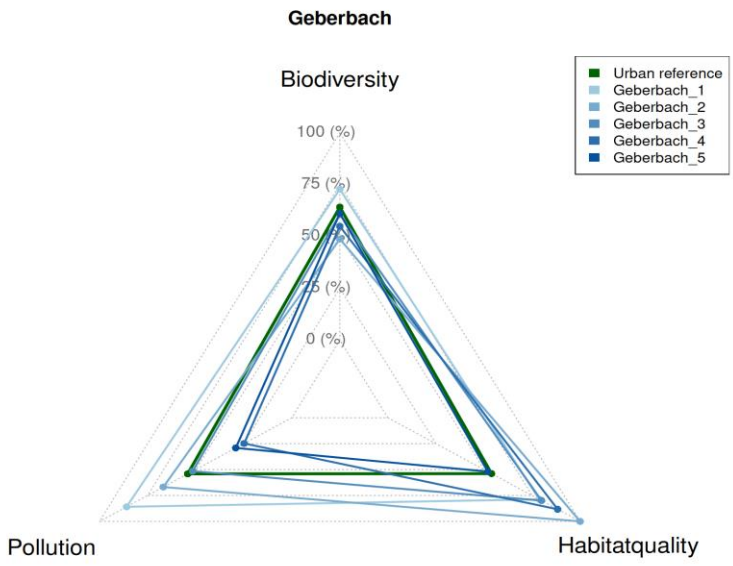

Figure 9 Spider plot with scaled ecological indexes for Biodiversity (mean percentage of EPT- Taxa, Shannon Index, Rheo Index, Fauna Index and Evenness), Habitatquality (mean percentage of shredders, percentage pela/mud habitats) and Pollution (mean SPEAR -Index, Saprobic Index) for Geberbach in five different sites and the urban reference site (as weighted mean)

The benthic invertebrate community of Geberbach consists of sensitive, rheophilic species in the urban reference site. The abundance of EPT-Taxa and indicator species was above urban reference mean values. These groups diminish with increasing distance to source. Along this gradient of urbanization, the Shannon-Wiener-Index (in-stream diversity) decreases as well (Figure 9). Mud and slick loving species (percentage of pelal), as indicators of impoundment are increasing, as well as species that show organic pollution (Saprobic Index) and effect of pesticides (SPEAR-index). The percentage of shredders are generally abundant in Geberbach, and only fall below average at the last sampling site (Geberbach 5). The amount of this functional group is substantially higher than in Teplica and Bílá Nisa. This explains all sites being above urban reference (Figure 9). Sensitive mountainous species that prefer fast currents were found in all sites with numbers above average. Possibly a similar rithralization effect that was described for Bílá Nisa can be found in the benthic invertebrate community of Geberbach as well.

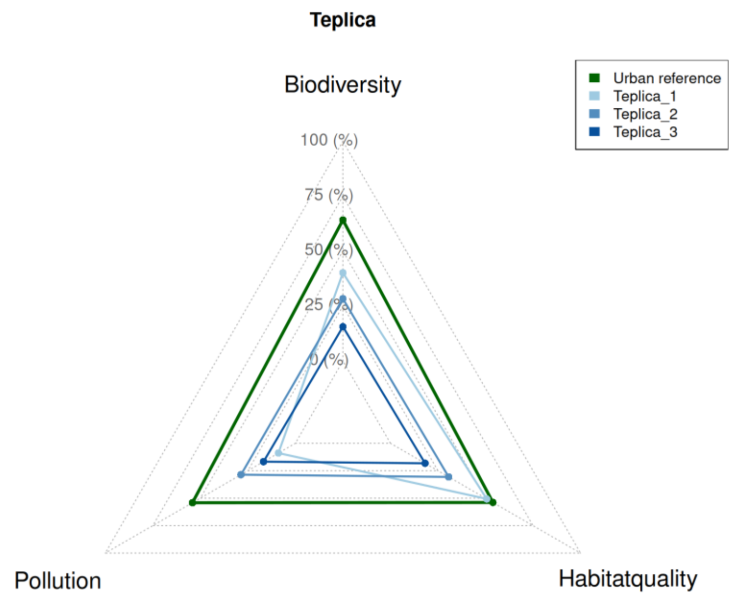

Figure 10: Spider plot with scaled ecological indexes for Biodiversity (mean percentage of EPT- Taxa, Shannon Index, Rheo Index, Fauna Index and Evenness), Habitatquality (mean percentage of shredders, percentage pela/mud habitats) and Pollution (mean SPEAR -Index, Saprobic Index) for Teplica in three different sites and the urban reference site (as weighted mean)

The species composition of Teplica shows a severely disturbed mountainous stream. All Indicator were below urban reference conditions (Figure 10). In Teplica there were almost no insect larvae in all sites (percentage EPT-Taxa, amount rheophilic-taxa, the community is shifted towards insensitive species, that prefer mud habitats (percentage of pelal). Diversity of benthic invertebrates (Shannon-Wiener-Index) in below average for all sites. Teplica had the highest amount of pollution of the three streams. The indicators that display chemical pollution, show that almost no pollution sensitive species are inhabiting Teplica river. The high levels of pollution are most probably the cause for depletion of sensitive species. The number of shredders is lower than in Geberbach but higher than in Bílá Nisa, which is consistent with urban morphology mapping that showed galleries of trees lining Teplica river.

Physico-chemical characteristics as assessed in the monitoring showed no distinct variation among waterbodies (Table 6). In spatial characteristics there is a clear decreasing gradient from urban reference to downstream sites in the proportion of canopy cover and an increasing proportion of impervious surface for Bílá Nisa and Geberbach. As the project site in Teplica lies within an urban park the proportion of canopy cover is high for an urban site, which in beneficiary for the stream ecology but cannot balance the harmful impact of pollution.

	BN1	BN2	BN3	T1	T2	T3	GB1	GB2	GB3	GB4	GB5
Different Substrates	7,00	2,00	5,00	5,00	4,00	7,00	8,00	5,00	8,00	8,00	9,00
pH	7,95	7,86	7,58	7,97	8,25	8,22	8,23	8,20	8,27	8,27	8,29
O2	9,44	9,98	11,10	8,80	10,66	10,92	10,40	9,70	9,82	8,75	7,60
Water Temperature	14,10	14,10	11,50	15,30	15,78	15,30	11,20	14,90	14,10	16,50	17,00
Electric Conductivity	120	130	141	493	501	498	651	687	684	679	689
Proportion Impervious Surface	0,13	0,41	0,40	0,00	0,19	0,41	0,09	0,40	0,38	0,42	0,39
Proportion Canopy Cover	0,48	0,24	0,31	0,38	0,67	0,36	0,70	0,31	0,24	0,28	0,34
Distance_to_source [m]	6753	8538	9355	26504	28411	29061	3088	5688	5841	7086	8287

Table 6 : Physico-chemical and spatial characteristics of the three project streams Teplica, Bílá Nisa and Geberbach, Results from mzb monitoring

7. Project Streams: Physico-Chemistry

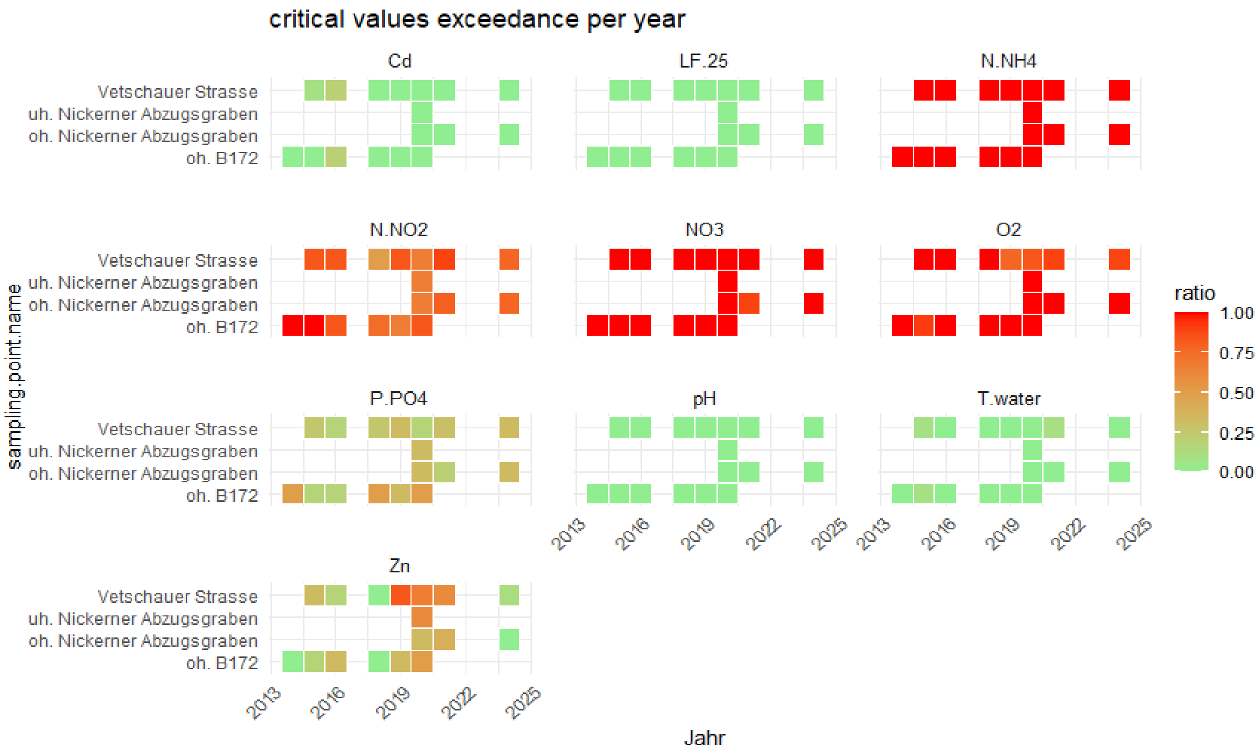

Figure 11 Exceedances of physico-chemical values per year (2013-2025) in different measurement stations in Geberbach. Red colour indicates a regular exceedance of ecocritical values, green colour indicates that no exceedance was measured. Data from Sächsischen Lan

Chemical data for Bílá Nisa and Geberbach was obtained from ReBioClim project partners. In Geberbach the exceedances for the nutrients Ammonium (N-NH4), Nitrite (NO2), Nitrate (NO3), and Orthophosphate-P (P-PO4) are especially critical (Figure 11). In nearly all measurements, these substances exceeded the ecologically relevant thresholds (Bundesministeriums der Justiz, 2016). In 2024, the annual mean concentrations exceeded the threshold value for Ammonium by a factor of 9, for Nitrite and for Nitrate by a factor of 3 (Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG), 2025).

In Bílá Nisa ecocritical concentrations of the nutrient phosphate have increased both upstream and downstream since 2022. Electrical conductivity is increased in the downstream section. Repeatedly very high values of the highly ecotoxic heavy metal zinc have been measured (Johnson et al., 2025). According to local partners just above the project site is an old industrial site, which leaks toxicants. Those can be at least partly responsible of the measured pollution levels. Furthermore, zink is part of tire wear and is washed into urban streams by stormwater runoff. Historical data (years 2013 and earlier) for Cybina show ecosystem critical levels of nutrients as nitrate and Orthophosphate-P as well as high summer peak temperatures. For Teplica there is no chemical data available, although effects of the community of benthic invertebrates show major pollution.

The results of the survey on urban stream morphology and benthic invertebrate composition show highly degraded ecosystems in the pilot reaches of the ReBioClim project. They also show an increase in different habitats, substrates and benthic colonisation whenever there are sections with trees, an open stream bed and a lesser technical embankment. This becomes apparent in the downstream section of Bílá Nisa (Bílá

Nisa 2) and in the middle part of Geberbach (Geberbach2 and 3). The higher ecological quality of the urban reference sites in Bílá Nisa and Geberbach indicates that colonisation with sensitive invertebrate species is possible in those streams whenever urban stressors are reduced. The results of the biological monitoring indicate that in Teplica river the major limiting factor is chemical pollution. This major stressor on the stream ecosystems needs to be diminished before structural measures can show beneficiary results. In Piaśnica there is no colonization of benthic invertebrates possible at this point due to complete canalization of the pilot section.

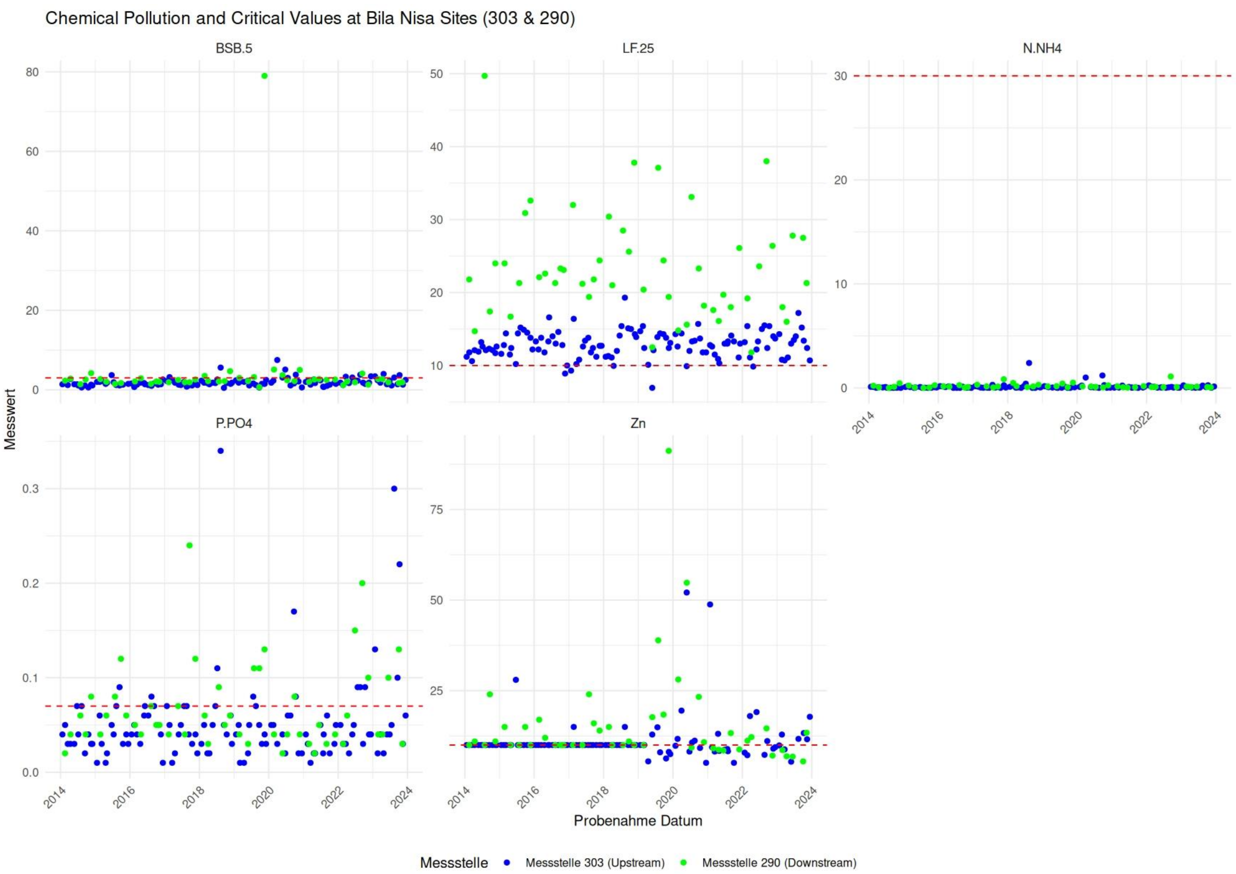

Figure 12: Physico-chemical data for two measurement stations in Bila Nisa from 2014 to 2024, the ecosystem critical values are displayed as red line, Data from Povodí Labe, státní podnik 07.11.2024

8. Stressor Analyses

Based on the findings of chapter 4 the main drivers and stressors were summarised and assessed based on their impact on the project streams (Table 7). For each stressor a degradation effect (state) was characterized.

Table 7 DPSIR (Driving forces, Pressures, States, Impacts and Responses) approach to analyse relevant stressors in the ReBioClim pilot sites and to formulate restoration goals.

Driver	Pressure	State	Impact	Response/ Restoration Goal
Urban development, Land-use change	Technical Stormwater Management	Excessive stream bed erosion	- Deficient sediment balance - Deepened in stream - Altered habitats	Promote dynamic river processes
Urban development, Land-use change	Technical Stormwater Management	In-stream barriers	- Limited migration for fishes and MZB	Increase ecological connectivity
Urban development, Land-use change	Technical Stormwater Management	Regulated discharge and catchment imperviousness	- Missing natural dynamic - Linear flow - Fast rise and fall of stormwater level	Establish natural discharges
Urban development, Land-use change	Technical Stormwater Management	Regulated discharge and catchment imperviousness	- Missing natural dynamic - Linear flow - Fast rise and fall of stormwater level	Promote dynamic river processes
Urban development, Land-use change	Technical Stormwater Management	Technical Embankment	- Reduced stream-process dynamics lead to homogeneity of substrates, flow and habitats - Reduced biodiversity	Promote dynamic river processes
Urban development, Land-use change	Technical Stormwater Management	Technical river bed	Missing Interstitial leads to missing groundwater exchange, missing habitats, missing type specific organisms	Promote dynamic river processes

Driver	Pressure	State	Impact	Response/ Restoration Goal
Urban development, Land-use change	Point source	Organic/ chemical/ nutrient pollution in streams	- Poisonous for (semi-) aquatic species - Low in-stream biodiversity	Reach good chemical water quality
Urban development, Land-use change	Artificial infrastructure and human activities	Segmented Ecosystems	- Loss of biodiversity	Reconnect fragmented ecosystems
Urban development, Land-use change	Artificial infrastructure and human activities	Urban Heat Island (UHI) - Significant higher temperatures than in rural areas	- Negative impact to human and non-human health	Reduce urban heat island effects
Urban development, Land-use change	Anthropogenic Climate Change	Increasing frequency of extreme and uncontrolled flooding	- Danger of flooding urban infrastructure and residential areas	Improve flood protection
Urban development, Land-use change	Anthropogenic Climate Change	Rise in peak temperatures and overall mean temperatures	- Pressure on cold-water adapted fish and MZB species (reduced Oxygen availability) - Reduces absolute and functional diversity of MZB, fish and other (semi-)aquatic organisms	Reduce heat stress
Urban development, Agricultural practices	Non-point source pollution	Organic/ chemical/ nutrient pollution in streams	- Poisonous for (semi-) aquatic species - Low in-stream biodiversity	Reach good chemical water quality

9. Ecological Restoration Goals

Table 8 Restoration goals and targets with proposed measures and the effects on Climate adaptation, Biodiversity and Quality of Life

Response/ Restoration Goal	Restoration Target	Restoration Measure	Description	Effect on Climate Adaptation	Effect on Biodiversity	Effect on Quality of Life	Indicators of Restoration Success
Promote dynamic river processes	Promote natural sediment dynamics	Direct flow to prevent or enable bank erosion	Use rocks, plants, or fascines to steer the water away or towards the banks. Promote natural sediment provision.	Near-natural streams are more robust against climate-related changes to the water balance.	Natural river banks increase habitat availability and connectivity for fish, MZB and macrophytes and enable dynamic river processes.	Natural streams invite to play and observe nature.	Increased diversity of in-stream substrates and habitats
Promote dynamic river processes	Promote natural sediment dynamics	Enhance natural provision of sediment by erosion or add sediment	Add stream type specific sediments to balance out bed load deficite due to altered ecological connectivity.	Near-natural streams are more robust against climate-related changes to the water balance.	Natural stream bed sediments increase habitat availability and connectivity for fish, MZB and macrophytes and enable dynamic river processes.	Natural streams invite to play and observe nature.	Increased diversity of in-stream substrates and habitats
Promote dynamic river processes	Promote natural sediment dynamics	Natural bank stabilization with fascines	Use bundles of live branches or tree roots to reinforce banks and encourage vegetative growth.	Near-natural streams are more robust against climate-related changes to the water balance.	Stream bank structures made of natural materials promote dynamic river processes and create habitats.	Natural streams invite to play and observe nature.	Increased diversity of in-stream substrates and habitats

Promote dynamic river processes	Promote natural sediment dynamics	Sediment augmentation	Add stream type specific sediments to balance out bed load deficite due to altered ecological connectivity.	Near-natural streams are more robust against climate-related changes to the water balance.	Natural stream bed sediments increase habitat availability and connectivity for fish, MZB and macrophytes and enable dynamic river processes.	Natural river beds invite to play and observe nature.	Increased diversity of in-stream substrates and habitats
Response/ Restoration Goal	**Restoration Target**	**Restoration Measure**	**Description**	**Effect on Climate Adaptation**	**Effect on Biodiversity**	**Effect on Quality of Life**	**Indicators of Restoration Success**
Increase ecological connectivity	Enable fish migration	Build fish passage	Create channels or structures to allow fish and MZB to bypass migration barriers.	Near-natural streams are more robust against climate-related changes to the water balance.	Bypasses allow fish and MZB to move within the stream. Organisms migrate e.g. to reproduce, find food or colonise new habitats.	Natural streams invite to play and observe nature.	Increase in benthic and fish biodiversity
Increase ecological connectivity	Reconnect stream sections	Remove in-stream barriers	Remove technical barriers like pipes and culverts OR if necessary, build them more ecofriendly (as short as possible, filled with natural substrate and possibility of wildlife passing along the stream) to improve migration of organisms and increase habitat diversity.	Near-natural streams are more robust against climate-related changes to the water balance.	Longitudinal connectivity allows sediment transport, which is important for habitat diversity and migration of organisms to make use of different habitats.	Natural streams invite to play and observe nature.	Number of removed in-stream barriers, Number of connected stream sections, Increase in benthic and fish biodiversity

Establish natural discharges	Water retention in riparian zone	Reconnect floodplains	Reconnect the stream to existing floodplain or created temporary wetland (e.g. parks functioning as rainwater retention basin) by lowering banks and allow flooding.	Retention of water in reconnected temporary wetlands mitigates floods caused by heavy rain events and stores water in the landscape for longer drought periods	Floods "clean" the river bed from fine sediment and enhance in-stream habitat for fish and macro invertebrates. Deposited sinesediment in the floodplain fertilizes the soil.	Retention of water in designated temporary wetlands mitigates floods and reduces damages to houses and infrastructure.	Increased retention area [m²]
Response/ Restoration Goal	**Restoration Target**	**Restoration Measure**	**Description**	**Effect on Climate Adaptation**	**Effect on Biodiversity**	**Effect on Quality of Life**	**Indicators of Restoration Success**
Establish natural discharges	Maintaining minimum discharge	Reduce water extraction	Minimize water withdrawals to maintain ecological integrity. Prioritize withdrawals if necessary.	Near-natural streams are more robust against climate-related changes to the water balance.	Maintaining minimum water discharge ensures habitat availability for fisch and MZB	Maintaining minimum water discharge protects groundwater ressources, supports ecosystem health, supports water quality.	Increased number of days maintaining minimum water discharge
Establish natural discharges	Maintaining minimum discharge, seasonal change from high to low waterlevels	Remove dams or adjusted operation rules	Change dam operation rules reflecting natural hydrological regime.	Near-natural streams are more robust against climate-related changes to the water balance.	Natural hydrologic regimes ensure habitat availability and connectivity for fish, MZB and macrophytes and enable dynamic river processes.	Natural streams invite to play and observe nature.	Minimized number of drought days
Establish natural discharges	Decrease imperviousness, enhance infiltration	Unseal impervious surfaces, use permeable pavements	Use permeable pavements or remove sealed surfaces completely to increase ground-water inflitration and decrease stormwater run-off.	Permeable pavements control stormwater through infiltration to the ground below.It retains water supporting groundwater recharge and decreases stormwater run-off.	Permeable surfaces flatten stormwater hydrographs and therefore reduce the risk for MZB to be flashed away. They also filter toxic run-off.	Permeable pavements support the reduction UHI effect in the city.	Increased retention area [m²]

Promote dynamic river processes	Permeable interstitial zone	Fine sediment retention	Create technical fine sediment retention in areas with increased fine sediment loads and maintain them.	Near-natural streams are more robust against climate-related changes to the water balance.	Retention of finesediment prevents river bed from clogging and enhances habitat quality for fish and MZB.	Natural streams invite to play and observe nature.	Increased diversity of MZB, Increased exchange of stream and groundwater
Response/ Restoration Goal	**Restoration Target**	**Restoration Measure**	**Description**	**Effect on Climate Adaptation**	**Effect on Biodiversity**	**Effect on Quality of Life**	**Indicators of Restoration Success**
Promote dynamic river processes	Create natural embankment	Add groynes, baffles, dead wood and circulation trees	Use natural embankment to promote river dynamic processes (targeted substrate erosion and sedimentation, diversification of flow).	Near-natural streams are more robust against climate-related changes to the water balance.	Natural stream bank structures and dynamic river processes create and enhance habitats.	In stream structures such as stones and dead wood invite to play and listen to the sounds of nature.	Increased diversity of in-stream substrates and habitats
Promote dynamic river processes	Create natural embankment	Remove concrete channel, installation of fascines where necessary	Remove technical embankment to allow for natural fluvial processes and connectivity. If necessary, use bundles of living branches or tree roots to stabilize the bank and promote plant growth.	Near-natural streams are more robust against climate-related changes to the water balance.	Natural river banks increase habitat availability and connectivity for fish, MZB and macrophytes and enable dynamic river processes.	Natural stream banks invite to play and observe nature.	Increased diversity of in-stream substrates and habitats

Promote dynamic river processes	Promote natural river bed	Remove technical river bed	Remove technical riverbed to allow for natural fluvial processes and connectivity. If necessary, use natural materials to create habitats.	Near-natural streams are more robust against climate-related changes to the water balance.	Permeable water bed structures increase habitat availability and connectivity for fish, MZB, plants and algae. Permeability of the interstitial zone allows groundwater exchange.	Natural stream beds invite to play and observe nature.	Increased diversity of in-stream substrates and habitats

Response/ Restoration Goal	Restoration Target	Restoration Measure	Description	Effect on Climate Adaptation	Effect on Biodiversity	Effect on Quality of Life	Indicators of Restoration Success
Reach good chemical water quality	Prevent illegal discharge of waste water	Connection of households to existing wastewater treatment plants. Install small wastewater treatment plants in remote areas.	Improvement of wastewater disposal of a municipality by connecting households and businesses to the existing central wastewater treatment plant.	Reduced organic/ chemical/ nutrient pollution in streams minimize hazards caused by interaction of pollutants with high water temperatures and concentration effects caused by low discharges.	Reduced organic/ chemical/ nutrient pollution in streams increases habitat quality.	Good water quality invites people to play in the water, swim and fish.	Reduced input and load of pollutants, High diversity of sensitive aquatic species, Number of connected households. Number of small wastewater treatment plant
Reconnect fragmented ecosystems	Increase landscape connectivity	Add transversal green corridor	Connect ecosystems by transversal corridors for wildlife movement.	Connected green spaces enable larger scale fresh air channels, water infiltration and stormwater runoff management.	Connect ecosystems enable wildlife movement and connect urban with suburban areas.	Green corridors through cites envite to rest and find shade in overheated cities.	Increased number of connected ecosystem, Connected area [m²]

Reconnect fragmented ecosystems	Increase landscape connectivity	Create an interconnected network of green spaces	Create continuous ecological zones and recreational routes to enable air corridors, connect ecosystems, and spaces for rest.	Connected green spaces enable larger scale fresh air channels, water infiltration and stormwater runoff management.	Connect ecosystems enable wildlife movement and connect urban with suburban areas.	Green corridors through cites envite to rest and find shade in overheated cities.	Increased number of connected ecosystem, Connected area [m²]
Reduce urban heat island effects	Increase urban vegetation cover to 30%	Turn gray to green-blue infrastructure - Urban afforestation	Transform fallow land into forests with native plant and tree species.	Densely vegetated areas help to cool the air, provide shade and stores rainwater.	Densely vegetated areas provide habitat and promotes biodiversity.	Densely vegetated areas reduce UHI in the city by improving air quality and microclimate, reduce stress and allow interaction with nature.	Afforested area [m²], reduced peak temperatures in summer and at nights

Response/ Restoration Goal	Restoration Target	Restoration Measure	Description	Effect on Climate Adaptation	Effect on Biodiversity	Effect on Quality of Life	Indicators of Restoration Success
Reduce urban heat island effects	Decrease imperviousness	Turn grey to green-blue infrastructure - Use permeable pavement	Use permeable pavements or remove sealed surfaces completely to increase ground-water infiltration.	Permeable pavements retain water, support groundwater recharge and support blue-green infrastructure.	permeable pavements support the connectivity of densely vegetated, therefore promote biodiversity.	Permeable pavements support the reduction UHI effect in the city.	Increased unpaved area [m²]
Improve flood protection	Watercourse development	Increase space for river and floodplain	Widening of the stream corridor to reduce uncontrolled flooding and downstream flooding risk.	Increased natural retention area mitigates floods caused by heavy rain events and stores water in the landscape for longer drought periods.	Near-natural streams are more robust against climate-related changes to the water balance. Enlarged stream corridors facilitate movement of species and increase habitat availability.	Retention of water in the floodplain reduces flood peaks and reduces damages to houses and infrastructure.	Increased retention area [km²]

Improve flood protection	Manage of natural flooding / runoff	Manage rainwater	Measures to retain water, e.g., through communal retention facilities, facilities to improve infiltration (including rainwater infiltration systems), other rainwater utilization facilities in public areas (green roofs)	Serves to adapt to climate change induced increase of heavy rainfall. Promotes natural water retention in the area.	Green roofs and other vegetated areas promote biodiversity of urban insects and bird.	Retention of water in the floodplain reduces flood peaks and reduces damages to houses and infrastructure. Green roofs have positive psychosocial benefits and allow interaction with natural green spaces.	Number of installations, increased green roof area [m²]

Response/ Restoration Goal	Restoration Target	Restoration Measure	Description	Effect on Climate Adaptation	Effect on Biodiversity	Effect on Quality of Life	Indicators of Restoration Success
Improve flood protection	Watercourse development	Reconnect floodplains	Support the stream's ability to flood adjacent lands by lowering the banks or lift stream bed by adding sediment.	Increased natural retention area mitigates floods caused by heavy rain events and stores water in the landscape for longer drought periods.	Near-natural streams are more robust against climate-related changes to the water balance. Enlarged stream corridors facilitate movement of species and increase habitat availability.	Retention of water in the floodplain reduces flood peaks and reduces damages to houses and infrastructure.	Increased retention area [km²]
Improve flood protection	Manage natural flooding / runoff	Reduce surface sealing	Measures promote natural water retention in the area by unsealing surfaces and reducing new sealing, particularly in areas with increased precipitation or runoff.	Serves to adapt to climate change induced increase of heavy rainfall. Promotes natural water retention in the area.		Retention of water in the floodplain reduces flood peaks and reduces damages to houses and infrastructure.	Increase of unsealed area [m²]

Improve flood protection	Watercourse development	Restore and reconnect side arms	Re-establishing the connection between a stream's main channel and its natural floodplain features to increase water retention capacity and reduce damage to buildings and infrastructure.	Increased natural retention area mitigates floods caused by heavy rain events and stores water in the landscape for longer drought periods.	Near-natural streams are more robust against climate-related changes to the water balance. Enlarged stream corridors facilitate movement of species and increase habitat availability.	Retention of water in the floodplain reduces flood peaks and reduces damages to houses and infrastructure.	Increased retention area [m^2]

Response/ Restoration Goal	Restoration Target	Restoration Measure	Description	Effect on Climate Adaptation	Effect on Biodiversity	Effect on Quality of Life	Indicators of Restoration Success
Reduce heat stress	Create shade, reduce peak water temperatures below <20°C	Less frequent mowing	Reduce maintenance frequency to support the growth of natural plants and trees.	Native riparian plants along stream banks provide shade and reduced air temperatures. In addition, they stabilize soils.	Diverse native riparian vegetation creates a stream environment for temperature sensitive species. Furthermore, they provide food and habitats for insects, birds and mammals. They filter toxic runoffs.	Riparian plants invite to play, harvest edible plants and find shade in overheated cities.	Summer peak temperatures <20C, Increased tree/shrub cover by 50 %

Reduce heat stress	Create shade, reduce peak water temperatures below <20°C	Plant riparian trees	Plant riparian trees to increase shade on waterbody to over 50%.	Native riparian trees along stream banks provide shade and therefore reduce peak water and air temperatures. In addition, they stabilize the stream banks against erosion.	Native riparian trees create a stream environment for temperature sensitive species. Furthermore, they provide food and habitats for insects, birds and mammals. Riparian trees filter toxic runoffs.	Riparian trees invite to play, harvest edible plants and find shade in overheated cities.	Summer peak temperatures <20C, Increased tree cover by 50 %
Reach good chemical water quality	Enhance self-cleaning potential of the stream	Add in-stream structures	Add in-stream structures such as dead wood or stones for more heterogeneous flow to increase self-cleaning potential of the stream.	Near-natural streams are more robust against climate-related changes to the water balance.	In-Stream structures increase habitats and oxygen supply for microbial self-cleaning processes.	In stream structures such as stones and dead wood invite to play and listen to the sounds of nature.	Reduced input and load of pollutants, High diversity of sensitive aquatic species
Response/ Restoration Goal	**Restoration Target**	**Restoration Measure**	**Description**	**Effect on Climate Adaptation**	**Effect on Biodiversity**	**Effect on Quality of Life**	**Indicators of Restoration Success**
Reach good chemical water quality	Reduce stormwater run-off, enhance infiltration	Build permeable pavements	Use permeable pavements to filter stormwater run-off from roads to filter urban runoff and pollutants.	Permeable pavements control stormwater as it allows infiltration of water through the surface to the ground below. It retains water and decreases stormwater run-off.	Permeable surfaces reduce pollutant concentrations by filtering stormwater.	Good water quality invites people to play in the water, swim and fish.	Reduced input and load of pollutants, High diversity of sensitive aquatic species

Reach good chemical water quality	Reduce diffuse input of pesticides and nutrients	Inform about and promote biological practices for agriculture in the catchment	Measures to maintain and implement “good professional practice” in agricultural land management.	Reduced organic/ chemical/ nutrient pollution in streams minimize hazards caused by interaction of pollutants with high water temperatures and concentration effects caused by low discharges.	Reduced organic/ chemical/ nutrient pollution in streams increases habitat quality.	Good water quality invites people to play in the water, swim and fish.	Reduced input and load of pollutants, High diversity of sensitive aquatic species
Reach good chemical water quality	Reduce stormwater run-off, enhance retention of chemical pollutants	Plant riparian buffer strips	Plant riparian buffer strips of at least 5 meters to filter urban runoff and pollutants.	Riparian buffer strips effectively retain chemical loads mobilized due to climate related extreme events.	Riparian buffer strips allow natural interactions between riparian and aquatic zone by creating habitats and provision of food.	Riparian buffer strips invite to play, harvest edible plants and find shade in overheated cities.	Reduced input and load of pollutants, High diversity of sensitive aquatic species

D. Implementation Process

The aim of ReBioClim is to restore urban streams in a community-based approach based on scientific metrics. The above summarised restoration goals are implemented in different ways in the course of the project. In a first step the ecological restoration goals were used as a content basis for the Co-Design workshops led by TU Delft (attachment restoration toolkit). Each goal was visualized and processes as a toolkit for the participants to elaborate on specific measures and visions for the project streams.

The site descriptions (attachment files) will be handed over to local partners to be used in the further planning and implementation process. As they provide a good overview over the project stream they can also be translated in local languages and handed over to stakeholder and the interested public.

E. Conclusion

All project streams are impacted due to chemical pollution, morphological alteration, missing connectivity to the riparian zone and altered hydrology, named urban stream syndrome. Due to these stressors in-stream biodiversity is generally low in comparison to reference conditions. It became clear that data availability to asses these conditions in the four ReBioClim project cities is very different. From almost unlimited open access on public infrastructure in Dresden, to a good basis of non-public recourses in Jablonec nad Nisou, to unavailable data recourses in Senica due to restriction to non-existence of in-stream biological data in Poznan. These challenges were met by conduction own surveys, which give better understanding of the in-stream biodiversity and will be the basis for monitoring of restoration success in the future. The good ecological quality of benthic invertebrate colonization in the urban reference sites of Geberbach and Bílá Nisa, with high abundance of sensitive mountain species shows the potentials of ecological restoration. Recolonisation and higher in-stream biodiversity of the highly degraded urban sites is possible. The collected data shows a gradient of ecological degradation with further distance from source, with increasing urban stressors. Reducing urban stressors may enable sensitive species to travel to downstream sections again. Basis for successful recolonisation is a good chemical water quality, natural hydrology and functioning habitats. The available data shows four highly influenced urban streams with a great potential for multi-purpose transformation of the riverbed and banks into an attractive, aesthetic and closer to nature form.

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